EMERGENCY COMMUNICATIONS PREPAREDNESS IN CANADA

A study of the command-and-control model and the emergence of alternative approaches

by

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ABSTRACT

In recognition of the fact that communications commonly are considered to be essential to effective disaster preparedness and response, the present study addresses several related themes concerning the role of communications infrastructures -- i.e., equipment facilities on the one hand, and established patterns of interpersonal relationships among government decision-makers and industry representatives on the other -- in peacetime emergency communications planning and response processes. Its investigative tasks include the choice to apply the implicit guiding model in North American emergency management, namely, the "command-and-control" theoretical model, to a specific single-country peacetime disaster context: the Canadian case. That choice rests upon a recognition of the methodological difficulties and challenges in dealing with an emerging and highly dynamic configuation of multiple institutional players, new technologies and residual government policies respecting the telecommunica-tions sector.

The study's findings suggest an appreciation of the complexity and nuanced context within which multiorganizational and especially multijurisdictional peacetime crisis management occurs, sometimes understood as the emergence of other frameworks. This investigation contributes to the disaster literature by providing the first exhaustive study of Canada's national emergency communications structure and capabilities. It therefore can perhaps best be seen as a prologue or preliminary discourse to a broader international comparative effort of addressing questions related to communications preparedness in regard to peacetime disasters.

RESUMÉ

Du le fait que les communications sont normalement considerées essentielles pour fin d'assurer les préparations et réponses efficaces aux désastres, cette étude adresse quelques thèmes respectant le rôle joué par les infrastructures de communication -- i.e., les équipements et installations aussi bien que les patrons de relations interpersonelles établies entre les prenneurs de décision gouvernementaux et les répresentants de l'industrie -- dans les processus de la planification et réponse concernant les communications d'urgence en temps de paix. Les tâches investigatrices de cette étude incluent le choix d'appliquer le modèle implicite de quide en Amérique du Nord pour la gérance des urgences en temps de paix, cette-à-dire le modèle théorique «command-et-contrôle,» dans un contexte très précis d'un seule pays: le Canada. Ce choix était basé sur une reconnaissance des difficultés et défis méthodologiques dans le traitement d'une configuration émergente et dynamique composée des joueurs institutionaux multiples, des nouvelles technologies et des politiques gouvernementalles residuelles respectants le secteur de télécommunications.

Les resultats de l'étude suggèrent une appréciation de la complexité de l'environnement et le context nuancé dans lequel prends lieu la gérance de crise en temps de paix multiorganisationelle et surtout multijurisdictionelle, parfois considerée comme une autre approche. Cette enquête apporte à la littérature sur la gérance des désastres en produisant la première étude exhaustive sur les structures et les capacités canadiennes relatives aux communications d'urgence. En conséquence, cet ouvrage pourrait-être regardé comme un prologue ou discours préliminaire à une effort internationale comparative et plus large qui s'adresserait aux questions relatives aux communications dans les situations de désastre en temps de paix.

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ABBREVIATIONS

AC	Alternating Current
ACCTA	Advisory Committee of Commercial Telecommunications Agencies
ADP	Adaptive Differential Pulse
ADM	Assistant Deputy Minister
ADMSM	Assistant Deputy Minister, Spectrum Management
AES	Atmospheric Environment Service
AESS	Automatic Electronic Switching System
AFCEA	Armed Forces Communications Electronics Association
AM	Amplitude Modulation
AMPS	Advanced Mobile Phone System
AMSS	Automatic Multiple Site Selection
APCO	Association of Public Safety Communication Officers
ARP	Air Raid Precautions
AT&T	American Telephone and Telegraph Company
ATM	Automatic Teller Machine
BCSC	British Columbia Systems Corporation
BCTel	British Columbia Telephone Company
BOC	Bell Operating Company
BPCQ	Bureau de la Protection civile du Québec (now Sécurité Publique du Québec)
BUTN	Broadband Universal Telecommunications Network
CATV	Cable Television
CBC	Canadian Broadcasting Corporation
CCIR	International Radio-communication Consultative Committee
CCITT	International Telegraph and Telephone Consultative Committee
CCS	Common Channel Signalling
CDO	Civil Defence Organization
CEGHQ	Central Emergency Government Headquarters
CEMNET	Communications Emergency Management Network
CEMO	Canada Emergency Measures Organization
CHAT	Crisis Home Alerting Technique
CICA	Canadian Industrial Communications Assembly
CITA	Canadian Independent Telephone Association
CNCS	Cellular Network Control Station (also MTSO)

CO	Central Office
CPCS	Common Program Control Station
CPU	Central Processing Unit
CRTC	Canadian Radio-television and Telecommunications Commission
CRTU	Comité régional des télécommunications d'urgence (Regional Emergency Telecommunications Committee)
CTCA	Canadian Telecommunications Carriers Association (subsequently Telecom Canada and now "Stentor")
DBS	Direct Broadcast Satellite
DC	Direct Current
DCWCS	Direction, Control and Warning Communications System
DEW	Distant Early Warning
DGRR	Director General, Radio Regulations
DIDS	Decision Information Distribution System (USA)
DISA	Direct Inward Service Access
DMS	Digital Multiplex Switching System
DND	Department of National Defence
DOC	Department of Communications
DoC	U.S. Department of Commerce
DoD	U.S. Department of Defense
DRC	Disaster Research Center (University of Delaware)
DRP	Director, Regulatory Policy and Plans
DRP-E	Chief, Emergency Telecommunication Programs
EA	External Affairs
E&I	Employment and Immigration
EBS	Emergency Broadcast System
EC	Environment Canada
EHF	Extremely High Frequency
ELT	Emergency Line Treatment
EMA	Emergency Management Agency
EMO	Emergency Measures Organization
EMP	Electromagnetic Pulse
ENTO	Emergency National Telecommunications Organization
EOC	Emergency Operations Centre
EPC	Emergency Planning Canada; Emergency Preparedness Canada
EPS	Emergency Planning Secretariat
EPU	Enhanced Privacy Unit
ESS	Electronic Switching System

FAA	Federal Aviation Administration (USA)
FCC	Federal Communications Commission (USA)
FEMA	Federal Emergency Management Agency (USA)
FIN	Finance
FM	Frequency Modulation
FTS	Federal Telephone System (USA)
FX	Foreign Exchange
GTA	Government Telecommunications Agency
GHz	Gigahertz
GRS	General Radio Service
GSA	Government Services Administration
GTA	Government Telecommunications Agency
GVRD	Greater Vancouver Regional District
HF	High Frequency
HWC	Health and Welfare Canada
Hz	Hertz
ICAO	International Civil Aviation Organisation
IECC	Interdepartmental Exercise Co-ordinating Committee
IETO	Interdepartmental Emergency Telecommunications Committee
ISDN	Integrated Services Digital Network
ITC	Industry, Trade and Commerce
ITU	International Telecommunication Union
IWG	Implementation Working Group
JEPP	Joint Emergency Planning Program
LAN	Local Area Network
LETS	Law Enforcement Teletype System
LF	Low Frequency
LLC	Line Load Control
LPRT	Low-Power Relay Transmitter
MACEP	Ministers' Advisory Committee on Emergency Preparedness
MF	Medium Frequency
MHz	Megahertz
MILNET	Military Network
MIS	Management Information System
MRS	Mobile Radio System
MSAT	Mobile Satellite
MTSO	Mobile Telephone Switching Office (also CNCS)
NAERC	North American Electrical Reliability Council

NATO	North Atlantic Treaty Organisation (USA)
NAWAS	National Warning System (USA)
NCC	National Coordinating Center (USA)
NCD	North Central Dynamics
NCS	National Communications System (USA)
NEA	National Emergency Agency
NEAT	National Emergency Agency for Telecommunications
NEMS	National Emergency Management System
NETC	National Emergency Telecommunications Committee
NEPE	National Emergency Planning Establishment
NHW	National Health and Welfare
NMT	Nordic Mobile Telephone
NOAA	National Oceanic and Atmospheric Administration (USA)
NORAD	North American Air Defence Agreement
NRC	National Research Council
NRPS	National Restoration Priority System
NS/EP	National Security/Emergency Preparedness
NSTAC	National Security Telecommunications Advisory Committee (USA)
NTIA	National Telecommunications and Information Administration (USA)
NWS	National Weather Service (USA)
OC	Operations Centre
OECD	Organisation for Economic Co-operation and Development
ONA	Open Network Architecture
OPX	Off-Premises Extension
OSCCR	On Scene Command and Coordination Radio
OSI	Open System Interconnection
PABX	Private Automatic Branch Exchange
PBX	Private Branch Exchange
PCB	Polychlorinated biphenyls
PCO	Privy Council Office
PEP	Provincial Emergency Program
PSCC	Provincial Surveillance and Co-ordination Centre
PTT	Postal, Telephone and Telegraph Administration
R/ACCTA	Regional Advisory Committee of Commercial Telecommunications Agencies (USA)
RACES	Radio Amateur Civil Emergency Services (USA)
Radio-météo	Weather Radio
RCC	Radio Common Carrier

RCMP	Royal Canadian Mounted Police
REGHQ	Regional Emergency Government Headquarters
RETC	Regional Emergency Telecommunications Committee
RIR	Réseau inter-sites de radiocommunication (Integrated Radio Network)
RP	Restoration Priority
RSC	Remote Switching Centre
SAR	Synthetic Aperture Radar
SARSAT	Satellite-Aided Search and Rescue
SGG	Solicitor General of Canada
SHARES	Shared Resources High Frequency Network (USA)
SHF	Super High Frequency
SNOTEL	SNOpack TELemetry
SPC	Stored Program Control
SQ	Sûreté du Québec
SS	Selective Signalling
SSC	Supply and Services Canada
STP	Signal Transfer Point
SWIFT	Severe Weather Intelligent Forecast Terminal
SxS	Step-by-Step Switching System
TACS	Total Access Communications System
TAGA	Trace Atmospheric Gas Analyser
TAP	Terminal Area Protection
TC	Transport Canada
THz	Terahertz
TM	Telephone Maintenance
TPS	Telecommunications Priority Services
T4CDD	Tetrachlorodibenzodioxin
UHF	Ultra High Frequency
US-EBS	United States Emergency Broadcasting System
USFS	United States Forest Service
USGS	United States Geological Survey
VA	Veterans Administration (USA)
VADATS	Veterans Administration Data Service (USA)
VCR	Video Casette Recorder
VHF	Very High Frequency
VLF	Very Low Frequency
VSAT	Very Small Aperture Terminal
WEBS	Warning and Emergency Broadcast System

PART I
INTRODUCTION & THEORETICAL ELABORATION

Preface

Chapters One and Two comprise Part I of this study. The first chapter introduces the central thesis and related themes to be addressed. It also discusses the study's objectives, scope and methodology, and provides a brief summary of each of the other chapters.

The second chapter provides a theoretical elaboration of the prevailing model of emergency management that will be examined by this investigation. It also defines some of the basic concepts used in the study. In addition, other, non-hierarchical, approaches are considered which are apparent in a small but growing body of disaster literature and in the case studies presented as part of the present investigation. Finally, as regards possible explanations for this shift away from traditional approaches, a secondary theoretical discussion considers the respective roles of technological advances and market forces in shaping current Canadian emergency communications practices and policies.

CHAPTER ONE
Introduction

1.1 Objectives

Communications are essential to effective emergency preparedness and disaster response. Most of the current literature on disaster communications, however, focuses either on risk communications or on the role of the media in disasters. Very little academic research has addressed the subject of the present study, namely, the role of communication infrastructures -- that is, communications facilities and established patterns of relationships among government personnel and industry experts -- in the Canadian emergency communications planning and response processes.

The primary goal of the present study is to take a closer look at the implicit guiding model in North American emergency preparedness activities, namely, the command-and-control theoretical model. That approach will be examined in terms of its usefulness in describing Canadian emergency planning structures and emergency communications patterns. It also will be evaluated in terms of the actual behaviour of government decision-makers following the onset of major disasters as regards communications capability. Finally, other approaches will be considered which are suggested in the disaster literature, from the case studies and in the interviews undertaken as part of the investigation reported herein.

This study contributes to the literature on emergency communications preparedness by attempting to fill certain gaps in academic research. For example, for the first time, a compendium of information is provided on Canadian institutional structures and initiatives with respect to national emergency preparedness, including communications preparedness capabilities. Perhaps most significantly, however, is the fact that the present study challenges the prevailing theoretical model of crisis management by, first, pointing to difficulties experienced in applying it to actual planning and response activities, and second, citing instances where there is evidence of decentralized decision-making based upon co-operation, consensus and co-optation, and non-hierarchical communications patterns.

The conclusion drawn is that historical practices with respect to emergency preparedness need to be reconsidered in light of the evidence provided by this study. Additionally, given the widely recognized importance of effective communications at every stage of emergency planning and response, these findings indicate a need to look closely at current industry trends as well -- particularly in terms of the opportunities they might provide to improve communications preparedness by respecting public network survivability and reliability, fuller interconnectivity and interoperability of separate systems, and the conclusion of mutual aid arrangements among telecommunications carriers and large users to provide backup support to major public and private networks which become victim to a disaster agent.

1.2 Scope of study

It is important to set the parameters of the study reported herein by discussing what it does and does not attempt to accomplish. First, the focus of this study is peacetime emergencies -- such as, for example, large-scale industrial accidents and catastrophic natural disasters. It does not include consideration of wartime emergencies or external conflict-related approaches.

Second, the investigation will look at government planning and response activities related to sudden onset disasters - such as those associated with natural hazard agents (e.g., volcanic eruptions, earthquakes and the like), or technological agents such as toxic chemical accidents or major telecommunications failures. It will not be concerned with slow onset emergencies such as, for instance, famine or drought.

Third, the interest here is on the means by which messages are transmitted during peacetime emergencies such as major disasters -- that is, "communications lifeline infrastructures". These include the patterns of relationships and communications structures (pre-established and emerging) among planners and responders prior to and in the course of responding to large-scale emergencies. They also include the various communications technologies which make two-way, virtually instantaneous voice communication possible. Significantly, as discussed below, this investigation will not look at the specific content of the messages that are disseminated or exchanged in emergencies.

Additionally, emphasis will be placed on looking critically at some of the prevalent assumptions about technical communications lifeline infrastructures, together with the roles played by major public and private facilities networks to meet extraordinary increases in and disaster-specific response communications demand in disasters. To this end, the investigation will consider, first, the various existing communications technologies that may be employed to meet those demands; secondly, and perhaps most importantly, it will look at the established relationships among public safety organization personnel and with private sector experts --

especially those in the telecommunications industry -- in terms of their ability to explain actual disaster communication structures and practices.

Moreover, the role of broadcast communications in emergency preparedness and response will be considered, but only in terms of the provision of intraorganizational radio communications and the dissemination of public alerts and warnings. Technologies that reflect this capability include broadcast-like land mobile radio systems which remain the voice medium most commonly used by public safety agencies for internal communications. Their relevance to this study lies in their ability to provide backup support to other systems, together with the fact that they potentially could be used for interorganizational emergency communications. Another broadcast-like technology -- radio paging -- also will be looked at in recognition of its high penetration among public safety personnel and its possible utilization as an alarm medium.[1]

Similarly, information technologies or "computer" communications will be considered, but only in a cursory manner. Certainly, they are significant in terms of expediting the processing of information, and their employment for the purposes of training and response communications related to mapping and resource inventories is expanding rapidly. Moreover, it is anticipated that the role of data transmission will become increasingly important in future emergency preparedness planning and response activities, especially given the speed at which text and graphic images can be transmitted using digital modes. Just the same, it is expected that they will remain secondary to point-to-point voice communications in an actual disaster or other emergency situation. Once again, the decision to limit consideration of computer applications in disasters relates to the emphasis herein on real-time or virtually instantaneous voice communications capability.

Furthermore, this study will not look at the specific roles of the electronic and print media in disasters, although they are acknowledged to be crucial to any disaster response effort. Nor will it consider the perceptions of disaster "victims" as regards public warnings and information received from the public media and from government officials. The reason for excluding this important aspect of disaster communications is because a very comprehensive psycho-social or "Sociology of Disaster" literature already exists on these subjects; it is the aim of the present work to look at an area of study that largely has been neglected by academic research.[2] It is sufficient to note at this point, therefore, that pre-established co-operative arrangements between public safety response organizations and media personnel are recognized as essential to ensure that these resources will be utilized to the best advantage in order to reach threatened and disaster affected populations expeditiously. In that way, threatened populations can take mitigative measures to reduce the impact of the disaster agent. Alternatively, if the onset of the disaster is so rapid that adequate public warning is not possible, public information bulletins instructing victims as to what to do to reduce the consequences in terms of threat to life and property will serve to mobilize the affected population to undertake relief measures even before outside resources arrive to assist them.

Additionally, the plethora of issues raised by the literature on "risk communications" will not be addressed. In a broad sense, risk communication refers to any type of communication that informs about the existence, nature, form, severity or acceptability of risks (Plough and Krimsky, 1987). More specifically, it relates to "any purposeful exchange of information and interaction between interested parties regarding health, safety, or environmental threats" (Rogers, 1989: p.9).[3] That literature is concerned predominantly with efforts by scientific experts to raise the consciousness of politicians, media personnel and, ultimately, the public at large with regard to potentially dangerous situations such as those associated with hazardous waste storage and transportation, industrial pollution and the like. As a result, risk communication studies look at how messages are conveyed by experts to government and the public. They emphasize, in particular, the credibility of the sender, and the ability of the receiver to understand and implement expert recommendations.

Finally, the present study <u>does not attempt to introduce a new theoretical model</u>. Instead, it will evaluate the prevailing command-and-control theoretical model in terms of its ability to explain the behaviour of decision-makers and response personnel in actual communications preparedness planning and response activities. In addition, as appropriate, indications will be given of alternative approaches apparent in other recent disaster studies -- which are supported by personal interviews and case studies undertaken during the course of the present investigation -- that may evolve into a significantly modified theoretical framework for emergency management and communications preparedness. Nor will this study attempt to provide a comprehensive overview of communications in emergency management. Instead, as already mentioned, its focus will be twofold: it will look at various technologies that have actual and potential emergency or disaster applications; it also will consider the evolving relationships between public safety responders and with the private sector, in particular, the telecommunications industry -- which constitute a vital resource base for meeting the special requirements of public safety response teams for communications capability in crisis situations.

1.3 Central thesis and related themes

The central thesis that will be addressed is that the prevailing command-and-control theoretical model crisis management is the best model to explain behaviour in Canadian peacetime as well as defence-related emergency planning and response activities. It is postulated that the traditional model may not be adequate with regard to communications preparedness in large-scale disasters involving multiple jurisdictions and multiple agency involvement from different levels of government over an extended period of time. Instead, a growing body of recent social science research on disaster-related experiences, albeit still largely anecdotal, provides evidence of other decision-making structures and communication patterns in actual crisis situations related to large-scale disasters.[4] More specifically, they provide evidence of emergent co-operative/consensus approaches which include an increased emphasis on informal relationships among emergency planners, responders and with private-sector technical experts and essential equipment and services providers (e.g., Quarantelli, 1988a).

Some studies demonstrate, for instance, a proliferation of temporary alliances and non-hierarchical organizational and interorganizational communication patterns among the individual players who constitute the primary nodes on ad hoc disaster networks.[5] Additionally, the role of private experts appears to be increasingly significant in both disaster preparedness planning and response. This relates to their ability to provide government decision-makers with specialized and technical information that is crucial to effective disaster response in complex social situations -- particularly where jurisdictional boundaries are crossed and multiple organizations become involved. The present study similarly provides evidence based on case studies and interviews with participants in those processes which will be used to evaluate the prevailing model.

A number of other major themes or secondary theses also will be considered. These are propositions or statements which the author will attempt to prove or maintain. They relate either to specific questions arising from personal research or, alternatively, to broader issues or ideas raised in the social sciences literature suggestive of the emergence of either a modified or a different theoretical framework. Considered together, it is suggested, the results of the investigation reported here challenge the adequacy of traditional approaches.

The first theme refers to the possibility that disasters, by their nature, will reconfigure established relationships among government response agency personnel and with private sector experts, and this, in turn, will lead to innovative approaches in crisis management. It is anticipated, for instance, that public safety participants will not engage in the kinds of "turf battles" that characterize bureaucratic behaviour under normal conditions. Instead, they will work to achieve consensus among the various public organizations likely to become involved in responding to a large-scale disaster in their planning activities. In addition, they will initiate co-operative arrangements both with other government organizations and with private interests in order to facilitate the deployment of resources and expedite multiorganizational decision-making in disaster situations.

A related idea refers to the fact that legal authorities for Canadian peacetime disaster response management, as opposed to established federal planning structures, are decentralized. Thus, responsibility for managing the front-line response in a disaster rests with local governments. As a particular situation escalates, support assistance may be requested from the province and perhaps, through the provincial government, from the federal government as well. Just the same, and regardless of the formal authority structures in place prior to a disaster event, it is anticipated that in an actual crisis situation, response managers will turn first to those individuals whom they know personally to have the specialized technical or management expertise needed to handle the response operation.

It also is anticipated that governments and private industry will work together to develop and implement policies and programs aimed at, for instance, improving emergency communications capability. This most likely will be achieved through voluntary "co-optive" arrangements -- such as the creation of informal study groups set up to address specific questions, and by the appointment of permanent government-industry advisory committees. In these ways, those public and private sector participants who might become involved in responding to a disaster already will be known to one another. Similarly, it is anticipated that as regards emergency communications preparedness, relationships among the commercial carriers also will be co-operative and, for the purposes of essential service provision, non-competitive. Three of the case studies included in Part III reflect these trends. They are, first, the 1980 Mount St. Helens eruptions; second, the 1988 PCB fire at Saint Basile-le-Grand; and third, the study on the Comité régional des télécommunications d'urgence - Québec (Regional Emergency Telecommunications Committee-Quebec, hereafter, CRTU-Québec).

A <u>second</u> theme that will be considered relates to assumptions made by many public safety organizations that the availability of sophisticated new communications technologies will significantly improve disaster communications capabilities. As regards the impact of recent technological advances in the telecommunications sector, however, some U.S. studies dispute the validity of those assumptions, suggesting instead that they have jeopardized the cohesion of national telecommunications systems and, along with them, national emergency security preparedness.[6] The present study similarly refutes those assumptions, although it is suggested that remedial measures might be taken to rectify the situation by encouraging co-operative arrangements within the industry and with government as regards national communications preparedness.

Related to this is the idea expressed in some of the studies mentioned earlier that liberalized competition policies respecting public telecommunications service provision similarly may threaten national emergency communications capability. The combined impact of recent technological advances and the introduction of competition in telecommunications, especially long-distance telephony, it is suggested, has led to inconsistencies in industry technical standards and operational protocols. And these, in turn, have precluded full multinetwork integration and interoperability -- both of which are considered essential to effective emergency communications. Moreover, they have led to a centralization of network switching facilities and, oftentimes, to an over-reliance by carriers (and emergency users) on a single transmission medium. As a result, when network facilities are directly affected by a disaster agent, the scope of impact on subscriber service will be widened significantly. Two case studies address this theme: first, the 1988 fire at the Hinsdale, Illinois hub switching centre will be studied and, second, a fire the same year at the Saint Basile-le-Grand PCB storage warehouse site will be looked at.

A third thematic investigated in this study concerns the effect that prior disaster experience will have on emergency communications preparedness. It is anticipated, for example, that the shared experience of a major disaster -- whether it be localized or large-scale, environmental or technological -- will create an impetus for industry to undertake improvements to the telecommunications network. It also is expected that those shared experiences will lead to the increased political saliency of emergency communications preparedness generally and, in turn, to the development of public policies and programs emphasizing the importance of ensuring system survivability and adequate network redundancy. Furthermore, joint participation on advisory or planning committees and at disaster exercises or symposia on relevant topics will have a similar effect because these fora facilitate "networking" among the various participating telecommunications experts and government crisis managers. Case studies of the Mount St. Helens eruptions, the Saint Basile-le-Grand fire and the CRTU-Québec address this theme.

1.4 Methodology

The academic literature considered for the purposes of the present study included a small but growing body of disaster studies which have a communications preparedness element, together with extensive government documentation on: (1) disasters; (2) disaster preparedness and response; and (3) communications in disasters.[7] As already noted, while some of the risk communications literature was looked at initially, it was found to be rather nebulous and inappropriate since it focuses mainly on perceptions about potential hazard risks. Moreover, where it does look at communication in disasters, it is concerned predominantly with message content. The focus of the present study, in contrast, is not on the content of the messages transmitted in a disaster or other emergency, but instead, the ability of public safety organizations to establish sustainable physical links for two-way communications -- internally, with other government organizations, and with private industry. The interest here also is in point-to-multipoint communications linkages in terms of their alert and warning applications. As a result, the emphasis will be on academic research that discusses the use of communications technologies in emergency contexts on the one hand, and the interpersonal patterns of relationships and communications among decision-makers and other response personnel who will need to employ those technologies in a response operation -- in other words, "lifeline communication infrastructures."

Given the small amount of academic and government commissioned research on this subject, a review of the available studies was supplemented by personal interviews. These were conducted with over a hundred individuals working for public safety and other government and private industry organizations, all of whom have been actively involved for many years in emergency preparedness planning and/or response. Several of those interviewed also have been involved directly in regional or national emergency communications preparedness. These interviews were done either face-to-face or by telephone, and they included visits to provincial, state and federal emergency measures organizations in both Canada and the United States, as well as to different emergency government headquarters, communications co-ordination centres, emergency operations centres, government telecommunications agencies and regulatory agencies, and telephone company network management control centres -- in Montreal and Quebec City ; Victoria and Vancouver; Bothel and Olympia, Washington; Ottawa; and Washington, D.C.

Additionally, the author attended several national and international seminars, symposiums and conferences on emergency preparedness-related subjects, as well as participating in a week-long course on emergency communications planning at the Canadian Emergency Preparedness College, Arnprior, Ontario. Moreover, since early 1989, the author has taken part in the semi-annual meetings of the Quebec Regional Emergency Telecommunications Committee (CRTU-Québec), a government-industry forum chaired by the Canadian Department of Communications. In addition to being a permanent member of that committee, she also is a member of one of its subcommittees -- on long-distance network overload. Presentations of some of the research findings summarized herein have been made to several of the gatherings mentioned above, as well as to a national meeting of DOC regional emergency telecommunications officers.

Finally, four case studies have been included for the purposes of evaluating the central thesis and addressing questions raised by the secondary theses or related major themes as outlined in section 1.3 above. Two of the case studies are based on secondary source accounts and personal interviews; the other two use primary source materials. One of the case studies also reviews the author's personal experience as a participant-observer. Additionally, two of the case studies deal with Canadian experiences -- one with an emergency response operation, and the other with a federal mechanism for emergency telecommunications planning. The two others concern disaster response operations and, to a limited extent, subsequent remedial planning activities in the United States.

The decision to include both Canadian and American cases was based on a recognition of the very close integration of the two countries' national security/emergency preparedness structures as well as their domestic telecommunications networks, leading to the conclusion that lessons learned from experiences in one country might be applicable in the other. Throughout the present study, however, particular emphasis has been placed on Canadian experiences, approaches to and perspectives on emergency communications preparedness planning and response capability. U.S. experiences have been considered for comparative purposes only. It is anticipated, for instance, that valuable lessons can be learned from U.S. experiences -- such as the implications for communications preparedness capability of AT&T's divestiture (leading to the creation of the National Coordination Center) and that country's problems with trying to establish industry standards in a highly competitive marketplace in order to meet increasingly complex emergency requirements. Also of relevance to Canadian communications preparedness capability is the United States' significantly greater recent experience in handling large-scale disasters which have affected large urban centres and damaged communications facilities that are integral to the national public telecommunications infrastructure.

1.5 Chapter summaries

Chapter Two, the second chapter in **Part I**, elaborates on some of the basic concepts applied in this study together with providing a description of the command-and-control model of crisis management. Some other approaches that have become evident in the disaster literature also will be discussed. Additionally, the chapter looks at the different kinds of communications that commonly occur in disaster situations. Finally, it considers the role of technological advances in emergency communications preparedness, and suggests that market forces rather than a technological imperative are the main determinants of current trends away from traditional hierarchical telecommunications architectures, and towards geodesic configurations -- in terms of both the emerging industry structure and interorganizational patterns of relationships.

Part II discusses Canadian approaches to emergency preparedness planning and response generally and to emergency communications preparedness in particular. Chapter Three looks at government approaches in this area and provides both an historical and a structural context for evolving and shifting policies and industrial strategies related to national communications preparedness. Chapter Four, in turn, describes the Canadian telecommunications industry structure and discusses some of its strategies aimed at enhancing network reliability and survivability in the event of a major telecommunications outage. In addition, it looks at current trends related to liberalized competition and the implications of user demand for customized services for emergency preparedness. It also discusses several government/industry programs designed to improve national communications preparedness.

Part III provides an overview of a wide range of communications technologies currently available, and considers some of the opportunities and consequences of their introduction on Canadian national communications preparedness. Chapter Five describes the concept of networking and then looks at telephony and radio communications from a technical perspective as well as in terms of their applications in emergencies. Chapter Six, in turn, looks at some supplemental and emergency-only communication systems.

Part IV presents the four case studies which are used to evaluate the central thesis and related themes outlined earlier. In this way, an environmental scan is provided of some of the major questions or issues related to North American disaster communications capability and associated interpersonal patterns of relationships among participants in the emergency planning and response processes. Chapter Seven discusses the Mount St. Helens volcanic eruptions of 1980. Chapter Eight considers the Hinsdale, Illinois hub switching station fire of May 1988. Chapter Nine looks at the Saint Basile-le-Grand PCE storage site fire of August 1988. Chapter Ten describes the structure and activities of the CRTU-Québec.

Part V reviews the lessons learned from the literature, each of the case studies and the author's impressions derived from the personal interviews and her involvement as an observer-participant as they pertain to traditional emergency management approaches. It also draws some conclusions about the central thesis and the various related themes or secondary theses, and with regard to evidence of the emergence or evolution of a substantially modified theoretical framework, and suggests the possible direction that future research in this area could take. It also assesses the methodology used to meet this study's specific research objectives.

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1 Technically a one-way transmission medium, radio pagers signal the receiving party to call in for a detailed message. Modern electronic paging systems also have the capability of transmitting a tone alert signal and displaying a very short written message such as a telephone number.

2 See, in particular, the numerous incident studies published by the Universities of Colorado and Delaware in the United States, and, in Canada, by Emergency Preparedness Canada (including those prepared by Carleton University's Emergency Communications Research Unit). For the most part, these provide descriptive accounts of disaster events. They also

include impressive survey studies of victim perceptions and reviews of public health programmes aimed at assisting devastated communities to recover from such catastrophes.

[3] Also see Covello and Waller, 1984; and Fiksel and Covello, 1986.

[4] Many examples are provided by studies conducted under research grants provided to the Disaster Research Centre, University of Delaware, Newark, Delaware. Others are provided by studies undertaken by the Natural Hazards Center, University of Colorado, together with the case studies included in Part IV of the present study.

[5] See Britton, no date; Dynes and Aguirre, 1979; Kent, 1987; Lagadec, 1982; and Stillman, 1984.

[6] In large part, these studies were commissioned by the U.S. Department of Defense around the time of the U.S. federal court's decision to break up the AT&T Bell System. See, for example, Bolling, 1983. Also see National Academy of Sciences, 1987; and some studies by SRI International, namely, 1982; Foster, 1980; Ailes and Rushing, 1982.

[7] During the course of this investigation, a great deal of information was collected from several Canadian and U.S. government sources. Some of that material is of a confidential nature. As a result, in this study, only unclassified documents will be cited directly. Moreover, specific reference will not be made to any confidential information, although general references thereto may be included for the purpose of clarification (without attribution).

CHAPTER TWO
Theoretical Elaboration

2.1 Introduction

This chapter provides definitions of some of the basic concepts used in the present study. It also reviews the different types of communications that commonly occur in disasters and other peacetime emergencies. Subsequently, the prevailing command-and-control model of crisis management will be described and evaluated in terms of what actually occurs in the course of preparing for and responding to disasters, especially as regards emergency communications capability.

Some other approaches which suggest the emergence of non-hierarchical or "geodesic" networks as opposed to hierarchical systemic approaches then will be introduced and discussed in terms of their ability to address some of the inadequacies of the prevailing model. It is suggested that the traditional command-and-control model increasingly is being modified or supplemented by more co-operative and to some extent co-optive approaches, which are reflective of non-hierarchical communication configurations and informal patterns of relationships among the government decision-makers and response personnel involved in emergency planning and response.

An additional theoretical discussion will consider the roles of technological advances in regard to Canadian emergency communications practices and policies. Significantly, while it is acknowledged that they have helped shape the facilities network context within which communications preparedness activities now occur, technology is neither the sole nor necessarily even the principal factor shaping these developments. Instead, it is suggested that market forces, and in particular, user demands for specialized and customized services, are the main determinants of emerging alternative approaches to communications preparedness in this country.

2.2 Definition of concepts

2.2.1 Emergencies and disasters

Most communities are not prepared to respond to a large-scale disaster. This is due to the fact that even to the extent that civic organizations do plan for disasters, they often fail to recognize crucial differences between localized emergencies and disasters (Quarantelli, 1988c: p.10). Emergencies, for example, may be defined narrowly as everyday breakdowns which usually can be handled by local resources and personnel (Quarantelli, 1988a: p.19). Alternatively, as is the case in the present study, the term may be used broadly to cover the entire range of preparedness activities from localized to emergencies to full-blown catastrophes. A disaster, however, always refers to a disruption of the social context itself -- that is, it definitely cannot be handled by local resources and personnel.[1] Disasters also connote suddenness; and they may have either natural or human causes. They can be thought of as "catastrophic events, frequently associated with the forces of nature: earthquakes, tornadoes, hurricanes, or volcanoes." On the human or technological side, events "such as explosions, chemical spills or industrial accidents are also described as disasters" (Perry, 1985: pp.15-16).

Indeed, the majority of organizations do not plan for disasters at all -- the exception being those whose normal operations are crisis oriented, such as police, fire, hospitals and public utilities. Even these, however, tend to ignore the distinct possibility that they themselves might be affected and their operations disrupted by a disaster. As a result, their preparedness orientation is primarily towards meeting day-to-day emergencies, rather than coping with a major disaster. They often act as though a disaster can be treated as a "big accident", with the corresponding expectation that established standard operating procedures will be adequate in any crisis situation.

Similarly, the social sciences literature on crisis management tends not to distinguish between normal-time emergency contingency planning and disaster preparedness. Just the same, case studies like those included in the present work suggest a significant qualitative difference between emergencies and disasters -- that is, there is a difference of kind and not just of degree.

In this study, the terms emergency and disaster are used at times almost interchangeably, although they are not considered to be fully substitutable. The term **emergency** will be used as an "umbrella concept". Within the context of overall crisis management, it encompasses planning, preparedness and response activities related to incidents that threaten small and large communities alike, and which range from localized industrial accidents to catastrophic natural disasters such as earthquakes and hurricanes.

The term **disaster**, in turn, will be used to refer to those emergency situations that place extraordinary demands upon public and private sector organizations and to which it is beyond their capacity to respond satisfactorily. The focus of the investigation reported here, it is worth underscoring, is on emergency or disaster management approaches within the context of a severe threat to many lives and possible extensive damage to property or the environment -- that is, in terms of large-scale, sudden onset technological or natural disasters that require intervention by multiple government response organizations.

2.2.2 Other concepts

Emergency or **disaster communications** include:

> communications or signals essential to the conduct of emergency response activities by duly authorized emergency organizations, including communications directly concerning the safety of life, preservation of property, maintenance of law and order, alleviation of human suffering and need, and the dissemination of warnings of ... any disaster or other incident endangering the public welfare (Government of Canada, no date).

The term **technology**, in a broad sense, refers to tools or objects which can be seen and touched. According to Langdon Winner, it refers to a diverse collection of phenomena, including, "tools, instruments, machines, organizations, methods, techniques and the totality of all these and similar things in our experience" (1977: pp.11-12). As it is employed in the present study, it includes all the apparatus employed as well as the procedures and methods that people use to accomplish a particular task together with the organizational or social arrangements that constitute the context within which those activities are undertaken.

Information, in turn, can be defined as "patterned matter-energy which makes a difference in an individual's decision-making" (Eveland, 1987). Purposeful use distinguishes information from technology. And, thus, when information is rearranged for an instrumental purpose, it too is considered to be technology.

Telecommunications relate to the transmission of two-way electronic signals over some distance. Accordingly, they comprise a variety of information dissemination technologies, as distinguished from information processing -- i.e., computer -- technologies. That is, telecommunications are the means of electrical message transmission; significantly, they do not take into account either the content of messages associated with the electronic media or the ability to manipulate information associated with computer or data communications.[2] Moreover, as regards the present study, the concern here is with telecommunications in terms of the provision of instantaneous message transfer capability in disasters -- specifically, that which can be provided using the public switched network, by radio-telephony or private radio communication systems. This study is not concerned either with message content or its manipulation and storage.

The term **infrastructure** is employed herein to refer, on the one hand, to equipment or technology and, on the other, to interpersonal relationships of planners, responders and others involved in providing technical espertise, communications equipment and services provision. In terms of emergency communications preparedness, the equipment side includes telecommunications network configurations, architectures or protocols, as well as transmission and switching technology. The interpersonal side is comprised of governmental and industry management and operational structures normally involved with emergency preparedness and response activities. People become infrastructure because they manage information flows.

2.3 Disasters and communications

The function of communications in a crisis related to a disaster or other emergency is to enable decision-makers to make choices by providing information that will enable them to avoid, reduce or remedy negative consequences.[3] That information is about, first, the probability and characteristics of possible future crises; second, the fact that a crisis is at hand; third, alternatives for action during a crisis; fourth; what has happened as a result of the crisis; and fifth, why the crisis has occurred (Williams, 1957: pp.15-16).

Certain basic communications requirements are common to all kinds of disasters and other peacetime emergencies. First of all, there is the need for adequate and, significantly, appropriate communication facilities -- such as telephones, hand-held radios, transportable earth stations, cellular radio-telephones and the like. Indeed, the ability to access operational communications infrastructure cannot be over-emphasized. No disaster response action will be effective without the technical means to exchange information quickly among a variety of public and private sector response organizations.

In addition, there is the need for access to the electronic media and, correspondingly, for the media to have access to key government officials and technical experts in order to be able to convey accurate information in a timely manner to the public -- especially as regards preventative and/or reactive measures to be taken by the threatened or affected population in order to reduce the impact of the disaster agent. In fact, emergency organization personnel point more frequently to the lack of communication facilities and organizational communications capabilities (technical and staffing) to meet dramatically increased disaster communication demands than to any other disaster-related problem.[4]

In terms of communication configurations or patterns of relationships among intervening parties in a disaster, there also is a need for pre-established, but flexible, procedures which constitute the foundation for emergency communications structures among the various public safety and industry experts involved in order to assist them in managing the response operation. For example, it is important to determine in advance the criteria to be used to decide which organization will play the lead "co-ordinating" role at a joint emergency operations centre (EOC) established to manage a particular response operation; what the respective roles and responsibilities of each agency likely to become involved will be, etc.

Robert Stallings (1971) describes three types of relevant communication during disasters and in disaster relief. They include intraorganizational, interorganizational and person to organization communications. For the purposes of the present discussion, Stalling's final category has been divided into two distinct categories. Thus, four categories of disaster-related communications will be considered here, namely: (1) <u>intra</u>organizational communications; (2) <u>inter</u>organizational communications; (3) organization-to-public communications; and (4) public-to-organization communications.[5] The different categories will be considered first in terms of the types of channels used for message transfer, and then with respect to the kinds of problems that could arise in a disaster situation.

The channels through which information sources deliver their messages involve either mass or individual media. On the one hand, mass media communications generally take the form of: (1) bulletin boards (including electronic or computer-to-computer); (2) printed information of an explanatory or reporting nature, such as newspapers, leaflets and mailed circulars; (3) public address systems in office buildings, schools or shopping centres; (4) mobile loudspeaker systems; and, finally, (5) broadcast radio and television. Individual media, on the other hand, include public and private telephone service, amateur and citizen-band radio, private courier services, personnel messenger services, letters or memoranda, and face-to-face meetings. The associated technologies are fixed and mobile radio, telephone and radio-telephone units including cellular; telegraph and telex; facsimile; walkie-talkies; and electronic pagers.

The messages transferred within and between organizations involved in responding to the disaster and to the general public -- that is, the first three kinds of emergency communications mentioned above -- may take place either in pre-event planning and training exercises, or for alerting and status reporting following the onset of a disaster. In the pre-event phase, they could be employed to establish liaisons, arrange for mutual aid, prevent rumours and educate the public on measures to be taken to prevent or reduce the effects of the disaster agent. During and after a disaster strikes -- as in the case of a major earthquake, flood or toxic chemical spill -- they may be used to notify, report developments, dispel rumours, provide advice on how to protect lives and property affected by the disaster, and request assistance. To be effective, communications in disasters must be accurate and timely. They also have to be authoritative, credible, relevant, informative and reassuring.

2.3.1 Intraorganizational communications

Respecting intraorganizational communications, the primary effect of a disaster will be a rapid and dramatic increase in the volume of communications traffic as response teams and administrative groups within the organization attempt to clarify their roles and responsibilities, while mobilizing available resources in order to provide relief. Problems experienced with internal communications during disasters usually are associated with the unfamiliarity by organizational personnel of the communications medium or facilities employed. In the first place, the disaster may require the use of media that are new. Alternatively, groups such as those that depend heavily on volunteers (e.g., the Red Cross, Salvation Army or Saint-John's Ambulance) might experience problems because the small professional staff that conducts normal activities suddenly is expanded by large numbers of temporary personnel whose integration into organizational operations requires more oversight than time allows. Additionally, many public safety organizations rely almost entirely on private radio systems which are often function specific and can only monitor communications on other radio frequencies. As a result, many of these organizations will turn to regular telephone (e.g., fanout) and the broadcast media to mobilize personnel in a crisis situation related to a major disaster.

Radio communication is most often the principal medium used for communications among individual field units, while telephone switchboard or private branch exchange (PBX) systems are used most often at organizational headquarters. Increased volumes of internal communications traffic usually can be handled by using additional radio frequencies, if they are available. Moreover, a limited amount of portable radio equipment could be borrowed (in Canada, through Department of Communications (DOC) regional offices) to supplement existing systems. And many larger Canadian municipalities operate mobile communication vans which could be dispatched to the disaster site to provide a field command post for the main response organization involved. But perhaps the most important measure to take in order to alleviate the strain on organizational communication systems during an emergency is to reduce user demand. This can be achieved by setting priorities on the kinds of messages transmitted, and by developing procedures to shorten message length or signal the degree of urgency of the outgoing message so that lower priority communications can be "bumped" off the system temporarily.

2.3.2 Interorganizational communications

As regards interorganizational communications during disasters, public telephone continues to provide the primary means for communicating among officials in different public response organizations, as well as among the different orders of government. The main problem encountered as a consequence, and especially in a large-scale disaster, is that telephone service will be intermittent at best and may be lost entirely for a period of time, depending on the extent of physical damage to cables, microwave towers or telephone company central office switches. Even when there is no physical damage to telephone system facilities, the phenomenon known as "convergence"[6] may cause fuses to blow and telephone switches to overload, with the result that the computers that co-ordinate telecommunications traffic flows in normal times may crash, or network managers may decide to invoke line load control (LLC) or "essential line treatment" (ELT)[7] to protect a limited number of pre-designated public service lines from losing call-out capability. When LLC/ELT is applied, most local subscriber lines will be temporarily unable to receive dial tone, although their ability to receive calls will not be affected (unless, of course, their end office switch is blocked as a result of a surge in incoming traffic).

Teletype systems also are used extensively for certain kinds of interorganizational communications. Their most common uses in a disaster context include weather watches, weather warnings and meteorological updates, and they are regularly monitored by local police, fire and public works agencies as well as by the broadcast news media and regional emergency measures organizations.

Until quite recently, radio communication was not commonly used for communications between public safety organizations. Exceptions are to be found in two kinds of communities: first, in those localities that have experienced a large-scale disaster and, secondly, in small cities where several municipal organizations share radio frequencies as a cost-saving measure.

As part of pre-event planning for disasters, organizations can reduce the problems associated with interorganizational communications in a several ways. One would be to establish a set of unlisted telephone numbers known to only a few emergency organization personnel. Hot lines (i.e., direct dedicated or leased lines) also could be established between municipal emergency operations centres, police and fire department headquarters, and with the provincial emergency measures organization and provincial police or the Royal Canadian Mounted Police (RCMP).

Except in remote areas, following the onset of a major disaster, additional telephone service often can be obtained within a single working day,[8] because the major regional telephone companies either maintain or have access to vehicles equipped with a bank of telephones and, in some cases, a mini central office (CO) switch that could be transported to the disaster site. Finally, amateur radio clubs and citizen-band radio operators, private taxi companies equipped with mobile radios, and private couriers with hand-held radios or walkie-talkies could be asked to fill crucial voids for short periods.

In recent years, as the risk of major industrial accidents has increased and the potential impact of natural disasters becomes more acute given the concentration of populations in urban centres, more and more municipalities are tying into regional disaster response communication networks. In their simplest form, these involve the establishment of a shared or "common" emergency-only frequency, which is monitored continuously by the central dispatch or operational centres of the different public safety agencies. Increasingly, however, they are taking the shape of sophisticated multiorganizational intermunicipal and in some cases, province-wide systems which allow two-way voice and data communication over digitalized networks. It is anticipated that over the course of the next several years a fully integrated emergency communications network will evolve on a national scale in Canada.

These systems were first introduced in Canada in the Atlantic provinces as a result of repeated incidents where civil defence authorities[9] and municipal and provincial police were unable to communicate with each other or with helicopter pilots involved, for example, in offshore search and rescue operations. In Nova Scotia, to mention the earliest, a province-wide switchable communications grid has been in place for several years. It is accessible to every emergency response organization, as well as to organizations such as those providing road maintenance, park ranger and snow removal services. A similar concept recently has been implemented in New Brunswick and is now in the process of being implemented in the provinces of Quebec and Prince Edward Island. Some western provinces and territories also are laying the groundwork for the establishment of compatible intra- and, potentially, interprovincial/territorial radio communication systems.

2.3.3 Communications to the population

The third category of communications in disasters are those involving the transfer of information from emergency organizations and local authorities **to the population** that is either threatened or affected by the disaster agent. This could involve face-to-face communications in the form of Town Hall meetings with residents, or it may mean holding press conferences to advise the public via the broadcast and print media of an impending threat to the community, such as a weather-related event. Alternatively, outside sirens may be used along with mobile loudspeakers or public address systems in schools and other public buildings for the purpose of sounding a public alarm for immediate action. And where evacuation, is necessary, easily identifiable messengers -- such as uniformed local fire and police personnel -- may circulate through neighbourhoods knocking on doors to advise residents. Following the initial alarm and warning, communications from public safety agencies to the public at large likely will be restricted to emergency broadcasts over local radio and television at regular intervals to advise on the status of relief measures being taken, and to public meetings with government officials and technical experts to answer questions and provide details about the longer term impacts of the event.

The message content in these kinds of communications is, of course, very important, as is the credibility of the information source. Messages must be worded very carefully so as to avoid extreme reactions. Initial warning and advisory communications have to provide clear and concise information about what is happening and what action is required of community residents. Finally, to maximize their effectiveness, they need to be issued by a single, recognizable authoritative source -- such as the mayor or the local emergency measures office. When the message is verbal rather than written, recipients can be advised to tune into their local radio or television station for more details. This is because it is generally agreed that people will be less likely to hesitate in acting or challenge the authority of the person issuing a directive if they are reassured that the mass media are being kept informed as to what is going on.

In contrast, messages to the public that are designed simply to inform rather than to raise an alarm need to provide both summary information (for those just tuning in) and regular updates on the unfolding situation. In addition, special telephone numbers could be publicized for those requiring individual emergency assistance. Use of the telephone for other purposes needs be discouraged to prevent overloading the public telephone system. Finally, prominent public officials cannot become involved personally in the front-line response; instead, their presence at the local co-ordination centre is essential because it ensures that they will be kept abreast of events by the heads of the various agencies also present there as they unfold. It also means that they will be on hand to make decisions related to those developments as well as being available for press conferences and media interviews. Technical experts similarly can be brought in to help officials field questions from the public and the media.

2.3.4 Public to emergency organization communications

The fourth category of communications in disasters is communications **from the public to emergency organizations**. These may take the form of letters requesting information or registering a complaint prior to or some time after a disaster; telephone calls (such as "911" calls); and face-to-face meetings at organization headquarters or possibly at the disaster site itself (especially if the telephone system is not operational).

The main problem experienced with this last kind of communications during a disaster is the situation mentioned earlier whereby emergency organizations may become inundated with information messages from the public, including the mass media. In the early period immediately after a disaster, most incoming call traffic will involve damage reporting, followed by calls for individual assistance. It is estimated that local telephone exchanges could reach saturation levels within five to seven minutes after the onset of a major disaster. Toll switching offices usually will become overloaded within about 15 minutes.[10] System overload typically blocks the public telephone network to the point where it may be several hours before it will be able to accommodate the demand for circuits into (or even within) the local calling area. System overload does not mean that the network is not operational; instead, it means that considerable delays in receiving dial tone for outgoing calls may be experienced, and that calls coming into overloaded switches might not be completed.

During the response and relief phases following a disaster, the majority of calls congesting the public telephone system likely will come from outside of the affected community. Significantly, this situation may be exacerbated on the one hand by North American hub and toll switch configurations and, on the other, by automatic network management programs which have been designed in such a way that as many as ten outgoing toll calls can be processed successfully for just one call coming into a local exchange. Moreover, the number of incoming calls from other areas will increase as the scope of the disaster increases. Regional broadcast media, therefore, could be asked to instruct their listening and viewing audiences not to attempt to call into the affected area in order to allow their families, friends or business associates to call out.

Since emergency organization switchboards also can expect to become swamped with incoming calls after the onset of a disaster, several unlisted telephone numbers could be reserved exclusively for, first, interorganizational government and response agency communications, and second, emergency outgoing calls. In addition, as mentioned earlier, federal programs exist in Canada to assist municipal authorities -- through their provincial governments -- to establish priority telephone number listings in order to prevent degradation of local network access, together with priority service restoration in the case of service loss due to a disaster or other emergency. These confidential listings are compiled by regional DOC offices from information provided by provincial and territorial governments. They are updated semi-annually and forwarded to the telephone companies to program into their network databases.

As a result of commonly applied regulatory provisions requiring telephone companies to grant access to public telephone service on a non-discriminatory basis, coin-operated public telephones also receive LLC/ELT and priority restoration treatment. In this way, the general public can access the public switched network even if they are unable to get dial tone on their residential or office lines. It also is common practice among emergency measures personnel to keep on hand a roll of quarters to be used in public telephones installed in the lobbies of most government buildings. This is because many government organizations operate AC-powered switchboards which, absent an independent backup power source such as an on-premises generator, are susceptible to the public utility power failures that so often occur during disasters due to fallen power lines and the like.

And while line load control or essential line treatment places no restriction on incoming calls, if the organization is without power, staff may not be aware that calls are coming in since the switchboard will not light up. Moreover, getting dial tone does not mean that the call will go any further than the nearest congested telephone company CO switch. Regional government/industry advisory groups now are studying ways to apply new systems software technologies and perhaps redefine priority listings so that priority call routing -- that is, inter-central office and long-distance calling -- also could be provided to pre-identified essential service users.[11] Given the high costs associated with the implementation of such programs, however, it is likely that an interim mechanism will be developed to provide restricted access in an emergency to local emergency measures officials and the mayors of the affected communities to federal and provincial government private line networks.

2.3.5 Communications and other problems in disasters

Problems encountered during a crisis very often are misunderstood to be "communications problems" -- whereby organizations or the public are not adequately informed about what has happened, what is being done, and/or what action must be taken by private citizens. How often has the reader heard it said after a disaster that communications were botched, that vital information was withheld, or that response personnel were not able to talk with each other?

Thomas Drabek (1986) maintains that what is commonly perceived as a communications problem often is related not to the absence of communications equipment or skilled personnel to operate them, but instead is "a problem of control and managerial autonomy" (pp.175-176). Indeed, in most of the cases looked at during this investigation, the physical means of communicating were not the cause of the trouble. The problems most often experienced are interpersonal ones.

In a crisis, there will be a dramatic increase in communications among the various organizations involved in the response operation. And the broader the scope of the disaster impact, the greater the need to communicate is expected to be. From a command-and-control perspective, such a sudden upsurge in communication levels during a disaster are treated as a "communications failure". Alternatively, and the author shares this perspective, they are viewed not as a failure, but rather as an anticipated consequence a complex situation requiring multiple agency involvement. Thus, it could be concluded that crisis co-ordination needs to be considered in a different way -- not as a need to focus on centralized command decision-making in order to take and retain control of a situation, but instead as a cybernetic process that may result in greater flexibility and facilitate rapid and effective disaster response. This refers to the fact that when the actors have made a choice, they seek or receive further information about the result of the choice (i.e., feedback), and then compare it with the desired outcome.[12]

Also as regards problems associated with interpersonal communications in disaster situations, there are three sets of management problems that commonly occur in disasters, all of which have something to do with communications. The first concerns the flow of information, and it relates to problems of control and autonomy at the interpersonal level. A second set of problems often experienced in disasters relates to decision-making and, more specifically, the exercise of authority associated with conflicts or misunderstandings about organizational responsibilities for new disaster tasks; clashes over jurisdictional territory; and the tremendous stress to individual players experienced by some response agency staff. A third set of problems concerns responders' perceptions about the need to emphasize co-ordination among the various players involved and, correspondingly, the possible loosening of pre-existing, formalized command structures (Quarantelli, 1988b).

In addition, there are significant differences between preparing for and actually managing a disaster response operation which need to be taken into account. In this regard, a parallel can be drawn with the military's distinction between "strategy" versus "tactics." Strategy refers to an overall approach to looking at a problem or achieving a goal; good disaster planning, therefore, involves the development of a set of strategies to meet anticipated contingencies that could be followed in preparing for a sudden disaster. Good disaster management, by contrast, involves using particular tactics to handle specific situational contingencies that were not accounted for in the planning stage (Quarantelli, 1988b).

Both emergency planning and disaster management can be evaluated in terms of their results during an actual response operation. These include: (1) their ability to mobilize personnel and resources; (2) their ability to process and distribute large volumes of information within and between organizations; (3) their ability to exercise authority effectively and make appropriate decisions; and (4) their ability to co-ordinate the response operation effectively among the diverse organizations involved.

Significantly, there is not an automatic direct link between good disaster planning and disaster experience. Certainly, however, there is an indirect relationship between the two. For instance, it is widely acknowledged that the best preparation for a sudden disaster is prior experience. Good disaster management thus can be measured in terms of resolving the management problems that commonly occur in disasters -- that is, avoiding or effectively overcoming problems with information flow; exercising in an appropriate way authority and decision-making responsibilities; and finally, from the perspective of the present study, loosening formalized command structures so as to achieve effective multiorganizational co-ordination, co-operation and co-optation of private-sector expertise and resources.

2.4 The command-and-control model

This section provides a description of the prevailing implicit command-and control theoretical model of crisis management. It also considers some other approaches which are apparent in the disaster literature, specifically, those that emphasize co-ordination and co-operation among diverse organizations and across multiple jurisdictions.

The origins of the command-and-control model are in the wartime preparedness concerns that resulted from the Second World War combined with Cold War fears about a possible nuclear attack on North America. The notion of command-and-control derives from the idea that someone should go in and "take charge," and tell people what to do to bring a situation under control. It is a military-style model that relies heavily on standardized operational procedures and formalized, hierarchical chains of command and communications. Perhaps most significantly, the model assumes, first, a clear mandate to control and, second, a single core command force which will manage the response and control damage.

Communication is integral to the command function. Those individuals holding a hierarchically superior position within an organization structured along the lines of this model initiate communications to inform their subordinates for the purpose of directing their behaviour in some way (Katz and Kahn, 1966).

Enrico Quarantelli, a pioneer of disaster research, makes the following statement about North American practices as regards disaster preparedness planning. He says that:

> there is a strong tendency to assume that disaster planning can borrow much from military situations and settings. Thus, it is often visualized that the best model for disaster organizational preparedness and managing is ... a command-and-control model. This is the notion taken from the military area that a top-down, rigidly controlled, and highly structured social organizational model ought to be developed for disaster purposes (1988a: p.55).

Historically, Canadian and U.S. emergency preparedness <u>planning</u> practices and structures have been "oriented towards increasing the centralization of authority and the formalization of procedures" -- suggestive of the command-and-control model of organizational behaviour. In addition, emergency organization recruitment patterns in both countries traditionally have attracted individuals with military or paramilitary -- e.g., police or fire department -- backgrounds. And the organizations involved in preparedness planning routinely have operated by what Dynes and Aguirre (1979) refer to as "co-ordination by plan" (p.73). This means that the emphasis is placed on an extension of normal-time duties to handle crises. It also presumes that established standard operating procedures will be adequate for dealing with all types of contingencies.

Significantly, however, North American governmental <u>response</u> to disasters, in contrast to emergency planning practices, legally and historically has been decentralized rather than centralized. This is reflected in the fact that the constitutions of Canada and the United States each give the authority to manage the front-line response in peacetime emergencies to the local authorities having jurisdiction over the threatened or affected areas. Provincial or state and federal authority in this area is in a support capacity only. There are two significant exceptions: namely, when the disaster impact area crosses provincial or state boundaries and, alternatively, if it threatens national security.

In addition, private and public sectors have been given separate responsibilities for different disaster-related tasks. For example, Canadian and U.S. governments have always relied on private firms to supply most of the emergency equipment and other essential supplies and services, together with specialized technical expertise to meet their needs in a particular disaster situation. Today, that dependence is more pronounced than ever, and in many areas of government activity it even has been extended to include reliance on private expert knowledge and advice on preventative as well as remedial action to mitigate the effects of modern technological or industrial disasters.

Significantly, the involvement of multiple organizations and different levels of government makes the possibility of centralizing decision-making in a disaster an increasingly remote one. Nor is a bureaucratic-style "grab for power" considered likely in a large-scale disaster. In fact, instead of power being grabbed by the military or another government agency, there actually may be a tendency for authority not to be fully exercised in these situations (Quarantelli, 1982: p.10).[13] Furthermore, it is anticipated that those (private and public sector) parties who are asked regularly to aid governments' disaster response efforts may expect to be consulted as well on how their resources can best be utilized to facilitate recovery.

It generally is accepted that under stable conditions, a formal hierarchical or bureaucratic decision-making structure provides an effective model for large organizations to manage their functional activities (Gillespie, et al., 1976: p.56). This is because it creates predictable patterns of behaviour and communication, and encourages routinized skill development. But disasters create situations of extreme environmental uncertainty for organizations. And whereas bureaucracies operating in normal times are seen as the "epitome of rationality and of efficient implementation of goals and provision of services" (Eisenstadt, 1959: p.303), the extent to which bureaucratic behaviour persists in a disaster or other emergency situation will depend on the type of dynamic equilibrium that the organization experiences in relation to its environment. In some instances, it may maintain its functional autonomy, or it may extend its spheres of activity and power. Alternatively, and as more often happens during a crisis, it could experience a "subversion of [its] goals and activities ... in the interests of different groups with which it is in close interaction." Eisenstadt (1959) refers to this as "debureaucratization" (p.312).

Therefore, in actual disaster situations, crisis conditions likely will cause bureaucratic organizations to operate very differently than they do under normal-time conditions. That is, they will organize their resources and operate in a less formal way. And as regards their activities in responding to a disaster, they will operate both at the organizational and interorganizational levels through co-ordination by feedback rather than by plan.[14]

Russell Dynes (1978) suggests that this is because organizations are affected by crisis situations associated with major disasters in different ways:

> Some organizations, such as business concerns, suspend operations and release their personnel and their resources for the use of emergency organizations. Others remain active, but convert extensively to disaster work, as in the case of utilities. Some established organizations, such as the police and hospitals, continue tasks that are part of their normal pre-disaster responsibilities. Others, notably the Red Cross and the Salvation Army, are prepared to deal with emergencies but must rapidly expand their staffs and resources to do so (1978: p.50).

Indeed, even in military activities, the command-and-control model may be more fiction than fact. The armed forces do not themselves operate in such a rigid, hierarchical manner -- especially in conflict situations (Quarantelli, 1988c).

In disaster situations, it also is widely recognized that centralized (bureaucratic) organizations are not able to react as quickly to a crisis as decentralized ones. This again is related to the fact that they tend to have complex communication configurations for internal information exchange, and because most of the information that is distributed within the organization and to other organizations and the public originates at the upper levels of the management hierarchy and does not get diffused down to the operations personnel.

Some reasons for the trend away from traditional hierarchical approaches to disaster preparedness planning and management, it is suggested, relate to an apparent growing consensus among decision-makers and disaster managers that what is needed instead is the nurturing of a disaster "consciousness" -- that is, a move towards greater flexibility together with continuous preparations and exercises which involve the extension of normal-time organizational activities to accommodate extraordinary disaster demands.[15]

According to Quarantelli, a fundamental problem with applying the command-and control model to peacetime disaster management stems from the assumption that:

> disasters create a tremendous discontinuity with everyday life, which lowers the effectiveness of individual behaviour and reduces the capacities of the social organizations involved. Given this, planning is centered on the development of mechanisms to control supposedly widespread, maladaptive, individual behavior and on the creation of ad hoc structures to replace the supposedly disruptive and nonfunctioning social organizations in the disaster area (1988a: p.55).

Louise Comfort (1985) similarly calls for a rethinking of traditional disaster management approaches in light of the growing complexity of modern disasters. She says that, "the emergency response process, initially designed in standard, hierarchical format for reactive agency operations, demands careful reconsideration in increasingly interdependent social environments" (p.155).

Another reason that the command-and-control model may not be considered useful for describing what actually happens after a peacetime disaster is because communities simply do not operate under a unitary command situation. As a result, according to two Australian authors, Wettenhal and Power (1969), "military organizations, which prepare for disasters by strictly conditioning their members in total institutions, may be quite unprepared for the task of controlling the post-disaster behaviour of civilians" (p.263).

Indeed, recent social science research provides a growing body of evidence favouring a modification of the command-and-control model through the adoption of non-hierarchical approaches to regional planning and response. Studies done by the Disaster Research Center (DRC) since the early 1980s, for example, indicate that "co-ordination" rather than "control" likely will be the best that can be achieved in managing peacetime disasters.[16]

In order to achieve effective disaster planning, it may be more appropriate to develop something along the lines of an "emergent response co-ordination model" (Quarantelli, 1988a: p.56). The key words here are "emergent" and "co-ordination." By **emergent** is meant situation-specific or ad hoc. It also infers evolution or ongoing change. In relation to providing an alternative to the traditional model, it suggests something that is not yet clearly defined -- that is, indications of trends towards developing new frameworks for studying disaster-related activities.

As regards **co-ordination**, definitions will vary. To some it may mean integrating the activities of one's own organization with those of the other organizations involved in the same situation. To others it might simply mean keeping other organizations informed about one's actions and intentions (Quarantelli, 1982: p.9).

Co-ordination, in a disaster context, perhaps best can be understood in terms of its objectives. These include "the avoidance of material waste, duplication of effort, excessive coverage and/or loss of time and effort" (Taylor, 1986: p.70). Thus, the main purpose of co-ordination relates to the realization of co-operative goals.[17] In a disaster, this involves ensuring that resources are distributed to the areas of greatest need, and in an equitable manner. Another major purpose of co-ordination is to ensure that the methods employed by the various agencies involved in a response activity do not conflict with those of the others. Effective co-ordination, therefore, is achieved by sharing resources, including information, specialist staff, equipment, and the like. It also could be achieved by dividing up the disaster affected area (geographically) among response organizations with comparable resources, or by establishing clear divisions of labour so that each takes on responsibility for a particular service or function.

Obstacles to effective interagency co-ordination include the possible physical disruption of communication facilities which would make contacting other responders difficult. Another obstacle might be the perceptions of an individual or an organization about what is urgent, leading to inappropriate response behaviour or conflict with another organizations' activities. A third obstacle could be inadequate training of organizational officials. A fourth might be the public image of the co-ordinating organization -- that is, its perceived capacity to undertake the task (Taylor, 1986: p.71).

Some of the DRC disaster studies also suggest that a loosening of the command structure combined with decentralization of decision-making to lower levels of public safety organizational hierarchies provide the most effective community response (Quarantelli, 1988b and 1988c). This is because the tremendous sudden increase in information flows in a disaster make it impossible for up-down hierarchical communication patterns to occur in a timely manner. Normal-time power and authority relationships quickly become irrelevant as channels for information exchange become overloaded and communication is blocked entirely or delayed significantly. When this occurs, subordinates will have to fend for themselves, while their superiors struggle to retain (or regain) control of the situation as best they can.

Under disaster conditions, routine bureaucratic organizational behaviour -- especially as it pertains to command communications -- will be inappropriate and ineffective both in terms of the type of information that is exchanged and the speed with which it is disseminated to those who need it to make decisions. In like manner, impersonal contractual relationships and formalized rules will be replaced in a disaster situation by a mode of informality and a general attitude of "to hell with the rules; we'll do what has to be done now and account for it later." This suggests the application of an entirely new set of values and priorities -- ones that attach particular importance to getting the job done effectively and quickly (Ponting, 1975: p.9).

Often, entirely new organizations will be created as a result of a disaster, due to the shifting dynamics of the specific situation at hand.[18] Factors that encourage these emergent organizations to form include the following: (1) emergency demands exceed community capability; (2) little interorganizational co-ordination; (3) authority lapse; (4) low community preparedness; (5) lack of prior experience; and (6) the crisis remains inadequately defined (Mileti, et al., 1975: pp.72-73).

From a command-and-control perspective, the creation of new authority structures in a disaster situation becomes all-important in order to overcome the anticipated social disintegration supposedly caused by the disaster agent. Accordingly, for the collective good, decision-making is best done in a centralized manner. Those decisions then are communicated in an authoritative way so as to induce compliance by the affected population. A related assumption made by advocates of this approach is that in a crisis, threatened citizens would not be capable of making rational decisions for themselves.

But according to Dynes and Aguirre (1979), the emergence of new groups in disasters relates not to the need to take charge and control the response, but instead to a requirement to rework established standardized operating procedures or to create new means to carry them out (p.71). Ad hoc co-ordination groups also may emerge when there are perceptions of a need for overall co-ordination and when information is considered problematic,[19] and their membership will be determined by previous patterns of interaction among the various actors (Drabek, 1986: p.165).

Comfort (1985) maintains that "the critical importance of information for optimal decision-making increases geometrically with the scale of the disaster, the scope of the geographic impact, and the number of people involved." Generating that information during a major crisis similarly will depend "upon effective communications patterns already in place within and between participating agencies" (p.155). It also will require "the activation of an information search and decision-making system that is substantially more sophisticated and adaptive to complexity than [that] designed for routine, single agency operations" (Thayer, 1968: p.157). It may even necessitate the redesigning of organizational functions together with a reallocation of time designated for information search, analysis and communication.

A number of the basic premises of the traditional model are brought into question by some recent disaster studies, including the present investigation. One such premise is that the decision-makers' situation in the upper echelons of the organization, and the assumption that they are in possession of all the information they need to make good decisions that then will be successfully communicated to and implemented by their subordinates. A second premise that is challenged is that emergency authorities have been clearly defined, and that they are known and accepted by all of the players. Third, the model assumes that, in a crisis, control can be centralized effectively at the top and all information coming into the organization will enter at a single entry point. Fourth, in relation to communications, the model assumes that adequate facilities are available to ensure uninterrupted telecommunications, and that crisis decision-makers will be able to access them easily.

2.5 Networks versus systems

The discussion that follows looks first at bureaucratic "systems" and, subsequently, at non-hierarchical patterns of relationships and communication configurations or "networks" established among organizational personnel and between organizations which usually emerge after a major disaster. The characteristics of bureaucratic structures and operations will be described along with consideration of the weaknesses of those structures and patterns of behaviour in terms of emergency preparedness and disaster management. It has been postulated that in disasters, informal and personal communication networks will take precedence over formal, bureaucratic or hierarchical relationships within and between organizations participating in the disaster response.

The following characteristics define a **system**. First, it is comprised of a set of parts which are sufficiently interdependent that a change in the state of one will affect the state of all others. Second, it has a clear boundary which separates it from the external environment. Third, it has a formal structure which depicts the various patterns of relationships between the component parts. Fourth, the various parts share common goals (Pettman, 1975: p.133). Thus, a system can be defined as a "set of parts coordinated to accomplish a set of goals in a consistent and regularized manner" (Churchman, 1968: p.29).

As regards the behaviour of bureaucratic managers, in normal times, according to modern rationalistic theorists, bureaucrats working in large public organizations consistently will try to increase the size of their departmental budget and extend the mandate assigned their office (e.g., Tullock, 1965).[20] Motivations for this kind of behaviour are that it might lead to increased personal income, enhanced job security and prestige, or improved departmental status and influence. Within bureaucratic systems, interpersonal or interorganizational alliances usually are long-term or permanent in nature, and they are based on established hierarchical structures.

Public bureaucracies exist because certain vital social functions are deemed to be best performed by non-market oriented organizations. The public bureau's specific social function will determine its internal structure and behaviour and vice versa. Generally speaking, they consist of the following common elements: (1) a hierarchical structure of formal authority; (2) an underlying informal structure of authority; (3) extensive personal loyalty and involvement among officials; (4) an extensive set of formal rules; (5) established standardized operating procedures; (6) a hierarchical communications structure; and (7) a complex matrix of informal and personal patterns of relationships (Downs, 1967: p.32).[21]

Indeed, even those bureaucracies, such as public safety organizations, that engage in emergency planning and preparedness as part of their regular activities rely on established rules and standard operating procedures to deal with routine (non-disaster) contingencies. Like other bureaucratic organizations operating under normal conditions, they too have a permanent hierarchical structure of authority and predominantly pyramidal patterns of communications. Also like other bureaucracies, they have additional, informal structures of authority together with a matrix of personal communication patterns and relationships. These informal and personal relationships within and between organizations are particularly relevant to understanding government organizational behaviour in disasters.

Gordon Tullock describes bureaucratic communications as being of three types -- formal, subformal and personal (see Jones, 1980). Formal communications transmit "official" messages, i.e., those pertaining to operating procedures, departmental directives, status reports and the like. Subformal messages are transmitted through the use of informal authority structures. Experience and example teach organizational members what those structures are. In contrast to formal communications, these are mainly horizontal, connecting peers within the organizational structure. The third category includes personal communications. These are used to transfer messages between officials acting as individuals rather than in their official capacity (Downs, 1967: p.56). For the purposes of the present discussion, Tullock's subformal and personal categories have been combined and they are referred to herein as "informal" linkages. These imply underlying organizational relationships and external communication links to other organizations, especially those with overlapping responsibilities; they also may involve the establishment of personal contacts in private industry, and especially among equipment suppliers and essential service providers such as public utilities -- including the telephone companies -- and broadcasters.

A **network**, in contrast to a system, in an organizational context, is comprised of relationships within or between organizations that are loose, unpredictable and ad hoc. A network is not like a bureaucratic system because it is "devoid of any institutional framework, lacks coherent goals, reflects few patterned relationships, yet points to a variety of ... functional linkages that have emerged probably more out of informal contacts than from formal institutional arrangements" (Kent, 1987: p.69).

In times of crisis or disaster, it has been suggested that informal and personal patterns of communications often will take precedence over formal hierarchical relationships. First, temporary alignments and communication linkages will be established within and between bureaux -- by "boundary personnel"[22] -- in order to meet extraordinary resource demands. Specialists, including bureau technical staff and private industry suppliers, as a result will become organized in emergent, flexible, non-hierarchical (what are referred to here as geodesic) expert networks. Finally, the emphasis in disaster situations will be on co-operative and co-ordinative arrangements among response managers rather than on command and control.

It also has been found that competition among government bureaux for limited resources under normal conditions will be replaced by temporary alliances formed to meet the exigencies of the particular crisis at hand. Co-ordination and co-operation, together with a certain amount of co-optation of private sector knowledge and other vital resources will predominate in a disaster situation because they are needed to speed up response time and eliminate confusion resulting from overlapping mandates that could put lives, property and/or the environment at serious risk. Co-optation of private resources is discussed in section 2.7 below.

According to Gillespie et al. (1976), disaster organizations, in contrast to other government bureaucratic organizations, are characterized by: (1) loosely defined centres of power; (2) an informal administrative structure; and (3) a shortage of equipment and trained personnel (p.56). Moreover, disaster management is almost necessarily interorganizational. And as the severity of the disaster increases, it often becomes interjurisdictional as well.

Additional common elements of disaster networks include the following: First, there are those communication links that are established because they are essential to scan and assess constantly the disaster site, and then mobilize and direct emergency resources to it. Second, while in-place formal communication systems are vital for assessing and mobilizing available resources, new informal "back-channel" information sources may be equally important. Third, the Emergency Operations Centre (EOC) is a crucial part of the ad hoccommunications network created as a consequence of a disaster. This is because it provides a centralized location for receiving, processing, analysing and dispensing critical information.[23] Fourth, additional "critical nodes" or key points on disaster networks usually include the disaster site; public safety units such as police, fire, and search and rescue teams; the broadcast and print media; other governmental jurisdictions (such as from neighbouring communities and other orders of government called upon to provide support; and a variety of formal and informal community groups (Stillman, 1984: pp.40-41). Inadequate participation and access by or the absence of any of these elements, it is suggested, could create obstacles to disaster communications and, consequently, to effective response efforts.

Disaster networks are always multiorganizational. They cannot be called systems because they are comprised of loosely coupled separate organizational structures whose degrees of interdependence undergo episodic but temporary change as a consequence of the specific disaster event that generates their creation (Perry, 1985: p.4). Just the same, there are some critical strengths inherent in this loose coupling of organizational elements into a disaster network. Among others, but perhaps most significant, are the interpersonal linkages that "guide their responses, especially their relative rank regarding influence on decisions" (Drabek, 1981: p.19). Organizational resources, and particularly communications capability, will push certain government agencies to the forefront.

Patrick Lagadec (1982) provides a model of the networks of relationships among intervening parties in a disaster. These parties include: operators; safety authorities; the authority in charge of rescue operations; official experts; potential victims; and outside groups such as political personalities, independent experts, the press, etc. (p.394). According to Lagadec, different types of disaster networks also exist -- including: (1) an information gathering network which is multichannel, and has formal and informal linkages; (2) a network of organizational and external technical experts familiar with the specific disaster agent involved; (3) a decision-making network comprised of government and public safety agency representatives; and (4) an information dissemination network (p.4).

In order to understand the dynamics of disaster networks, Lagadec maintains that each intervening party must know who the other major actors are together with their primary and secondary goals; the criteria to be used in decision-making; uncertainties surrounding resources availability; unresolved conflicts and the like. As a result, he concludes that to be effective in a crisis situation, interorganizational information exchange networks must be in place and functioning before the disaster occurs. This is because in a crisis situation, it is too late to forge effective co-operative interpersonal communication configurations.[24] Additionally, a key handicap to overcome during a disaster is the "beyond the fortress mentality" whereby the players may be reluctant to establish relationships with the outside during the crisis period. This is another reason that pre-established patterns of relationships among potential responders need to be established prior to the onset of a disaster (1982: p.12).

With regard to international disaster relief management, Kent (1987) similarly describes that community as a network rather than a system. He refers to it as "an amalgam of non-binding contacts, sustained by various channels of communication and by an awareness of who is around" (p.69). However, the components of the network are "too diverse, their interests too disparate, to engender the interdependence, the boundaries, the shared institutional goals and values that would comprise a system" (p.72). "On occasion," Kent states, "various components of the network will align themselves to promote particular interests, and will also work in concert to assist in relief. However, such arrangements are rarely enduring" (p.69). He concludes that these practices have led to the creation of "an intense web of communications, to which most relief actors have access," facilitated "by the increased familiarity that exists between many of the network components" and "spawned through the contacts that have often been made in the course of a variety of relief operations" (p.72).

2.6 Geodesic networks and disaster management

Since the early 1980s, the North American telecommunications sector has been characterized by a very high rate of technological change.[25] These developments have transformed the way in which facilities networks are thought about, planned and constructed. They also have been accompanied by changing industry structures wherein traditional regulated utilities monopolies increasingly are being challenged by competition in, for example, equipment and long-distance services provision.

The combination of significant and continuous technological developments together with increased demands by business users for customized services that, in turn, has further stimulated moves towards liberalized competition has created at the institutional level a North American communications configuration that looks like a geodesic dome.[26] The image that this creates is one where networks now have to allow for communications links that go vertically from the top down, together with horizontal links joining communities of interest at various levels within an organizational pyramid, as well as those connecting communities of interest in different organizations at lower and lower levels of their own structural hierarchies. Consequently, many more direct, point-to-point linkages are required which do not necessarily coincide with formalized organizational hierarchical structures. In addition, the emerging networks must be organized in such a way as to be capable of supporting multiple organizational pyramids -- and, also significantly, regardless of where the principal players are located geographically (Foster, et al., 1982).

Before 1980, the most important elements of national telecommunications networks were telephone company switches.[27] Indeed, until very recently, in terms of capital investment requirements, they were considered much more important than transmission links.[28] Thus, when switching was expensive and transmission, relative to switching, was not, the network looked like a pyramid: 100 million telephone terminals feeding into 22,000 telephone company central office switches, connected to 1,000 tandem switches, and so on.

The evolving telecommunications facilities networks in Canada and the United States, however, today reflect the revolutionary recent transition to much cheaper switching and other forms of network intelligence relative to transmission costs, and along with this, the movement of more switching capability closer to the end user. Indeed, for some large users, network terminals do not necessarily terminate; they now interconnect (e.g., local area networks, and direct connection to private exchanges and centrex multiplexers). What currently is emerging, therefore, is a kind of convex ring, with nodes connected along paths of minimum length -- that is, what Peter Huber (1987) refers to as a "geodesic network". Its typology is triangles placed in a sphere, or, alternatively, rings placed on a pyramid. In contrast to older, rigidly hierarchical technical network configurations which made each link dependent on the one above and the one below, today's "smart" switches and terminals can hand-off and receive traffic from all sides.

Some of the emerging non-hierarchical approaches to emergency preparedness management suggest similar trends at the policy level, particularly as regards emergency communications. These developments appear to be based on a growing recognition among planners and experienced disaster managers of the importance of ensuring effective communications as a critical aspect of any crisis management activity. Such networks -- be they physical facilities or interpersonal relationships -- essentially shape "the flow, direction, purpose and sources of communications links [and thereby] influence the course of organizational decisions ... as well as the essential organizational structure, design, programmatic implementation and fundamental mission(s)" (Stillman, 1984: p.39). They become all the more significant in a large-scale disaster.

The political context of normal-time government organizational operations, it will be recalled from the discussion above on the command-and-control model, is one in which bureaucratic decision-makers compete with each other in the areas of goals, functions, jurisdiction, and material resources. This leads to interorganizational competition for limited resources. It also may lead to poor performance where rivalry is intense and organizational boundaries are weak, especially when there is an overlap of mandates or competing organizational missions.

With regard to meeting the demands of rapidly changing conditions of uncertainty during a disaster or other peacetime emergency, however, Canadian emergency planners and disaster managers alike are adamant that there is no place for bureaucratic rivalry. At these times, co-operation based on the sharing of information and other crucial resources, they maintain, could make the difference between the success or failure of a particular response operation. In addition, in order to assure effective emergency response, emergency roles together with specific organizational responsibilities need to be defined clearly -- before disaster strikes.

Related to this is the need to institutionalize broad-based (interorganizational) allegiances that often develop as a result of shared disaster experiences. They also may result from the entry by a new breed of disaster managers into this field. These individuals, unlike their predecessors, do not come from military backgrounds or from police or fire departments. They often have been trained in crisis management , and this has encouraged them to develop and apply new types of co-operative problem-solving techniques, and to establish and maintain disaster-relevant interorganizational networks that would come into play in the kinds of of disaster scenarios which they have determined they might eventually confront (Britton, no date).

2.7 Co-optation

In addition to public sector participation in disaster networks, private sector experts also have a vital role to play in effective disaster response. Indeed, in order to make most policy decisions related to disaster management, public officials increasingly ask for advice from outside experts -- including, for example, for interdisciplinary interpretations of the anticipated consequences of government action or, alternatively, inaction. This is because, in part, recent advances in communications technologies and the resulting proliferation of alternative information sources and new sophisticated computer analytic techniques have overtaken the ability of senior bureaucrats and their political heads to process all the information they receive, even under normal circumstances. Consequently, there also is growing reliance on the private sector for specialized information that departmental staff are unable to generate as quickly.

In addition, many major policy questions cross the functional boundaries of government ministries, and their complexity has seriously taxed government resources allocated for information gathering and interpretation. As a result of these combined developments, policy-making in Canada has moved towards a situation in which private knowledge frequently is "co-opted" by governments to help shape public policy. This is reflected in the fact that private industry representations now constitute the principal alternative sources of information to staff reports for senior bureaucrats, and to departmental advice for ministers. At the same time, they provide valuable feedback to government thinking as outlined in White and Green Papers, and in the summary reports of advisory boards, commissions and special committees set up to address specific topics (Faulkner, 1982: p.248). Viewed in a positive light, these trends have led to broader-based inputs used in developing public policies. On the negative side, they may serve to perpetuate the tendency of policy-makers to work behind closed doors, selectively employing private sector knowledge to justify decisions arrived at for quite different reasons.

The principal safeguard against abuse of powers so derived is competition in the provision of expert advice. In terms of emergency communications preparedness, the subject of the present study, additional safeguards are introduced -- namely, the nature of disasters (in particular, their suddenness) and the lack of precedent upon which planners normally depend. It is suggested that these two charactistics of disasters encourage the creation of emergent crisis management structures and stimulate more flexible planning for possible future disasters.

Another result of co-optive relationships among private industry and public safety agencies are non-systemic patterns of relationships and informal interorganizational communications configurations. The emerging expert networks that are the product of these include, in addition to government response agency personnel, participation by various private organizations and individual experts who constitute supplementary and primary "nodes" on those networks. Moreover, like the technical networks, government decision-making structures in the context of emergency preparedness management are moving towards more open networks in which information would be allowed to enter or exit at any of a number of organizational gateways.[29]

Also with regard to emergent disaster preparedness networks, multiple organizational memberships and contacts will provide an improved knowledge base of the operations of the different organizations likely to become involved in future response efforts and facilitate interorganizational communication during disasters. Furthermore, over time, regular participation on interorganizational and advisory committees, and in planning exercises or post-event debriefings eventually might result in personal friendships among the individuals involved; these, too, would facilitate interorganizational disaster communications.

Emergency communications preparedness in Canada, it is suggested, is exemplary of current broad trends towards more co-operative, co-ordinative and voluntary co-optive arrangements among public bureaux, and with private industry. Significantly, all of the major commercial carriers that might be called upon by governments to help meet disaster communications needs appear to approach the task of improving national communications preparedness capability with considerable good-will and efficiency. Canadian telephone, cellular, satellite and paging companies, and the radio common carriers have been very accommodating in addressing the special needs of government agencies in emergencies by bringing in or borrowing transportable switches, installing new equipment at the site of the emergency, and providing the other carriers emergency access to their respective microwave networks. Moreover, these services are provided at regular, and sometimes even at no cost, depending on pre-established arrangements and the duration of the disaster requirement.

2.8 Technological imperatives

The public telecommunications network in Canada today, as was mentioned earlier, is moving towards open network architectures.[30] These trends provide evidence of the industry's de-emphasis on hierarchical arrangements, and its preference for establishing protocols and procedures that are designed specifically to enhance the network's ability to respond quickly to fluctuating communications traffic levels -- including dramatic increases in call demand associated with disasters. No attempt, however, will be made here to determine the extent to which these and like developments have been affected by changing facilities network configurations or vice versa.

This is not to dismiss the significant role that technological advances have played in shaping national emergency communications preparedness. Instead, they are put into a context that implies interactive and multiple forces at work leading to the new approaches to crisis management that have been observed over the past decade or so. The argument here is that while technological advances have been part of the various processes shaping facilities network structures and influencing government policy with respect to emergency preparedness, technology alone has not determined the outcome.[31]

Certainly, technology affects the social context to which it is introduced. It also serves to enlarge the scope of human activity. The author's position does not go so far as the technological determinism perspective, according to which technology is not considered to be a neutral tool employed to serve human ends; instead it is seen as having taken on the characteristics of self-generation or self-perpetuation, while human beings, for their part, have "lost their roles as active, directing agents" (Winner, 1977: p.29):

> Understood in its strongest sense, technological determinism stands or falls on two hypotheses: (1) that the technological base of a society is the fundamental condition affecting all patterns of social existence and (2) that changes in technology are the single most important source of change in society (pp.75-76).[32]

It is argued here that it is not possible to prove that technology is the primary determinant of social change. Moreover, it is strongly suggested that the pursuit of technological innovation itself actually may be driven by those same social forces which it subsequently directs into new areas. It therefore is suggested that human activity stimulates technological innovation and invention, which in turn helps determine the course of future human activity in a particular context.

With regard to the role played by technology in shaping Canadian emergency communications policy, it similarly is suggested here that while integral to that process, again it is not the only -- or necessarily the most significant -- determinant. Granted, new communications technologies provide opportunities for improved network efficiency. Just the same, it is questionable whether certain current trends -- such as, for instance, call traffic aggregation and the centralization of long-distance switching capability at distant hub stations, or the concentration of telecommunications traffic along fewer and fewer transmission routes actually have been positive developments as regards national communications preparedness. To the contrary, the criteria commonly used to measure efficiency in this area emphasize maximum transmission path redundancy. Thus, it could be argued that current network management practices, spurred by new technologies, may in fact decrease Canada's communications preparedness capabilities rather than enhance them.

Furthermore, it is suggested that other forces or trends in the industry, in combination and interacting with new communications technologies may play a more central role both in redefining the facilities network and stimulating the emergence of new approaches to communications preparedness policy-making. Indeed, there appears to be a persuasive body of evidence indicating that user demand and other market forces related to competition in the telecommunications sector may be more important factors stimulating the emergence of new decision-making structures which are co-ordinative, co-optive and flexible.

Additionally, these new structures, comprised as they are of broad memberships representing the different orders of government together with private industry, are expected to play an increasingly significant role in the future in adapting and improving both the facilities network base and operational procedures with respect to emergency communications management. Thus, market demand is expected to drive future technological innovation rather than the reverse; technical innovation, for its part, will provide additional opportunities to fine-tune services demand for these special communities of interest.

The creation of the National Coordination Center in the United States, directly related to the U.S. Defense Department's worries about the effects of the breakup of the AT&T Bell System on national emergency preparedness telecommunications, provides an illustration of the points made earlier. It constitutes a structural framework for preparedness planning in which industry representatives are permanently available to advise government on action to be taken to ensure maximum communications and response capability. It also provides evidence of the movement in that country towards more open policy-making in respect to emergency communications whereby private experts play an active role as advisers to government in both national planning and implementation.

In Canada, similar though less formally structured advisory bodies exist to advise governments regarding emergency communications preparedness. One of these is the industry Advisory Committee made up of representatives from the Stentor (previously Telecom Canada) membership. Another is the Carrier Working Group for defence communications. Most significantly for the purposes of the present study, is the evolving structure of the Regional Emergency Telecommunications Committees. All of these government/industry advisory mechanisms reflect a concerted movement in Canada towards more co-operative and co-optive arrangements with industry to shape future policy in respect of national emergency communications preparedness.

2.9 Conclusions

While the role of communications in disasters generally is recognized as being integral to effective emergency preparedness and response, certain assumptions made by emergency organizations regarding the ability of the Canadian telecommunications infrastructure to meet the tremendous demand for communications after a major natural or industrial disaster are challenged by this study. In the first place, it commonly has been assumed that an adequate communications lifeline infrastructure (that is, equipment and trained personnel) is in place. Secondly, it has been assumed that public telecommunications networks will function satisfactorily in a disaster. In contrast, it is suggested here that it may be more appropriate for planning purposes to assume that neither is the case.

Furthermore, the human factor in emergency communications is considered to be a crucial element in every phase of preparedness planning and response. This is because emergency organizations operate at different jurisdictional levels, and disasters are notorious for ignoring political boundaries. Consequently, pre-established relationships among individuals working in public safety organizations and the private sector will help determine the extent to which existing communications resources will be deployed effectively in a disaster situation. Additionally, emergency response efforts to meet extraordinary demands for communications in disasters likely will be co-operative rather than competitive if the alternative equipment suppliers and service providers already know one another.

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1 Charles Fritz provides a classical definition of a disaster as "an event, concentrated in time and space, in which a society ... undergoes severe danger and incurs such losses to its members and physical appurtenances that the social structure is disrupted and the fulfillment of all or some of the essential functions of society prevented" (Fritz, 1962: p.655).

2 This definition, by attempting to distinguish telecommunications in a very narrow sense from information processing activities, is not able to accommodate the current melding of telecommunications -- that is, message transfer -- and message transformation characteristic of information processing activities. However, it is beyond the scope of the present study to try to resolve this dilemma.

3 A crisis is defined as a situation in which the actor faces the necessity of making an appropriate choice for action in order to avoid or reduce damage.

4 These are discussed in section 2.3.5 of this chapter.

5 Much of this discussion is derived from Enrico Quarantelli's extensive research on organizational behaviour in disasters. See, for example, Quarantelli, 1982: pp.7-10.

6 Convergence occurs when tens of thousands of calls come pouring in simultaneously -- locally from concerned or affected citizens to emergency agencies, and from outside communities to seek information on the welfare of friends and family.

7 The federal government program is known as "line load control" (LLC), but the industry more often refers to it as essential line treatment. See Chapter Three for a discussion of this and other federal/industry programs.

8 Depending on how far away the disaster stricken area is from telephone company landlines or a microwave tower.

[9] Civil defence may be defined as the collective activities of government agencies -- local, county, regional, provincial and federal -- attempting to protect citizens, their property and the environment from the consequences of disasters affecting all or a substantial part of the population in a given location.

[10] Personal communications with personnel at Bell Canada Provincial System Control Centre, Montreal.

[11] Notably the CRTU-Québec's Long-distance Network Overload subcommittee.

[12] A very simple illustration of this process is the home furnace which is a self correcting system.

[13] Authority problems in disasters stem from jurisdictional ambiguities or overlaps on the one hand, and the exigencies imposed by new, non-routine tasks, on the other. At this point, it may be useful to consider the roles of "power" and "authority" in organizational relationships and particularly within the context of formalized bureaucratic communication configurations. According to Katz and Kahn (1966), power is relationship specific, while authority is hierarchical position specific. On one hand, individuals have **power** over others to the extent that they can arbitrarily divulge -- or, alternatively, withhold -- information for which others have a communicative need. **Authority**, on the other hand, refers to formalized, standardized positional power. It gives a superior the ability to command a subordinate in ways consistent with a tacit or formal agreement regarding what specific areas that authority to command covers, when, and how it is to be exercised (cited in Thayer, 1968: p.207).

[14] Co-ordination by plan assumes a clear, pre-determined blueprint for action, based on established standard operating procedures for any anticipated contingency. Co-ordination by feedback essentially involves decision-making by trial and error (Dynes and Aguirre, 1979: p.71).

[15] See Dynes, 1983 for a discussion of some of the problems with the command-and-control model of disaster management.

[16] Originally established at Ohio State University, and now located at the University of Delaware.

[17] Organizational co-operation can be defined as an exchange that is considered to be "any voluntary activity between two organizations which has consequences, actual or anticipated, for the realization of their respective goals or objectives" (Levine and White, 1961: P.583). Thus, organizations co-operate by exchanging elements.

[18] The most common being citizens' groups made up of individuals from the affected communities who work together in a voluntary capacity to provide relief to their neighbours and to ensure that government compensation is distributed equitably.

[19] Disasters place extraordinary demands on the limited resources of public agencies and, as a consequence, timely and accurate information becomes crucial to ensure that the best use can be made of what is available.

[20] The so-called "creeping mandate phenomenon" is one wherein organizations that have been set up to perform a limited function extend their authority over functions that properly belong to others and in which they have no particular expertise. One type is that of "the inclination of central agencies with narrow mandates and professional skills to drape themselves with the mantle of experts in public administration." Another type of mandate creep "takes place among line departments who take advantage of the prevailing view that everything in government is interconnected in order to grab a share of someone else's turf" (Laframboise, 1982).

[21] Key to modern bureaucratic processes are the formal and informal patterns of relationships within and between organizations. They regulate the flow of information, upwards to the executive (i.e., "winnowing") and downwards from the executive for implementation (Tullock, 1965: pp.137-141).

[22] Boundary personnel include those individuals who occupy boundary roles between organizations and facilitate the exchange of information and resources. They (1) hold positions that require contact with people in other organizations; (2) are members of two or more organizations (such as a police chief who is also a member of a municipal administrative

council, etc.); and/or (3) are people having extensive friendships rather than holding certain positions. See Dynes, 1978: pp.54-55; and Mileti and Sorensen, 1987.

23 Significantly, EOCs allow government response agency representatives to gather together in one place. Thus, they provide a means to expedite information exchange and dissemination, thereby facilitating co-operative decision-making and reducing the likelihood of a duplication of efforts.

24 The Three Mile Island incident provides an example. The dynamics of the disaster network included, first, the absence of a clear resource plan and, second, the absence of a plan for public information (Lagadec, 1982: p.395).

25 Among the important technological factors stimulating radical change in the telecommunications industry were the Bell Labs' invention of the transistor in 1947, followed by the development of integrated circuits a decade later.

26 Geodesic, in architectural engineering terms, refers to a spherical grid of triangles. It is also used to refer to the shortest possible distance between two points along a surface, especially a curved surface. Derived from Huber's (1987) descriptive model of the U.S. industry, it suggests a non-pyramidal organizational structure in which communications patterns are non-hierarchical and can link directly any two nodes or parties.

27 These constitute the intelligent electronic interface among users and service providers. They route, concentrate and distribute voice and data message traffic.

28 The other integral element of the public network which moves that same traffic from one place to another.

29 Reference is again made to the role of boundary personnel. These individuals have the job of interacting with other organizations, such as on interorganizational committees. Ideally, interactions among boundary personnel would be frequent and reciprocal.

30 These are the technical protocols that allow more complete interconnection and integration among separate physical networks.

31 See section 2.2 for a definition of technology.

32 Also see White, 1949: p. 366.

PART II
CANADIAN APPROACHES TO EMERGENCY AND COMMUNICATIONS PREPAREDNESS

Preface

Chapters Three and Four constitute Part II of this dissertation. Part II provides an overview of government and industry approaches to emergency preparedness generally and communications preparedness in particular.

Chapter Three discusses Canadian government approaches in this area and includes a compendium of historical and descriptive information derived from government archival documents. Specifically, it reviews the various legal authorities, roles and responsibilities for civil emergency planning. It also describes the history and operational structure of Emergency Preparedness Canada and the National Emergency Agencies. As regards emergency communications preparedness, the role and responsibilities of the federal Department of Communications are considered, together with the structure and functions of the proposed National Emergency Agency for Telecommunications and a National Emergency Telecommunications Committee. Subsequently, other federal roles respecting communications preparedness are discussed.

Chapter Four provides an overview of the structure of the Canadian telecommunications industry and looks at various industry strategies and initiatives aimed at maximizing the country's response capability. It then discusses a number of government/industry programs currently in place which are designed to enhance national communications preparedness. Finally, it considers the possible consequences of certain industry trends on Canada's emergency communications capability.

CHAPTER THREE
Government Approaches

3.1 Introduction

This chapter looks at some of the institutional structures that have helped determine Canada's past approach to emergency planning, including for communications preparedness. It also considers other influences that challenge the appropriateness of that approach with regard to peacetime preparedness, and provide indications of the emergence of alternative frameworks for emergency planning. To that end, an historical overview of the evolution of emergency planning and preparedness in Canada is provided -- from its origins in the Second World War to the present time. Additionally, the roles and responsibilities of the major federal departments and agencies involved in emergency communications planning are discussed, together with those of the provinces and territories, and, in turn, Canadian municipalities. Finally, the role played by Canada in international emergency communications preparedness and planning is looked at.

Historically, the Canadian approach to emergency preparedness policy has been

> to foster a consultative and co-operative environment within which to provide a strong common national purpose for all levels of government, leading towards mutually acceptable emergency response preparations (DOC, 1986a: pp.2-3).

The aims of the Canadian government in this regard include: (1) providing leadership with respect to emergency preparedness; (2) developing a credible national capability to meet emergencies; (3) working towards adequate standards of essential emergency services; and (4) sensitivity to humanitarian needs. Whereas before the mid-1960s emergency planning was primarily oriented towards wartime preparedness or "civil defence," afterwards, those goals were to be achieved by putting in place arrangements required to meet <u>peacetime</u> emergencies, with supplementary requirements for meeting wartime contingencies.

Today, the Canadian emergency planning structure is comprised of a series of arrangements among federal, provincial and territorial governments that have resulted in the appointment of a minister responsible for emergency planning in each government. Supporting these are emergency measures organizations with co-ordination and policy development roles as well as operational (i.e., response) responsibilities. Ministerial committees also have been formed for intergovernmental consultation and negotiation with regard to emergency preparedness.

Generally speaking, the role of each order of government in Canada in this regard is to mitigate the adverse effects of emergencies through planning and preparedness measures, "which can reasonably be considered to be beyond the responsibilities or capabilities of private individuals or organizations and to react promptly and efficiently when an emergency does occur" (EPC, 1974: p.4). Their related functions are six-fold:

(1) **Informing** the public to assist them to understand government policy and to know how to get assistance when needed.

(2) **Warning** -- including analysis and forecasting of potential emergencies and maximizing warning time to the extent possible.

(3) **Co-opting** -- of private resources considered essential to meet emergency needs.

(4) **Providing** government resources to meet emergency needs.

(5) **Restoring** -- i.e., using real and financial resources to return things to normal after and emergency.

(6) **Changing** policies where considered desirable.[1]

Emergency Preparedness Canada (EPC), Ottawa, is the central Canadian organization that develops federal emergency preparedness policy. In addition, it undertakes research and provides education to emergency managers at all levels of government. It also makes arrangements for the continuity of government operations in emergencies, and it co-ordinates and supports the emergency planning activities of other federal departments and agencies together with those of provincial, territorial and municipal governments. Regional offices of EPC are located in each provincial capital. They have similar overall responsibilities and liaison functions with the respective provincial/territorial authorities. In addition, a number of supporting interdepartmental committees and federal working groups also have been created to study specific emergency preparedness questions.

Each federal department, agency or Crown corporation is required to identify their responsibility area for national emergency planning. Excepting those federal departments and agencies that have a direct mandate to do so, other federal bodies would act as "lead" or, alternatively, "resource/support" agencies in an emergency situation. The former are required to develop detailed plans for coping with such contingencies and to co-ordinate their plans with the appropriate provincial or territorial agencies (Blake, 1977: p.2). They also would be expected to take control and manage the emergency response in situations "in which the predominant factor involved is one which comes within the department's normal responsibilities."[2] Thus, the guiding principle in Canadian federal emergency planning is that it is to be an extension of day-to-day functions; accountability to Parliament for preparedness and initial action would rest with the minister responsible for the most closely related normal functions.

Those federal departments and agencies with special resources or which provide particular services that might be needed in an emergency similarly are required to prepare contingency plans for the kinds of emergency situations in which their resources likely would be needed. The Department of Communications, for instance, often would be involved as a resource or support department; it would play a lead role only rarely. An example of when the DOC would play a lead role would be a major disruption of national communication services. The Canadian Broadcasting Corporation (CBC) and the Canadian Radio-television and Telecommunications Commission (CRTC), both of which are Crown agencies for which the Minister of Communications also is responsible, would become involved in meeting federal emergency communications responsibilities only as resource agencies.[3]

Primary responsibility for meeting peacetime emergencies or disasters lies with the persons or organizations who are directly affected. That is, it begins at the individual level; institutionally, it begins at the local or municipal level. Often, however, response involvement may go beyond the affected local authorities' ability to cope with the situation. In such cases, provincial/territorial and federal governments would provide support to the response operation, but, significantly, only at the request of the local authorities involved (EPC, no date (d): p.1). In a similar way, emergency communications response also would be managed at the lowest action level. Support requirements that cannot be met locally would be processed upward (through DOC regional offices) for resolution (DOC, 1989b).

Regarding civil or peacetime emergencies, the Canadian government's goals are to provide "leadership" towards improved emergency preparedness generally; to develop a national capability to meet all kinds of emergencies (i.e., a multi-hazard approach); to establish adequate and uniform national standards of emergency services; and to address humanitarian concerns (DOC, 1989b: pp.1-2). The federal government would become directly involved in emergency response in cases where it affects an area for which it has primary responsibility under the Constitution. These include: air or maritime rescue operations, coastal oil spills, air crashes, and situations affecting federal properties (EPC, 1974: p.3). They also include foreign military action or hostilities.

In any of those situations, provincial and local authorities might be asked to provide (non-financial) support to the federal authorities. As a consequence, provincial and territorial emergency preparedness policies are designed to reflect and complement federal approaches. To that end, most of the provinces and territories have concluded agreements with the federal government which delineate their separate responsibilities.

3.2 History of Canadian civil emergency planning

What is now referred to as Canadian emergency preparedness had its origins in national civil defence policies developed in the context of World War II. Indeed, as early as 1936, the Government of Canada and the various services of the Canadian Armed Forces were discussing plans for civil defence (EMO, 1973: p.16). Prior to that time, Canadian civil emergency planning had been on an as-needed basis.

The term "civil defence" refers to measures taken to protect the civilian population in wartime.[4] It includes any measures, other than those taken by the military, to reduce the effects of a hostile attack on the civilian population -- whether they are taken before, at the time of or after an attack. "Civil defence planning," in contrast, includes not only civil defence measures as such, but also the planning required to ensure continuity of democratically elected government at all levels (federal, provincial/territorial and municipal). This is because continuity of government is considered to be vital to assisting the population in surviving the conditions created by a war emergency. It is also essential to economic recovery after a national emergency (Drury, 1964b: p.1).

Through most of the 1960s, the Canadian government's planning emphasis remained on wartime emergency measures. Afterwards, it shifted gradually towards planning for peacetime emergencies. Today, civil emergency preparedness planning in Canada is concerned predominantly with contingency planning in respect of natural disasters and urban industrial or other environmental accidents.[5]

It is suggested here that the federal government's earlier preoccupation with wartime planning reflected wartime and early postwar government institutional structures, and that these do not correspond to present-day realities. Similarly, traditional approaches to civil emergency planning and crisis management are challenged by the present study on the grounds that they, too, are reflective of a hostile international environment that no longer exists. During that earlier period, the institutional structures of government reinforced hierarchical decision-making and military-style emergency planning and response. Through the 1950s and 1960s, however, Canadian institutional structures began changing as governments around the world started shifting the focus away from policies driven by the perceived imminence of war and towards closer economic integration. The result was "paper preparedness" -- that is, plans that merely reiterated established organizational (i.e., bureaucratic) imperatives. But because there were no "national" emergencies, those plans were not actually tested and thus could not be evaluated properly.[6]

Then, from the late 1960s on, new players came onto the Canadian federal institutional scene. And they, in turn, became involved in emergency planning. Particularly significant to the present discussion was the creation of the Department of Communications in 1969, and that department's assumption of federal responsibility for national communications preparedness. Also significant was the expansion, in 1966, of the Emergency Measures Organization's civil protection mandate; subsequently, it would place a much greater emphasis on peacetime emergencies. The planning initiatives of these two agencies eventually led to the emergence of alternative approaches to emergency preparedness which are consultative, co-operative and co-ordinative rather than control-oriented.

Regarding communications preparedness specifically, before the mid-1960s, federal activities were approached from a purely technical or engineering perspective -- that is, "can it be done?" As a result, government planning in that area focussed on the development of emergencies-only capabilities and separate communication systems. Today, in contrast, communications preparedness planning is increasingly multidisciplinary, involving the participation of different kinds of users and suppliers and emphasizing the use of technologies that are used on a daily or at least a regular basis for normal-time operations.

3.2.1 Civil defence origins

North American public concern about civil defence grew dramatically with the advent of massive air raids on Europe during the Second World War. As a result, Canada introduced air raid precautions which provided for active fighter defence; early warning radar; blackouts; and rescue and emergency relief organizations. The Air Raid Precautions (ARP) organization, for example, was set up in **1938** "to organize a warning system, to set up and enforce lighting restrictions at plants and other vulnerable areas, to prepare a system of protection from high explosive, incendiary and gas bombs and to establish an organization for the treatment of casualties" (EMO, 1973: p.16). In addition, the ARP operated a number of coastal defence centres and provided clothing, gas masks and sirens to local communities. It also gave financial assistance to volunteer local civil defence organizations and the provinces. The central ARP committee at the time recommended that handbacks be prepared for use by local authorities and volunteers, and that the Department of Pensions and National Health, in co-operation with municipalities and provinces, be made responsible for air raid precautions. By the end of 1941, one in 27 of the estimated 2.5 million Canadians living in vulnerable areas worked as ARP volunteers. By **1945**, however, the ARP had virtually ceased to exist -- except in British Columbia, where Japanese balloon bombs were still considered a threat.

The first peacetime Canadian civil defence co-ordinator was appointed in October **1948** to supervise the work of federal, provincial and municipal authorities in planning for public air raid shelters; provision of emergency food and medical supplies; and rapid evacuation of possible target areas.[7] Also in **1948**, the Canadian government established the War Book Committee in reaction to the escalation of the Cold War. Its purpose was to plan the activities of the different government agencies in the event of war. A new national civil defence organization also was set up at that time within the Department of National Defence.

And in **1950**, a federal Civil Defence Co-ordinating Committee was established. Comprised of senior representatives from federal departments having civil defence responsibilities, its objectives were similar to those of the ARP, emphasizing the establishment of local civil defence organizations. The federal role would be in a support capacity -- that is, to provide guidance, direction and co-ordination. Among other things, it would provide an advance warning system and supply warning devices to municipalities located in potential target areas. In addition, it would help finance provincial civil defence programs, and give training courses to emergency managers (EMO, 1973: p.16.).

In **1951**, federal powers and duties with respect to civil defence were assigned to the Department of National Health and Welfare (NHW).[8] During the next two decades, that federal organization operated under a variety of titles and was overseen by a number of different departments. But throughout those years, its mandate remained essentially unchanged. It was to develop plans and procedures that would ensure the protection of the Canadian population in a wartime situation. Primary responsibility for civil defence planning lay with local governments; the role of the federal government, as previously, was to be that of providing support to local and provincial initiatives. Gradually, all of the provinces established their own emergency measures organizations, and a series of federal/provincial conferences were held to determine the "spheres of activity" of the different orders of government.

In **1952**, the Canadian government agreed to assume 50 per cent of the costs of developing provincial and municipal emergency measures programs. It also participated in the North Atlantic Treaty Organisation (NATO) meeting on civil defence at which it agreed to exchange public information and program reports with other NATO member countries. A year later, the Canadian Civil Defence College was established at Arnprior, Ontario (near Ottawa). There, key federal and other planning personnel would receive training, and research would be conducted in the area of civil defence procedures and equipment.

Up until 1957, Canadian civil defence activities centred exclusively on planning for the survival of the population in the event of a nuclear attack; subsequently, the focus shifted to ensuring the "continuity of civil government" during and after such an attack. In **1957**, the federal Emergency Measures Organization (EMO) was created within the Privy Council Office. It was given a mandate to plan for the continued operation of government, the provision essential government services, and national resource management. It also was made responsible for Canadian activities related to NATO civil emergency planning. Federal activities concerning population survival planning, warning, rescue, shelters, etc. would remain with National Health and Welfare.

In **1959**, however, following the publication of Howard Graham's survey of Canadian civil defence programs and policies, responsibility for all of these federal activities was significantly decentralized.[9] Until then, Canada's civil defence program had relied almost entirely on groups of volunteers who were assisted (mostly just financially) by government. Subsequently, the federal government's policy would be as follows: that "civil emergency planning both for survival and for the maintenance of government, is [considered to be] a continuing responsibility of government at all levels" (EMO, 1961: p.15).

The EMO was to retain responsibility for continuity of government. In addition, it would become the overall co-ordinating agency for federal department and agency civil defence planning for NATO activities, and the liaison with other (NATO and non-NATO) countries in respect to emergency planning. It also was charged with helping provincial governments and, through them, municipal authorities in areas of civil defence planning that were not already the responsibility of another federal body.[10]

As regards other federal activities in the area of civil defence, National Defence would retain responsibility for national warning and communication systems; monitoring explosions and fallout damage; decontamination; and rescue services. The Royal Canadian Mounted Police (RCMP) was given responsibility for controlling traffic and maintaining law and order during civil defence-related operations. Health and Welfare was made responsible for administering the Civil Defence College, and for managing programs to assist provincial governments in providing emergency health services, social assistance, essential supplies and accommodation. The designation of additional civil defence responsibilities among federal, provincial and municipal governments were outlined lather through a series of federal/provincial conferences. For instance, the provinces and municipalities would be responsible for providing essential services to their populations, while the federal government would co-ordinate planning in areas of activity considered "essential." Moreover, the federal government would provide financial support to the other orders of government for their emergency planning activities.

In **1960**, the Diefenbaker government launched a new civil defence campaign -- to support the construction of home fallout shelters. It also announced its intention to build regional centres in each of the provinces with the aim of ensuring continuity of government. To be known as Regional Emergency Government Headquarters (REGHQs), those facilities would be used to house federal, provincial and military officials responsible for the provision of government services. In a major civil or wartime emergency, the REGHQ also would direct those operations of the federal and provincial governments of the affected area considered to be essential to survival.

In addition to the REGHQs, a central emergency government complex (CEGHQ) was built near Ottawa. It would house federal ministers and small cores of senior bureaucrats in the event of a national emergency. They, in turn, would be supported by larger departmental staffs to be accommodated at other relocation centres, also in the Ottawa area. Furthermore, emergency communication systems were developed in order to link these units both with each other and with the Ottawa "central complex." Finally, lists of federal essential services staff were compiled by all the federal departments and agencies, and by provincial authorities under the oversight of the Emergency Measures Organization. These continue to be maintained today, and they would be used in the event of a national emergency or large-scale disaster affecting the National Capital Region.

As is apparent from the above discussion, there was considerable federal activity in the area of civil defence planning in Canada following World War II and into the early 1960s. During that time, a country-wide attack warning system and a national Emergency Broadcast System (EBS) also were set up, and federal plans were set down for the provision of emergency resources -- i.e., medical and social welfare supplies, manpower, communications, transportation, etc. Moreover, surveys were done of buildings that could be designated as fallout shelters; and a wide-scale public information program produced several publications on home fallout shelters and municipal survival planning guides, together with public education films, television and radio broadcast programming -- all on civil defence preparedness. Finally, six permanent REGHQs were built across the country.

3.2.2 Transition to peacetime disaster emphasis

In **1963**, responsibility for the EMO was transferred to the Minister of Defence Production. That department also took over administration of the Civil Defence College.[11]

In **1965**, the EMO was transferred again, this time to the Minister of Industry. Civil defence responsibilities were further decentralized under the Civil Emergency Planning Order effecting that transfer.[12]

Under the new order, emergency powers, duties and functions would be divided among twelve "lead" departments. They included: Agriculture, Defence Production, External Affairs, Finance, Fisheries, Justice, Labour, National Defence, National Health and Welfare, Postmaster General, Public Works, and Transport. For the purposes of the present study, the two relevant departments are National Defence (which, among other things, retained responsibility for establishing national attack warning and continuity of government communication systems) and Transport, had been given responsibility for setting up an Emergency National Telecommunications Organization (ENTO) and, through the CBC, providing a national Emergency Broadcast System.

Significantly, in **1966**, as noted earlier, the EMO's civil protection mandate was expanded to place greater emphasis on federal response in <u>peacetime</u> emergencies and disasters. At that time, it was renamed the Canada Emergency Measures Organization (CEMO). This action was taken in response to the June 1965 federal-provincial Minister's Conference on Civil Emergency Planning at which was recognized the need for broad-based plans to cope with major peacetime disasters. It also was provoked by the November 1965 power blackout on the eastern seaboard which had affected large areas of southeastern Canada. However, as the 1967-1968 federal Estimates and Commons Debates suggest, by the time the Trudeau government came to office in 1968, the CEMO was already languishing.[13]

In mid-**1968**, the CEMO was transferred back to the Department of National Defence. Thereafter, it would report to a deputy minister rather than to the minister.[14] CEMO's loss of proximity to the prime minister was extended by this decision. In addition, federal financial support for emergency planning declined steadily during the second half of the 1960s, again reflective of the weakened political saliency of civil defence and emergency planning.

From this brief discussion, it can be concluded that during the 1950s and into the 1960s, Canadian emergency planning emphasized wartime and military defence. But during the latter decade, the EMO and especially its successor, the CEMO, were explicitly charged with co-ordinating federal responses to peacetime disasters. Furthermore, each was involved increasingly in federal programs to assist provincial and municipal authorities with their own emergency measures activities. The CEMO also began participating directly in many major disaster response operations.

In **1970**, the director of the Canada Emergency Measures Organization announced a new national objective -- namely, "to develop throughout the nation non-military plans and preparations for responding to emergencies caused by internal or external threats to the social, political or economic structure of Canada" (Public Archives of Canada, no date (a)). This statement infers a retention of the CEMO's co-ordinating responsibilities for wartime planning and their extension, where applicable, to meet peacetime disaster needs. In this regard, "internal threats" have implications for Canadian sovereignty; they include "preparations to meet floods, hurricanes, tornadoes, civil unrest and disorders -- in fact, any peacetime emergency which can disrupt, damage or destroy our civilian society and, hence, hinder national development" (Wallace, 1979: p.8). "External threats," in this case, still refer to armed attack -- that is, defence in its traditional sense.

In October **1972**, the Dare Report was submitted to the federal Cabinet. In it were outlined a number of recommendations to improve Canadian crisis management methods together with federal institutional structures so as to enhance interagency co-ordination in all types of emergencies -- both peacetime and wartime. Perhaps the most significant recommendation made by the Dare Commission was that individual federal departments and agencies take charge of handling emergencies within their normal areas of operation.

This led to every federal ministry being directed to undertake and orient their emergency planning towards peacetime disasters which could directly affect their operations or might require them to provide support to another government department or agency. Additionally, several federal departments were given enlarged supervisory and co-ordination responsibilities in line with the lead department concept introduced earlier. For example, responsibility for emergency preparedness in regard to radiological defence was assigned to National Defence, while the shelters program was moved to Public Works, war supplies planning to Supply and Services, and emergency transportation to Transport. The Department of Communications (created in 1969) was given responsibility for emergency communications.

In **1974**, an Emergency Planning Secretariat (EPS) was set up in the Privy Council Office to oversee general federal policy development in emergency planning. Still, a large portion of its "co-ordination" responsibilities were delegated to CEMO, and that organization remained in National Defence. At the same time, the CEMO was restructured, significantly reduced in size and renamed the National Emergency Planning Establishment (NEPE).

In **1975**, the NEPE's name again was changed -- this time to Emergency Planning Canada (EPC). It would now hold less direct responsibility for federal emergency preparedness, and although it subsequently became much more actively involved with developing peacetime response measures, it continued to decline in national political status. By contrast, provincial and municipal emergency planning organizations were becoming much more active on a regional level.

In **1980**, ministerial responsibility for EPC was given to the president of the Privy Council. This change raised the profile of federal emergency planning activities considerably. From that point on, particular emphasis would be placed on "intergovernmental" consultation and federal-provincial-territorial joint planning for peacetime emergencies. At the same time, the Joint Emergency Planning Program (JEPP) was created to provide financial support for disaster-related planning and response projects. Moreover, emergency planning working groups were established in each of the provinces.

In **1981**, another Emergency Planning Order was issued, replacing the Civil Emergency Planning Order of 1965. This initiative was reflective of an apparent renewed interest by the federal government in emergency measures.[15] Whereas the earlier order had delineated federal powers and provisions for emergency preparedness in a wartime context, the new one signalled a definitive shift towards peacetime disaster preparedness -- that is, "peace first, war second." Subsequently, Canadian emergency planning would focus on strategies designed to meet major peacetime contingencies, although (supplementary) provisions to meet wartime needs also would be developed.

Significantly, EPC's particular responsibilities were not outlined in the 1981 order. Instead, the heads of ten "lead" departments and agencies were directed to identify possible types of emergencies within their respective areas of responsibility and develop plans for handling them. Within each of these organizations, provisions also were made for a National Emergency Agency (NEA) to be activated in the event of a national emergency so as to enable them to carry out their essential functions. The ministries identified therein included the following: Agriculture; Communications; Employment and Immigration; Energy, Mines and Resources; Finance; Health and Welfare; Industry, Trade and Commerce; Public Works; Canada Mortgage and Housing Corporation; and Transport.

Finally, the most recent federal legislation in respect of emergency preparedness was enacted in **1988**. It reiterates and expands upon major aspects of the 1981 order with regard to federal ministerial tasks and responsibilities in this area. It also provides, for the first time, clear formal authorities to EPC (now known as Emergency Preparedness Canada) to oversee, this time in a more direct manner, the efforts of individual federal departments and agencies to develop sector-specific contingency plans and procedures.

Thus, as a consequence of several Cabinet decisions which shuffled and reshuffled emergency preparedness functional responsibilities among a number of different ministers, federal emergency measures in Canada experienced a decline through the 1960s and 1970s -- as measured in terms of budgetary allocations, ministerial responsibility, and statutory as well as delegated authorities. More recently, however, the co-ordinating agency for federal emergency preparedness, EPC, has been very active in helping other federal departments and agencies together with provincial, territorial and municipal governments to develop measures designed to meet a widening array of peacetime disaster needs, in particular, in the area of environmental and industrial risks. Table 3.1 provides an overview of the history of Canadian civil emergency planning since the Second World War.

TABLE 3.1

Chronology of Federal Emergency Planning in Canada

1938 Air Raid Precautions (ARP) organization set up by Canada's Defence Committee. Its purpose was to prepare against the possibility of an attack against Canada.

1948 First Canadian civil defence co-ordinator appointed.
War Book Committee created to plan activities of the different government agencies in the event of war.
National Civil Defence Organization (CDO), created in Department of National Defence. [P.C. 29/4855]

1950 Civil Defence Co-ordinating Committee established, comprised of senior representatives of federal departments and agencies with civil defence responsibilities.

1951 CDO moved to Department of National Health and Welfare (NHW). [P.C. 985, 1951]

1952 Canadian government participated in North Atlantic Treaty Organization (NATO) meeting on civil defence at which it agreed to exchange public information and program reports with other NATO countries.

1953 Canadian Civil Defence College established at Arnprior, Ontario.

1957 Additional Emergency Measures Organization (EMO) created in Privy Council Office (PCO); CDO remained in NHW. Two federal organizations now were involved in civil emergency preparedness.

1959 Graham Report issued, recommending a major reorganization of civil defence responsibilities.
The CDO in NHW was abolished; its formal survival and planning responsibilities were transferred to the EMO.
The EMO also was assigned the role of co-ordinating all civil aspects of defence policy.
NHW, the Justice Department and DND also assumed some functional responsibilities for civil emergency preparedness. [P.C. 1959-656]

1963 EMO moved to the Ministry of Defence Production. [P.C.1963-993]

1965 EMO moved to the Ministry of Industry. [P.C. 1965-1041]
Civil defence and emergency planning responsibilities were divided among 12 departments and four agencies.

1966 EMO was charged by Cabinet with responsibilities to provide and co-ordinate the federal response to peacetime disasters. It was renamed the Canada Emergency Measures Organization (CEMO).

1968 CEMO moved (back) to DND. [P.C. 1968-1302 and P.C.1968-1581]

1973 Radiological defence, emergency transport, emergency communications, war supplies and the Civil Defence College responsibilities were removed from CEMO. [Memorandum of Understanding, 1973]

1974 Following issuance of the Dare Report, the Emergency Planning Secretariat was set up in the PCO to oversee general federal policy development in that area. CEMO remained in DND, but was restructured and reduced in size as the National Emergency Planning Establishment (NEPE).

1975 NEPE's name was changed to Emergency Planning Canada (EPC) under the Federal Identity Program.

1980 President of the Privy Council was made responsible for providing ministerial guidance for policy development, interdepartmental co-ordination and liaison with provincial governments in the area of emergency planning. S/he was to be supported by the Assistant Secretary to Cabinet for Emergency Planning, who was in charge of administering EPC. EPC subsequently developed into an integrated organization comprising the Office of the Assistant Secretary to Cabinet and the planning staff, with administrative support services provided by DND.

1981 The Emergency Planning Order signalled a definitive move away from wartime-related preparedness and towards peacetime disaster planning. [P.C. 1981-1305]

1984 Ministerial responsible for federal emergency planning was given to the Minister of National Defence.

1986 Emergency Planning Canada's name changed to Emergency Preparedness Canada.

1988 Passage of the Emergencies Act (which replaces the War Measures Act) and the Emergency Preparedness Act, which clarifies the role of EPC with regard to federal emergency preparedness and restates the lead-agency structure of the Canadian emergency preparedness approach. It also gives EPC legislated authority to oversee federal peacetime activities in this area and requires it to report annually to Cabinet on the progress of federal planning, including that done by individual departments and agencies.

3.3 Emergency authorities

The various federal legal authorities respecting emergency preparedness generally and emergency communications specifically are discussed, in turn, below. They include: (1) the Emergencies Act; (2) the Emergency Preparedness Act; (3) the National Defence Act; (4) the Expropriation Act; (5) the Broadcasting Act; (6) the Canadian Radio-television and Telecommunications Act; (7) the Department of Communications Act; (8) the Radio Act; and (9) various Orders-in-Council.

Significantly, no single federal body in Canada has received a legislated mandate giving it direct overall responsibility either for national emergency planning generally or for communications preparedness in particular. Instead, jurisdictional authority in this area has been delegated by the prime minister to EPC and its predecessors, and to a number of "lead" departments and agencies.

Each federal organization involved in emergency planning (and there are several) is, of course, trying to meet its responsibilities as it understands them. Unfortunately, they are not always laid out clearly and may overlap with those of other departments or agencies. This has led, on the one hand, to some duplication of efforts. On the other hand, it has resulted in a certain reluctance by some organizations to expend their own limited resources to meet them. This is because it is often assumed that another agency with similar responsibilities would be in a better position (in terms of expertise or other resources) to do the job.

Two Cabinet decisions in particular -- one in 1965, the other in 1981-- together with two recent pieces of federal legislation, constitute the main authorities under which civil emergency planning and preparedness activities now take place in Canada. The first of these, privy council order 1965-104[illegible] is better known as the "Civil Emergency Measures Planning Order." But by the late 1970s, it had become outdated in two ways. First, it no longer reflected the actual institutional structure of the Canadian federal government. (For instance, the departments of Communications, Employment and Immigration, Solicitor General, and Supply and Services were not included.) Secondly, it emphasized civil defence preparations for wartime and public order civil emergencies; it was virtually silent on natural and technological peacetime disaster preparedness.

Emergency Planning Order P.C. 1981-1305, issued in May 1981, revoked the 1965 order and provided definitions which reflected the government's new orientation emphasizing peacetime preparedness. Accordingly, it defines an emergency as "an abnormal situation that requires prompt action beyond normal procedures to prevent or limit injury to persons or damage to property or the environment." "Emergency planning," according to the order, includes "the preparation of plans and arrangements of those exceptional measures to be put into effect that have as their purpose the mitigation of the adverse effects of an imminent or actual emergency."[16] Under the order, every minister presiding over a federal department, agency or Crown corporation would be responsible for planning initiatives related to their normal operating activities. In addition, Emergency Planning Canada was to initiate and co-ordinate federal planning on the broader issues.

Section 3 of the Emergency Planning Order assigned to ministers three general responsibilities: first, to identify the risks that could affect their operations; second, to co-ordinate relevant federal response as well as planning when assigned co-ordinating responsibility for a particular kind of disaster risk or related emergency service provision; and third, to prepare to provide support resources (i.e., equipment and personnel) to other ministers having lead responsibility in an emergency situation.

In addition to their other planning responsibilities, those ministers were to take such measures as necessary to prepare for the establishment of the National Emergency Agencies, and ensure their effective operation in any region of Canada in time of national emergency. In addition, and particularly significant to the present study, they were to:

> secure the co-operation and active support of the private sector and the government of the provinces and ... the municipalities ... for such joint studies, plans, and preparations as may be necessary to discharge [their] responsibilities.[17]

International planning -- such as with the United States, through the North American Air Defence Agreement (NORAD), and with other nations signatory to the North Atlantic Treaty (NATO) -- also would be the responsibility of selected federal departments and agencies, depending on the subject matter to be dealt with, and it would be co-ordinated by EPC. For example, DOC provides delegates to NATO Civil Communications Planning Committee meetings; it is also co-chair of the Canada/U.S. Emergency Planning Committee for Telecommunications. National Defence, in turn, represents Canadian relationships with regard to emergency communications in NORAD.

As regards the most recent legislation affecting federal activities in the area of peacetime preparedness, the Emergency Preparedness Act was introduced on 26 June 1987 and proclaimed on 1 October 1988.[18] Its introduction rescinded the 1981 Emergency Planning Order, although in the period before its coming into effect, EPC and the other federal departments were directed to continue as though that order was still in place. Passage of the Act was in direct response to the Federal Task Force on Program Review's recommendation that such legislation be brought forward. The task force's review of federal civil emergency planning had concluded that, first, it lacked co-ordination and common direction; second, interagency arrangements in the area of federal preparedness were ad hoc at best; third, accountability was uncertain; fourth, the provinces were frustrated by the lack of federal co-ordination; and, fifth, EPC lacked the authority required to perform its assigned duties effectively, particularly as regards federal planning co-ordination. Additionally, scarce financial resources that had been identified specifically for emergency planning occasionally had been diverted to other activities with higher visibility. The task force also made another more general recommendation:

> While departments should retain the lead role in preparing for and responding to emergencies within their authority, there is a need for a strong central organization with a clear legislated mandate to give direction, guidance and support, to ensure compliance, and to ensure co-ordination, both within the federal government and with the provinces in developing emergency plans (EPC, no date (f)).

The Emergency Preparedness Act is intended to provide a fully safeguarded legislative framework for Canadian emergency preparedness. To that end, it sets out the roles and responsibilities of EPC in federal law. Among other things, the Act designates EPC as a separate agency of the Crown, with a responsibility to report to Parliament on an annual basis on the status of the emergency preparedness plans of all federal departments -- both nationally and regionally.[19] As a consequence of its passage, work is now proceeding to issue additional orders and regulations pursuant to the Act (EPC, no date (b)).

The Emergency Preparedness Act also is intended to provide a statutory basis for improved co-operation between federal and provincial/territorial governments in this area. This is especially significant since large-scale disasters tend to fall within provincial or territorial jurisdiction. The federal role in such cases would be to provide support and assistance, upon request from the provincial and territorial authorities. To do this effectively, of course, requires sufficient pre-planning in order to identify quickly and match departmental resources with the types of contingencies in which they would be most useful to meet the needs of responders in a crisis situation (EPC, no date (b)).

According to the terms of that legislation, every federal minister is responsible for "identifying the civil emergency contingencies that are within or related to the Minister's area of accountability and developing a civil emergency plan therefore." Such planning involves the following:

(1) Assessing possible contingencies and vulnerabilities that could directly affect their operations -- for example, ranging from labour disputes to major telephone service or power outages to natural disasters.

(2) Putting into place (and testing regularly) off-hour emergency procedures.

(3) Identifying organizational needs for temporary alternative work sites in the event of a disaster or other peacetime emergency.

(4) Developing drills to accommodate a reduction in communications capability or, alternatively, substantial increases in communications volume at critical operational focal points.

(5) Identifying likely emergency information needs -- internal and external -- and developing procedures to meet them.

(6) Preparing for the possible need to set up an emergency operations centre.

(7) Identifying unusual tasks the requirement for which could arise in an emergency, and pre-assigning responsibilities within the organization.

(8) Making arrangements with other entities -- government and private -- with which it might be necessary to interact in an emergency.

(9) Being prepared to adapt responsibility assignments and internal communication configurations in order to ensure that those charged with managing the emergency will be available to do so (including designating alternates for key personnel).

(10) Ensuring that everyone who needs to know about the departmental or agency emergency plan is fully briefed.

(11) Preparing for the preservation of essential records.

(12) Training individual crisis managers, and conducting regular tests and exercises of organizational contingency plans (EPC, no date (b)).

In addition, federal ministers are to ensure that their plans provide assistance to provincial and local authorities relative to their regular responsibilities, including, for instance, the development of federal/provincial regional plans, and ensuring the safety and welfare of departmental employees during an emergency.[20]

EPC's role, as provided in the Emergency Preparedness Act has not been changed in any fundamental way; nor has it been expanded. It remains one of co-ordination and guidance. Similarly, the responsibilities of individual ministers for emergency preparedness within their own areas remain unchanged. Just the same, the new legislation does appear to give EPC more clout to pressure other federal departments and agencies to develop and exercise their contingency plans.[21]

The Emergencies Act, a companion bill to the Emergency Preparedness Act, received royal assent on 21 July 1988. Essentially, this Act shares the intent of the earlier War Measures Act, which was revoked at the time of its introduction. But while it places certain limitations and temporary measures on the rights of Canadians in a national emergency, it is subject to the Canadian Charter of Rights and Freedoms and the Canadian Bill of Rights.[22] IThe Emergencies Act also is consistent with the United Nations International Covenant on Civil and Political Rights. Moreover, and especially significant, is the fact that it was drafted in consultation with the provinces, territories and other interested parties.

The Emergencies Act defines four kinds or levels of "national emergencies" covered by it. Its defines a "national emergency" in a very general way as:

> an urgent and critical situation of a temporary nature that imperils the well-being of Canada as a whole or that is of such proportions or nature as to exceed the capacity or authority of a province to deal with it and thus can be effectively dealt with only by Parliament in the exercise of the powers conferred on it by the Constitution (Government of Canada, 1988a).

The kinds of emergencies covered by the Act relate to , first, "public welfare"; second, "public order" -- including threats to the security of Canada which are beyond the capacity or authority of a province to handle; third, "international" emergencies -- such as intimidation, coercion or serious use of force that threatens the sovereignty, security or territorial integrity of Canada; and finally, "war."

In contrast to the earlier War Measures Act, the Emergencies Act was very carefully thought out. For one thing, unlike the War Measures Act, its implementation would it enable the Canadian government to discharge its responsibilities in so-called public order emergencies that escalate to become national emergencies without resorting to an "apprehended insurrection" provision (as happened in the October 1970 Crisis). And it eliminates the need for introducing new legislation to handle individual major emergencies -- legislation that might be seriously flawed given the short time for drafting it and the restricted debate surrounding its passage in the face of a national crisis.

It also places significant constraints on the federal government's use of its special temporary emergency powers. For instance, where the effects of the emergency are confined to one province, the federal government may declare an emergency only after the provincial government has indicated that its capacity to cope with the situation has been exceeded. Additionally, time limits and geographical limitations are placed on the application of emergency powers. For instance, there is a requirement to return to Parliament, within seven days, with full justification for any action taken together with the requirement for parliamentary approval for continuation of emergency powers. Finally, there is a requirement that the federal government consult the provinces prior to declaring a national emergency (EPC, no date (d)).

3.4 Emergency Preparedness Canada

For the most part, the history of Emergency Preparedness Canada (EPC) already has been documented in the context of overall Canadian civil defence and emergency preparedness.[23] Like federal emergency planning activities generally, EPC's status has parallelled fluctuations in international tensions and domestic political trends. These have been reflected in corresponding increases and decreases in the agency's operating budget. For example, EPC's predecessors saw the greatest expansion during the 1957-1963 period, under Prime Minister Diefenbaker. In contrast, from 1968 through the late 1970s -- during the Trudeau era -- it experienced a long period of decline. During that time, the gradual warming of east-west relations led to a concomitant decreased probability of a nuclear attack on North America. This made the need for civil defence preparedness less urgent. Furthermore, the rise of provincial primacy in the postwar period led federal emergency planning in Canada to be increasingly oriented towards providing support for provincial initiatives.

However, since the early 1980s, issues related to federal emergency preparedness (and with them, EPC) have intermittently received renewed interest by Canadian policy-makers. The principal contributing factor that helps to explain this is the publicity surrounding major disasters and certain dramatic events which have had obvious significance for emergency preparedness -- such as, for instance, the Soviet Cosmos nuclear satellite crash in northern Canada; the Mississauga train derailment; the Gander air crash; the sinking of the Ocean Ranger; the Hinton, Alberta rail crash; the Barrie, Ontario and Edmonton, Alberta tornadoes; the PCB fire at Saint Basile-le-Grand; tire fires in Ontario and Quebec, etc. On the international scene as well, catastrophic disasters such as the Mount St. Helen's volcanic eruption; the Chernobyl nuclear plant disaster; destructive earthquakes in Mexico City, California, Iran and Armenia; mudslides associated with earthquakes in South America, etc. all have received tremendous media coverage -- both of threatened and actual devastation as measured in terms of lives lost, and property and environmental damage.

3.4.1 Co-ordinating role

The primary role of EPC is to develop and implement policy, co-ordinate federal planning, and provide the federal interface with provincial and territorial governments in respect to emergency preparedness. EPC also is responsible for training and public information communications in the area of emergency planning and preparedness on the one hand, and response on the other. It is worth emphasizing, however, that EPC is not responsible for co-ordinating the emergency preparedness activities of all levels of government -- only at the federal level. Its specific functional duties in this regard are set out in sections 4 and 5 of the 1988 Emergency Preparedness Act. EPC's overall mandate can be summarized as follows:

> to advance civil preparedness in Canada for emergencies of all types by facilitating and co-ordinating, among government institutions and in co-operation with provincial governments and international organizations, the development and implementation of civil emergency plans.[24]

As regards EPC's mandate with regard to fostering and co-ordinating Canada's participation in international emergency preparedness, of particular significance is EPC's co-ordination of Canadian participation on several NATO civil emergency planning committees. For example, Canada is an active member of the alliance's Senior Civil Emergency Planning Committee and participates on eight other supporting planning boards and committees. EPC also co-ordinates Canadian participation in emergency planning in association with the emergency measures organizations of other countries, and especially in Canada-U.S. planning through NORAD.

3.4.2 Organizational structure

EPC is headed by an executive director who is supported by a director general Readiness and Operations; a director general Program Development; and a director general Corporate Programs. In addition, regional directors are located in each provincial capital.[25] The executive director, EPC reports to the minister responsible for emergency preparedness -- who currently also is the National Defence minister.[26]

EPC's Readiness and Operations branch provides liaison with provincial and territorial EMOs through the EPC regional offices. It also provides a program of public information on a wide range of emergency preparedness activities. Additionally, it makes arrangements to ensure continuity of elected government during an emergency, and maintains a centralized co-ordination centre to monitor emergencies and provide an operations centre to federal ministers, if needed. Moreover, that branch manages the JEPP which assists provinces, territories and municipalities to finance emergency preparedness activities. It also manages the federal Disaster Financial Assistance Program which has been set up to help meet the costs of disaster relief. Other federal programs related to emergencies are managed by the Readiness and Operations branch include the Emergency Services Worker's Compensation Program; the Vital Points Program; and the Protection of Essential Records Program.

The Program Development branch of EPC co-ordinates and facilitates the development of emergency policies and programs. To that end, it monitors the federal government's overall level of emergency preparedness. It also sponsors research in the area of emergency preparedness, evaluates crisis management plans; co-ordinates the emergency preparedness activities of other federal departments, agencies and Crown corporations; manages training programs; and conducts national conferences and symposia on specific emergency preparedness topics.

The Corporate Programs branch provides financial management of emergency preparedness activities overseen by EPC. It also handles personnel management, staff training, and the like in the area of internal human resource development. In addition, it provides corporate planning; corporate policy analysis; secretariat, audit, security and related services. Furthermore, this branch provides the liaison to Parliament and the central agencies, and it monitors regulatory affairs, access to information and translation services. It also develops management information services and provides administrative support to the agency (EPC, 1989c: Appendix C, pp.63-65).

In meeting its various domestic and international planning, preparedness and oversight responsibilities, EPC is assisted by a number of interdepartmental federal committees which provide both input to policy development and subject experts to the planning process. The senior of these is the Ministers' Advisory Committee on Emergency Preparedness (MACEP), formed in 1989. This committee is comprised of selected civil government department representation as well as National Defence, all at the assistant deputy minister (ADM) level. The committee is chaired by the EPC executive director, and it meets semi-annually. Significantly, participation at meetings is non-substitutable. This means that, in contrast to the constitution of other interdepartmental committees convened to address emergency preparedness questions, the membership of this forum will not be allowed to deteriorate to lower levels of departmental involvement. In the event, for example, that an ADM does not attend a MACEP meeting, there would be no official representation by that particular department or agency at the meeting. Among the recommendations put forward by MACEP have been the establishment of a timetable for developing federal orders and regulations pursuant to the Emergency Preparedness Act and the Emergencies Act. It is expected that this task will be completed by 1993 (EPC, 1989c: p.4).

The MACEP is supported by three subcommittees, each of which also is chaired by EPC. The first of these is the Policy Implementation Working Group (IWG). Its membership is from civil government departments, plus DND. The purpose of the committee is to co-ordinate federal emergency planning in support of the MACEP. The second is the Interdepartmental Exercise Co-ordinating Committee (IECC). Its membership is similarly drawn from civil government departments, plus DND, and its purpose is to plan and co-ordinate civil departmental policy in national and international emergency exercises. It, in turn, is supported by the Government Emergency Book Working Group. The third subcommittee providing support to the MACEP is the IWG on Public Protection Policy. Its members are from Public Works, National Defence, External Affairs, National Health and Welfare, and EPC. Its purpose is to develop concepts associated with public protection in an emergency. Other interdepartmental structures have been established to address specific related subjects.[27]

3.5 National Emergency Agencies

As was already mentioned, the structure of Canadian emergency planning today is based on the concept of "lead" departments or agencies referred to in the discussion on the Emergency Planning Order 1981-1305. That is, those ministries that have a specific mandate to co-ordinate preparations for and response to certain types of emergencies will play the lead federal role in setting down and exercising contingency plans in those areas. Indeed, every federal ministry has an emergency commitment. Also as was mentioned earlier, some have major additional preparedness responsibilities. Reference is made here to one of these -- provisions for the establishment of the National Emergency Agencies, which during a national emergency would have the authority to take control of government resources and operations, and possibly commandeer additional (private) resources, as the situation requires.

Emergency roles and responsibilities of federal departments and agencies follow from their day-to-day activities. Additionally, some reconfiguration of duties would occur during a major emergency in order to meet federal objectives more effectively, and assign new tasks more precisely. Therefore, NEAs have been planned for each of the critical or "essential" service areas. The national emergency preparedness policy established by the Canadian government requires the formation of 11 NEAs in all. As regards the activities of the NEAs for peacetime civil preparedness and wartime support to the Canadian defence effort, section 7 of the 1988 Emergency Preparedness Act outlines the responsibilities of federal ministers. The Act also provides statutory authorities to EPC to develop plans for implementation of the NEAs.[28] Autumn 1990 was set as the target date for completion of the related federal arrangements, including concrete plans for the formation of the NEAs. Table 3.2 below lists the agencies and indicates which federal minister is responsible for each (EPC, 1989c: pp.5 and 6).

TABLE 3.2
National Emergency Agencies

Minister Responsible	**Activity or Sector**
Agriculture, Fisheries and Oceans	Food
Canada Mortgage and Housing	Housing and Accommodation
Communications	Telecommunications
Employment and Immigration; Labour	Human Resources
Energy, Mines and Resources	Energy
Finance	Financial Control
Health and Welfare	Health and Welfare Services
Industry, Science and Technology; Supply and Services*	Industrial Protection
Prime Minister's Office	Public Information
Public Works	Construction
Transport	Transportation

* Energy, Mines and Resources; Forestry; External Affairs; and National Defence also play a role in emergency planning for industrial production.

Relevant to this discussion are planning projects underway at Environment Canada, respecting the activities of the Atmospheric Environment Service (AES) -- as regards severe weather watches and warning broadcast communications -- and the Department of National Defence with regard to the provision of emergency communication facilities under the

Continuity of Government Program. Similarly, the DOC's progress on the formation of the National Emergency Agency for Telecommunications (NEAT) is of interest.[29]

Although the "control and regulation of national resources" focus of the NEAs originally established by the 1981 Emergency Planning Order has been retained in the new legislation, it also reflects the recognition by law-makers that, in a peacetime public welfare or public order emergency, the federal government would act in a support capacity only, while municipalities and provinces or territories would be the front-line crisis managers. This acknowledgment of provincial/territorial primacy in this area suggests a growing awareness among federal legislators of the need for the different orders of government to work more closely together, as part of a co-operative intergovernmental consultative process, to plan for and respond to peacetime emergencies. With regard to international and wartime emergencies, of course, the federal government would retain primary responsibility for managing the response; it, in turn, would receive support from the provinces and local authorities.

3.6 Emergency communications

Regarding emergency communications capability, the Canadian government historically has relied on the commercial carriers to meet most of its non-military communications requirements. In addition, the Canadian military, from the early years of civil defence, developed its own specialized communication functions. As a consequence, then as now, it had its own world-wide private telephone and data networks, But unfortunately, the development of those capabilities took little account of the value of internetwork compatibility or the shared use of its systems by other federal agencies. As a result, the Canadian government had to develop a parallel domestic system to handle civil emergency communications.

During the Second World War, the need for compatible government communication systems became acute, and the necessity of establishing priorities for using the restricted communication resources available to it was widely recognized. The military, in a wartime situation would, of course, always come first; thus, in order to meet other government emergency communication needs in wartime, additional dedicated facilities were acquired to supplement the defence network.

The underlying premise upon which the Canadian emergency communications planning and preparedness today is based is always to rely on systems that are used for regular normal-time operations. This is because communications facilities and equipment that are used often will be more familiar, better maintained and their limitations will be known by emergency users. Moreover, from a practical financial perspective, the development and installation of special purpose -- emergency-only -- communication systems would incur substantial additional costs related both to testing and maintenance. Such systems also might require special skills to operate them and training programs for potential users therefore would be necessary. Additionally, specialized equipment that has been stockpiled for contingency applications only might be left sitting in storage for very long periods of time. When it is finally brought out, it may be found to be completely corroded inside the casing. Or, it may be difficult to locate spare parts, and even if they are found, there may be no instruction manuals or staff on hand who are familiar with the equipment and could make it operational quickly.

Significantly, there are some fundamental differences in the Canadian industry structure as compared with that in the United States which make emergency communications planning and preparedness more straightforward in this country. First and foremost is the fact that Canada has a nationally owned radio and television broadcasting service -- the CBC -- which reaches more than 98 per cent of the domestic population. Moreover, all overseas public long-distance services traditionally have been provided by a single corporation -- which was, until recently, also nationally owned -- namely, Teleglobe Canada. Additionally, all domestic satellite services are provided by a single corporation, Telesat Canada, whose ownership is shared between the federal government and the telephone companies. Finally, private Canadian common carriers and broadcasters are for the most part grouped into national associations such as Telecom Canada, the Canadian Association of Broadcasters, etc, (Larson, 1985b). Finally, the much smaller size of the Canadian marketplace means that relationships among users and suppliers are formed more readily through joint participation at national conferences and the like.

The specific characteristics of the Canadian communications industries also can potentially facilitate government/industry discussions and expedite public/private sector arrangements to develop national policy in the area of emergency communications. Particularly significant are the continuing studies and negotiations on questions related to technical innovations that could affect network survivability, interconnectivity and interoperability -- all of which are essential to ensure adequate communications capability in a crisis situation. They also make it easier for individual government officials to know the industry participants personally, and for competitive service providers to know their counterparts, thereby making it possible for operational arrangements to be made informally and rapidly in a major disaster or other peacetime emergency in order to meet special government needs.

In this way, governments also might be able to "co-opt" private expertise to assist them in developing policy -- with the added benefit that, given adequate industry input to the process, those policies actually will be implemented. This is because, on one side, policies that take full account of actual technological capabilities and industry limitations will be more likely to keep to a minimum the costs assumed by service providers in meeting government emergency communications needs. They also will emphasize existing technologies rather than promote emergency-only facilities. On the other side, the process encourages the industry to keep in mind government needs respecting emergency communications in their regular corporate strategic planning. Consequently, as new technologies become available, minor adjustments (such as in the development of computer software to integrate those technologies) might be possible which would accommodate essential-user needs at little or no additional cost.

In the United States, by contrast, it is considerably more difficult to establish and maintain a close telecommunications industry-government relationship. This is due mostly to the far greater number of service and equipment suppliers in that country. The result has been significantly increased telecommunication costs to the U.S. government for national security/emergency preparedness (NS/EP) communications. Eventually, however, competition is expected to bring them down. Furthermore, the largest U.S. industry players, through their voluntary participation in the National Co-ordination Center (NCC) and on the National Security Telecommunications Advisory Committee (NSTAC), are working with the U.S. government to provide coherent and harmonious national emergency communications planning and preparedness capability.[30]

Today, Canada's national emergency communications system -- including for multi-hazard peacetime, and strategic and continuity of government contingencies -- continues to depend heavily on the public switched telephone network. This is supplemented by dedicated or leased-line services, public and private microwave and radio-telephone systems, and the Emergency Broadcast System (EBS) which uses the facilities of the CBC radio/television and affiliated broadcast stations. Moreover, under a variety of government-industry programs discussed in the next chapter, additional telephone or radio-telephone service can be obtained quite quickly from the telephone companies and radio common carriers. Finally, the Department of National Defence's extensive microwave and private line network together with its HF radio assets also can be made available for peacetime emergencies through arrangements with EPC and the DOC, if they are not required to meet DND's own needs.

3.7 The Department of Communications

3.7.1 Authorities

The Department of Communications' authorities to act with respect to emergency communications, are contained in: (1) the Department of Communications Act;[31] (2) the Broadcasting Act (especially sections 18(2) and 27); (3) the Radio Act (section 60); (4) the

CRTC Act and (5) the CBC Act (the latter two regarding the Emergency Broadcast System); (6) the Emergencies Act; (7) the Emergency Preparedness Act; (8) the Teleglobe Canada Act; (9) the Railway Act; (10) the National Transportation Act; (11) the Telegraph Act; (12) the Telesat Canada Act; and (13) other federal emergencies legislation to be enacted as required (DOC, 1989d). Additional commitments by the DOC with respect to emergency communications derive from several federal Cabinet decisions, ministerial directives, interdepartmental agreements, federal-provincial-territorial emergency preparedness Memoranda of Understanding, and related arrangements among individual federal departments, and with provincial and municipal authorities.[32]

3.7.2 Role and responsibilities

The principal federal player with regard to developing and implementing national emergency communications policies in Canada is the Department of Communications. That department also also has a mandate (which it has as yet been unable to complete) to develop a national telecommunications policy -- included within which would be a national emergency telecommunications policy. In addition, the DOC is responsible for managing the Government Telecommunications Agency (GTA), and to oversee the CRTC and the CBC with respect to emergency broadcasting. Moreover, the DOC is responsible for planning the National Emergency Agency for Telecommunications.[33] To that end, it has drafted an organizational structure for the NEAT and has prepared a departmental Emergency Book (EPC, 1989c: p.10). Additionally, the department has established emergency telecommunication planning committees in each of the provinces and the Yukon. Their constitution and activities are aimed specifically at facilitating national emergency communications preparedness, and assisting in planning for the NEAT at the regional level.

With the DOC's creation in 1969, the Communications minister assumed responsibility for telecommunications policy from Transport Canada and for emergency communications from the Emergency National Telecommunications Organization. Additional emergency communication roles were acquired by the DOC from National Defence in 1971.[34]

3.7.2.1 Emergency Planning Order 1981-1305

This order provides a comprehensive list of the ministerial duties assigned to the Minister of Communications respecting emergency communications preparedness. And although it since has been replaced by federal legislation, ministerial duties in this area have not changed. According to the order, they are as follows:

(1) Identify possible emergencies that could have an impact on the telecommunications sector, and prepare, test and implement, when required, appropriate plans and arrangements -- beyond those normally taken by the carriers -- to ensure that essential service facilities will survive or can be restored quickly.

(2) Provide technical and related assistance on all communication preparedness matters as required by other ministers.

(3) Provide planning assistance and advice to the provinces, territories and municipalities, and assist them with the preparation of joint regional plans;

(4) Plan and arrange for the safety and welfare of employees of the DOC and of the Crown agencies for which the minister is responsible (i.e., CBC, CRTC).

(5) Prepare legislation, procedures and arrangements so that essential telecommunication systems can be managed and manipulated effectively to enable government response agencies to continue to communicate during and after the emergency.[35]

The above pertain to the minister's responsibilities in regard to peacetime emergency and disaster preparedness. As regards wartime planning, the following additional responsibilities have been assigned to the Minister of Communications:

(6) Develop telecommunication plans that will support the defence of Canada, the Canadian and allied forces and alliances, and the mitigation of the effects of an attack on Canada.

(7) Plan and prepare a National Emergency Agency for Telecommunications to control and manage all essential communications.

(8) Ensure the development and maintenance of a National Warning System (in co-operation with DND) and the Emergency Broadcast System.

(9) Exercise telecommunications censorship (DOC, 1986a: pp.7-8).

Finally, according to the 1981 Emergency Planning Order, the DOC, in co-operation with DND, is responsible for the physical facilities that comprise the REGHQ communication system (both normal and emergency). The preparatory work is co-ordinated by the DOC regional offices, through the Regional Emergency Telecommunications Committees (DOC, 1984: p.9). During a national emergency, DOC regional directors or their designate operating from the REGHQ would have the responsibility to "control, regulate and maintain all essential telecommunications resources, facilities and services."[36] In addition, the DOC regional directors or their designates are responsible in the various provinces and territories, in co-operation with the Department of National Defence (DND) and the CBC, for the operation of the National Warning (siren) System and the EBS (DOC, 1984: p.10).[37]

3.7.2.2 The Emergencies and Emergency Preparedness Acts

As regards the Emergencies Act and the Emergency Preparedness Act, both of which were passed in 1988, these two pieces of legislation together with related regulations and orders currently being developed serve as a basis for planning and for use of national communication assets and resources in support of provincial and territorial emergency responsibilities.[38] Thus, the DOC has committed its resources to:

> develop concepts, undertake research, plan and arrange implementation of national programs and preparations that will generally improve the prospect for effective telecommunications in support of Canadian response during international, national, regional and municipal emergencies (DOC, 1986a: p.8).

Importantly, the DOC itself does not own communications equipment which could be provided to fulfill emergency communication needs. As a result, its function in this regard is to assure provision of adequate communications support to federal, provincial and municipal response elements. This would include first, government-furnished communications equipment such as, for instance, borrowing tadio-equipped vehicles, etc. from the Department of Transport or possibly personnel and communications equipment from DND; second, making arrangements for commercially leased communications; and third, communications equipment and services provided by activation of the National Emergency Agency for Telecommunications/National Emergency Telecommunications Committee in a national emergency.

Under both the 1981 Emergency Planning Order and the Civil Emergency Preparedness Management Order being drafted by EPC pursuant to the 1988 Emergencies and Emergency Preparedness Acts, the DOC is required to plan initiatives for meeting federal emergency or disaster contingencies in its particular discipline -- that is, communications -- either in a lead agency or, as importantly, in a support role. The DOC would be named lead agency very rarely. Just the same, its broad support function would involve it (through its regional offices) in most large-scale disaster response operations (DOC, no date (f): p.3). The specific provisions of the new order as regards national communications preparedness are outlined in the next section.

The DOC also has been charged with providing professional advice and technical assistance on emergency communications matters to other federal departments and agencies, and to provincial, municipal and essential non-telecommunications industry response elements. Through the GTA, for example, the department is to make the necessary arrangements to provide adequate telephone and data communications to federal departments and agencies both for normal use and for emergency use. Another responsibility of the DOC through the GTA relates to the survivability of government telecommunications; it is to provide shared services and intercity networks across Canada. In exercising this responsibility, the GTA procures telecommunication services in bulk and ensures equitable sharing within government networks. Moreover, it must cater to special departmental requirements for their own systems. Thus, while the GTA deals mainly with the normal day-to-day business of administrative communications support service, it also would become involved in meeting the special emergency or disaster communication needs of federal civil agencies.

In addition, the DOC has to determine, in detail, what government communication systems and services are considered "essential." These are defined as those which all those having an obligation to respond to an emergency require in order to do their job effectively.

The DOC's emergency support function involves providing federal communications support to response elements in the following order of priority:

(1) federal government departments and agencies having immediate response functions;
(2) provincial agencies, as requested by provincial authorities;
(3) affected municipalities whose requirements cannot be met through provincial arrangements, and only when they have been validated by the province;
(4) accredited non-governmental organizations whose functional role is included in the response plans of municipal, provincial and federal agencies; and
(5) telecommunication carriers to assist in re-establishing minimum public telephone service.[39]

An example of that support would be the collection and assessment of data, in co-operation with provincial authorities and common carriers, to determine the extent of damage to critical networks. Another would be the co-ordination of arrangements for providing communication services to support municipal and provincial emergency operations centres in an emergency situation. Similarly, the DOC might provide emergency communications support by controlling the assignment of radio frequencies and co-ordinating their usage by emergency response agencies operating within a disaster area and from that area to the exterior. Additionally, they could involve co-ordinating priorities with provincial authorities for re-establishing service; assisting carriers by expediting the movement of equipment and personnel into damaged areas; or identifying sources of equipment and support materials to facilitate the replacement, restoration, maintenance or expansion of essential services. Other examples include giving advice to service users with regard to alternative traffic routing, and concluding co-operative arrangements among carriers and essential service users to plan restoration action (DOC, 1990a: pp.2-3).

The DOC similarly must define and implement measures, beyond those normally taken by the commercial carriers, to ensure survivability and ready restoration of essential systems and services in the event of failure during an emergency or disaster; this relates directly to its authority to "control" and "maintain" essential communications. Control involves regulation of the demand for and provision of emergency communication facilities and services -- from equipment to the co-ordinated assignment of radio frequencies -- while maintenance refers to its responsibility to keep essential federal communication facilities operational (Larson, 1985a: pp.3-4). Furthermore, the DOC is charged with preparing legislation, procedures and arrangements so that the essential systems can be managed and manipulated effectively to ensure that those government agencies responding to an emergency will be able to continue communicating both during the emergency and afterwards.[40]

3.7.2.3 Civil Emergency Preparedness Management Order

Pursuant to the requirements of the Emergencies Act and the Emergency Preparedness Act, EPC is now preparinga new Civil Emergency Preparedness Management Order with the co-operation of other departments and selected agencies. On the one hand, the order will provide details on the responsibilities of federal departments and agencies in general as regards emergency preparedness, and on the other, it will outline those of individual federal ministers respecting selected key sectors with regard to the development of departmental emergency plans. The ministers for whom individual responsibilities are assigned by the order include the Prime Minister; the Ministers of Agriculture; Communications; Employment and Immigration; Energy, Mines and Resources; Environment; Finance; Fisheries and Oceans; National Health and Welfare; Industry, Science and Technology; Justice; National Defence; Public Works; Supply and Services; Transport.; the minister responsible for Canada Mortgage and Housing Corporation; the Secretary of State for External Affairs; and the Solicitor General.

The Minister of Communications, if designated as the "Lead Minister" for federal involvement in an emergency -- such as, for example, a major telecommunications service loss affecting a significant or key portion of either the national public switched or government network -- would, first, "act as or designate the primary spokesperson on the behalf of the federal government"; second, "be responsible for the co-ordination of support provided by other ministers"; third, "co-ordinate public information activities"; fourth, "consult with the minister responsible for emergency preparedness and with any other ministers affected, with a view to the recommendation to the Governor in Council of orders or regulations which may be required ... in connection with the use of federal resources, or ... with the provision of assistance other than financial assistance to a province"; fifth, "consult as required with the government of a province in which the emergency occurred or which is affected by the emergency"; sixth, where the emergency is a provincial emergency that has not been declared to be of concern to the federal government ... consult with the minister responsible for emergency preparedness with a view to a recommendation to the Governor in Council that the emergency be so declared"; seven, "ensure the maintenance of such records as may assist in a subsequent review of federal involvement in the emergency"; and eight, "undertake such other duties and responsibilities with respect to the emergency as the Prime Minister may direct" (DOC, 1991a: Annex D, pp.5-6).

Regarding emergency communications preparedness, section 18 of the draft order outlines those responsibilities specifically assigned to the Minister of Communications in this respect. That section, as revised by the DOC acceptable to EPC, is quoted in part below. Accordingly, the Minister of Communications is responsible for developing and maintaining civil emergency plans for:

2(a) "the provision of advice and assistance to federal departments and agencies with respect to the telecommunications requirements of their emergency functions";

2(b) "the provision of advice and planning assistance to provinces and municipalities with respect to emergency telecommunications";

2(c) "co-ordinating the provision of an emergency broadcast service, based on the facilities of the Canadian Broadcasting Corporation and, as required, privately owned networks and stations";

2(d) "facilitating the provision of appropriate telecommunications equipment or services required in emergency response operations, as requested by lead federal departments or responsible provincial authorities";

2(e) "providing advice and assistance ... to private or public telecommunications undertaking in mitigating the disruptive effects of emergencies on domestic and external telecommunications";

2(f) "the provision of guidance, advice and co-ordination assistance to Canada's national and international telecommunications undertakings in respect of emergency operations";

2(g) "the co-ordination and, as required, management of essential line protection [Line Load Control] and other programs to ensure the availability of telecommunications to meet federal requirements during periods of system overload or degradation..."

Regarding preparedness to deal with national emergencies, the minister also is responsible for developing and maintaining civil emergency plans for:

3(a) "the emergency regulation of telecommunications undertaking and networks in Canada ...";

3(b) "the direction and control, as required, of essential civil telecommunication resources, facilities and services in Canada, other than those of the Canadian Forces, the Royal Canadian Mounted Police and the Department of External Affairs and International Trade"; and

3(c) "the provision of civil telecommunications support ... to the Canadian Forces and the armed forces of Canada's allies" (DOC, 1991a, Annex D: pp.1-2).

Significantly, no agreement has been reached with regard to a fourth responsibility respecting national emergencies and emergency communications capability. It concerns provision of a national public warning system. Apparently, EPC and the Minister of National Defence -- who currently has responsibility for providing a public (siren) warning system -- want the DOC to provide a system to replace the national siren system. The DOC is reluctant to undertake this responsibility without a commitment by the federal government of the necessary financial resources in advance (DOC, 1991a: p.1). This subject is discussed in Chapter Seven in terms of proposals for a new Warning and Emergency Broadcast System.

3.7.3 Organizational structure for emergency communications

Since 1984, DOC personnel involved in fulfilling that department's mandate in the area of emergency communications have been headed by the assistant deputy minister, Spectrum Management (ADMSM). In this regard, the ADMSM is responsible for issuing directions, approving activities and authorizing response actions. Moreover, s/he represents the department as a member of the MACEP, and co-chairs the Canada-U.S. Emergency Planning Committee for Telecommunications. In addition, the director general, Radio Regulations (DGRR) and the director, Regulatory Policy and Plans (DRP) assist the ADMSM and are responsible for overseeing emergency planning and preparedness activities within the department. The chief, Emergency Telecommunication Programs (DRP-E) is directly responsible for planning and preparations, and is the co-ordinator of departmental emergency response. The DRP-E is also a Canadian delegate to the NATO Civil Communications Planning Committee, as well as the Canadian co-ordinator of the Canada-U.S. Emergency Planning Committee for Telecommunications. Additionally, s/he either is or provides the departmental membership on other interdepartmental emergency planning committees and working groups (DOC, 1988a: p.5).

The Spectrum Management branch of the DOC also contains the specialists who work full-time on emergency communication activities. However, these are few in number, and they consequently must be complemented by technical experts from other sectors within the DOC to assist them in handling the increasing volume of activity in this area. For example, experts in the GTA are involved in planning the (dedicated) network configurations for federal government traffic, and making arrangements with industry for those networks to access the public switched network on a limited basis for the provision of emergency services. Similarly, professional experts at the Communications Research Centre compile and analyse research data used in developing that department's emergency communication plans.

Regional directors of the DOC are the senior regional officials responsible for peacetime emergency communications. They or their designate also chair the Regional Emergency Telecommunications Committees. Deputy regional directors are the alternates to the regional directors, and they are responsible for planning and preparedness in the regions. Managers, Spectrum Control supervise regional planning and preparedness activity. Emergency planning officers at the regional level are directly responsible for planning and preparedness, and they co-ordinate regional emergency response as regards communications. Finally, the district managers of the DOC are responsible for planning and preparedness activities within districts, depending on the particular regional configuration. They also may liaise with provincial and municipal governments, and provincially-based federal officials on behalf of the regional director (DOC, 1986a: pp.13-14).

Due to the sensitive nature of federal-provincial-territorial relations with respect to emergency planning, it is suggested here that DOC regional office staff are in a good position to co-ordinate communications-related national policy initiatives. This could include making the initial approaches to provincial governments, and to officials in neighbouring American states with regard to developing cross-border arrangements for mutual assistance emergency communications. Moreover, operational activities -- such as the allocation of human and equipment resources either in actual emergencies or in exercising contingency plans,the establishment of regional EOCs, etc. -- also might best be handled by the the DOC's regional offices.

Especially crucial is the fostering of a close working relationship between the various DOC and EPCs regional offices, and with DND and CBC regional operations as well, each of which has shared or complementary emergency communication roles. This could be achieved directly; alternatively and perhaps more effectively, it might be accomplished through the RETC mechanism.

3.8 National Emergency Agency for Telecommunications

The second part of Emergency Planning Order 1981-1305 defines the responsibilities of the various National Emergency Agencies, among them the National Emergency Agency for Telecommunications for which the Department of Communications is responsible. The purpose of the NEAT is to control and manage all essential communications facilities and services in a national emergency.

During the height of the Cold War years of the 1950s, the Canadian government undertook several measures aimed at enhancing the prospects of survivability of elected government, industry and the general public in the event of a nuclear attack on North America. Pertinent to the present discussion was the formation by Cabinet in 1960 of the NEAT's predecessor, the Emergency National Telecommunications Organization. At that time, responsibility for emergency communications was transferred to ENTO from the Minister of Transport, in recognition of the critical importance of communications in civil defence. ENTO was to assure that essential government users would have at their disposal "adequate and survivable" communications -- prior to, during and after a national emergency.

In wartime, ENTO would be the executive agency of the federal government charged with controlling and administering the national telecommunications system. Its <u>peacetime</u> function was to:

> initiate and co-ordinate the plans and arrangements necessary to ensure that the telecommunication services and facilities of the country will be available in wartime for use by government and its various agencies, particularly the Armed Forces, and by private users having essential functions to perform in the interest of national survival (DOC, no date (b): p.1).

The ENTO also was to constitute a central peacetime planning agency, the structure of which would include trained federal officials and an interdepartmental/industry executive advisory committee. It also would rely on a committee support structure to assist it in exercising its peacetime planning and co-ordinative functions. The latter was to be comprised of an Interdepartmental Emergency Telecommunications Committee (IETO), and an Advisory Committee of Commercial Telecommunications Agencies (ACCTA). In addition, the ENTO would be supported by ad hoc government-industry working groups formed to study specific communications-related questions.

In 1962 it was decided to decentralize the ENTO structure in order to permit the gathering of regional data, address provincial emergency communication requirements, and implement regional wartime plans and regulations. The regions, in turn, were directed to form regional planning committees to assist in the preparation of regional plans in accordance with the national plan.

When the federal Department of Communications was created, responsibility for overseeing the ENTO was brought under its jurisdiction. By that time, however, civil defence and emergency planning already were being de-emphasized at the federal level. Indeed, subsequently, the ENTO's activities ceased entirely in favour of other federal and departmental priorities. Interest in peacetime emergency preparedness was renewed only in the late 1970s at which time federal activities in emergency communications planning similarly were revived. The 1981 Emergency Planning Order reflects this renewal. As the discussion earlier indicated, that order-in-council expanded the DOC's role concerning emergency communications. Among other things, it directed the DOC to form a National Emergency Agency for Telecommunications to replace the ENTO.

3.8.1 Functions

The functions of the NEAT are twofold; it would have both a planning function and an operational or response function. The former would involve identifying, on the one hand, special federal (and to the extent possible, provincial/territorial) government communication needs during crises and emergencies, and, on the other, the communication resources available to meet them. It also would involve initiating and co-ordinating plans to meet those requirements. To that end, arrangements would be made through the NEAT with the largest government users, with those agencies that would be able to provide support emergency communications, and with commercial service providers.[41]

Additionally, it would involve determining the possible effects of various peacetime disaster agents and war-related factors on telecommunications plant facilities and service provision so as to draw up appropriate plans for coping with each situation. Finally, it would create opportunities for discussion among those users and possible supplementary service and equipment suppliers likely to be directly involved in a national emergency response and set down written plans, procedures and mechanisms to execute them. In general, the planning requirements are expected to emerge from the work of the National Emergency Telecommunications Committee and the regional committees, while the solutions to the questions raised thereby would be found by their subcommittees and ad hoc working groups (DOC, no date (i): pp.18-19 and p.5).

On the operational side, the NEAT would be instituted to the level considered appropriate, upon DOC's receiving information of a major emergency or large-scale disaster.

With regard to peacetime emergencies, the NEAT's operational functions likely would be handled entirely at the regional level. In such instances, DOC/NEAT-Ottawa probably would not intervene directly. Instead, they would provide guidance and procedural advice; they also would co-ordinate support activities from outside the region (DOC, no date (i): p.21). NEAT's operational functions are summarized below.

(1) When called upon to do so and authorized by legislation, to control, regulate and maintain all essential telecommunications resources, facilities and services in Canada -- other than those operated by or on behalf of the Canadian Forces or by any forces so operating therewith, and those operated by the Department of External Affairs, and the Royal Canadian Mounted Police.

(2) Ensure the provision, maintenance and co-ordination of the Emergency Broadcasting System and, in co-operation with DND, a National Warning System.

(3) Conduct effective liaisons with other countries in order to maximise the compatibility and co-ordination of international telecommunication networks and systems -- especially those of the United States, and NATO member countries.

(4) Determine the nature and extent of any damage to any portion of the national telecommunications system, and establish the priority for its repair, replacement or restoration.

(5) In accordance with established policy, exercise censorship control over telecommunications (in wartime only).[42]

Thus, the DOC through the NEAT, would be responsible for assigning priorities of demand in a national emergency. It also would be the only authority to demand that service from a provider -- be it a commercial carrier or another government department or agency capable of providing back-up communications (Larson, 1985a: p.5).

To institute the NEAT (or some portion thereof), DOC-Ottawa would call in its departmental response team and advise DOC regional offices in the affected area(s) to cease normal activities and form response cells. These, in turn, would monitor the situation and prepare to respond to requests for communications support. The NEAT's planning procedures then would be implemented, and the initial response team at DOC-Ottawa, as well as the response cells in the regions would be built up by the addition of other departmental staff and committee members, as required, to assist them to provide communications capability to the designated federal lead department or agency, provincial and municipal governments, and the response effort generally (DOC, no date (i): p.20).

Significantly, what differentiates the NEAT from its predecessor is its emphasis on peacetime as opposed to wartime planning. As a result, all of the major programs initiated under the ENTO were to be reconsidered and, where appropriate, updated to bring them in line with this new orientation. Essentially, this involved attribution to the DOC of a significant federal planning function, since that department's role in national emergency communications preparedness would depend to a large extent on the completion of other federal departmental and agency plans.

3.8.2 Operational structure

Also under the provisions of the 1981 Order, the DOC was to develop an operational structure for the NEAT. It would be made up of representatives from the Department of Communications, other federal departments and agencies that have an emergency communications requirement in a crisis situation, and the provinces and territories. It would look something like the organizational chart presented in Figure 3.3 below.

A significant advantage of the NEAT's functional structure is that it also could be employed in smaller elements -- both in Ottawa and at the regional level. In a peacetime emergency requiring only partial institution of the NEAT, the Minister of Communications would be the chairman of the NEAT. In wartime, the only occasion likely to require its full institution, the minister would become the general controller of telecommunications, with extended emergency powers. The NEAT executive heads the working elements of the organization; its members would be chosen from the various federal departments and agencies represented, but they would of necessity also be experts in telecommunications.[43]

The committees of the NEAT and, in particular, the National Emergency Telecommunications Committee and the Advisory Committee of Commercial Telecommunications Agencies (ACCTA) form part of the organization's planning structure. That is, they would provide input to the NEAT executive to assist in establishing national policy and developing macroplans. Each committee would be chaired by the deputy chair, NEAT. Individual advisors appointed to both committees would be part of the operational structure of the NEAT during a crisis situation; at such times, they would provide a liaison to their parent organizations. Additional committees and subcommittees or working groups could be formed on an ad hoc basis to support the planning work of the NEAT.[44]

The National Emergency Telecommunications Committee, in turn, would be made up of communication experts from the DOC and other federal departments and agencies (at the ADM/DG level), representing a few of the major federal telecommunication users. The ACCTA similarly would be made up of a cross-section of the carrier industry at the vice-president level; it would represent the service provider community. The ACCTA would advise the Chairman and the NEAT Executive on technical capabilities and resources available within the national telecommunications (including broadcasting) system. They would also advise the NEAT on the most effective methods for providing emergency communication services, and in the preparation of plans and contingency measures to ensure their availability in a crisis.

FIGURE 3.3
Organization of the National Emergency Agency for Telecommunications (NEAT)[45]

General Controller of Telecommunications
Headquarters NEAT
Chairman, NEAT
Deputy Chairman, NEAT
Co-ordinator, NEAT
Controller of Telecommunications Resources
Controller for Telecommunications Regulations
Controller of Telecommunications Censorship (Wartime only)
Sub-controllers and Assistants

National Emergency Telecommunications Committee (NETC)
Representatives from:
DND
EA
EC
E&I
EMR
FIN
HWC
ITC
SGC
SSC
TC
CBC
EPC

National Advisory Committee of Commercial Telecommunications Agencies (ACCTA)
Representatives from:
CBC
Unitel
CRTC
Telecom Canada
Teleglobe
Telesat

Regional Headquarters NEAT
(each province)
Regional Chairman
Deputy Regional Chairman
Regional Controllers:
- Telecommunications Resources
- Telecommunications Regulations

Regional Emergency Telecommunication Committee (RETC)
Representatives from:
DND
E&I
EMR
ITC
SGC
TC
CBC
EPC
Other Experts

Provincial Govt
Communications
EMO

Municipal Govt
EMO

Regional Advisory Committee of Commercial Telecommunications Agencies (R/ACCTA)
Representatives from:
CBC
Unitel
Telephone Co.

In the context of the NEAT, the regions are defined in accordance with provincial/territorial boundaries. In this way, the regional element of the NEAT provides provincially and territorially located federal departments or agency staff, and provincial/territorial and municipal authorities with a channel for assembling and communicating regional data and related information to the national emergency communications planning process. This decentralized structure has the added benefit of enhancing effective support to response authorities involved directly in managing a localized emergency or disaster (DOC, no date (i): p.14).

The specific structure of the regional component of the NEAT would vary according to the specific requirements in each province or territory as well as the communication resources available at that level. However, they would consist of a number of common elements as well. These include a regional chairman, a deputy regional chairman, and a regional controller of Telecommunication Resources and Regulations, respectively. They similarly include a Regional Emergency Telecommunications Committee (RETC) and some form of regional advisory committee comprised of commercial service providers operating in the province.

The planning functions of the regional element of the NEAT are especially significant to the national planning process. This is because in contingency planning, everything that can be foreseen must be taken into account and documented in advance of a crisis. Additionally, every necessary action that could reasonably be taken similarly must be taken ahead of time. Regarding regional operations in response to a peacetime emergency, the scale of action taken by the regional element of the NEAT would depend on two things: the nature of the emergency, and its scope.

Significantly, DOC Ottawa has advised that it has been instructed not to pursue its planning work regarding implementation of the NEAT. It apparently has been concluded that it is not considered necessary to put in place a national organization of that nature since it would be extremely unlikely that a national emergency would occur of the kind that would be likely to interrupt telecommunications service in all regions of the country simultaneously. For similar reasons, and given the absence for provisions for the establishment of regional elements of a NEAT in the new Emergency Management Order being developed to replace the 1981 Emergency Planning Order (revoked by the Emergency Preparedness Act of 1988), the DOC has discontinued its planning work in this area as well. Instead, its emphasis has shifted to the National Emergency Telecommunications Committee concept, and the continued development of the Regional Emergency Telecommunications Committees.

3.8.3 Regional models for a National Emergency Telecommunications Committee

The DOC's participation in numerous interdepartmental and intergovernmental meetings related to emergency communications reveals some significant trends in federal communications preparedness in Canada. Addressing these issues in emergency preparedness is currently achieved, for the most part, within the context of the Regional Emergency Telecommunications Committee fora. It is anticipated that, at the national level, the DOC's leadership in this area eventually will culminate in the establishment of an active NETC as well, which would function along lines similar to those of the already functioning RETCs.

As Fig. 3.3 above suggested, the core membership of the NETC would include, in addition to the DOC, Employment and Immigration (including the NEA); Energy, Mines and Resources (including the NEA); Environment Canada; External Affairs; Health and Welfare (including the NEA); Industry, Trade and Commerce (including the NEA); National Defence; Supply and Services; Transport (including the NEA); Solicitor General; CBC; and Emergency Preparedness Canada. Other members would include representatives from all the federal departments and agencies that either have a substantial need for communications during a major emergency or, alternatively, could provide support communication facilities and expert personnel. It also could include, from time to time, participation by the provinces, territories and individual consultants.

The proposed NETC, like the RETCs, while having a somewhat different emphasis, provides a potentially effective means for "isolating needs plus providing the basis for identifying solutions through commercial carriers and other communications members" (DOC, 1988a: p.5). It would derive most of its activities from the outfall of the NATO Civil Emergency Planning Committee.

The NETC undoubtedly would benefit considerably from the contributions of private-sector specialists and telecommunications carrier representatives who become involved in subcommittee and working group projects concerning the detailing of technical and administrative arrangements required to meet special needs and extraordinary demands for communications in a national crisis. Moreover, participation by the commercial carriers in the national planning process would provide a valuable expert knowledge base which could be called upon for information on concerning new industry developments and related technical considerations.

The NETC concept is still being developed at DOC's head office; it has yet to be realized in an institutional form. And while the DOC's RETC program only very recently became operational throughout the country, some regional committees -- notably those in British Columbia and Quebec -- have been active for several years. In the absence of a national planning committee for emergency communications preparedness, these regional bodies provide a practical model for both the structure and operations of the proposed NETC. In addition to including representation from federal departments and agencies operating in the regions which have a known need for communications support during emergencies, the RETCs also encourage participation by provincial and territorial governments and, in some cases, from municipal authorities who have expressed similar needs. Also represented on the regional committees are the commercial carriers operating in the respective provinces or territories, together with CBC regional emergency planners.[46]

3.9 Other federal roles in communications preparedness

3.9.1 Continuity of government program

The 1988 Emergency Preparedness Act charges EPC with establishing arrangements for ensuring the continuity of civil government during a national emergency. This program originally began in 1959, at the height of the Cold War. Essentially, its purpose is to provide a decentralized system of emergency government in the event of a nuclear attack on North America. The program was established to ensure the continued operation of democratic government authority and the provision of essential government services, both aimed at the survival of the Canadian population (Wallace, 1963: p.7).

An important aspect of the Continuity of Government program is its network of central emergency government headquarters interlinked by supporting regional (i.e., provincial), zonal and local facilities. Its objective is to keep the machinery of central and local governments in action (even if only on a skeleton basis) and also the public utilities (Hodsoll, 1966: p.8). On the central government level, these protected installations are comprised of a group of shelters situated outside the Ottawa area.[47] In addition, there are six permanent emergency regional government centres or REGHQ. These are situated, respectively, at Valcartier, Quebec; Shilo, Manitoba; Camp Borden, Ontario; Debert, Nova Scotia; Penhold, Alberta; and Nanaimo, British Columbia. Each installation is considered to be a relatively safe and protected location outside of potential target areas. There are also four "interim" (since the late 1960s) emergency government headquarters located in New-Brunswick, Newfoundland, Prince Edward Island and Saskatchewan (Wallace, 1970a: p.3). And there is a group of zonal headquarters which represent, for a province or territory, a control level between that government and the municipalities. Finally, there are hundreds of emergency municipal government centres across Canada.

As regards emergency communications, each emergency government facility is kept operationally ready, and they are fully equipped with communication facilities -- including landline telecommunications and radio as well as additional plug-in facilities to enable government agencies to install their own (portable) communications equipment.[48] Moreover, most of the private and government-owned telecommunication companies have established comprehensive corporate emergency plans, together with protected accommodations from which to operate.

Other aspects of the Continuity of Government program include determination of departmental functions in terms of deciding which operational functions must be continued during a national emergency, and developing contingency plans to ensure their provision. They also include the pre-assignment of key officials and employees who would carry out those essential functions, together with the establishment of lines of succession of authority. Additionally, the program involves analysing departmental records to determine which are vital (i.e., "essential records") to the continued operation of government, and arranging for their safe storage. Related to these activities are the development of employee mobilization plans so that government employees can be advised as to where they are eventually to report during an emergency; an employee survival plan (related to personal survival measures); and departmental resource surveys to maintain up-to-date records of equipment and other resources that would be required for emergencies, including those that could be used by other agencies (Wallace, 1961: pp.16-17).

Significantly, the Continuity of Government program was put on hold in 1968 following a federal government freeze on capital expenditures.[49] However, as a result of the passage of new federal emergencies legislation in 1988, it is again under review -- this time to determine what arrangements are necessary to guarantee continuity of elected government and the provision of essential government services in the four kinds of emergencies identified in the Emergencies Act (EPC, 1989c: p.32).

3.9.2 Canadian Broadcasting Corporation

The Canadian Broadcasting Corporation is a proprietary Crown corporation which historically has reported to Parliament through either the Secretary of State or the Minister of Communications. It originally was established to provide a national broadcasting service in Canada. To that end, the CBC operates two television networks, two AM radio networks, two FM radio networks, and a shortwave (international) service. The corporation has a decentralized operational structure, with broadcast station facilities in all the provinces and both territories.

The CBC actually has two national alert-type networks -- its national news alert network and the National Warning (siren) System. The CBC's news alert system is used frequently; the other not at all. Indeed, the CBC reports that the siren system costs it roughly $70,000 to $80,000 a year to maintain, and the corporation does not want to keep it up. However, its news alert system is not one that the CBC likely would want to be required to share freely, given that it is in competition with other broadcasters to provide newsbreaks to the public.

The CBC's functional responsibilities in peacetime emergencies are restricted to public warning. Just the same, while its facilities may be used to disseminate warnings, the corporation does not itself initiate them. To that end, it provides access to its broadcasting facilities to the federal government for the national Emergency Broadcast System. In this regard, the CBC provides service indirectly to the Canadian population to the extent possible; it also provides technical assistance and consultant service to the DOC in this regard.

The Minister of Communications, in co-operation with the Minister of National Defence, has responsibility for providing an Emergency Broadcast System on an international, national, regional and local basis -- over CBC facilities. Such broadcasting also is co-ordinated to meet the general requirements of Canadian and NATO civil emergency plans (EPC, no date (a)). The CBC's role in emergency communications preparedness is discussed more thoroughly in Chapter Seven with regard to the EBS.

3.9.3 Canadian Radio-television and Telecommunications Commission

The Canadian Radio-television and Telecommunications Commission (CRTC) is a departmental Crown corporation,[50] and it reports to Parliament through the Minister of Communications. It is a federal regulatory agency which has a centralized administration and regional representatives across Canada. Among the commercial telecommunication carriers, the CRTC regulates B.C.Tel, Bell Canada, Unitel, Northwestel, Teleglobe Canada, Telesat Canada and Terra Nova Telecommunications. The CRTC also has concluded that Cantel, which provides cellular telephone service in shared markets with the landline telephone companies, falls within its jurisdiction as well.[51] Finally, the CRTC is the licensing authority for all broadcasting undertakings in Canada.[52]

The CRTC's mandate regarding telecommunications derives from responsibilities previously charged to the Department of Transport. That department's emergency-related responsibilities included placing under federal government control all transportation, meteorological and telecommunications resources, facilities and services in Canada -- with the exception of those operated by the Departments of National Defence and External Affairs. Transport's other responsibilities in terms of emergency communications included the establishment and operation of the ENTO, and providing an Emergency Broadcasting Service over the facilities of the CBC (Drury, 1964a: p.8). These latter responsibilities were transferred to the Department of Communications at the time of its creation in 1969. As a consequence, while the CRTC would provide support to the Minister of Communications in a national emergency, it has no direct emergency oversight role as regards the telecommunications industry; that responsibility rests with the minister and the DOC.

The CRTC's functional responsibilities in relation to emergency communications include the development and dissemination to individuals and private organizations of information on federal policy, such as procedures for obtaining assistance, with respect to radio and television broadcasting. In addition to its informing role, the CRTC also has a limited warning role. In this regard, it is responsible for developing an understanding of the indicators of potential emergencies that might affect radio and television broadcasting capability, and for collecting and analysing related data with the aim of forecasting the nature and extent of their potential impact on Canadian broadcasters.[53] Moreover, the CRTC is responsible for the preparation, promulgation and implementation of federal regulations aimed at facilitating the handling of emergencies which could affect the operation of broadcast stations in emergencies -- and particularly the Emergency Broadcast System.[54]

3.9.4 Environment Canada

Environment Canada's responsibilities with regard to emergencies include, among other things, matters relating to meteorology. The department's Atmospheric Environment Service (AES) is responsible for the execution of its functional responsibilities in emergencies as they pertain to these activities.[55]

The AES has its headquarters in Ottawa, together with ten major regional offices and over 50 local weather offices. Its atmospheric monitoring facilities include ships; balloon ascents; aircraft; automatic reporting stations; and a sophisticated computer base. It also has established nation-wide networks to gather surface and upper-air data on a continuous basis, and to gather information on air quality, scattering of pollutants and chemical reactions in the atmosphere. As part of this program, the AES operates a conventional radar network of 14 stations across southern Canada (from Newfoundland to Alberta). It also is engaged in continuous severe weather research and development -- specifically, Dopplar radar systems, and storm detection and tracking techniques.[56] Through projects like the development of the severe weather intelligent forecast terminal (SWIFT), the AES also makes use of the latest artificial intelligence technology in severe weather prediction (EPC, 1989c: p.13).

At the national level, the AES participates in federal response co-ordination activities such as nuclear emergency response testing; nuclear submarine accidents; satellite re-entries etc. Internationally, it is active in supporting the World Meteorological Organization and in the planning and implementation of international science and operational programs. The AES also participates in many international emergency exercises and tests (EPC, no date (a)).

Regarding emergency communications, part of the AES' normal operations is to maintain weather watches, and to issue warnings and advice on the expected duration and intensity of life-threatening meteorological events based on information provided by its data collection network and forecasting system.[57] In addition, it collects information on ice build-ups in navigable waters for use by shipping companies, hydro-electric dams and flood control agencies.

Since the AES' most recent policy on peacetime emergency response was approved in April 1989, its focus has been on participating on national and regional preparedness committees; reviewing existing plans; forming response teams; developing training courses and exercises for forecasters; conducting case studies of significant storms; and upgrading its severe weather detection and forecast techniques (EPC, 1989c: p.14). The AES' activities in regard to localized weather-related natural disasters include operational support in terms of providing meteorological information dissemination in major forest fire fighting, monitoring west coast earthquake and volcanic activity, and the like.

The public and special interest users are informed by the AES of meteorological conditions over a variety of communications media.[58] These include press wire service; satellite services; cablevision; telephone circuits; and perhaps most significant to the present discussion, "Weatheradio" -- a bilingual radio station operated in major Canadian urban centres which transmits weather information continuously over VHF-FM radio, and provides up-to-the-minute weather forecasts and reports.[59]

Continuous weather broadcasts are reported at five to eight-minute intervals on Weatheradio channels; they include public and maritime forecasts, advisories and warnings, together with special weather information of interest to local residents such as farmers or sports enthusiasts. Additionally, Canada and the United States employ the same three frequencies for Weatheradio: 162.44 MHz, 162.475 MHz and 163.550 MHz, all on the VHF-FM band. To use the same frequencies, the two services must co-ordinate their programs closely, especially in border areas.[60] This makes it possible for travellers equipped with a Weatheradio receiver to keep track of weather changes wherever they are in either country. Weatheradio and Environment Canada's potential expanded role in national alert/warning are discussed in Chapter Seven.

3.9.5 National Defence

The Department of National Defence was created in January 1923 as the result of a Cabinet decision to amalgamate the departments of Naval Services, Militia and Defence, and the Air Board. Intended as an economy measure, it also was designed to improve co-ordination of national security policy. The move brought the the three services under a single minister, and although during World War II, in practice, they acted as three separate ministries, following demobilization their integration was gradually realized. In 1951, a chief of staffs was named to co-ordinate training and operations of all three services; in 1964, one chief of defence staff replaced the individual service chiefs; and in late 1972, the civil and military branches merged into a single headquarters in Ottawa, where senior staff appointments to the assistant deputy minister level are filled by both civilians and service officers (Harris and Cooke, 1989: p.1428b).

In addition to the regular Armed Forces, the Canadian Reserve Forces are comprised of part-time members of the Armed Forces. Their role is to augment and support the Regular Force when called upon to do so. Currently, they include the Primary Reserve, the Supplementary List, the Cadet Instructors List and the Canadian Rangers. The first is divided into the Naval Reserve, the Militia, the Air Reserve and the Communications Reserve, each composed of volunteers who train on weekends or at short summer camps. The second is made up of those who have left the Regular Force or the Primary Reserve, but are available if needed. The Rangers include reservists located in sparsely populated areas of the country; their special contribution is an ability to provide expert local knowledge which is particularly useful in search and rescue, and other emergency operations in remote areas (Hillmer and Cooke, 1989: p.1858c).

DND's primary role in national emergency planning is to prepare for war. Thus, the Armed Forces "are charged with providing combat-ready forces for a variety of national and international commitments."[61] DND's functional responsibilities in emergencies involve providing government authorities with information related to military plans and operations, including the defence of Canada, Canada/U.S. and NATO defence, and United Nations peacekeeping activities. In addition, it is responsible for gathering information on radiological, biological and chemical defence capabilities for protecting the civilian population. (It is not, however, responsible for the physical protection of the civilian population or for providing fallout shelters.)

As regards the department's policy on peacetime emergency preparedness, Parts I and II of the 1988 Emergency Preparedness Act empower DND to play a support role only, and then only after receiving authorization to do so through its minister. Just the same, it can provide a useful reservoir of skills, resources and capabilities to assist civil governments in meeting extraordinary needs during an emergency or disaster. Additionally, in conjunction with the Canadian Coast Guard, it has responsibility for co-ordinating air and marine search and rescue operations. Moreover, in a life-threatening situation, any senior command officer has the authority to commit DND resources; however, its personnel can only be deployed under the Canadian Forces command-and-control structure -- that is, they cannot take instructions from anyone but their commander.[62]

Concerning DND's involvement in emergency communications preparedness, the department is responsible, in wartime, for providing a portion of the means of disseminating information and instructions from the federal government to the Canadian population. Related to this is DND's responsibility (in co-operation with the CBC) for maintaining and operating the The National Warning System.[63] DND also shares responsibility with Emergency Preparedness Canada for the Government Alert System, and for the operational readiness, including communications, of the central and regional emergency government headquarters. Moreover, DND alone is responsible for emergency government communications down to the zonal emergency headquarters level, although the DOC is responsible for planning and co-ordinating the physical facilities that comprise civil government communications within and directed from emergency government headquarters (EPC, no date (a)).

As regards the Emergency Broadcast system, DND in co-operation with the DOC provides the physical link between the REGHQs, the CEGHQ and the local CBC broadcast stations. The EBS telephone circuit is an off-hook dedicated voice line which is used primarily to authenticate messages provided over the local emergency teletype warning circuit. Attack and fallout warning messages would be transmitted from the REGHQ to the CBC over this circuit and then broadcast to the public.

Respecting DND's authority to provide "aid to the civil power," this refers to its role in assisting civil authorities and providing humanitarian assistance during a peacetime emergency or disaster. When requested to do so, it can provide assistance to federal departments, provincial, territorial and municipal governments and, in some cases, even to private individuals and organizations. That assistance takes the form of providing transportation, equipment, supplies, human resources, communications, and the like (EPC, no date (a)).

Usually it is the Canadian Militia (now part of the Reserve Force) that is called out to provide "aid to the civil power" in cases requiring the maintenance or restoration of public order.[64] Since 1870, Canadian troops have helped to maintain or restore order some 140 times, half of which occurred before 1900. They also have been called out approximately 20 times to suppress penitentiary riots (Pariseau, 1989: p.40c). In addition, military police may be used for traffic control and similar duties in a major peacetime emergency or disaster. Similarly, signal personnel might be brought in to help out with emergency communications, and military engineers could be used in rescue operations, to clear debris, etc.

Requests for DND communications support, as with all other DND resources, must be processed through formal government channels, starting at the regional emergency operations centre (DOC, 1989d). For example, National Defence was called on to assist civil authorities in handling the Soviet Cosmos 954 nuclear satellite crash in the Far North (Hutchison-Benson, 1981). Their role in that incident was to locate rapidly, isolate and secure any radioactive components, and establish joint operational centres for command-and-control purposes. In terms of the kinds of emergency communications resources used in that and other satellite re-entry incidents, the normal communications capability of the Whitehorse Armed Forces detachment were made available -- namely, a 12-channel VHF mobile radio-telephone, a one-channel handheld radio-telephone, Northwestel telex, and the capability to transmit classified information.

3.10 Provincial/territorial governments

The provincial and territorial governments play an important part in national emergency planning and communications preparedness. Indeed, after the municipalities, they play the leading crisis management role in dealing with peacetime disasters. Under the Constitution, there are certain areas of normal and emergency government activity in which the provinces have complete jurisdiction -- such as in the fields of law and order, health and welfare. In addition, they are responsible for maintenance and repair of roads and road bridges; assigning to municipal governments their operational roles (including maintenance and repair of water and sewage systems, rescue, warden, emergency communications, emergency public information and emergency transportation); fire fighting; electrical and gas utilities; communications from the REGHQs to provincial government agencies and municipalities; and co-ordination and direction of emergency operations of municipal governments.

In such cases, federal officers operating regionally might be used by the provincial or territorial governments to assist them in their planning as well as response operations. Similarly, where the federal government would be responsible in an emergency for the creation of controls, for instance, on the distribution of emergency food supplies, most of the staff used to do so would be drawn from provincial or territorial government departments and private industry. As a result, contingency plans developed by federal and provincial/territorial governments to meet emergencies are intended to be complementary. Moreover, they provide guidance to municipal governments in preparing local emergency plans so as to ensure the continued operation of municipal government, survival of the local population and operation of municipal emergency services (Wallace, 1970b: pp.7-8). In areas of a province or territory not administered by an incorporated municipal government, they also must make all the necessary preparations or arrangements to protect threatened populations.

As regards emergency communications preparedness, provincial and territorial governments also have a role to play in developing and implementing a coherent national policy. Once again, this relates to the fact that, in a peacetime disaster situation, the federal government would support their response initiatives.

In the early years of Canadian civil defence and emergency planning, Ottawa set the pace, while the provinces reacted to federal initiatives. An exception to that practice was the Province of British Columbia which, as early as 1951, passed regulations permitting municipalities to "organize, establish and put into operation any scheme or plan for civil defence."[65] Since the early 1970s, however, the provinces and territories increasingly have taken initiatives to develop their own emergency programs and to encourage municipalities to do the same. This has been done despite limited federal financial support for those activities. Indeed, several provinces require their incorporated municipalities to establish a peacetime disaster plan, and have given them guidelines and technical assistance to do so. Today, every province in Canada maintains an emergency measures organization to stimulate emergency planning and response activities at that level as well as within and between municipalities.

Crucial to effective provincial or territorial emergency preparedness, including emergency communications, is joint planning with other levels of government. This begins with "an examination of the most prevalent and the most serious probable emergencies in each province or territory," the goal being to identify "both the nature and scope of any outside assistance which might be required and the circumstances under which it would be called for" (EPC, 1981: p.10).

A significant benefit of federal-provincial-territorial joint planning is that it enables the provinces and territories to know precisely what federal resources can be made available to them for each kind of emergency that they might expect to encounter. Furthermore, federal departments would benefit from monitoring developing situations -- regarding, for example, hazardous waste storage sites, and thereby be better prepared to accede promptly to provincial requests for emergency aid. Additionally, shortfalls could be detected with respect to both federal and provincial/territorial capabilities. Finally, the existence of pre-established co-operative arrangements would help the government in charge of managing the emergency to do so with more confidence as to the resources available and greater speed, thereby reducing the impact on the local population (EPC, 1981: p.10).

In order to establish a basis for intergovernmental co-operation in emergency preparedness for the full spectrum of possible emergencies and disasters that confront Canadians, the federal government has negotiated Memoranda of Understanding on Emergency Preparedness with each province and territory; agreements have to date been signed with eight of the provinces and both territories. Since many federal orders and regulations relating to the 1988 Emergencies Act will have to correspond with provincial and territorial arrangements, discussions on a federal-provincial-territorial consultation process also have been initiated (EPC, 1989c: pp.33 and 34).

Another significant element in federal-provincial-territorial co-operation in the area of emergency preparedness is the Joint Emergency Planning Program (JEPP). Initially approved in October 1980, this program provides federal grants to provincial, territorial and municipal governments for individual projects which enhance the national capacity to respond to emergencies. Project proposals are submitted by provincial or territorial EMOs for evaluation by EPC Regional Directors and senior managers according to established criteria. The federal financial contribution is negotiated separately for each project, and annual federal funding approximates 25 cents per capita. To be eligible, JEPP proposals must, first, have a clear objective that supports joint priorities; second, have an agreed, identified beginning and end; and third, involve a substantial provincial financial commitment (EPC, 1989c: p.7).

In the past, JEPP grants have favoured the development and evaluation of emergency plans, training, and the purchase of communications and emergency response equipment. In the 1989-1990 period, a total of 98 JEPP projects were approved, of which 35 were for communications equipment purchases (not including computers or information management systems). These represented 35.7 per cent of JEPP projects approved for that fiscal year. In dollar terms, during the same period EPC administered some $6.91 million in federal contributions to the JEPP, of which 41.1 per cent ($2.84 million) was spent on communications-related projects.[66] For fiscal year 1990-91, total JEPP funding was less, at just over $6.4 million. Of that amount, close to $2.5 million was spent on communications related projects. This represented roughly 39 per cent of the total. For fiscal year 1991-92, JEPP funding increased somewhat, to nearly $6.5 million -- of which $2.5 million was spent on communications-related projects (approximately 38.6 per cent of the total). Table 3.4 below provides a breakdown, by province and territory, of JEPP funding for 1989 through 1991.

TABLE 3.4

JEPP Project Funding, 1989-1991[67]

Province/ Territory	No. JEPP Projects	No. Coms. Projects	$ Total	$ Coms	Coms as % Total
B.C.					
1989-90	5	1	97,000	5,000	5
1990-91	5	1	121,843	5,000	4
1991-92	12	4	238,459	41,971	18
Yukon					
1989-90	3	3	133,983	133,983	100
1990-91	2	1	253,000	124,000	49
1991-92	2	1	294,367	124,000	42
Alberta					
1989-90	22	7	425,023	117,195	28
1990-91	17	10	508,833	319,110	63
1991-92	19	8	429,123	215,684	50
NWT					
1989-90	7	2	261,118	29,555	11
1990-91	5	2	232,477	55,848	24
1991-92	5	1	285,998	9,998	4
Sask.					
1989-90	21	10	485,328	148,067	31
1990-91	11	5	424,375	109,229	26
1991-92	22	10	445,716	133,876	30
Manitoba					
1989-90	16	7	557,460	85,930	15
1990-91	14	10	363,551	50,487	14
1991-92	9	3	390,913	53,994	14
Ontario					
1989-90	1	0	1,900,000	0	0
1990-91	1	0	1,900,000	0	0
1991-92	1	0	1,900,000	0	0
Quebec					
1989-90	1	1	1,500,000	1,500,000	100
1990-91	3	2	1,587,683	1,518,000	96
1991-92	3	2	1,666,308	1,625,925	98
N.-B.					
1989-90	3	0	173,600	0	0
1990-91	2	0	192,561	0	0
1991-92	2	0	124,500	0	0
N.S.					
1989-90	2	1	337,500	300,000	89
1990-91	2	1	337,500	300,000	89
1991-92	3	1	349,500	300,000	86
P.E.I.					
1989-90	9	1	815,606	500,000	61
1990-91	4	0	205,653	0	0
1991-92	5	0	217,512	0	0
Nfld.					
1989-90	8	2	220,152	22,239	10
1990-91	9	2	283,951	14,876	5
1991-92	3	0	151,515	0	0

(TABLE 3.4 Continued)

Province/ Territory	No. JEPP Projects	No. Coms. Projects	$ Total	$ Coms	Coms as % Total
TOTAL					
1989-90	98	35	6,906,770	2,841,969	41
1990-91	75	34	6,411,427	2,496,550	55
1991-92	86	30	6,493,911	2,505,448	39

3.11 Municipal governments

As was discussed earlier, emergency preparedness planning covers two major areas: first, protection of the civilian population in emergencies to help ensure its survival and, second, continuity of elected government at all levels. Since the majority of Canadians live and work in municipalities, and because essential resources and services are located there, peacetime emergency measures have become the accepted responsibility of municipal governments. Moreover, and perhaps more significantly, local officials are likely to have the best knowledge of local conditions and local requirements to deal with an emergency situation. This includes knowledge about who to call, what equipment and other resources are available within the municipality and in nearby communities, and what people are to do in the event of a disaster. It is somewhat ironic that the resources available to local organizations to develop an operational capability to respond to an emergency are severely limited -- especially since it is at that level that the initial tasks of survival must be carried out.

For these reasons, it is considered significant that every Canadian municipality establish a written emergency plan and designate an Emergency Planning Officer. Such a plan must include an emergency resources inventory; information about mutual aid arrangements with neighbouring communities; and radio signs and frequencies, and/or telephone numbers, as appropriate, for all contact personnel in the various government departments that would likely become involved in response operations, and for industry contacts and emergency measures officers in surrounding areas. But setting down a written plan is not enough; it must be regularly tested, exercised and updated.

Respecting emergency communications preparedness at the local level, especially important is the establishment of an emergency communications supplemental plan. It would include detailed information about industry contacts -- such as local telephone company emergency measures staff; the CBC and private local broadcast radio and television station personnel; the cable television company operating locally; cellular telephone company emergency contacts; and other telecommunications and radio common carriers providing service in the local area. This would be in addition to detailed information respecting local government radio frequency allocations, call numbers and equipment inventories as well as contact points for the local amateur radio club and citizen band operators' association. Moreover, co-operative pre-arrangements could be made with local ambulance companies, taxi companies, courrier firms, and major construction and transportation companies operating locally to act as emergency information relay contacts in an emergency. Needless to say, when a disaster strikes, it is too late to try to establish these predominantly informal contacts and relationships. For this reason, pre-planning is crucial to efficient and effective response.

Furthermore, since not all disasters are foreseeable, it is important to inform the local media as quickly as possible when a disaster either strikes or threatens so that they can assist in alerting the public. Where there is some lead-time, local newspapers could be provided with background information and instructions as to the actions that individual citizens can take to reduce the impact of the threat. Similar instructions could be given in a radio or television interview with the mayor and local emergency information officer, and they might be posted at local schools, hospitals, service stations, hotels, banks, etc. (Casault, 1976: p.12).

3.12 International communications preparedness

Canada's emergency preparedness planning activities at the international level have included the preparation of policy and civil emergency plans together with exchanges of information leading to the co-ordination of national civil emergency measures with those of the United States and other member countries of the North Atlantic Treaty Organization (NATO). This has been done predominantly through NATO's committees structure -- for example, as regards communications and the negotiation of related multilateral and bilateral agreements. Of particular significance is Canada's relationship with the United States in this area, which has been described as "exceedingly close."

Emergency Preparedness Canada co-ordinates Canada's civil emergency planning activities with other members of NATO.[68] For example, EPC has arranged for Canadian representation on several NATO civil emergency planning committees responsible for determining that alliance's wartime resource requirements -- including communications -- and with developing plans and arrangements for NATO civil wartime agencies to meet them. EPC also co-ordinates the Canadian government's overall working relationship with the United States with respect to civil emergency preparedness.

In terms of emergency communications, specifically, NATO's emphasis historically has been on information security. That is, its activities focus on the possible effects of introducing new technologies on the provision of secure voice, data and image telecommunications. An exception to this is in the area of jointly funded infrastructure programs; these provide the facilities necessary for the deployment and operations of the NATO forces, including airfields, pipelines and telecommunication installations. Moreover, NATO provides advice and co-ordination of multilateral efforts, including the pooling of common technical information and standardization of emergency communication facilities and practices.

In the early postwar days, NATO's strategic communications consisted of point-to-point links that relied primarily on government-owned Postal, Telephone and Telegraph Administration (PTT) circuits. That network was later expanded by a limited number of NATO-owned links employing terrestrial line-of-sight microwave and tropo-scatter systems. In the late 1960s, new NATO policies emphasizing "flexible response" required a greater exchange of information among member countries; better communication facilities consequently were required to ensure command-and-control capability by NATO forces under a broad range of contingency situations (NATO, 1984: p.179). By 1965, NATO had finalized plans to provide direct communication links between NATO headquarters and all NATO-member capitals, as well as with the three major NATO commanders. In 1969, NATO established a communications centre at its Brussels headquarters. And in 1970, NATO's first communications satellite became operational.

Considering Canada's emergency preparedness relationship with the United States, it originally was formalized in the North American Air Defence Agreement (NORAD), which was ratified by Ottawa in 1957 and, more recently, in the Comprehensive Agreement on Civil Emergency Preparedness and Management of 1986. In March 1951, the first Canada/U.S. Civil Defence Agreement was concluded. It called for co-operative civil defence planning and put earlier arrangements on a legal international basis. In November 1963, a new agreement was ratified by the two governments, as a result of which much of Canadian and U.S. civil emergency planning has been done along parallel lines. Its goal was to provide for "mutual assistance" in the event of an attack, and continuous technical consultation between the two countries. In addition, Canada and the U.S. have established:

> emergency communications links between our border regions; the operating procedures for reporting radiation fallout have been standardized and ... our radio broadcast messages are consistent so that persons will not be confused if they happen to pick up a broadcast from the other country (Wallace, 1965: p.21).

In August 1967, the Agreement on Co-operation between the United States and Canada clarified concerns respecting technical consultation, and made special provisions for sharing equipment and waiving border restraints in an emergency (DOC, no date (b): p.3).

The Department of National Defence is Canada's liaison with the United States through NORAD -- primarily for the purposes of establishing an effective continental attack warning system which is operated through NORAD facilities at Colorado Springs and North Bay, Ontario.[69] Together, Canadian and American alert/warning systems provide for cross-linking the exchange of information at every level -- such as between NORAD regional headquarters and with the NORAD stations, on a north-south basis. Canada's nuclear detonation reporting system is similarly linked to and works with the United States' system (Drury, 1964a: p.17).

Regarding the role of the Department of Communications in international communications preparedness, that department represents Canadian interests at the NATO Civil Communications Planning Committee. It also is responsible for the control of radio emissions in wartime.

The origin of the DOC's participation in NATO is Articles 2, 3 and 9 of the North Atlantic Treaty. Article 2 defines the aims that member countries will pursue. Article 3 binds the parties to concerted action. Article 9 establishes the North Atlantic Council and charges it with the creation of subsidiary bodies, as necessary. This provides for the establishment of those in which the DOC participates. Additional related authorities are included in Canada's 1981 Emergency Planning Order, and in the federal legislation passed in 1988, which commits Canada to meet its military and civilian obligations to its allies under the Treaty.

The main NATO activities with which the DOC currently is involved are as follows :

(1) The Senior Civil Emergency Planning Committee -- which reports directly to the North Atlantic Council. It controls the activities of the civil planning boards and committees dealing with matters such as energy sources, civil communications, and the like.

(2) The Civil Communications Planning Committee -- which is a subsidiary body of the Senior Civil Emergency Planning Committee. It is responsible for the planning of civil communications with a view to determining their suitability and continued use to meet emergency, wartime and survival period requirements in the political, economic and military fields. It also is responsible for providing communications for the NATO Civil Wartime Agencies.

(3) The NATO Communications and Information Systems Committee (NACISC) -- which is the senior multinational advisory body for co-ordinating related civil/military advice and policy recommendations.

(4) The Allied Long Lines Agency -- which provides a focal point within NATO for the formulation of policies and plans to meet the long lines (terrestrial telephone) communication requirements of the alliance.

(5) The Allied Radio Frequency Agency -- which is the NATO agency responsible for establishing policies concerning the management of military use of the radio frequency spectrum and providing engineering assistance to member countries.

(6) The NATO Joint Communications Electronics Committee. Established in October 1969, it brings together senior national military and civilian representatives to develop advice related to communications electronics.

(7) The NATO Integrated Communications System. In March 1971, the Council agreed to establish NICS and create a special agency, the NICS Management Agency to be responsible for its planning and implementation. The NICS concept is based on developing a common-user, automatically switched grid network for voice, data and image traffic. In its first stage, a series of stand-alone subsystems were installed to automate voice and telegraph communications. The second stage, to be completed in 1995, involves the geographic and technical expansion of those sub-systems and their consolidation into a single, fully integrated dedicated telecommunications system.

(8) The NATO Command, Control and Information System and Automated Data Processing Committee. Created in October 1970, its activities include recommending policies concerning command, control and information, and initiating the overall organization for the system.[70]

The Department of External Affairs also has some functional responsibilities during emergencies that relate to international emergency preparedness and communications. For instance, it is responsible for disseminating information, through Canada's missions abroad, to Canadian nationals, organizations and interests regarding means of obtaining assistance in coping with emergencies. It is also responsible for collecting and analysing indicators of potential emergencies -- through its posts abroad and its own world-wide communications network -- and forecasting the nature of potential emergencies. Related to this, External Affairs must develop and operate systems to maximise warning time and precision through the application of its existing communications network with missions overseas. Moreover, "the department is also the usual vehicle for provision of assistance to nations in distress." And it is responsible for providing exceptional resources at reasonable levels in relation to risks, including diverting normal government resources to meet emergency needs and, if necessary, co-opting non-federal resources to facilitate the physical protection of people, their relocation or rescue, provision of emergency medical, health and welfare arrangements, etc. (EPC, no date (a)).

External Affairs also operates an Emergency Operations Centre in Ottawa which recently has been expanded and renovated. Additional and updated electronics equipment has been installed to enhance the efficiency of its media monitoring, collection and storage of data, and display of information and graphics. Finally, highly secure Canadian and U.S. Stu-III key telephones have been purchased for use in emergencies, together with secure facsimile (EPC, 1989c, pp.16-17).

3.13 Conclusions

The discussion in this chapter suggests that considerable progress has been made in Canada towards effective emergency preparedness and planning, especially in the area of emergency communications. A definitive shift in federal policy away from "civil defence" planning that was preoccupied with wartime preparedness occurred after the mid-1960s. Since then, increased attention has been given to peacetime contingency planning and preparedness strategies related to natural and industrial disasters. This trend reflects, on the one hand, the growing public awareness of the risks of natural and other disaster agents in their immediate environment. On the other, it suggests a growing consciousness among municipal and provincial decision-makers of their roles in disaster response, accomplished by more policy initiatives taken at those levels.

Certainly the threat of a nuclear attack on North America appears to be less likely than for many years -- especially given the dissolution of the Soviet Union. It therefore is not surprising that the Canadian military establishment has experienced substantial cutbacks, particularly in terms of its overseas bases and combat forces. EPC's close affiliation with DND similarly has put it at a disadvantage in terms of selling emergency preparedness as a political issue.

Suburban train derailments, toxic chemical spills, tire fires and the like, however, have made Canadians more conscious of their personal vulnerability in such situations. They also have underscored serious inadequacies in public education about mitigative measures that can be taken with regard to industrial disaster agents. Moreover, they have served to emphasize the necessity of local planning -- in order to prevent disasters in the first place and, when they do occur, to reduce their impact on the affected community.

Ironically, municipal authorities, who in any localized incident would be responsible for managing the front-line emergency response, have the fewest resources (in terms of human expertise and equipment) to cope with a large-scale disaster. As a result, provincial and territorial governments need to support municipal emergency planning by helping them to prepare and exercise local disaster plans, and encouraging them to establish co-operative mutual aid arrangements with neighbouring communities. It also requires the training of municipal emergency measures personnel to help ensure effective response at minimum cost to the governments involved. Furthermore, most disasters are confined within the geographical boundaries of a single province or territory; thus, federal officials would assist those authorities in a support capacity only, and the other orders of government would become involved in a local response operation only at the request of the local authorities.

It has been suggested that peacetime emergencies are very different from defence-related crises -- in terms both of the degree and the kind of involvement they require from private citizens, industry and elected officials. As a result, they require a different approach towards preparedness planning and response. Indeed, while it may be appropriate to use a military-style command-and-control approach in defence-related crisis management, it is anticipated that in a peacetime disaster situation, co-operative co-optation will prove more effective. This is because, in these circumstances, it is less important that someone "take charge" so to speak, and more important that private citizens look after themselves to the extent possible.

Moreover, public perceptions about how a particular disaster is being managed may be more important (politically) than maintaining formal authority structures and established standard operating procedures. For this reason, pre-planning and the fostering of informal co-operative relationships among those individuals who likely would become involved in a response operation within a given geographical region, and including private sector experts and essential service providers, cannot be overvalued. Indeed, it is often these informal linkages that work the best in a crisis situation; certainly there is no substitute for the personal confidence that results when the responder knows exactly who to contact to get help quickly.

As regards national communications preparedness, decentralized planning has resulted in the emergence of new approaches to policy-making in this area. For example, the creation of Regional Emergency Telecommunication Committees at the provincial/territorial level has encouraged informal and personal relationships to develop among essential service users and their suppliers. It also has stimulated the players to take initiatives together which have the effect of reducing confusion in an actual emergency, and which are aimed at reducing the costs of meeting their respective emergency communications needs as well.

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1 EPC, 1974: p.4. Also see EPC, no date (a).

2 An example would be Transport Canada's responsibility in an off-shore oil spill. See EPC, 1974: p 4.

[3] Blake, 1977: Fig.1, p.4. Permanently staffed planning groups in each lead department and agency conduct specialized planning with assistance from internal experts and advisory committees, including representatives from other departments, industry, and the provinces.
[4] For a review of Canadian civil defence through the 1970s, see Scanlon, 1982.
[5] As regards natural disasters, EPC and the various Regional Emergency Telecommunications Committees are working on developing a generic national disaster plan based on a catastrophic earthquake scenario. Similarly, experiences such as the Mississauga train derailment and the Saint Basile-le-Grand PCB fire which required the immediate evacuation of thousands of residents from the area surrounding the disaster site have caused government planners to place greater emphasis on technological disasters.
[6] A notable exception was the October Crisis. In that instance, the Quebec and federal governments responded in a traditional, military style, and they were severely criticized for having done so.
[7] Much of this historical discussion is derived from Public Archives of Canada, no date (a).
[8] See Government of Canada, 1951.
[9] See Government of Canada, 1959a.
[10] See Government of Canada, 1959b.
[11] See Government of Canada, 1963.
[12] See Government of Canada, 1965.
[13] See ***Hansard,*** 1967 and 1968.
[14] See Government of Canada, 1968a and 1968b.
[15] See Government of Canada, 1981.
[16] See section 2 of P.C.1981-1305.
[17] See section 5 of P.C.1981-1305.
[18] See section 3.7.2.3 in this chapter for a discussion on the Civil Emergency Preparedness Management Order being prepared by EPC pursuant to the 1988 Emergency Preparedness Act.
[19] As part of economies announced in the tabling of the most recent federal budget on 25 February 1992, EPC has been folded back into the Department of National Defence (EPC, 1992: footnote, p.3). EPC's oversite authorities, however, are retained.
[20] EPC plays a facilitative and co-ordinative role in advancing civil preparedness in Canada for all types of emergencies. It is not, however, responsible for co-ordinating activities of provincial and local governments. Nor is it responsible for either preventing or responding to emergencies (EPC, 1992: p.3).
[21] A major difference between this Act and the 1981 Emergency Planning Order is that the Act has been formally scrutinized by the Canadian Parliament. As a result, it will be more likely to be taken seriously by federal ministers. The key provision in this regard is the requirement that EPC report regularly to Parliament on all federal emergency preparedness initiatives.
[22] The Parliament of Canada has the responsibility for confirming the invocation of any part of the Emergencies Act, and for overseeing its use once it is invoked (EPC, 1992: p.5).
[23] Also see EPC, 1988a.
[24] EPC, 1989c: p.1; also p.36 regarding the federal government's centralized emergency operations centre.
[25] The territories are served by provincial regional directors.
[26] The executive director of EPC has reported at times to the Defence minister, to a deputy minister, Defence, to the president of the Privy Council, and to other ministers or deputy ministers. With the passage of the most recent federal budget, the executive director now reports to the deputy minister, Defence instead of the minister, suggesting another decline in the agency's status as measured in terms of proximity to the prime minister.
[27] Some 25 in number, they include: (1) the Interdepartmental Civil Mobilization Planning Committee (supported by the Working Group on EMP Protection, the Input/Output Modelling Subcommittee, the Working Group on emergency Government Designés Program, the

Working Group on Accommodation and Damage Assessment, and the Working Group on Information Requirements for Mobilization); (2) the Interdepartmental Committee on NATO Civil Emergency Planning; (3) the Advisory Committee on Vital Points; (4) the Advisory Committee on Essential Records; (5) the CEGHQ Activation Committee; (6) the Interdepartmental Board on Defence of Shipping; (7) the Civil Aviation Co-ordination Committee (CACC); (8) the DND/EIC Steering Committee on Human Resources; (9) the Earthquake Working Group; (10) the Major Industrial Accident Co-ordinating Committee; (11) the Working Group on Integrated Federal Data Processing; (12) the North America Defence Industry Base; (13) the Interdepartmental Working Group on Defence Industrial Preparedness; (14) the Interdepartmental Committee on Strategic Mineral Commodities; (15) the Task Group on Emergency Management/News Media Co-ordination; (16) the Canada/U.S. Consultative Group; (17) the National Emergency Arrangements for Public Information Steering Committee; (18) the Communications Advisory Committee under the Security Advisory Committee; (19) the Working Group for Public Awareness under the Major Industrial Accident Co-ordination Committee; (20) the Advisory Committee on Information Management; (21) the Communications Working Group; (22) the Planned Liaison Committee; (23) the Telecommunications Advisory Committee; (24) the Armed Forces Communications Electronics Association Steering Committee (AFCEA); and (25) the CANUS Land Operations Committee. See EPC, no date (e): pp.1 and 2-7.

[28] EPC, no date (c). Interestingly, under the 1988 federal legislation, EPC appears to have been delegated responsibility for defining ministerial duties with respect to the National Emergency Agencies -- as part of its functions regarding the development of federal civil emergency plans. (See section 5 thereof.) Interestingly, this could be construed as constituting a form of legislated delegation of prime ministerial authority respecting the definition of ministerial responsibilities!

[29] See section 3.8 of this chapter.

[30] Both were set up in the mid-1980s as a result of problems experienced by U.S. government NSEP users related to AT&T's divestiture.

[31] The DOC was established under Part II of the Government Organization Act 1969 (Statutes of Canada 1968-69: Chapter 28). Its communications mandate is summarized as follows: "The department is responsible for telecommunications and the development and utilization of communication undertakings, facilities, systems and services for Canada. The department co-ordinates, promotes and recommends material policies with regard to communication, assists Canadian communication systems and facilities to adjust to changing domestic and international conditions, plans ... telecommunication services for departments, branches and agencies of the Government of Canada and protects Canadian interests in international telecommunication systems" (Public Archives of Canada, no date (b): p.2). DOC's predecessor was the Telecommunications and Electronics Branch of the Department of Transport. First known as the Radio Service Branch, it had acquired the responsibilities of the Radio Branch of the former Department of the Marine and Fisheries in 1936, and those of the Government Telegraph and Telephone Service of the Department of Public Works in 1948.

[32] To date, agreements have been signed with eight of the provinces and both territories. See EPC, 1989c: p.33; and DOC, 1986a: pp.7-8.

[33] See section 3.8 of this chapter.

[34] That part of its mandate and additional related peacetime tasks assigned to the DOC are outlined in the Emergency Planning Order, P.C. 1981-1305. And although that order has since been replaced by the 1988 Emergencies Act, the guiding principles set out therein continue to govern the DOC's activities in this area.

[35] DOC, 1988a: p.2; and DOC, no date (a). Also see Government of Canada, 1988b.

[36] That is, other than those belonging to National Defence, the RCMP and External Affairs. See Government of Canada, Order-in-Council, P.C.1981-1305: Schedule Part 1, Item 2.

[37] The Emergency Broadcast System and the proposed Warning and Emergency Broadcast System (WEBS) are discussed in Chapter Six.

[38] DOC, 1989d: Communications Annex. Generally speaking, federal policy respecting emergency communications is based on the principle that each federal department and agency will provide emergency planning leadership in its particular discipline.

[39] DOC, 1990a: p.2. Also see DOC, 1991a regarding the Civil Emergency Management Order. This document outlines in detail the minister's responsibilities regarding provision of emergency communications support (section 18 (1,2)). The only area of responsibility not yet resolved in respect of the DOC's support functions concern the provision of a national public warning system. From the DOC's view, the department's assumption of that responsibility would require the allocation of sufficient funds from Treasury Board to put a modern system in place to replace the aging and unreliable sirens. Moreover, there is some question of overlapping mandates in this regard because the Minister of Defence also has responsibility for providing a national warning system.

[40] DOC, no date (a). See also DOC, 1986a: pp.8-10.

[41] DOC, 1991a and Government of Canada, 1981: section 1.

[42] See Government of Canada, 1981: section 1.

[43] It is even possible that senior industry representatives might be named to the NEAT Executive.

[44] DOC, no date (i): pp.11-12. Significantly, plans for the NEAT have never gone beyond the conceptual stage. Perhaps this is due to the decreasing likelihood of an attack on North America, the only scenario that would require its full implementation. Still, it is recognized that a need exists for a national planning body, some elements of which would participate in the NEAT if needed. As a result, the focus has shifted to establishing a NETC which would carry out that function. It would include the membership of the ACCTA.

[45] Source: DOC, no date (i): appended after p.24.

[46] Chapter Ten provides a case study of the CRTU-Québec (Regional Emergency Telecommunications Committee - Quebec). That discussion provides additional insights into the possible application of the as yet embryonic structure of the RETCs as a model for a centralized NETC.

[47] That is, the CEGHQ at Carp, Ontario.

[48] Order-in-council P.C. 1959/656 allotted the task of providing, maintaining and operating emergency communications in support of the Continuity of government program to DND. This was subsequently reaffirmed by P.C.1965-1041 and 1981-1305.

[49] Funds were subsequently provided in the late 1980s for construction of an REGHQ at Fredricton, New Brunswick, but it has not yet been done.

[50] This means that it is a federal department under the meaning and purpose of the Financial Administration Act.

[51] Some provinces question the CRTC's jurisdiction in this matter.

[52] Technical licences are given by the DOC.

[53] This is to be done in conjunction with the DOC and DND.

[54] Additionally, it has a broader role to play in emergency communications preparedness: "to strengthen national defence and world-wide telecommunications" -- which relates to its regulatory responsibilities for approximately 70 per cent of the domestic public telecommunications industry (EPC, no date (a)).

[55] Public meteorological forecasts were instituted by the Meteorological Service of Canada as early as 1876. At that time, they were telegraphed from Toronto to the "principal places" of Canada, but there existed no way for individual Canadians to obtain the information readily. Instead, weather forecasts were posted on Post Office and Telegraph Office bulletin boards, and in local newspapers. In addition, storm warnings were telegraphed to marine agents who hoisted storm signal blankets on towers or exposed headlands. With the introduction of the radio and, later, television, the service was able to make available more quickly meteorological information on short-term changes in the weather and atmospheric conditions. See Miller, 1975: p.6.

56 Dopplar radar is one of the latest advances in weather forecasting. It differs from conventional radar in that it is able to determine wind directions within a storm, together with gauging both the distance and intensity of a storm by detecting precipitation. It has been estimated that the Edmonton tornado warning could have been extended 20 minutes beyond that provided by conventional radar had Dopplar radar capability been available in the region. See Norris, 1988: p.3. In response to the Hague Report issued after the 1987 Edmonton tornado, the Environment Canada minister announced a $14 million federal program to modernize existing weather radar and computer systems, and the AES was directed to prepare a plan to evaluate and install Dopplar radar.

57 A "weather watch" is undertaken when atmospheric conditions are favorable to the development of severe weather conditions. A "weather warning" is given when weather conditions pose a threat to property, lives or the environment. A "severe weather warning" is issued when severe weather conditions either are prevailing or imminent. In 1989-1990, more than 200 separate severe weather events were reported by the AES.

58 These include governments and public agencies who may have to co-ordinate a rescue or response operation, sensitive industries like aviation, forestry, construction, agriculture, marine, recreation, fisheries, etc. and hikers, mountaineers, cyclists and other outdoors sports enthusiasts, to name a few.

59 To receive Weatheradio broadcasts the user must be equipped with a crystal-controlled radio of good quality; this assures reliable reception to distances of up to 65 km (line-of-site) from the transmitter. Alternatively, a non-crystal multiband VHF-FM radio receiver or a relatively inexpensive fixed-tuned weather radio can be used, but these may be affected by interference from neighbouring frequencies or poor reception. An ordinary AM or FM radio receiver cannot pick up Weatheradio transmissions.

60 In the United States a similar service is called NOAA Weather Radio. See EPC, 1978. Also see Environment Canada, 1988.

61 EPC, 1989c: p.21. The National Defence Act deals only with emergency preparedness or disaster planning in the case of war or the maintenance of law and order.

62 Commanding officers, if so directed, could work under the direction of a civilian agency.

63 The siren activation circuit of that system links the REGHQs with the local telephone company. Over this, the REGHQ would instruct the telephone company to call the agencies responsible for turning on the siren. This also is discussed in Chapter Six.

64 This has nothing to do with a declaration of martial law, under which the military would take over the operations of government from the civil authorities.

65 Government of British Columbia, 1951 and 1959. Cited in Scanlon, 1982: p.9.

66 EPC, 1989c, 1990 and 1991 (not yet tabled in Parliament): Appendix A.

67 Emergency Preparedness Canada, 1989, 1990, and 1991 (not tabled): Appendix A.

68 Canada is one of 16 member states which have signed and ratified or acceded to the North Atlantic Treaty which entered into force on 24 August 1949. The other member countries are Belgium, Denmark, France, the Federal Republic of Germany, Greece, Iceland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Turkey, United Kingdom and United States.

69 EPC, 1989c: pp.40-41. A national/continental alert would first be given at NORAD headquarters at Colorado Springs. It would then be sent to the Canadian Federal Alert Centre at North Bay, Ontario and, finally, it would be diffused to the various Provincial Alert Centres. Sirens would then be used to warn the public that an attack is expected. In recognition of the latter commitment, the Mulroney government decided in 1985 to upgrade Canada's North Warning System.

70 NATO, 1984: pp.179-180 and 181. Also see DOC, no date (h): p.2-3.

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CHAPTER FOUR
The Canadian Telecommunications Industry and Government/Industry Programs

4.1 Introduction

This chapter will take a brief look at the Canadian telecommunications industry structure. It also will discuss major industry trends in order to provide a context within which to evaluate their possible effects on emergency communications preparedness capability. In addition, it will consider some of the strategies developed by the Canadian industry with regard to network survivability and related questions. Finally, a number of joint federal government/industry programs will be described which are designed to enhance Canada's emergency communications capability.

Due to the overwhelming reliance of Canadian governments on the public switched network for as much as 95 per cent of their communication needs, the telecommunications industry plays a crucial role in Canadian emergency communications preparedness planning. The number one priority of the industry in this area historically has been "to provide for continuity of service to the extent possible in times of emergency, whether these be the hazards of flood, fire, or other disasters of peace."[1]

As regards the provision of emergency communications during peacetime disasters, the Canadian telecommunications industry operates on the basis of assumptions that successful conversion to emergency operations depends, first, on simplicity and, secondly, on the ability to incorporate under emergency conditions the same procedures used to operate under normal circumstances (Hummel, 1980: p.3). In this way the best possible service in emergency situations can be achieved without incurring additional costs either to users or suppliers. Thus, the Canadian industry traditionally has advocated an approach to disaster communications service provision that reflects the prevailing model of crisis management in that it assumes that all kinds of emergencies can be treated in the same way, and that established procedures will be adequate to meet the demands for additional services resulting therefrom.

4.2 Canadian telecommunications industry structure

The Canadian telecommunications industry is comprised of more than 2,000 separate but integrated networks. The companies involved vary in size from small rural co-operatives to large public or privately owned networks. All are under some form of governmental regulation -- be it federal, provincial or municipal. Stentor, the association of the nine regional telephone companies and Telesat Canada originally was organized in 1931 (as the TransCanada Telephone System) to co-ordinate long-distance communications in Canada, with the aim of providing a high-quality national system capable of providing complete telecommunications service -- including voice transmission, teletype, data facsimile, radio and television program transmission, and telemetering services. In addition, major microwave routes operate from coast-to-coast, predominant among which is Unitel Communications Inc.'s (formerly CNCP Telecommunications, and hereafter, Unitel) nation-wide system. There also are several tropo-scatter radio and satellite systems operating in the northern regions of Canada which provide both general telecommunications and private governmental and defence-related services.

The major Canadian telecommunications common carriers include the Stentor members; Unitel; Teleglobe Canada; the radio common carriers and cellular radio-telephone service providers, including Cantel and the Cellnet association members; and the independent telephone companies. Each of these will be discussed in turn below.

In addition to these carriers, British Columbia Rail (B.C.Rail) operates a microwave system along its rail right of way in British Columbia,[2] and it provides similar competitive services to those offered by Unitel on a regional basis. There also are a rapidly growing number of "enhanced" or value-added services providers which use leased facilities to provide specialized services such as electronic and voice mail, facsimile, videoconferencing, teleshopping, various kinds of database services, graphics messaging, electronic data interchange services and the like (Federal-Provincial-Territorial Task Force, 1988: pp.9-10). Additionally, there are numerous private microwave operators -- including cable companies, transportation and utilities companies, and even some credit unions and banks -- who potentially could offer competitive services to the public.

Together, the various Canadian telecommunications networks consist of five coast-to-coast systems. These include: (1) Stentor's microwave and fibre optic cable systems; Unitel's microwave and fibre optic cable systems; and Telesat Canada's national satellite system. In addition, CellNet and Cantel have partial transCanada microwave systems and it is anticipated that within the next few years they, too, will operate their own separate coast-to-coast microwave systems.

4.2.1 Stentor

Stentor is an unincorporated co-operative association of major Canadian telecommunications companies which co-ordinates the planning and operation of the national telecommunications network, distributes jointly-earned revenues, and markets products and services nation-wide.[3] The member companies include AGT (formerly Alberta Government Telephones); Bell Canada; British Columbia Telephone Company (BCTel); The Island Telephone Company (Island Tel); Manitoba Telephone System (MTS); Maritime Telegraph and Telephone Co., Ltd. (MT&T); The New Brunswick Telephone Company (NBTel); Newfoundland Telephone Company (NfldTel); SaskTel; and Telesat Canada.[4] The ownership type and serving areas of each member company is presented in Table 4.1 below.

TABLE 4.1
Stentor Member Companies[5]

Company	Type of ownership	Serving area
AGT	Investor owned[6]	Province of Alberta (except City of Edmonton)
Bell Canada	Investor owned	Portions of Quebec and Ontario; and eastern portion of Northwest Territories
BCTel	Investor owned	Major portion of British Columbia
Island Tel	Investor owned	Prince Edward Island
MTS	Provincial Crown Corp.	Manitoba
MT&T	Investor owned	Nova Scotia
NBTel	Investor owned	New Brunswick
NfldTel	Investor owned	Portion of Newfoundland
SaskTel	Provincial Crown Corp.	Saskatchewan
Telesat Canada	Govt. Canada & Major Telecommunications Companies	All of Canada.

A wide range of telecommunications facilities are provided by the Stentor member companies for the transmission and switching of both local and long-distance telecommunications traffic. Most notable among these is a national fibre-optics system,[7] two coast-to-coast microwave relay routes,[8] and a national communications satellite system provided by Telesat Canada.[9]

The association is a unique telecommunications organization in that it owns no assets and employs no staff. Instead, it is managed by a Board of Directors on which a senior executive from each of the member companies sits. The President is appointed by the Board and oversees the operations of the association so as to ensure compatible national and international policies and programs. In addition, three councils -- (1) Marketing; (2) Finance and Carrier Relations; and (3) Network -- comprised of management staff from the member companies are responsible for developing and implementing national policies, common strategies and goals. Finally, a staff organization, responsible to the President, interacts with the three councils, and it, once again, is comprised of employees from the member companies.

4.2.2 Unitel

Formerly CNCP Telecommunications, Unitel is a national facilities-based carrier which provides a wide variety of competitive voice, data and messaging services -- until very recently with the notable exception being public local and long-distance telephone services (i.e., MTS/WATS) -- across Canada.[10] The company was formed in 1980 as a partnership that combined some of the telecommunications operations of Canadian National Railway Company, which was government-owned, and Canadian Pacific Limited, which was investor owned.[11] In 1988, Canadian Pacific Limited purchased Canadian National's share of CNCP, and in September 1989, Rogers Communications Inc. acquired 40 per cent equity interest in the company.

Unitel, like the Stentor companies, operates its own national microwave relay system and switching centres.[12] It also has fibre optics systems installed along major high density routes as part of what eventually will become a separate nation-wide fibre optic network.

Like the Stentor companies, Unitel provides real-time network management from the Unitel National Network Management Centre in Toronto. It does not, however, have regional centres, and all of its network control operations are located in Toronto. Service restoration is managed by personnel located in the company's switching and transmission centres across the country.[13]

The business services currently offered by Unitel in the competitive segment of the market include services offered directly to customers using its own facilities, together with services provided indirectly to customers by leasing channels to other (resale and value-added) service providers and high-volume users. They are as follows: (1) private line telephone; (2) public switched data; (3) private line data; (4) switched teleprinter and other text, including facsimile; and (5) audio and video broadcast program transmission. In June 1992, Unitel was allowed to enter the domestic long-distance public voice market in areas served by federally regulated carriers. Unitel also offers Telex and public message service (i.e., telegram or telegraph).

4.2.3 Teleglobe Canada

Teleglobe Canada, a federal Crown corporation until the time of its sale to Memotec Data Inc. (now Teleglobe Inc.) in April 1987, has an exclusive mandate for the carriage of international (except Canada-U.S.) telecommunications traffic. In this way, it provides the telecommunications link between Canada and most other countries of the world.[14]

Through its international gateway switches located at Montreal, Toronto and Vancouver, Teleglobe provides overseas telephone, telex, telegraph and cablegram services, leased circuits, data services, facsimile as well as transmission of broadcast radio and television program services. These services are provided by linking the domestic networks of the Stentor companies and Unitel with Teleglobe's international gateway circuits.

Teleglobe's networks are comprised of undersea cables,[15] earth stations,[16] and satellite transponder facilities partly-owned by Teleglobe or leased from Intelsat. Together, these allow Canadian users to call approximately 220 destinations around the world, and to direct dial as many as 189 overseas locations. In addition, Teleglobe provides overseas Telex service to 220 countries, and telegraph service is provided automatically to every country in the world.[17]

Teleglobe also established a Network Management Centre in 1979, in Montreal, Quebec. It provides real-time monitoring of the company's international trunking network, as well as its three gateway offices. In addition, it provides the liaison with the Stentor networks, Unitel, and the international gateways operated by overseas administrations.

Service restoration capability is provided through arrangements to transfer traffic to other undersea cables or via alternative satellite facilities in the case of a cable failure, and to reroute traffic to other switches, such as those operated by AT&T for European traffic, in the event of a switch failure. Asia-Pacific traffic is restored by transferring circuits to satellites; five transponders on Intelsat's Pacific satellite are reserved for that purpose on a shared basis with other Pacific rim countries (Hoffman, 1990: p.44).

4.2.4 Radio common carriers and cellular service providers

The Radio Common Carriers (RCCs) are a small but growing part of the Canadian telecommunications industry. First licensed by the DOC in 1963, they receive and transmit signals from mobile transmitters and to mobile receivers within a specified geographical area. In this way the RCCs can provide one-way radio paging, and two-way land mobile radio, air-to-ground and marine radio, as well as message forwarding, alarm monitoring and data transmission services on a competitive basis.

As regards cellular radio-telephone, the DOC issued licences in 1985 to provide this service on a duopoly basis in each regional market -- by the telephone companies and a private operator, Cantel Inc. Interconnection to the public switched network and between cellular companies is provided by Stentor's network.[18]

Cellular service provided by the telephone companies is co-ordinated nationally through CellNet Canada, an association of Telecom-member company cellular affiliates as well as 'edmonton telephones' Cellular and Thunder Bay Telephone Co. Planning and engineering support is provided to CellNet members through Bell Cellular's central staff operations, and service restoration is controlled by the various Provincial Network Operations Centres, with the exception of Bell Canada (Hoffman, 1990: p.52).

Cantel, a wholly-owned subsidiary of Rogers Communications Inc. also provides cellular service in and between most cities in Canada. Most of that company's intercell transmission facilities are provided on its own digital microwave network, although some are leased from Stentor and Unitel. National network management facilities are provided from a Toronto-located National Network Operations Centre, and service restoration is based on a network design that allows for an overlay for all cell cites whereby an adjacent switch would take over the cell in the case of a switch failure. Cantel, like the CellNet companies, has plans to put in operation a second cellular network control centre to provide backup support in its largest serving areas (Quebec and Ontario).

4.2.5 Independent telephone companies

There are close to a hundred other telephone companies operating in Canada in addition to the Stentor members. The largest of these are shown in Table 4.2 below, together with the type of ownership and their serving area. Most of the remaining independents operate in Ontario and Quebec under provincial, municipal, co-operative or private ownership (Federal-Provincial-Territorial Task Force, 1988: p.7).

The Canadian Independent Telephone Association (CITA) is an association that was founded in 1905 and is comprised of 42 Canadian companies operating telephone systems in the Yukon, British Columbia, Northwest Territories, Alberta, Ontario and Quebec. In addition to interconnecting with the Stentor companies as part of the national public switched network, the independents also interconnect with Alascom, Ontario Northland Telecommunication, Sogetel, Télébec Ltée and Unitel. Together, the independents operate approximately 270 local exchanges (of which four-fifths are now digital), and they provide roughly 550,000 network access lines.

TABLE 4.2

Largest Canadian Independent Telephone Companies[19]

Company	Type of ownership	Serving area
'edmonton telephones'	Municipally owned	City of Edmonton, Alberta
Northern Telephone	Investor owned	Portion of Ontario
Northwestel	BCE Inc. owned	Western portion of Northwest Territories, Yukon and northern British Columbia
Prince Rupert City Telephones	Municipally owned	City of Prince Rupert, British Columbia
Québec Téléphone	Investor owned	Portion of Quebec
Télébec	Investor owned	Portion of Quebec
Terra Nova Telecommunications	NfldTel owned	Portion of Newfoundland
Thunder Bay Telecommunications	Municipally owned	City of Thunder Bay, Ontario

Network management services are provided to the independents by Stentor's National Network Operations Centre in Ottawa and by the respective Provincial Network Operating Centres. As regards service restoration capability, most of the independents have few or no backup facilities due to the fact that they generally serve small rural and remote communities. Just the same, even during major system failures, service may be degraded, but it is almost never lost entirely for more than a very short period of time.

4.3 Industry strategies to maximize response capability

It will be recalled that the philosophy behind the Canadian telecommunications industry's approach to emergency preparedness is to ensure continuity of service. Consequently, the major telephone companies, though responsible for their own contingency planning and response strategies, are closely integrated in a national system of networks through Stentor member company agreements, and by arrangements with Unitel and the independents. Moreover, the guiding principle underlying their emergency planning is a reliance on pre-established standard operational procedures used for day-to-day applications as the key to effective emergency response. In this way, both the equipment and the contingency responses required will be familiar to those who may need to use them in a disaster situation.

Significantly, common industry strategies and practices to minimize service disruption have been implemented and are exercised regularly, by all the major telecommunication companies operating in Canada. In addition, personal contacts have been established bilaterally and through the Regional Emergency Telecommunications Committees (RETCs) between the major carriers which facilitate the provision of temporary backup transmission and switching capability in major emergencies.

The criteria applied to assess the effectiveness of Canadian industry strategies respecting emergency communications preparedness include: system **survivability**, **interconnectivity** and **interoperability**. These will now be discussed, in turn, with regard to their implications for efficient communications capability in a disaster.

Moreover, a variety of programs and procedures implemented by Canadian common carriers through arrangements between the federal Department of Communications (DOC) and Stentor are designed to maximize response capability in emergency situations. They fall into two broad categories: (1) network management, and (2) plant maintenance. The first category refers to voice, data and other communication signals carried over telephone company facilities. It concerns, specifically, developing methods to control the volume of traffic carried along a particular transmission path in order to prevent the overloading of switching equipment. The second includes everything dealing with the physical transmission and switching facilities, including the electronic devices used to send those communications signals over short or long distances. These will be discussed in sections 4.4 and 4.5 below, respectively.

4.3.1 Survivability

The mission of regulated telephone public utilities is to construct and maintain the necessary equipment, plant and human resources to provide a reliable communications network that will permit the public to communicate via voice or data between one point and the rest of the world, and at the lowest cost possible -- before, during and after a disaster. Survivability of adequate telecommunications facilities is thus an important consideration in the planning, operation and control of the domestic public telecommunications network. **Survivability** refers to the ability to provide a minimum acceptable level of service, including under extremely adverse conditions (Hoffman, 1990: p.6).

The major elements that ensure system survivability and service reliability are the size and the dispersal of the various networks. To improve the survivability of Canadian networks, therefore, adequate redundant intra and intermodal capacity together with highly developed rapid restoration techniques are required. Indeed, the multiplicity of transmission modes and routes across Canada makes it virtually impossible for any peacetime disaster, regardless of its magnitude, to destroy the entire national telecommunications system. Moreover, the circuits of individual trunk groups are further diversified by sharing them on all available routes. Bypassing of likely target areas and those considered vulnerable to industrial or natural disasters is also provided throughout the country by the telecommunications component of the federal Vital Points Program.[20]

To ensure minimum telecommunications capability for the continuity of government in an emergency, some degree of cross-country communications is required.[21] Thus, key telecommunications company installations must also be protected against electromagnetic pulse (EMP) and other physical effects of nuclear detonations or severe meteorological disturbances. Fibre optic or lightguide transmission systems (discussed in Chapter Five) offer significant advantages with regard to immunity from electrical and electromagnetic interference. Additionally, fibre cables can be installed parallel to or even mounted on high-voltage power lines. They also may be used in and around electrical generating stations and power substations. In this way, should power to a microwave repeater be carried on wires within the optical cable, it too would be protected from all interfering effects to which the fibre is immune -- for example, power line induction and lightning strikes which could generate severe voltages on the powering systems that might knock out repeaters (Gudmundson, 1981). However, unless switching and microwave facilities are also protected by hardening, the system could not survive a worst-case disaster (i.e., nuclear war). The telecommunications portion of the federal Vital Points program, administered by the Department of Communications in co-operation with National Defence, addresses questions concerning installation protection or "hardening." System survivability can be further enhanced by larger geographical spacing between repeater points, resulting in fewer repeater stations to be protected in the national system.

Another way to improve system survivability has to do with network design. SaskTel's broadband network, for example, provides fully interconnected service between Saskatchewan's 51 largest communities. Initially installed to provide cable television (CATV) and some telephone trunks, the system ultimately will provide complete integration of voice, video and data services. Its network configuration involves the conversion from a "tree" configuration to a "ring" structure.[22] The latter is designed to link 50 or so master digital switches which, in turn, will be connected by fibre to approximately 300 digital "slave" remote switching units. A ring configuration as opposed to a conventional CATV network topology means that transmission service could be provided in either direction, around a loop. In this way, it would be possible to avoid a failed section while retaining full service elsewhere in the system (Gudmundson, 1981).

4.3.2 Interconnectivity

By **interconnection** is meant the connection of a communications channel, facility service, apparatus or equipment with another. Network or system interconnection similarly involves the connection of the transmission facilities of one telecommunications carrier with other transmission facilities, either user-owned or furnished by a competing commercial carrier. To enable communication between two telecommunications service providers, the following must be considered: first, the electrical and physical characteristics of the medium chosen for interconnection; second, the signalling used to ensure reliable transmission and reception of information; and third, the means of effecting flow control in order to align the rate of information exchange with the processing capabilities of the switch. Interconnection services available in Canada include services such as foreign exchange (FX), tie-trunk service, off-premises extension (OPX) service, full-period private line service, and bulk facilities service. Each of these is currently possible through the interconnection of Unitel with the Bell Canada and British Columbia Telephone Company (BCTel) networks.

Telecommunications interconnection technology had its origins in advances made in the 1960s in the development of new materials and processes used to interconnect electronic components. Among the key developments in that area are included printed wiring technologies, automated assembly processes (i.e., wave soldering and numerically controlled wiring), thin-film hybrid circuits and highly reliable separable connectors. In this way, it became possible to build batch-fabricated, inexpensive and reliable electronic subsystems. Three additional external factors also came into play -- namely, the development of silicon integrated circuitry technology, automated systems for assembly and testing, and the architectures of electronic systems. Today, the electronic-based functions of current telecommunication networks are embedded in integrated circuitry. These circuits are connected by programmed media which determine connection length, propagation speed, etc. (Hoover, et al., 1987).

Conventional interconnection is achieved through multi-chip, large-scale integrated systems. Physically smaller devices with faster intrinsic speeds and lower intrinsic switching and storage energies have generated very large-scale integration, and they promise ultra-large scale integration on single, monolithic chips in the near future. These developments suggest a minimum channel length of between only 0.25 and 0.5 micrometres in silicon MOS devices for conventional circuits -- about three to five times smaller than currently available integrated devices (Hatamian et al., 1987).

Open system interconnection (OSI) is another new concept that involves standardized procedures or protocols for the exchange of information among terminal devices, computers, individuals, networks, processes and the like which are "open" to others for this purpose. OSI is essentially a reference model being developed jointly by the International Telecommunication Union's International Telegraph and Telephone Consultative Committee (CCITT) and the International Standards Organization. It eventually will provide a common basis for co-ordinating the development of international standards with the aim of full system interconnection.

Inferred in the discussion above is the importance of being able to interconnect networks in order to meet extraordinary communication needs. With this goal in mind, it is necessary to develop procedures and negotiate arrangements among government organizations that would be able to provide communications support to lead response agencies during a disaster. The appropriate body to undertake such a task at the federal level is the Government Telecommunications Agency (GTA). Respecting intergovernmental arrangements, discussions could be held under the auspices of the RETC meetings. And while, ultimately, formal agreements would have to be concluded, informal arrangements would be sufficient in the interim to make the available facilities resources known to those agencies that might require them in a major emergency, and to establish the necessary standard protocols to achieve technical interconnection with and between, for example, federal and provincial government-operated networks. In addition, commercial service providers need encouragement from governments to establish flexible operational procedures and informal arrangements so as to ensure accessibility by essential-user subscribers to other networks' facilities in an emergency. It also may be necessary for federal regulators to reconsider restrictions on network interconnection for the purposes of ensuring essential communications service provision in exceptional circumstances such as those associated with a catastrophic disaster.[23]

4.3.3 Interoperability

Where, in addition to the presence of physically interconnected communications media, there is a meaningful exchange of information between entities within a communications system across those media, the entities are said to **interoperate.** Interoperability necessitates consideration of a number of other considerations besides physical interconnection. These include: (1) basic technical incompatibilities; (2) standards bodies and proprietary architectures or "protocols"; (3) the network layer (of seven possible layers) and its substructure; (4) the applicability of CCITT Recommendation X.25, an interface specification or access protocol; (5) gateways -- defined as commercial equipment and enhancements; and (6) the specific application.

The national public switched network in Canada is considered to be fully interoperable. This means that the equipment used, system maintenance methods and emergency planning are uniform throughout the country. A central feature of interoperability is technical network compatibility, because only in this way will interconnection between networks be useful. For distinct communication networks to be compatible, they must share a number of features, as outlined below.

(1) **Standardization** -- which assures compatibility among the various equipment and circuitry in the network, and allows for emergency patching over different routes and facilities. Standardization also refers to common technical training approaches which will enable employees of one telecommunications company to assist those of another in an emergency situation.[24]

(2) **Flexibility** -- respecting multiple switching points, plug-in units and testboards, thereby permitting rapid service restoration.

(3) **Duplication of essential equipment** -- including common control circuitry such as senders and markers, each of which provides full backup capability. This also applies to multi-frequency and single frequency equipment.

(4) **Design margins** -- which involves designing equipment with a functional lifespan of 20 to 30 years, and installing it in buildings where it can operate unattended for long periods of time.

(5) **Buildings** -- are designed to rigid specifications; sensitive equipment is housed in their most protected areas.

(6) **Spare facilities** -- for example, trunk relay equipment, signalling units and carrier channel units. These are held in "hot" standby.

(7) **Power supply** -- backup and emergency power is available at all critical locations, such as telephone company central offices (COs), tandem and toll offices.[25]

4.4 Network management

Network management includes developing contingency plans for long-distance and local voice traffic control together with alternate call routing to be implemented automatically by switching central processing units (CPUs), or manually by telephone company network control staff. It also involves long-distance route diversification; metropolitan facilities junction planning; terminal area protection; and provisions for implementation of line load control (LLC) or essential line treatment (ELT) at the local level.[26]

The concept of network management is based on the division of the North American continent into several regions, each with its own regional switching centre. Two of these centres are located in Canada -- one in Montreal, Quebec and one in Regina, Saskatchewan. Moreover, each region is divided into sections which are managed by Provincial Surveillance and Co-ordination Centres (PSCCs); these, in turn, are subdivided into primary or district centres, toll (long-distance) centres and, finally, local or end central offices.

The Stentor companies provide a co-ordinated network nationally based on the objectives of: (1) responding to the changing service needs of the public; (2) efficient use of Canadian communications facilities; (3) meeting national emergency communication and defence requirements; and (4) maintaining established technical and operating standards. To that end, they operate a National Network Operations Centre in Ottawa, and they have established provincial network operations centre in each member company's territory.[27] Each of these centres provides network operation and management management, as well as network surveillance, monitoring and control functions. Operating in conjunction with the National Network Operations Centre is the association's National Data Network Control Centre which provides similar network surveillance, control and support of the DATAroute and DATApac national data networks. In addition, the national centre provides a liaison between the member companies and the federal government.

4.4.1 Alternate routing

Network switches are programmed to handle calls automatically along alternate routing paths designed to share traffic loads equally so as to prevent call blockages or completion delays. Alternate routing is implemented if the most direct route is already operating at full traffic-carrying capacity. When a call is dialled, the network switching equipment automatically searches for a free transmission path through the network, testing up to four or five alternatives. Traffic network management comes into play when either emergency or simple traffic overload conditions create demands for service that cannot be handled by the existing engineering circuitry layout pattern.[28]

For instance, there are a number of direct circuits between Ottawa and Vancouver, because the average volume of call traffic between these two points justifies their emplacement. As a result, when an Ottawa caller places a call to Vancouver, the switching equipment at the closest telephone company central office (CO) in Ottawa will try first to complete the call using one of the direct circuits. If these are all busy, the Ottawa switch will try its direct circuits to the Regina Regional Switching Centre. If that group of circuits is also in use, the call may be forwarded to Toronto and then on to Regina or Vancouver, and so on. This transmission path search takes place within just a few seconds -- a maximum of about 12 seconds for a coast-to-coast call using current switching technologies.

If all the automatic routing possibilities are already occupied -- as they often are on Christmas or Mother's Day -- telephone company network managers may decide to "massage" the system. This could mean temporarily reconfiguring traffic routing patterns hundreds or even thousands of miles around the network to access circuit paths that are not operating at full capacity. Alternatively, the caller may hear a recorded message advising that "all the circuits are currently busy."

Network management staff at district, provincial and regional co-ordination centres keep detailed records of long-distance traffic flows. At each of these, electronic status display boards provide information on exactly how trunk circuits and switching equipment are operating at any given moment. Flickering flags on the status boards indicate those switches that are operating at full capacity. In this way, problem situations are identified immediately. Regional centre status boards also show what is happening in the other North American regions. In addition, traffic managers are in direct voice contact with all control switching points in Canada, enabling them to make temporary changes in routing patterns quickly.

In emergencies, network managers also keep track of call traffic which normally uses the circuits that have been damaged or destroyed by the disaster agent; they then can reprogram the switching system to route calls around the damaged area. In so doing, however, they must ensure that that long-distance call rerouting does not overload other switches. Cable breakages or prolonged switching centre outages due to a disaster also may affect local area traffic.

Significant in emergency communications capability is the fact that the Canadian facilities network configuration differs from that employed in the United States. For example, at the local level, the Canadian network is configured in terms of the service coverage territory of a given switching centre. Theoretically, a local switching centre would house facilities for two to three telephone exchanges, depending on the average volume of call traffic in normal times. The communication channel capacity of an individual switch may vary -- from approximately 10,000 to 25,000 circuits.

As regards emergency communications capability, in Canada (unlike in the United States) the so-called "local loop" which connects the subscriber line to the public switched network does not extend beyond the nearest telephone company CO. Telephone company intercentral office cables connect the various local switching centres in a given local service are to each other; and these are connected also by wire line to the various COs whose traffic is routed through them. These, in turn, are connected to individual subscriber lines. Thus, even a call placed to an address across the street is routed via the telephone company's CO. And if the caller's line and the destination address on opposite sides of a particular switching centre's service territory boundary, the call would have to be routed as follows: it would be transmitted first from the call initiating terminal to the nearest CO. Then it would be transmitted on to the caller's switching centre, on to the destination switching centre, the destination CO and, finally, to the addressed subscriber line. Significantly, the local switching centre is connected to each of the COs in its coverage area as well as to other switching centres; it is not, however, connected to any of the COs that connect to another switching centre, even if they are in close proximity to one another.

In the United States, by contrast, it is commonplace to have two switching centres cover the same serving territory, with each connecting to several or all of the other's COs, in addition to its own. The advantage of this approach is that it provides an added degree of duplication or redundancy in the local network which is not available in Canada. As a result, if a cable is cut, customers within the affected serving area likely would not lose service. But in Canada, when a CO switch is lost, all the users within its operating territory will experience service loss until PSCC network managers intervene manually to reroute calls around the lost switch. The implementation of integrated services digital network (ISDN) in portions of the Canadian network is now under way, along with the introduction of common channel signalling.[29] This is expected to lead to a redefinition of conventional switching territories to resemble more closely local network configurations in the United States. In this way, Canadian long-distance and local call routing flexibility is expected to be will be improved significantly.

With regard to Canadian long-distance network management configurations, trunks are designated in terms of traffic volume.[30] A number of high-usage trunks (e.g., Toronto 7 and Montreal 6-10 switches) are programmed to handle a 30 per cent peak overload. This means that if 130 calls were being routed simultaneously through a given switch and there were only 100 circuits available for use, 30 calls could be rerouted automatically to alternate routes; additional callers would be advised that the circuits are busy and their call could not be completed at that time. The "Montreal 7" switch is the final trunk for eastern Canada -- that is, it provides the last alternate routing option for overloaded switches in the Eastern Region. If call routing demand is higher than the capacity of a particular trunk, an alarm (designated by an orange flag for high-capacity trunks) will flicker on the surveillance centre's electronic status board; if the trunk is jammed for an extended period or if automatic rerouting causes other switches to jam, network managers will be able to adjust call traffic patterns manually in order to handle the overflow.

In major emergencies or catastrophic disasters, current switching and transmission technologies do not allow a priority to be placed on long-distance calls -- even those initiated by "essential users." Bell Canada advises, however, that studies are underway with Northern

Telecom which are aimed at establishing some kind of "tagging" software procedure that would allow pre-identified emergency users to be given priority throughout the public long-distance network.[31] The Canadian emergency community, as well as Unitel and the independent telephone companies, also have been advised by Bell that if they find that they cannot complete a long-distance call in the normal way, pre-identified individuals in their organizations can do so through the telephone company's long-distance telephone operators (that is, if they are able to reach one!). To do this, they could be provided with special codes identifying them to the operator and, in turn, to network managers who then would themselves "patch" the call across the public switched network. Another option would be to route calls between essential-user Bell subscribers by patching them through to physically separate networks, such as those belonging to Unitel.[32]

4.4.2 Route diversification

Another measure that the telephone companies have built into the day-to-day operations of the long-distance public switched network is route diversification.[33] This refers to the geographic separation of primary and backup transmission cables between major nodes on the network. Its purpose is to prevent total service interruption. Route diversification thus provides added flexibility; it also provides a greater assurance that the telephone company will be able to handle fluctuating traffic volumes. It does this by allowing calls to be rerouted in a variety of ways along physically separated transmission paths, including, if needed, using the "protection channel" which backs up each primary transmission route.

Detailed plans have been set down by Stentor to ensure that if service is lost, the network would be able to restore partial service immediately by using the protection channel transmission routes. Thus, if the primary transmission route between two main centres or "nodes" fails due to traffic overload, built-in network management software would restore service as follows: Service would be restored immediately to all specialized services, including private line users and those identified as eligible for line load control/essential line treatment (LLC/ELT). Second, Department of National Defence (DND) circuits would be restored. Finally, 30 to 50 per cent of regular message toll service (i.e., long-distance voice) traffic would be restored.

To make that possible, the circuits in each traffic group are planned so as to divide them among available routes as evenly as is practical.[34] In this way, if loading among routes is roughly even, then the survivability of any cross-section thereof upon the failure of one route would be at approximately 50 per cent. This could be improved substantially by using the protection channel on the other route (EMO, 1968-69: p.7). Therefore, where only two landline transmission routes exist between two points on the national long-distance network (there are three between major urban centres), and where both carry approximately the same volume of traffic under normal circumstances, at least half of the calls would be unaffected by the failure of one of the routes. Where there are three equally loaded routes connecting two points, no more than a third of the switching and transmission capabilities would be lost.

4.4.3 Metro facility junction plan

Additionally, the telephone companies have put in place a national metropolitan facility junction plan to improve survivability of the Canadian public switched network. It is designed to alleviate the impact of a catastrophic disaster in a major urban centre on the public telecommunications network. Since close to two-thirds of Canadians live in 17 major urban areas, this plan provides a way to bypass hub switching stations located either within or near to those centres. The main characteristics of the plan are as follows:

(1) A number of through-circuits bypass metropolitan centres entirely.

(2) The various transmission routes connecting major traffic junctions do not cross each other at any point.

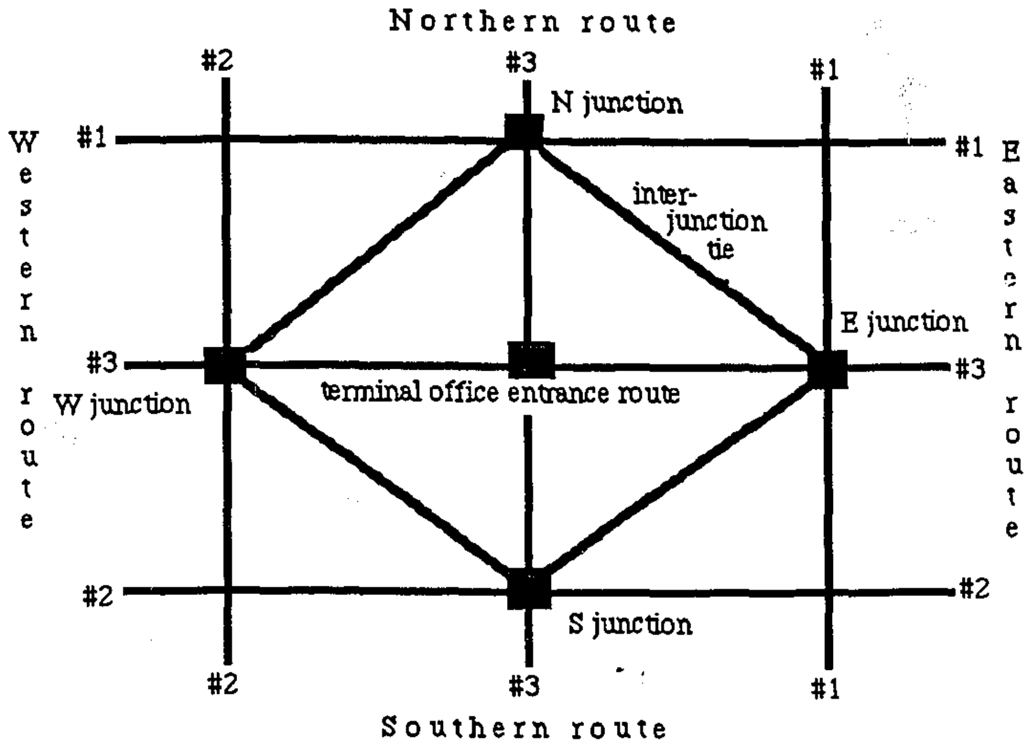
(3) Metropolitan junctions are planned so that only one transmission route in each direction passes through a common point.

(4) Traffic loads on all routes around metropolitan areas are roughly equal, so that failure along one route will restrict service interruption to that sector (EMO, 1969: p.7). Figure 4.3 below illustrates the metropolitan facility junction plan concept.

The number of junctions required around a given metropolitan area will be influenced by such things as the number of different routes required relative to normal long-distance traffic volumes. Other factors that have to be considered include the degree of dependence to be given to a particular junction, the amount of back-haul that would be acceptable, and the number and direction of normal transmissions -- e.g., incoming versus outgoing traffic (EMO, 1968-69: p.7).

To be effective, a minimum of two, and preferably three, fairly evenly loaded call routes are required in each direction around a metropolitan area. Each junction has a terminal link joining it to the terminal office: north-south junction service has routing points for east-west traffic, and east-west junctions are routing points for north-south traffic. Moreover, to enable maximum usage of protection channels for restoration, at least four junctions would have to be linked with the interjunction tie structure. Usually, junctions are located 35 to 50 km apart, so that even if a major disaster were to disable the terminal office, traffic routed through the surrounding junction points usually would not be affected (Bell Canada, 1969: p.7).

FIGURE 4.3
Metro Facility Junction Plan



Significantly, however, the Department of Communications has not provided any new guidelines to the telephone companies on safe siting and safe routing since the 1960s.[35] As a result, due to major technological advances -- in particular, the transition from analogue to digital switching and from copper and coaxial cable to high-capacity fibre optics transmission -- which have made possible the centralization of many network management functions while at the same time reducing diversity of transmission paths, carriers have not applied metropolitan junction planning concepts in the design of new networks.

4.4.4 Terminal area protection

Terminal area protection (TAP) is another aspect of Canadian communications emergency network management provisions for protecting the national public switched network. Facilities that are considered crucial to the domestic telecommunications system have been designed in such a way as to ensure that government authorities in all urban centres would have a way to communicate with the outside world, even if they were temporarily unable to talk to each other within the affected area.

Significantly, however, these facilities are designed to meet only the most basic communication needs of an otherwise isolated densely populated area. TAP circuits (also referred to as "Thread of Life" circuits) radiate outward towards nearby toll switching centres; TAP toll access offices are usually established on the outer fringes of larger Canadian cities. Only very small groups of reserved circuits (as few as 12) would be established between the TAP access office and a distant toll centre. In addition, only those telephone company network managers and government officials with a pre-determined need to use these circuits would know their numbers. TAP facilities are "hot" -- that is, operational -- at all times, and they are frequently tested by telephone company personnel. Moreover, the distant toll centre operator reached using TAP circuits has the ability to reach other network points -- including those that remain operational within an affected area -- without passing through any of the company's toll switching centres. The federal Vital Points Program, of which TAP is a part, together with LLC/ELT, which assures access by essential users to local telephone service, will be discussed later in the chapter (see section 4.6.1 below).

4.4.5 Carrier Working Group

The Carrier Working Group was established in 1951 to meet the Department of National Defence's (DND) national security telecommunications needs. Its executive members are from Stentor, Unitel and DND. Stentor also represents the independent telephone companies and American Telephone and Telegraph (AT&T) in the United States (because it has a direct liaison with that company in the provision of long-haul communications). Unitel similarly represents the telephone companies in Newfoundland and the Yukon along with Western Union. Thus, the group's industry representatives are the designers of Canadian network architecture planning. The purpose of the group is to provide a commercial carrier perspective regarding assurance of continuity of service -- in both normal and emergency contexts.

The Carrier Working Group's mandate is to analyse all defence network communication needs in Canada, and to meet military demands without prejudice. A particular concern of the Carrier Working Group is industry readiness as regards electromagnetic pulse.[36] Also as part of the defence planning program, approximately 600 essential command-and-control circuits have been identified. These are considered by DND to be vital to national defence and security. The minimum service objective of the industry with respect to these so-called "select circuits" is 99.99 per cent effectiveness (EMO, 1968-69: p.8).

Also included in the industry program for defence planning is the establishment and maintenance of a warning system that connects all Canadian military bases and installations. Only a few administrative circuits assigned to DND are carried on the public switched network. The rest are carried on DND-owned and operated switched networks which are connected to other security and defence switches that form the world-wide Autovon network operated by the U.S. Defense department. DND also operates a separate switched data network (ADDN) which carries low and medium speed data. Moreover, the military network interconnects fully with the integrated continental air defence system, NORAD.[37]

While defence planning has no direct link with peacetime emergency communications, it is possible that in a peacetime civil emergency -- should all else fail -- the Department of National Defence could be requested (through the DOC and EPC) to provide limited access to its physically separate network under the "aid to the civil authorities" provisions of the National Defence Act.

But curiously, most of DND's circuits currently are carried on digital fibre optic cables provided by major Canadian carriers. This means that they no longer meet the criteria specified in the "safe site/safe routing" guidelines outlined in ENTO 1/63 with respect to defence network survivability.[38]

4.5 Plant maintenance

The second broad category of strategies developed by the Canadian telecommunications industry to mitigate service loss is plant maintenance.[39] This refers both to preventative and restoration provisions related specifically to telephone company equipment and physical plant facilities. Therefore, whereas the network management programs discussed above relate to potential problems associated with handling abnormally high telecommunications traffic volumes, plant maintenance measures deal with the maintenance and repair or replacement of coaxial and fibre optic cables, microwave towers, satellite earth stations, repeater stations, switching equipment, buildings housing switches, etc. It also involves contingency planning for rapid restoration of service in the event of service loss, whether the problem is along landline transmission paths, at a microwave repeater station site or in a switching centre CPU.

Preventative maintenance is perhaps the most important factor in ensuring network survivability. The preventative function of plant maintenance is handled by arrangements among the Stentor companies and, on a less formal basis, with Unitel and the independents. Accordingly, communications equipment and facilities are checked, tested and given routine maintenance at regularly scheduled intervals. In addition, alarm systems have been installed throughout the national system to indicate a failure or possible failure, such as an engine running hot or a failed fuse (EMO, 1968-69: p.9).

The reactive function -- that is, service restoration -- is carried out by the telephone companies' Damage Assessment Centres. Thus, in a localized emergency, these centres would take over direction of restoring local cable and switch facilities to full operational status. In a major disaster resulting in more widespread damage -- such as one causing outages at more than one CO or switching centre -- they would report to the appropriate telephone company Status Centre location, which in an emergency becomes its emergency operations centre (EOC).[40] The EOC, in turn, would report the status of plant damage to the Regional Switching Centre, and it would report to Stentor's National System Emergency Operations Centre.

To perform normal day-to-day operations, line maintenance staff keep track of the status of the network within the telephone company's serving area. For long-distance communications, a control office has been designated for every toll circuit installed. It monitors the circuits and, when a failure occurs, gives instructions to all the other switching office CPUs along the affected route, and automatically implements (pre-programmed) contingency plans to ensure rapid service restoration. Large toll offices, and major cable and microwave routes maintenance centres are staffed 24 hours a day, 7 days a week (24/7); smaller offices are staffed 8 hours a day, 5 days a week (8/5), with expert technical staff on call nights and weekends.

To maintain the national telecommunications system, it is necessary to know, at all times, the operational status of the public switched network -- its individual component parts as well as the system as a whole. Thus, each of the major telephone companies maintains its own Network Surveillance Centre, which is co-located with its Network Control Centre. Management personnel at these centres assist in preparing joint national restoration plans, and they report any abnormal situation immediately to corporate management. In addition, they review and assess, on a daily basis, all system monitoring reports on potential as well as actual system failures. They also liaise with other surveillance centres across Canada and in the United States.

Like the status boards in the Network Control Centres that monitor call traffic volumes on the switches, video display screens in the surveillance centres show the status of every microwave repeater station and cable link between stations on the telephone company's network. A breakage or outage of any kind -- even a door left open at a station site -- would be indicated on the screen by a flashing alarm light over the station's call number. If maintenance staff responsible for the site do not call in to report on the situation within a two-minute time lapse, the nearest police station will be contacted to go and check out the site. Once the cause of the outage is known, the flashing light will be replaced on the screen by a coded symbol indicating that the situation there is known but not yet corrected. Surveillance Centre staff also are in continuous direct voice contact with every repeater station along every route, as well as with the company's mobile repair crew.

Intercity transmission facilities -- that is, cable for distances under 30 km, and microwave for longer distances -- contain many two-way radio channels, most of which are assigned to voice circuit services.[41] Two additional channels are reserved for circuit protection. And when an outage occurs along a transmission route, traffic is automatically switched to a "protection circuit" channel.[42]

Where the extent of the physical damage to the facility is such that protection channel coverage would be inadequate, **broadband restoration** allows for short-term rerouting.[43] When implemented, it may detour traffic around the damaged facility by up to hundreds of kilometres, utilizing the protection channels of other routes. Broadband Service Centres continuously monitor the microwave radio system and track which portions of the protection circuit are being used at a given moment. Broadband restoration is designed for failures of short duration caused by problems with the physical facilities of the system, not by traffic overloads. Telephone company Broadband Restoration Offices assign available protection channels on the company's microwave/fibre optic network for temporary service restoration.

Emergency restoration takes over where broadband restoration leaves off. It supplements broadband restoration in cases where damage along a transmission route is extensive, and where repairs or replacement of physical plant are expected to take several days or weeks. Emergency restoration procedures would be implemented in events such as that of a telephone company building that houses a repeater station, a microwave tower or a switch being destroyed by fire. Bell Canada's emergency restoration equipment, for instance, includes a 40-foot trailer unit containing a transportable 300-foot microwave tower capable of providing an estimated 2,340 voice circuits (or 78 voice and 2 television channels) in each direction. That company also has two mobile repeater trailers which house TD2 radio and power equipment as well as diesel generators; each of these is capable of restoring 780 voice circuits. In addition, it has four mobile COs strategically located in its operating territory. These could be made available to restore small community switching offices, thereby making it possible to restore up to 1,200 subscriber lines within 8 to 12 hours.[44] The other major telephone companies have some emergency restoration capability as well, including complete mobile switching centres and portable microwave towers which are distributed across the country.

Finally, a prolonged power failure cannot be tolerated if continuity of service is to be preserved. As a result, all telephone company switching centres are equipped with backup battery power as part of their emergency restoration equipment. These batteries are capable of operating on-site equipment at peak load for enough time to establish emergency power supplies following an interruption in commercial power. Major switching centres and microwave repeater stations also have permanently installed diesel or turbine-powered generating units to supply alternate current (AC) power for up to two weeks at a time. Moreover, all telephone company district offices have portable generating units ranging from 1.5 to 150 kilowatts for use during an extended power failure. Fuel and lubricating oil sufficient for several days of continuous operation is also stored at microwave repeater stations, and portable generating units are strategically located to be used in smaller telecommunications company buildings as well. In addition, complete radio-relay station trailers are available to replace temporarily damaged microwave stations. Finally, vehicles equipped with mobile and cellular telephones could be used to assist in providing power to hospitals, co-ordinating local emergency response communications operations, and providing other essential services in disasters.[45]

4.6 Government/industry programs

The main objective of emergency communications planning in Canada is "assuring there will be survivable essential telecommunications in an emergency" (DOC, no date (f): p.4). In addition to the Emergency Broadcast System (EBS), which provides formalized access to CBC broadcasting facilities to officials from the federal down to the municipal level, and the National Warning System, both of which programs are discussed in Chapter Six, the DOC oversees several other emergency communication programs. All of these require the co-operation of the telecommunications industry, other federal departments and agencies for their effective implementation. The main ones include Line Load Control; Vital Points; National Restoration Priority System; Inventory of Telecommunications Resources; and Emergency Response to Disasters. Each of these will now be discussed in turn. A brief summary of related support programs will then be provided.

4.6.1 Line load control/essential line treatment

The Line Load Control (LLC) concept -- commonly referred to as "essential line treatment" (ELT) by the telecommunications industry -- originated in the early 1960s.[46] The program was initiated as a way to ensure that essential telephone users would be able to originate calls even when the public telephone system was overloaded. In terms of emergency planning, LLC/ELT is essentially a preventative arrangement the goal of which is to ensure access to the local exchange portion of the public switched network in the event of a disaster or other emergency during which local switches are likely to be unable to accommodate the increased volume of traffic within the affected area. It achieves this by increasing "the possibility of essential users/responsible agencies placing the telephone calls required to deal with emergency situations."[47] In 1978, the Canadian Telecommunications Carriers Association (CTCA, now Stentor) and the DOC concluded a co-operative arrangement whereby, in the event of system overload, telephone service would be preserved for pre-identified individuals (or, more accurately, their telephone lines) who have vital functions to perform.[48]

The DOC's role in the program is to formulate and maintain a nation-wide list of the 120,000 or so telephone numbers (office and residential) of essential service personnel and emergency agencies. For the most part, those included on these listings are key organizational personnel who also have been identified in their parent organization's emergency plans. To be included under the LLC/ELT program, the telephone listings must meet the DOC's criteria for essential users or services. Other requests for inclusion -- such as for private firms providing emergency supplies and services -- must be approved at the regional level by the appropriate Regional Emergency Telecommunications Committee (RETC).[49]

In order to deal with the anticipated dramatically increased traffic load during a large-scale emergency or catastrophic disaster, the telephone companies have installed LLC equipment and ELT system software to assist in local network traffic management.[50] LLC/ELT is a voluntary program, currently provided at no charge by the telephone companies to government and other designated essential users. The capital requirements for implementation and ongoing maintenance of the program vary by company and geographic region, depending primarily on normal call traffic load conditions. For these reasons, each carrier will decide which of its switching centres are to be equipped with LLC/ELT capability. Similarly, the authority to invoke LLC/ELT rests with the individual telephone companies, except in very exceptional circumstances (such as a national emergency) when the federal Minister of Communications might direct the telephone companies to implement LLC/ELT.

The decision to implement LLC/ELT means that those lines that have been pre-identified in the telephone company's subscriber database will receive priority over other lines in receiving dial tone. This will enable them to originate calls even in a situation of acute network overload. Other users might find their service temporarily suspended; that is, they would not be able to get dial tone for up to several minutes.

Significantly, LLC/ELT also extends to public coin-operated telephones. In this way, the public at large is assured access to the public switched network to meet individual emergency communication needs. Nor does LLC/ELT implementation affect calls already in progress or incoming calls; the ability to receive calls would still be possible for all subscribers.

Perhaps the most serious limitation of LLC/ELT is that cannot guarantee call completion. Indeed, overload conditions at any telephone company switches along a call's transmission path will prevent the call from being completed.

For the most part, only individual lines are identified for priority access. Just the same, Centrex (i.e., a private branch exchange-like service which connects each line to a the telephone company central office), and some private branch exchanges (PBXs) also can be accommodated by LLC/ELT. With regard to PBXs, due to the variations in trunking configurations, etc., LLC/ELT apparently can be provided only to those with outgoing trunks under the control of an in-house console operator. Where this is the case, the main telephone number of the incoming PBX trunk lines would be included on LLC listings; extensions would not be prioritized, and special procedures would have to be followed by the telephone company to provide LLC/ELT to those lines.[51] Moreover, the program is available only in those areas that are served by an electronic exchange; LLC/ELT is therefore not available in smaller communities still served by mechanical or electromechanical switches.

DOC Ottawa has responsibility for developing guidelines and priorities to be used by government agencies in the selection of telephone numbers to be protected under the program. It is also responsible for developing, in co-operation with the regional offices, the computer software to compile and update the listings, and arranging for computer storage of confidential LLC data. Regional DOC staff, in turn, apply the national selection criteria to their own regional requirements, and they do the actual compiling of the LLC lists not only for the federal departments and agencies operating in the region but, through provincial authorities, for provincial and municipal departments and agencies as well.[52] Thus, the telephone companies provide the service, while the DOC is responsible with providing them the lists of telephone line numbers to be protected. Table 4.4 below provides examples of essential users and services included in the national LLC/ELT program.

TABLE 4.4
Line Load Control Allocations[53]

Essential users/ services	Maximum number/ type of lines to be listed
FEDERAL	
Cabinet Minister	one business line and one residential line
Emergency Operations Centre	All outgoing lines
Departmental EOC	All outgoing lines

- Transport Canada (Airport)	
- EPC Situation Centre	
- National Defence	
Personnel assigned to EOCs	one residential line per person (maximum of three per centre)
Commissionaire's desk (24/7)	one business line
Departmental Operations Centres	10 % of regular service to a maximum of ten lines
- Transport Canada - Air	ten business lines at each location
- Canadian Coast Guard	
- External Affairs	
- Solicitor General - RCMP/CSIS	
- Environment Canada - AES	
Penitentiary (Warden's Office)	one business line
Transport Canada	one business line
- Transportation of Dangerous Goods (TDG)	
Customs (Border Crossings)	one business line
Veteran's Affairs	Maximum ten business lines at each location
- Acute Care Hospital	
Armories	one business line
PROVINCIAL/TERRITORIAL	
Cabinet Minister	one business and one residential line
Emergency Measures EOC	All outgoing lines
Personnel assigned to EOC	one residential line each, to a maximum of three
Provincial Police	10 % of regular service to a maximum of ten
Communications Centre	outgoing lines per station and ten outgoing lines per centre
Correctional Institutions (Warden's Office)	one business line
Conservation Authority	one business line
Environment	one business line
Natural Resources	one business line
Armories	one business line
Highways Department	one business line per engineering yard
MUNICIPAL	
Mayor	one business and one residential line
Municipal EOC	All outgoing lines
Municipal Airport EOC	All outgoing lines
Personnel assigned to EOC	one res. line per person to a maximum of three
City Hall	10 % of regular outgoing service to a maximum of ten lines
Social Services	10 % of regular outgoing service to a maximum of ten lines
Transportation Services	one business line per sub-office or municipal yard (Highways)
Public Works (water and sewage)	one business line per pumping station and filtration/treatment plant
Health Services	10 % of regular outgoing service to a maximum of ten lines
Fire Department (Dispatch)	Maximum of ten outgoing lines
Fire Chief	one business and one residential
Volunteer Fire Departments	one business line per fire station in addition to an alert system
Municipal/Provincial Police	Maximum of ten outgoing lines per Communications Centre, and 10 % of

	regular outgoing service to a maximum of ten lines per station
Police Chief	one business and one residential line
Public Ambulance Service	Maximum of ten outgoing lines
Private Ambulance Service	10 % of regular outgoing service to a maximum of ten lines
Schools	
- Primary	one business line
- Secondary	one business line
- Universities	one business line
Hospitals	Maximum ten outgoing lines
Senior Citizens Homes/ Nursing Schools	10 % of regular outgoing service to a maximum of ten lines
Enclosed Arena/Stadium	one business line
Armories	one business line
Doctors with acute care hospital privileges in communities of 10,000 population or less	one business and one residential line
Salvation Army	10 % of regular outgoing service to a maximum of ten lines
Red Cross	10 % of regular outgoing service to a maximum of ten lines
St. John Ambulance	10 % of regular outgoing service to a maximum of ten lines
Hydro and Gas (Dispatch Centre)	one business line
Petroleum Tank Farms	one business line per company
Public Transit (Dispatch Centre)	one business line.

4.6.2 Vital points

The Canadian Vital Points program began in 1938. At that time, the federal Cabinet decided it was necessary to identify and protect certain government-owned and industry facilities considered essential to any preparation for a national war effort. The program was renewed in 1979, and today it is directed by a special Advisory Committee on Vital Points.[54]

There are two basic categories of vital points. The first includes those considered critical to the nation as a whole; these are very few in number and they are almost entirely federal government facilities. The second category includes other federally or provincially designated vital points, including "any telecommunications entity which is deemed by reason of its particular importance either by the individual owner or the Advisory Committee on Vital Points to warrant inclusion" and regardless of whether it meets other vital points criteria.[55]

A **vital point**, for telecommunication purposes, is defined as follows:

> A facility, a resource or a service considered essential to the security and continued functioning of the country or province/territory and which therefore warrants extra security precautions to protect it from interference, destruction, or disclosure (DOC, 1991b: p.4, para 4.2).

Thus, it is an essential feature of a national telecommunication facilities network without which cross-country service would be jeopardized. Together, the DOC and the commercial carriers have established the telecommunications portion of the Vital Points program.[56] Using their own data and information based on Royal Canadian Mounted Police conducted security surveys, common criteria have been established for uniform determination of telecommunications vital points nationally. Additionally, the kinds of protective measures that are to be taken to meet those criteria have been indicated. Finally, the program provides guidance to governments on these and related measures, and to the industry respecting the hardening of vital facilities.

Under the Vital Points program, carriers examine annually and categorize locations with reference to established criteria governing their identification. In addition, they provide, at their own expense, the means to protect their assets as vital points locations against vandalism, sabotage and common trespass. The carriers look to governments to provide any additional protection considered necessary with respect to threats of war, civil insurrection or riots (CTCA, 1978d: pp.1-2).

Federal listings of telecommunications vital points are classified as "secret"; and the locations identified therein are included in lists drawn up by DOC Ottawa. Its role is to review the lists provided by the carriers of which buildings, and other telecommunications company structures and facilities need to be protected, to ensure that they are accurate.

Provincial and territorial governments are now in the process of developing their own vital points lists, with assistance provided through regional EPC and DOC offices. The regional offices of the DOC are responsible for ensuring that communications vital points considered essential to the support of regional contingency plans are identified and listed. These latter lists are "confidential" (but unclassified), and they are registered with the Royal Canadian Mounted Police (DOC, 1984: p.6).

4.6.3 National restoration priority system

As already mentioned, the principal objective of the telephone companies is to provide maximum reliability of service for all subscribers (CTCA, 1978a, and 1978d: p.1). It is anticipated, however, that during large-scale disaster, for example, portions of the national telecommunications system would be rendered inoperable. In order to accommodate essential service provision under such circumstances, a National Restoration Priority System (NRPS, also known as the "circuit restoration" program) has been established in Canada so that if service loss does occur, selected services would be restored in a predetermined order of precedence. In this way, essential communication resources can be protected and managed effectively in the national interest.[57]

The NRPS program also involves developing and administering federal emergency plans to ensure restoration of point-to-point (dedicated) communication circuits serving federal government departments and agencies, and linking them with provincial and, in some cases, municipal authorities. In addition, it is designed to meet essential non-telecommunications industry requirements to facilitate government response activities. Those non-governmental customers who also may be considered eligible for priority restoration are to make application to the DOC for classification of the services for which they require priority certification.[58] The DOC, in turn, will classify all services so identified, and advise the carrier of the priority certification accorded.

The carrier, in the event that service is lost, and regardless of the cause, will restore certified private line services in the order of their assigned priority. Significantly, the carrier will implement the restoration system at its own cost. Additionally, since the design and configuration of Canadian telecommunication networks are now such that restoration of groups of circuits simultaneously may be the most efficient way to restore service, and regardless of individual user circuit priorities, the allocation of priority restoration to specific network facilities is to be at the discretion of the carrier.

To be practical and economic, the program must have a single policy for all conditions of peace and war. Secondly, it must contain the basic elements necessary to ensure national network integration and compatibility with U.S. networks. Third, it has to permit commercial carriers to meet normal demand for new services. Fourth, it must not impose unnecessary restraints on the normal operations of carriers or incur excessive implementation costs the carriers might be unwilling to assume. Finally, the carriers must retain exclusive authority to co-ordinate and control the activity of service restoration (CTCA, 1978b: pp.1-2).

Like the other federal emergency communication programs discussed earlier, the NRPS has been developed in co-operation with the telecommunications common carriers. Essentially, it establishes the right of selected telecommunication services to be restored, if they experience failure, before another affected service (DOC, 1983b: para 3.4). It is worth repeating that the type of services of concern in this regard are private line services. Thus, included in this category are individual, dedicated communication circuits and private switched networks -- as distinct from public switched network services (DOC, 1983b: para 3.5). Restoration priority listings, like line load control, then are determined and prepared by the DOC in consultation with government users, and they are updated quarterly. The DOC's authority for developing and maintaining this program derives from its responsibility to assist federal, provincial and municipal governments in planning for emergencies. The department's national NRPS plan, established in the mid-1980s, aims at implementing a NRPS across Canada, and sharing responsibility for its maintenance among special subscribers, the federal government and the telecommunications common carriers (DOC, 1984: p.7).

At the regional level, those services that are protected under the program are approximately (although not automatically) the same as those identified in regional line load control listings. As with LLC/ELT, the regional offices of the DOC apply national criteria and guidelines in establishing and updating their priority restoration listings. They also provide the lists of circuits to be included and assign priorities to the local carriers (DOC, 1988a: pp.9-10).

The criteria to be applied for priority restoration follow. Priority "1" would be assigned only to private federal and foreign government lines (i.e., for defence and diplomacy). And in those categories, they would be further restricted (under conditions ranging from national emergencies to nuclear attack) to a minimum number of circuits considered essential to national survival -- that is, for: (a) obtaining or disseminating critical intelligence; (b) conducting critical diplomatic negotiations; (c) executing command-and-control of military forces for defence and retaliation; (d) giving warning to the Canadian population; and (e) maintaining federal government functions (i.e., continuity of government).

Priority "2" would be assigned to private federal and foreign government lines (for public information). They would include a minimum number of additional circuits considered essential to maintain an optimum defence posture, and for alerting the population if attack appears imminent.

Priority "3" would be assigned to all other private line circuits belonging to the Department of National Defence and the diplomatic corps. They would be for those services other than those identified as priority 1 or 2 circuits, whose early restoration is considered necessary to maintain military defence and diplomatic posture for the maintenance of law and order, or to protect the health and safety of the national population.

Priority "4" would be assigned to those services whose early restoration is considered necessary to maintain public welfare and the national economic posture. Finally, Priority "00" would be assigned to those circuits that do not meet the criteria for any of the other priority assignments.[59] It is estimated that the national total of those users having an emergency response obligation and consequently likely would be involved in the program is about 120,000 in all -- a number comparable to that included in the DOC's national LLC/ELT listings.

4.6.4 Inventory of telecommunications resources

The DOC's Inventory of Telecommunications Resources program involves establishing a catalogue of public and private network capabilities and spare equipment on a region by region basis. The concept relates to the fact that major disasters -- such as tornadoes and floods -- invariably will quickly exhaust existing local telecommunication resources. Such an event also will create a demand for new or additional communications facilities to help public safety personnel manage the emergency response. This is especially likely to be the case in a large-scale disaster that occurs in a remote area.[60]

Under the program, the DOC manages a national information database on all licensed telecommunication users. It includes the radio frequencies assigned to each, and the number of radio receivers and transmitters operated by them.

The purpose of the inventory program is to provide an easily accessed information source to support emergency system restoration. Alternatively, it could be used provide additional telecommunications equipment to disaster response officials with the shortest possible delay. In extreme cases, it might even involve the DOC's commandeering of telecommunications equipment from a private company for the duration of an emergency.

Since it is very costly to provide emergency communications, especially to remote areas, attempts have been and continue to be made to find new ways to meet those needs at lower cost. Past experience has shown, however, that oftentimes public or private communication facilities actually were available in the disaster affected area and they could have been borrowed had prior arrangements been made. Consequently, the DOC is developing this program as a method for determining exactly what communication facilities exist in any given geographic area in Canada, together with the conditions and terms under which they could be made available in an emergency. Additionally, the department has used the program as a way to establish contacts with large private and government telecommunication users, as well as with potential service or equipment suppliers. The bulk of the work related to gathering this information is done by the DOC's regional offices (DOC, 1986a: pp.17-18). A hard copy of inventory-related information is produced approximately every six months and kept on file at DOC headquarters in Ottawa.

4.6.5 Emergency response to disasters

The DOC's Emergency Response to Disasters program involves selected departmental personnel who are authorized to work directly with commercial carrier Service Co-ordination Centres in order to obtain fixed telephone and data service for on-site emergency operations centres (DOC, 1985d: para 3.3). This program is in response to the DOC's mandate to provide communications assistance at the scene of an emergency or disaster. Significantly, however, it does not involve the stockpiling of communications equipment by the DOC itself. Instead, the department's practice in this regard has been to rely on the commercial carriers to the extent possible, including to bring in equipment that is beyond the local authorities' normal access -- e.g., flying in satellite earth station equipment to isolated areas.

In addition, the DOC encourages local police and fire departments to rotate their own spare communications equipment (including batteries) so as to ensure to the extent possible that what equipment is available locally is operational and could be borrowed by local authorities or a neighbouring community, if needed. This program is closely coupled with the Inventory of Telecommunications Resources program discussed in the previous section, which keeps detailed records of all significant regional sources of communications equipment and support materials.

The telephone companies, for their part, have agreed to co-operate with governments, through the DOC, to develop plans aimed at the prompt provision of emergency communications to the scene of a disaster. Their planning activities include:

(1) determining possible telecommunication needs under various emergency or disaster scenarios;

(2) preparing transportable equipment packages, and arranging for their rapid deployment -- including transportation and methods for shared use;

(3) establishing methods for handling requests by authorized personnel for emergency telecommunication services; and

(4) making estimates of the associated costs (CTCA, 1978a).

Ownership and control of the emergency communications equipment deployed in a disaster would remain with the carrier having prior custody of the equipment. Moreover, since speed is of the essence in emergency response, the telecommunication carriers have established a universal telephone number which is operational 24 hours a day, seven days a week at a central location in each province and territory; it is to be used by authorized persons when initiating emergency communication requests (CTCA, 1978a).

In the event of a major disaster, for instance, the response of the telecommunications carrier to a request by the DOC to provide emergency communications at the site of the disaster would be to dispatch immediately a radio or radio-telephone equipped employee to the site of the disaster. In this way, a direct communications link would be established between the disaster site and the public long-distance network. That interim link then could be made available to on-site emergency officials until other emergency communication facilities are installed (CTCA, 1978a).

The program includes other roles for the DOC that are not as apparent. For instance, the DOC may be required to act as an arbiter if two or more federal departments or agencies responding to an emergency each require equipment and circuitry urgently from the commercial carrier. In such a situation, the DOC would have to assign priorities for service provision in accordance with pre-established plans, by assessing the nature of their respective needs, or by consulting with the potential users (DOC, 1986a: p.15).

The DOC also is required to issue annually an updated list of departmental personnel authorized to contact the telephone companies; their corresponding office and residential telephone numbers would be activated at that time by DOC Ottawa, Stentor and Unitel, excluding Terra Nova Tel and Northwestel (DOC, 1985d: para 4.1). An update of smaller telephone companies' authorized listings would be activated by DOC regional offices, if applicable (DOC, 1985d: para. 4.2).

4.7 Other support programs

Safe Siting/Safe Routing is an old federal program. It deals with roads, railways and pipeline emplacement as well as telecommunications (DOC, 1963).

The telecommunications portion of the program is administered by the DOC. It concerns, specifically, the provision of guidelines to users or owners of private communication systems to ensure "that no single emergency will result in an inability to continue essential main trunk communications beyond the point where the emergency occurred" (DOC, 1986b: Appendix A).

The DOC's related guidelines recommend that common carriers, government departments and agencies, and key industries (those that provide services which are vital to the efficient functioning of the country) that own their own communication networks locate their main trunk routes in such a way that a minimum of two main routes are established with a separation of at least 35 km. Moreover, they are to provide suitable interconnections to allow maximum dispersal of national communications over several routes in an emergency. Respecting leased essential circuits, the DOC recommends that requisitions for such services require them to be routed over as many different main trunk routes as possible (DOC, 1986b: Appendix A).

The original proposals, contained in ENTO 1/63, were based on above-ground microwave system technologies. Since more up-to-date planning guidelines have not been provided by the DOC, the carriers have continued to try to implement, to the extent possible, the earlier planning rules. However, as was suggested earlier, some of the objectives included in that order cannot be met by buried fibre optic cable technology. Draft DOC document NEAT XX/86 proposes changes to the earlier guidelines in order to rectify this situation, but revised guidelines have not yet been issued to the carriers.

The **Switch Diversity** program involves local service planning for cities, such as Ottawa, where government offices may be served by a single telephone switching centre. It calls for key elements in federal departments and agencies to be connected to an additional or separate telephone company switch so that a major service outage does not sever all interdepartmental and external communications.

The **ElectroMagnetic Pulse Protection** program involves planning to protect major elements of telecommunications carrier and broadcast systems from failure due to radiation fall-out and severe weather, including, for example, magnetic storms. The probability of damage or malfunction of a given component of those systems depends on its innate sensitivity and the efficiency with with energy is coupled onto it from the electromagnetic fields. The latter depends, in turn, on the electrical and mechanical details of the associated circuitry, cables, shielding, and the like (U.S. Atomic Energy Commission and the Office of Civil Defense, 1969: p.2).

The kinds of components that are most susceptible to EMP damage are transistors, diodes and other low-voltage solid-state devices. EMP also can cause erroneous operation of logic circuitry such as that found in computers. Indeed most of the components that are susceptible to EMP are found in typical communications equipment -- such as radio transmitters and receivers, antennae, and telephone lines and switching centres. Just the same, it is worth mentioning that new fibre optic technologies overcome most of these problems. In addition, given that Canadian telecommunication carriers are well aware of the problems associated with EMP, those sites that are part of the industry's terminal area protection (TAP) initiatives discussed earlier in this chapter have been hardened against EMP damage.

Finally, the **Emergency Power Equipment** program addresses questions related to essential switch and Emergency Broadcast Service station protection. Significantly, while most major telephone switches have some backup power supply, not all broadcast stations do. Under this program, therefore, all essential switches and EBS stations are equipped with emergency power equipment.

4.8 Industry trends

4.8.1 Liberalized competition

Competition in telecommunications in North America was first introduced in the provision of terminal equipment. Subsequently, competitive entry was allowed into data transmission and processing markets as a result of regulatory forbearance. The decision by Canadian and U.S. regulators to forebear from regulation in those markets was based on assumptions that while basic telephone service distribution might reasonably be viewed as a natural monopoly -- that is, unprofitable for more than one supplier -- data processing obviously was not, especially given the tremendous growth and rapid changes in that industry dating from the early 1960s.

These developments, combined with broad U.S. federal policies favouring decreased regulation in all markets effectively opened the doors to competition in every aspect of domestic telecommunications in that country -- in public as well as private services provision, wherever regulatory authorities at the state level have not decided otherwise. They included, principally, U.S. federal court interventions respecting MCI's Execunet service offerings; CC Docket 78-72 on MTS/WATS; Computer II; and the 1982 Modification of Final Judgment, which required AT&T to divest itself of its local operating companies.[61]

In contrast, while in Canada there is considerable competition in terminal equipment and data transmission and processing, competitive entry in voice communications until this year was restricted to private telephone and radio communication voice services and, to a limited extent (i.e., a duopoly), cellular mobile radio service now available in a growing number of mid- to large-sized urban centres. However, long-term competitive pressures from companies currently operating in Canada -- notably Unitel -- as well as from foreign firms wanting to expand into our markets as a result of the Canada/U.S. Free Trade Agreement, have finally led federal regulators to open up the MTS/WATS market to competition in this country as well. Although that decision was only made in mid-June, Unitel has already announced that it plans to provide public long-distance service in competition with the federally regulated telephone companies by mid-1993.[62] In both countries, basic exchange service is likely to remain closed to competitive entry for the foreseeable future.

Canadian regulators' prolonged resistance to allowing competition in public long-distance telephone service reflects the often expressed concern that competition would put an end to long-distance subsidies to local service, thereby driving up local rates to unacceptably high levels. Substantially higher local rates, it is thought, could force some low-income subscribers to "drop off" the system. But recent experiences in the United States have shown that higher local rates have not, in fact, led to subscriber drop off, and that a better approach to preserving universal telephone service is through direct subsidies to low-income households.

Technological innovation triggered competitive entry in telecommunications equipment manufacturing, data processing, private and public voice and value-added services. Competition, in turn, has stimulated further technological innovation. It also has driven user demand towards customized services, and it has forced both established industry players and would-be market entrants to make creative adaptations to existing technologies that can be offered to users at attractive prices, with the aim of increasing or maintaining market share. The discussion that follows considers briefly some reactions by the industry to liberalized competition policies -- first, in terms of enhanced services provision and, subsequently, in terms of virtual private networks. The implications of these trends on federal regulatory approaches and, specifically, for emergency preparedness communications will then be considered.

4.8.2 Value added networks

To keep ahead of the competition, service providers have undertaken to educate users about the various types of services they can offer. Whereas in the past users generally had to take or leave what the monopoly provider said was available, in an increasingly competitive environment, suppliers know that if they do not listen carefully to their customers, they could lose them to competitors who will. Large users and firms that rely heavily on telecommunications to conduct business have been driven to develop organizational communications expertise in order to remain competitive in their own right. As a result, enhanced services vendors rather than equipment suppliers are increasingly the big money makers. Thus, while technology led to competition and competition in turn stimulated both technological innovation and expanded customer demand, customer demand has now overtaken competition as the principal impetus to innovation in information technologies.

Value-added or enhanced services are those that utilize computer software to manipulate intelligently either the transmission or the content of the message. This is contrasted with basic service, where information progresses from the point of origin to the point of destination subject only to delays resulting from network congestion or the transmission priorities of the message originator.

Enhanced services encompass the category of telecommunications-related offerings that will grow the most rapidly as innovative technologies and, particularly, new software management systems are introduced. The oldest of these applications, in the residential telephone market, is telephone answering services (dating back to the 1920s), which provide actual operator-answered services to customers. Other value-added services include:

(1) **on-line transaction services** that allow users to make credit card purchases, travel or ticket purchases, and access cash electronically through automatic teller machines (ATMs);

(2) **messaging services,** including voice messaging -- which permit users to exchange recorded messages by dialling a common telephone number into a secure "voice mail" system -- and electronic computer-to-computer message transfers;

(3) **alarm services** that use telephone lines to poll alarm installations;

(4) **telemetering** by utility companies to poll meters instead of sending out readers;

(5) **electronic information services** to access remote databases; and

(6) **videotex,** which allows users to retrieve and modify data as well as transfer funds or do home shopping (Contel, 1989: pp.4-5).[63]

Value-added networks generally are packet switched rather than circuit switched.[64] As a result, they do not tie up the communications circuit end-to-end; instead, they only use the network during the time that data are actually being transmitted. The construction of physically separate value-added networks using pipeline, railway and other utility rights-of-way is leading to a proliferation of bypass alternatives to local exchange access to long-distance gateways. At the same time, value-added service competition is leading to the deployment of non-standard network architectures. In terms of emergency preparedness communications, value-added networks provide valuable signalling capabilities that could be used to supplement centralized public network signalling. However, if non-standard architectures prevail, no such redundancy will be provided since they will not be interoperational with the public switched network (NRC, 1989: pp.71-72).

While network usage today is still primarily for voice communications, by the end of this century it will be used mainly for data services. Residential and small business users, as well as larger users, will have access to hundreds of low-priced data services (particularly remote database access). Broadband services, such as high-definition television and high-resolution facsimile, also will be available, along with a variety of voice and message storage and retrieval packages.

4.8.3 Virtual private networks

In recent years, user demands for customized services, combined with transmission capacity surplus due to the introduction of high-capacity fibre optic systems, also have encouraged a proliferation of virtual private networks that bypass portions of the public telecommunications network. While virtual network customers usually own some facilities (those which they use to handle everyday data and voice traffic), they rely on the public switched network to carry their peak-load traffic. Thus, virtual networks allocate public network capacity on a demand basis in order to assure adequate bandwidth to customers to enable them to meet fluctuating traffic requirements. Often, virtual links -- those dedicated to private users -- simply share space in a cable that also carries public network traffic. The result of this is that virtual network capacity is available only when the public network has capacity to spare.

It is anticipated that the trend towards customized services and, particularly, virtual private networks, will continue, and that more of the intelligence that delivers these services will reside in customer premises equipment. That premises-based network intelligence will add flexibility to network usage; but, where private networks are merely allocated public network spare capacity, no real redundancy will be added to the national network. As physically separate private networks also proliferate -- many with robust packet-switching capabilities -- they will augment (data) network redundancy; indeed, we can expect a substantial transfer of data traffic to private networks. Voice traffic, however, likely will continue to be carried mainly on the public switched (including leased lines) network.

The commercial industry responds primarily to demonstrated market demand. It will not, therefore, develop emergency preparedness features unless requirements for them are put forward by governments and regulators. Just the same, as intelligent networks proliferate, more features and services will be possible at little if any additional cost. The conversion to CCS-7, for instance, makes possible the use of stored intelligence in centralized data banks. These databases likely could be adapted to include customized triggering mechanisms to implement specialized end-to-end treatment of emergency traffic (NCS, 1989: pp.6-7).

4.8.4 Implications for future industry structure

The rapid deployment of emerging information technologies has easily outstripped attempts by some regulators and major established private-sector players to prevent or limit competitive entry into non-voice activities. Indeed, regulation has been used deliberately in both Canada and the U.S. to promote technological innovation, lower prices and, in some markets, even invite competitive entry. For example, in the United States, AT&T's divestiture and the associated requirement that the RBOCs provide "equal access" to their networks to competitive long-distance carriers removed the final barriers to open competition in public long-distance voice communications in that country. The court's decision reflected a policy trend that includes decreased regulatory oversight, and its replacement by market forces in determining the extent to which competition in the information sector will prove viable. It is anticipated that widespread availability of cellular mobile radio in smaller and smaller local markets and the gradual introduction of fibre optics in the "local loop" eventually will lead to competition in local service provision as well.

Canada, like most other countries, has lagged behind the United States in allowing competition in public voice services. However, a Federal-Provincial-Territorial Task Force study completed in late 1988, together with the CRTC's decision to allow Unitel to enter the public long-distance market, suggest that some Canadian regulators are now ready to consider allowing some degree of competition in public voice service (Federal-Provincial-Territorial Task Force, 1988). Just the same, the prevailing attitude among communications industry workers and some consumer groups in this country is that significant differences exist between the Canadian and U.S. markets, and that Canadian policy-makers therefore must proceed cautiously in order to avoid the political fallout that would result from substantial local rate adjustments following the introduction of competition in public long-distance telephone service.

Also of concern in a Canadian context is the impact that the failure of even a single entrant (and there may well only be one, given the much smaller size of the Canadian market) would have on the industry. Canadian governments have spent hundreds of millions of dollars over the past several years to protect fledgling industries and bail out companies whose aspirations went far beyond the depth of their pockets. The U.S. experience has proven that the dynamics of a competitive telecommunications marketplace almost certainly will lead to initial losses for all competitors, shake-outs and mergers. Significantly, however, in the longer term, those firms that do survive can be expected to do very well.

4.9 Distributed intelligence and emergency preparedness

Considered in global terms, the market environment that has emerged over the past two decades or so has resulted in a proliferation of networks, network architectures and network vendors. These developments have, in turn, led to incompatibilities among systems which may preclude full system interconnection and interoperability. Indeed, the situation has now evolved to the point where it is often difficult, if not impossible, to use one network's assets to back up those of another. Thus, while the variety of service offerings has grown rapidly, network interoperability actually has been diminished by the widespread deployment of specialized services using non-standard network architectures.

In the context of emergency preparedness communications, unless international and domestic regulators make provisions to link these discrete network units to the public telecommunications system by requiring the application of common gateway architectures, emergency preparedness communications will be jeopardized. Moreover, current trends in aggregated and centralized switching suggest that potentially dangerous precedents may be set which could threaten the network's ability to accommodate response requirements in the event of a large-scale disaster or a prolonged localized communications failure. The May 1988 Hinsdale, Illinois central office outage discussed in Chapter Eight, along with more recent experiences in the United States with major telecommunications outages, illustrate the extent to which the North American public switched network's redundancy capabilities have become restricted.

The replacement of hardware-based technologies with software-based network intelligence as the driving force in the evolution of network control also has significant implications for emergency preparedness communications. It involves the amassing of huge software databases used to program centralized hub switches to handle landline voice and data, cellular, satellite and terrestrial microwave radio message distribution. While these increasingly complex software-defined capabilities provide the network with the flexibility necessary for dynamic call routing and common channel signalling (CCS) together with adding an advantageous self-diagnostic and automatic restoration capability, they also introduce some new vulnerabilities to system survivability. For example, dynamic call routing (introduced in Canada since early 1991) is expected to make the network more robust in terms of handling peak period traffic and single switch failures. At the same time, the fact that it is all done <u>automatically</u> could actually hamper human supervision and manual intervention. In the very short term (such as the crucial minutes and first hours after the onset of a disaster) the system might only be able to cope with those contingencies for which it has been pre-programmed. Multiple switch outages or failures at remote, unstaffed switching stations could cause restoration delays and loss of telephone and other services across a wide geographical area, possibly for extended periods (i.e., several hours or even days).

Similarly, while CCS provides more flexibility in call processing and routing, it transfers the signalling function to a separate network -- one comprised of a very small number of signal transfer points (STPs). This physically distinct signalling network is not only very thin in terms of STPs, it also relies on just a few large software databases housed at centralized, and usually distant locations. A failure anywhere along the signalling route (which has only a single backup transmission path per critical node) could cause a large portion of the public switched network to fail as well, since it would not be able to process calls if more than one node were to fail.

Perhaps the most critical element in replacing hardware-based network control with network intelligence is, as indicated earlier, the opening up of the network itself to users. While this has the advantage of making the network's remote databases accessible to customers who want to reconfigure their own virtual networks, it also may make it susceptible to malicious intervention. This is because the more open the network architecture, the more vulnerable the system will become to hackers.

A related development is the fact that virtual networks -- unlike very small aperture terminals (VSATs) and other physically separate private networks employed primarily for data carriage -- use communications links leased from public system providers. They are consequently only as redundant as the public network itself. If, however, those separate systems were fully interconnected and interoperable with the public network, they might provide valuable short-term backup support to alleviate the effects of multiple system failures such as might occur in a major telecommunications outage. Linkages therefore need to be established to connect the public network with physically separate portions of virtual private networks as well as to other separate private bypass systems in order to improve public switched network redundancy.

Finally, the shift of switching capability towards customer premises may result in a situation where localized damage to a customer's property would cause them to lose all telecommunications capability. A related concern is the potential loss of service that could result from a power utility failure -- something that is entirely beyond the control of the customer. This is because, instead of using the public network's DC power supply, stored in batteries located in service provider installations, PBX and key systems depend upon AC power, which can be supplied either by an electric utility company or by a customer-owned power generator. Thus, while it may be desirable to place increased responsibility for control of traffic accessing the public network in the hands of the customer, if they lack the necessary backup emergency power, they will not be able to accommodate their service requirements at critical times.

4.10 Need for industry standards

As was suggested in the discussion above, the only way to make both physically separate (bypass) networks and virtual private network resources available to the public telecommunications system in a major emergency is through, first, the use of common technical standards and shared protocols to establish interoperability and, second, common interface gateway architectures for interconnectivity. The absence of such standards until recently in the computing industry has led to well-documented stories about the growing costs of doing business in the "information era." These refer repeatedly to incompatible operating systems, a plethora of system configurations, and the necessity to purchase additional software to convert data received using one format into another so that they can be used in conjunction with that acquired from sources employing different formats. The acceptance of common protocols and technical standards is integral to avoiding these kinds of problems in telecommunications.

Historically, the Bell System -- specifically, Bell Labs (and to some extent Bell Northern Research and Northern Telecom) -- has set industry standards, almost by default. Today, North American telecommunications network standards are more and more a product of negotiation among competitive suppliers of customer premises equipment and services (other than basic local service in both countries and public long-distance voice in Canada). The Canadian telephone industry has established a voluntary standards setting mechanism under the auspices of Stentor, the combined membership of which provides more than 90 per cent of domestic telephone service. Following the AT&T divestiture order, the U.S. industry created a similar mechanism, known as the T-1 Committee, which is sponsored by the Exchange Carrier Standards Association. The computer industry in both countries is also moving towards developing voluntary standards mechanisms for data processing.

In the current legal and regulatory environment, increased competition in equipment and unregulated enhanced services, together with increasingly complex microprocessor technologies, make the adoption of industry standards more important than ever before. The rapid introduction of new technologies in recent years may mean, however, that established standards will not be sufficiently specific to guarantee full interconnection and interoperability. this is because market pressures to remove barriers to competitive entry have caused service providers to introduce new products before standards have been clearly defined and broadly accepted. The deployment of T-1 and other digital network architectures in the United States for instance was, in fact, stimulated by delays in setting narrowband ISDN standards and the introduction of associated technologies (NRC, 1989: p.58).

IISDN, it will be recalled, is neither a product nor a service; it is a network architecture. That is, it is a set of internationally approved interface standards which, when implemented, will facilitate the integration of new systems to be provided by a growing number of suppliers.

It will permit, for example, a caller to telephone home to program the VCR or microwave oven, reset the thermostat, etc. ISDN is expected to be phased in gradually into the largest North American metropolitan markets over the next few years.

Open network architecture (ONA), ISDN's predecessor, is already an accomplished fact in the United States. It became a regulatory requirement in that country in June 1986, with the release of the Federal Communication Commission's (FCC) Computer III decision. The goal of ONA is to permit all users to interconnect with the public long-distance networks on a transparent basis. The absence of industry standards and differing interpretations among the major telephone companies have delayed its full implementation. Preliminary plans, however, have been filed with the FCC by AT&T and the regional Bell operating companies, and they have received temporary approval.

Common channel signalling system No. 7 (CCS-7), an integral part of ISDN, is similarly a set of internetwork gateway standards designed to protect the integrity of the system by ensuring interoperability and interconnection between major private and public networks. Discussed in this context, it is also a network architecture. That is, it acts as a secondary (packet-switched) network designed to keep track of detailed information about calls not available in earlier network management systems. CCS-7 is also the foundation for intelligent network architectures that will allow telephone companies to introduce new features quickly and economically.

Considered from an emergency preparedness perspective, these network standards and architectures, as indicated earlier, may actually increase network vulnerability to disruption -- in a number of ways. First, the number of users with access to network control software will be increased substantially. As noted above, more levels of network software will be made visible to users to enable them to adapt their portion of the network access point to meet specialized needs; the risk of network abuse will increase accordingly. This raises the question of system security yet to be adequately addressed.[65] Furthermore, the concentration of network software databases and the thinness of packet-switched signalling networks create additional system vulnerabilities. Finally, network interoperability is actually determined as a consequence of standards degradation associated with the deployment of so many emerging technologies so quickly that established standards have become outdated even before they can be adopted.

Just the same, technical standards and software protocols might also be used to protect critical network software -- such as through blocking or masking. Another positive aspect is the ability of common standards and network architectures to provide flexibility in network intelligence. This would make them better equipped to meet the special needs associated with a wide range of emergency contingencies. Examples of those possibilities include: (a) out-of-band common channel signalling; (b) robust packet-switching capabilities provided by interconnectivity and interoperability with private networks; and (c) the prospect of additional backup systems as a result of converging broadband (video) and communication technologies made possible by digitalized switching and lightguide transmission systems.

4.11 Conclusions

Canadian civil emergency planning has come a long way from its civil defence origins. This is particularly the case in regard to communications preparedness. A key element in this transition has been the co-ordination of industry and government initiatives through government/industry programs such as those described in this chapter. These programs also have encouraged formal and informal linkages to be forged among essential service users and their suppliers.

In addition, they have stimulated the Canadian telecommunications carriers to develop co-operative arrangements with each other aimed at ensuring the survivability of national networks and improving reliability in essential as well as regular service provision. Private sector involvement in emergency communications planning also has paved the way for increased co-operation in the area of overall network planning -- including, for example, the acceptance of common standards, operating procedures, interconnection protocols and other shared arrangements to protect the public switched network to the extent possible in the event of physical damage to terrestrial or microwave facilities.

Since communications are crucial to emergency response, co-operative pre-planning, involving the voluntary co-optation of private sector expertise, is considered to be a particularly significant aspect of Canadian emergency preparedness. And while in other areas of policy-making it may not be desirable to involve the industry that supplies the service under consideration in the formulation of public policy, in regard to communications preparedness, it would appear to be the case that their involvement is vital to assure the success of the process. The highly technical and dynamic nature of that sector makes it impossible for government officials to keep abreast of all the developments and their implications for the administration of government, including in an emergency situation.

It also is expected -- and past experience has proven -- that involvement by emergency communications suppliers, and particularly the public telephone utilities, at the pre-planning stage will reduce significantly the time it takes to meet the needs of response organizations in a crisis. This is because, when disaster strikes, they will put things into motion immediately within their own organizations to deploy equipment to the site and mobilize technical personnel, without waiting to be asked to do so. Perhaps more significantly, inappropriate action by private industry will be less likely since they will not have to try to second-guess local authorities about their communication needs.

Just the same, in regard to regular telecommunications service provision, current economic, regulatory, architectural and technological trends appear to be going in a different direction. Indeed, they have already fragmented North American telecommunications systems to such an extent that essential service providers, despite their desire as good corporate citizens to assist the response effort, would have great difficulty in coping with the effects of a large-scale natural disaster (e.g., a major earthquake) if it wiped out multiple switching centres in a metropolitan area such as Vancouver or Montreal. Additionally, network intelligence and other technological developments have outpaced regulatory activities aimed at ensuring common gateway architectures to allow interconnection between private and public networks. Moreover, the availability of all kinds of customer premises equipment, of which many different types are in use by public safety agencies and local governments, has increased so quickly that it is uncertain how many of them could be used together. For these reasons, telecommunications service providers and equipment manufacturers need to be given incentives to work together to ensure that their networks are interconnected and fully interoperable with the public switched network to the extent necessary in order to be able to provide a minimum acceptable level of service in extremely adverse conditions.

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1 TransCanada Telephone System, 1962, quoted in Henry, 1964: p.3.
2 That right of way extends from North Vancouver to Fort Nelson.
3 Regarding national network management, see section 4.4 of this chapter.
4 In addition, Québec Téléphone is an associate member.
5 Federal-Provincial-Territorial Task Force, 1988: p.6.
6 Formerly a provincial Crown Corporation.
7 Telecom Canada's high density coast-to-coast fibre optic network was placed in service in March 1990. It has a total capacity of 24,222 voice circuits, plus 8,074 protection circuits. Agreements have been concluded to install a second high density hybrid coast-to-coast route to provide diversity. The technology for the new route is expected to be based on SONET OC-48 technology, and it would provide a transmission capacity of up to 32,256 circuits per fibre pair (as compared with 8,074 on the current system).
8 Telecom Canada's first coast-to-coast analogue microwave radio route was installed in 1958. The second coast-to-coast route was placed in service in 1968.
9 Telesat Canada was established in 1969 by Act of Parliament with a mandate to plan, design, build and operate the world's first domestic geostationary satellite telecommunications system. It became a member of Telecom Canada in 1977, and is today a "mixed" company in which the Government of Canada is a major but not majority shareholder. The satellite services provided by Telesat are used by the terrestrial carriers to provide long-distance services between western and central Canada; and in the Northwest Territories, northern Quebec and parts of northern Ontario they are the primary means of providing telephone, data and facsimile services (Hoffman, 1990: p.37 and Federal-Provincial-Territorial Task Force, 1988: p.5).
10 On 12 June 1992 the Canadian Radio-television and Telecommunications Commission (CRTC) granted Unitel the right to interconnect to the local distribution facilities of the federally

regulated telephone companies -- serving Ontario and Quebec, British Columbia and the Atlantic provinces for the provision of competitive voice and data services.

11 The association between Canadian National Telegraph and Canadian Pacific Telegraph dates back to 1947 when they began joint operations for the provision of private wire services.

12 Unitel's first coast-to-coast analogue microwave network was completed in 1964. In 1991 its national digital backbone network was completed, following the same route as its analogue microwave system. This network is a hybrid system comprised of digital radio and fibre optic cables.

13 An agreement with Telecom Canada allows for restoration of circuits on either organization's facilities. However, rapid restoration requires broadband capabilities and crossover facilities that are already in place and due to the increasing complexity of the technologies used by Unitel and Telecom Canada, it may not always be possible to interconnect the networks for these purposes. Moreover, crossover facilities do not exist on a permanent basis for large circuit groups (Hoffman, 1990: p.36; and personal communications, DOC-Ottawa).

14 Canada-U.S. and Canada-Mexico traffic is usually carried by the telephone companies.

15 Currently, Teleglobe uses facilities in the following undersea cables: For Canada-Europe traffic, it uses CANTAT-2; TAT-5 (a limited number of trunks); TAT-6; TAT-7; TAT-8; TAT-9; and PTAT. For Canada-Pacific traffic, it uses ANSCAN; TPC-3; TPC-3 (for service restoration only); and TPC-4.

16 These are located at Lake Cowichan, British Columbia; Mill Bay, Nova Scotia; and Weir, Quebec.

17 Personal communication, Teleglobe Canada.

18 Cellular companies in Bell Canada and BCTel serving areas are allowed to carry long-distance traffic using their own or other carrier-provided facilities. Those cellular companies operating in provincially regulated serving areas, however, are required to have their long-distance traffic carried over the telephone companies' networks (Federal-Provincial-Territorial, 1988: p.10).

19 Source: Federal-Provincial-Territorial, 1988: p.8.

20 See section 4.6.2 in this chapter.

21 The situation in the United States is quite different due to the fact that that country's long-distance carriers' networks, while they are interconnected with the local telephone companies are not interconnected with each other. Consequently, they cannot as easily support each other as would be possible in Canada through Telecom Canada in the event of a major disruption such as the one that occurred in Manhattan on 17 September 1991. A major outage of the telecommunications system in a large city such as New York will have tremendous implications for businesses and the local economy. For example, retail stores rely on long-distance telecommunications to verify credit card purchases and place orders for new stock; manufacturing firms rely on them to co-ordinate marketing and production world-wide; financial service firms are linked by telecommunications to foreign markets. See The City of New York, 1991; and Hoffman, 1990. Also see Chapter Eight on the Hinsdale central office fire.

22 See Chapter Five for a discussion of the different kinds of telecommunications network configurations.

23 Unitel, Telesat and B.C. Rail have been allowed by the CRTC to interconnect to Bell Canada and BCTel (BCTel only for B.C. Rail) to provide private line voice and data services. Interconnection of Cantel's cellular service has also been permitted by the CRTC and some provincial regulatory authorities, as has interconnection to provide message toll service (MTS) by radio common carriers (including cellular providers in CRTC-regulated telephone company territory). Similarly, resale and sharing to provide non-MTS/WATS (i.e., long-distance voice) services, including to provide primary exchange voice service (except public coin telephone service) by non-facilities based carriers is permitted in the serving areas of Bell Canada, BCTel, Northwestel and Terra Nova Tel. Significantly, as noted earlier, interconnection for the

provision of MTS/WATS (i.e., public long-distance voice service), except as already noted with respect to mobile radio and cellular telephone service, has been permitted only since June 1992.

24 The Canadian Standards Association (CSA) is the organization that establishes and writes standards for electrical, data processing and data communications. In 1983, the CSA created a Standards Committee on Telecommunications. Its work involves the development of standards for voice terminal equipment, network protection from fire and shock hazards, and establishing coaxial and fibre optics standards. CSA also has assumed many of the functions of the DOC's Terminal Attachment Program Advisory Committee.

25 Bell Canada, 1969: p.24. Also see Hummel, 1980: pp.11-12.

26 See sections 4.4.2, 4.4.3 and 4.6.1, respectively, in this chapter.

27 These are co-located at the provincial surveillance co-ordination centres (PSCCs).

28 See EMO, 1968-1969: p.9. Also see EMO, 1969. While significant improvements have been made since then, this problem has not been entirely resolved.

29 ISDN is defined by CCITT-1 Series Recommendatins as "a network, in general evolving from a telephone IDN (Integrated Digital Network), that provides end-to-end digital connectivity tosupport a wide range of services, including voice and non-voice services, to which users have access by a limited set of standard multipurpose user-network interfaces" (quoted in OECD, 1988: pp.23+).

30 A **trunk** is a large-capacity long-distance channel connecting two exchanges or switching devices. It usually connects groups of several hundred customers through coaxial or fibre optic cables or via microwave.

31 LLC/ELT and more recently, CCS-7 software used in conjunction with high-capacity DMS digital switching, currently ensure local (that is, intraexchange) call completion for emergency users in a disaster situation. See section 4.6.1 in this chapter.

32 Informal arrangements are in place between operations personnel at Bell Canada and Unitel to lend circuits in the event of a major telecommunications outage experienced by either company. Thus, for example, when Bell's Morrisburg, Ontario microwave tower was sabotaged during a four-month strike in 1987, Bell was able immediately to borrow spare Unitel circuits; that company released a master group of channels from Montreal, and these were then fed into the CN Tower in Toronto. Through Telecom Canada, temporary routes were also obtained from Teleglobe which released a channel to St. John N.B., allowing access to the U.S.; and AT&T provided three radio channels (some of which routed traffic down to the southern United States and back up the East Coast to provide service between Montreal and Toronto). In that way, it took less than eight hours to restore service to essential users, and under 48 hours to restore nearly full service (81 per cent) (Pereira, 1989: p.20). The DOC advises that it took nearly five days before the formal exchange of letters between corporate management was completed okaying the arrangement. Similar informal arrangements to provide telecommunications capability in emergencies exist between other regional and independent carriers, and Unitel.

33 Routes are considered to be diverse if they have: (1) no common power sources; (2) have no common junctions; and (3) structures have a site separation of 200 metres or more. The goal of the industry is at least 35 per cent for a two-route system.

34 In March 1991, the Telecom Canada network was converted to high performance (dynamic) routing. This will require a review of their restoration objectives and perhaps a new approach to diversity and network survivability, since the cutting of a single fibre optic cable on a high traffic route could quickly overwhelm all spare and protection facilities on all the other technologies.

35 See DOC, 1963 regarding safe siting and safe routing under the ENTO.

36 **EMP** is defined as "a large, impulsive type of electromagnetic wave generated by a nuclear explosion." It commonly refers to high-altitude nuclear weapon detonation. It has been estimated that a 500 km high burst would affect the entire North American continent; a 300 km high burst would affect most, except the southern United States and Alaska; a 200 km high

burst would still affect a large portion of the continent, including the populated areas of Canada (Bodson, 1986: p.15).

37 The North American Air Defence Agreement.

38 See section 4.7 in this chapter on safe siting/safe routing.

39 The information included in this discussion is derived from a briefing provided by Bell Canada network management staff at the PSCC, Montreal, and personal interviews.

40 Bell Canada has 27 EOCs in Quebec. Its "611" centres are staffed by the same people who would staff the EOC and it is therefore easy for the company to adapt to an emergency situation. In addition, regular internal audits (incident reports) are done to monitor performance and adjust corporate response plans.

41 For example, the main Montreal switching centre manages approximately 60,000 intercity circuits, new Northern Telecom upgrades are expected to increase that number to 80,000 by the early 1990s. This means that currently, some 30,000 long-distance calls can now be handled simultaneously through that one centre. Approximately 30 per cent of these circuits are incoming, 30 per cent are outgoing, and 40 per cent are either-direction circuits.

42 **Protection circuits** are backup circuits installed along every intercity route. They do not carry normal traffic and are often leased out for special (e.g., television) events -- usually for a maximum of a few hours at a time. Thus, there is no absolute guarantee that they will be available immediately should an outage occur. Generally speaking, however, if the regular route fails, the telephone company will utilize its protection circuits in very short-term outage situations.

43 Originally, **broadband restoration** referred to restoration of failed analogue radio channels by transferring call traffic either to the protection channel or to a free channel on an alternate route. With the introduction of digital systems, it may also mean restoring a digital radio channel, a satellite transponder, or traffic carried on fibre optic cable. Failure of any one of the Telecom Canada transCanada networks will result in the application of broadband restoration, based on restoration plans developed by the National Network Operations Centre in Ottawa.

44 Bell advises that this equipment also could be made available to the other carriers in a severe telecommunications disaster.

45 Hummel, 1980: pp.10-11; also video briefing at PSCC, Montreal; and Poirier, 1989.

46 Different types of switches have different methods of providing service to priority telephone lines during a disaster or in times of network congestion. Yet, they all basically perform the same function. For example, telephone company activation of **line load control** (LLC) "allows access to a dial tone to permit origination of calls from phones designated as 'priority'. Calls in progress and incoming calls are not affected when this feature is activated. All other lines are denied service and their only indication would be no dial tone when they attempt to originate a call." **Essential line treatment** (ELT) similarly "allows access to dial tone to permit origination of calls from phones designated as 'priority' and delays dial tone to all other subscribers in that switch. However, it allows all subscribers to receive incoming calls." And **essential service protection**, in turn, "allows all telephones to originate and receive calls, but gives priority to lines designated as 'essential priority'. This is done by means of a 'queuing' method that will allow priority calls to jump ahead of all regular calls." In addition, trunk cricuits automatically receive a higher priority than regular lines. Definitions provided by Doug Elliot of BCTel, in RETC-B.C., 1990: item 12.

47 DOC, 1989d: para 3.3. The same document defines an **emergency** as: "an abnormal situation that requires prompt action beyond normal procedures to prevent or limit injury to persons or to property or the environment" (para 3.4). **Essential users** are defined therein as follows: "to qualify as essential users, the personnel must be designated to perform vital functions before, during, or after emergency situations" (para 3.6).

48 See DOC, no date (g). Also see DOC, 1989d and 1989e. These provide the current federal guidelines for the implementation of this program, subject to more recent revision.

49 DOC, 1989e: paras. 4.1 and 4.2.

[50] In accordance with CTCA, 1978d. LLC/ELT is not, it will be recalled, available in areas served by older mechanical and electromechanical switches.

[51] See DOC, 1988c; and no date (g).

[52] Details on regional and DOC Ottawa responsibilities are outlined in DOC, 1988a: p. 8.

[53] Source: DOC, 1989d: Appendices A, B and C.

[54] EPC, no date (b): p.1. Details of the Vital Points program also are provided in EPC, 1985 and 1987; and DOC, 1991b. That advisory committee's membership includes the following federal departments: Agriculture; Communications; Emergency Preparedness Canada; Employment and Immigration; Energy, Mines and Resources; Environment; Fisheries and Oceans; Health and Welfare; Industry, Science and Technology; National Defence; Public Works; the Royal Canadian Mounted Police; Supply and Services; and Transport.

[55] A telecommunications location qualifies as a **vital point** if it is: a regional, sectional or primary switching centre on the distance dialling network; a junction or district exchange on the telex network; a service co-ordination centre; a broadband restoration centre; an emergency operations centre; a Canadian Forces switched network switching office; a telecommunications office interfacing directly with an overseas cable terminal or an earth station interworking with an international satellite; an overseas cable terminal terminal; a satellite earth station interworking with an international or Canadian domestic satellite which connects heavy route domestic telephone, transmits and receives message and/or television and radio program traffic, telemetry, tracking and control data; an international gateway transit centre; a computer complex controlling the operation of a major network that is not part of the public switched networks; an intersection point of major broadband transmission routes; telecommunications offices with 25 or more interconnecting links to "priority 1" installations; telecommunications offices providing facilities to the REGHQs or the CEGHQ; alarm-receiving and order-transmitting centres on a broadband transmission route. Owners of this category of vital points are responsible for providing for their protection. See DOC, 1991b: after Annex F.

[56] DOC, 1983a; and 1986a: pp.16-17.

[57] Details of the NRPS program are contained in DOC, 1983b. Also see CTCA, 1978d.

[58] These listings are similar to the line load control and vital points listings maintained by the DOC. See CTCA, 1978d.

[59] DOC, 1983c: para 3.6; and CRTU-Québec, 1990a: Bell Canada presentation on "Priorité de service."

[60] See DOC, 1988a: p.10; and 1986a: pp.17-18.

[61] 60 FCC 2d 25 (1976); **MCI Telecom Corp. v. FCC,** "Execunet I", 561 F.2d 365 (D.C. Cir. 1977); cert. denied 434 US 1040 (1978); "Execunet II", 580 F.2d 590 (D.C. Cir. 1978); **Docket 78-72,** 81 FCC 2d 177 (1980); **Second Computer Inquiry,** 77 FCC 2d 384 (1979), 84 FCC 2d 50 (1980), 88FCC 2d 512 (1981), **CCIA v. FCC** 693 2d 198 (D.C. Cir. 1982), **Louisiana PSC v. U.S.,** 461 US 938 (1983); **United States v. American Telephone & Telegraph Company,** 552 F. Supp. 131, 195 (D.D.C. 1982), **Maryland v. United States,** 460 US 1001 (1983).

[62] The CRTC's 12 June 1992 decision allows Unitel and other carriers to enter the MTS/WATS market in areas served by Bell Canada, BCTel, Northwestel and Terra Nova Tel. The geographical areas that will be opened up to competitive long-distance service provision as a result include portions of Quebec and Ontario, the Northwest Territories, British Columbia, the Yukon, and Newfoundland. As regards those areas served by provincially owned or regulated telephone companies -- notably the prairie provinces -- this decision does not automatically open them to competition. It is expected however, that the decision will be extended to the serving area of AGT Ltd. as well (CRTC Telecom Decision 92-12, 12 June 1992; also Surtees, 1992: p.A-1).

[63] Also see OECD, 1988, No.18.

[64] **Packet switching** is a computer controlled method of data communications in which the message is split upinto segments which are then transmitted through a network and reassembled in their original form at the destinatin. The transmission channel is occupied only for the

duration of transmitting the packet and is then available for the transmission of others. Unlike circuit switching, the data network determines the rouging during (rather than prior to) the transfer of the packet. **Circuit switching** is a method of handling telecommunications traffic in which the source and the destinatin are connected by a single path for the duration of the communication by interconnecting incoming and outgoing circuits through a switching centre (CICA, 1983).

65 The growing number of mischievous penetrations of academic and governmental networked computer systems suggests the possibility of similar hostile interventions with telecommunications network control databases.

PART III
NEW COMMUNICATIONS TECHNOLOGIES AND EMERGENCY-ONLY SYSTEMS

Preface

Chapters Five and Six make up Part III of this dissertation. This part considers several existing communications technologies together with some emergency-only communications systems.

Chapter Five discusses the concept of networking and describes the different network configurations employed in Canada for: (1) telephony; (2) local mobile radio; (3) cellular radio-telephony; and (4) cable television. It then discusses telephone and radio communications, particularly as regards the evolution of the related technologies to the present day and their possible implications for national emergency communications preparedness capability.

Chapter Six looks at a variety of supplementary and emergency-only communication systems -- from two-way voice systems such as HF, ham and CB radio to fully integrated emergency networks. It also considers data, text and image transfer applications, together with specialized satellite-based systems and emergency broadcasting and warning systems.

CHAPTER FIVE
New Technologies and Emergency Communications

5.1 Introduction

From an emergency preparedness perspective, the introduction of new communication technologies has both advantages and disadvantages. On the positive side, the use of improved information processing and storage capabilities enhances network management. Moreover, economies of scale associated with the concentration of telecommunications traffic with higher bandwidths over fewer cables associated with the introduction of fibre optics allow for lower prices. Finally, electronic switching features make possible new services such as call-forwarding, which help ensure that emergency responders and government decision-makers can be reached easily. On the negative side, these and related innovations mean that the network has become thinner, with fewer transmission routes carrying more and more traffic. At the same time, while electronic switches are getting smaller physically, they can accommodate much more simultaneous voice and data traffic in one place; and this means that any breakdown in the system will affect more users across wider geographical areas than ever before (*New York Times*, 1988).

Communications technology refers to the range of techniques and tools employed to facilitate communications. The general characteristics of communication technologies as they have evolved since the mid-19th century are as follows: the invention of the telegraph in 1837 and of the telephone in 1876 permitted almost instantaneous communication by wire over long distances. Wireless communication -- telegraph (1895), shortwave radio (1926), and high frequency (HF) radio (1946) -- overcame the deployment constraints of linking communication points by wire or cable. Microwave technology (1950s), in turn, provided vastly increased capacity channels and made possible the transmission of television signals; it also led to the development of satellite and space communications. Fibre optic or lightguide technologies together with advances in microprocessing technologies in the 1970s and 1980s have led to the availability of a plethora of new interactive service options.

In recent decades, the main thrust of technological innovation in this area has been to expand exponentially both the capacity and the capabilities of telecommunications switching and transmission facilities. As a consequence, modern transmission technologies now can carry different kinds of messages simultaneously -- including facsimile, video and computer data signals in addition to television, telephony, teletype and telegraph. Off-air broadcasting also has been supplemented by direct broadcast satellites (DBS), cable television (CATV), video casettes and video casette recorders (VCRs). And cable companies are upgrading their distribution systems to allow data transfers and, when permitted by the regulators, two-way voice communications. Telephone companies similarly are improving the public telephone system through the introduction of digital -- and very soon, optical -- switching and high-capacity fibre optic cable.[1] Finally, and perhaps most significantly, greatly expanded transmission capacity and more rapid switching capability have facilitated computer data processing over the public telephone network (Melody, 1988: p.473c).

We now are witnessing the increased deployment of narrowband networks as well as the emergence of broadband systems to provide voice, data, teleconferencing, facsimile, etc. over a pair of or a single fibre cable. Moreover, in this decade, narrowband fast packet-switched networks will be used for the deployment of both voice and data traffic in a fully digitalized system. Broadband circuit-switched networks will emerge to carry video information. Also anticipated is the integration of broadband circuit-switched and narrowband fast packet-switched networks. Furthermore, in the coming years, the broadband universal telecommunications network (BUTN) will evolve as a hybrid network of switched narrowband and broadband integrated services digital network (ISDN) channels. The tremendous traffic-carrying capacity of optical systems also is expected to be introduced in commercial markets which will provide individual subscribers with virtually unlimited communications capability.

It is anticipated that the bandwidth available to all telephone subscribers in an optical environment also will allow substantial upgrading of basic telephone service, and at much lower cost than existing technologies (i.e., where services require more than two lines per subscriber, the loop currently requires additional wiring). Moreover, utilization of the excess capacity for enhanced data and image services would permit service providers to spread loop costs over a wider range of services, with the result that these new markets might ease upward pressures on basic telephone rates (Harrold and Strock, 1987).

Advancing technology is forcing users, suppliers and policy-makers to think about entirely new sets of issues. This, of course, is not new in the telecommunications field. But the next decade likely will witness less in the way of new technological inventions and more in the area of managing and improving already existing ones. For example, open network architecture (ONA) is neither a new product nor a service; it is a set of tariff standards.

Similarly, ISDN is not a product or a service; it is an interface standard which allows otherwise incompatible operating systems to talk to each other (Contel, 1989).

Until the late 1970s, voice distribution was the primary activity of the telecommunications industry. Today, we no longer think strictly of voice communications when we think of telecommunications. Instead, we think of "information" distribution -- which includes everything from voice to data to text to graphics to images. In a similar way, the computer industry traditionally was equated with data processing, and data meant numerically coded information only. Now, data can be graphics and images as well. We also have moved from data processing to batch processing and interactive processing. A third previously distinct area of business activity employing information technologies is that of office automation (more specifically, word processing), which started out as text presentation and text manipulation, and later moved into information manipulation involving spreadsheets, and the like (Lotoschinski, 1988: pp.61-64).

Voice private branch exchanges (PBXs) have become voice/data PBXs; digital in nature, they can carry both types of information messages. Similarly, local area networks (LANs) have become almost indistinguishable from PBXs. Typically thought of as a very localized mechanism used to connect a small number of computer peripherals, LANs now can handle voice communications as well as video. Furthermore, large business users for the most part have moved away from mainframe computers and are using personal and mini-computers instead. As a result of these developments, management information systems (MIS) departments, telephone systems and office automation equipment increasingly are being integrated through structural wiring (cabling) systems into information service bureaux within organizations. Moreover, telecommunication terminals can be made to act like other types of terminals; modems serve as bridges between office automation and telecommunication activities, and between data processing and telecommunication terminals.

Just as the functional boundaries within organizations have become fuzzy as telecommunications, data processing and office automation functions merge, so too are the boundaries separating the computer and telecommunications industries. In the 1970s, Bell Laboratories together with Northern Telecom, IBM, and Xerox represented the three distinct elements of business information activities -- namely, telecommunications, data processing and office equipment. Today, there are so many suppliers capable of offering integrated service capabilities that it is no longer meaningful to talk about "equipment" suppliers. Instead, we talk about "services" vendors. Former data processing sector players (like IBM) are now involved in manufacturing PBXs (via Rolm) and also offer long-distance telephone service (through

MCI). Similarly, former telecommunications-only providers (like AT&T) are now offering office automation services (with Olivetti), and so on.

With regard to customer premises equipment, there similarly has been a proliferation of different brands and a variety of built-in enhancement features. These developments, combined with lower prices associated with integrated circuitry and a tremendous augmentation of microchip programming memory capacity have led to customized services available to a broader business user market -- one that now includes medium-sized and even many small firms. One of the most significant results of these trends has been the emergence of a more knowledgeable and consequently, more demanding, user community -- one that is aware of the technological developments in progress and, as a consequence, wants the latest and the best applications to meet their specialized needs. The cumulative effect is a new dynamic in the information distribution business: that is, market-demand driven developments in value-added or "enhanced" services such as distributed computing (i.e., on-line time sharing among organizations), computer networks within individual organizations, and interenterprise networks. Megabit communications also have emerged in association with the increasing demand for higher speed communications of all types.

Technological innovation in telecommunications so far has triggered competitive entry in Canada into customer premises equipment, non-voice (e.g., data, telex, facsimile), private long-distance voice service and, recently, (though only to a very limited extent) cellular mobile radio. In the United States, competition extends into public long-distance voice markets as well, although regulatory restrictions in that country still preclude competitive provision of basic (i.e., local) telephone service.

Current trends in telecommunications are expected to alter fundamentally the configuration of future networks. They can be grouped into three general categories: (1) transmission modes; (2) switching; and (3) software program network management. But in order to understand better the implications of technological change on the national telecommunications system, it will be useful to look first at the basic network. As suggested above, the most far-reaching changes in the next several years will be in the area of enhancing network management capabilities through improved software management systems, rather than by introducing radically different technological concepts.

In this chapter, descriptions of existing and emerging technologies in this sector will be provided. This will be followed by consideration of some of the advantages and disadvantages associated with them in terms of emergency preparedness communications. For example, improved network management and enhanced traffic-carrying capacity provided by fibre optic technologies are positive factors. However, centralized and remote network control, together with consolidation of switching and transmission facilities have increased the potential for choke-point network failures.

5.2 Technical network configurations

In general terms, a "network" is taken to mean any collection of distributed equipment that can provide a transmission path between two terminals. The complex of communication nodes, links, and even interpersonal power relationships within organizations provide the basis for network topology. Network topology or configuration is a mapping of the connections or links among the various nodes.

In conceptual terms, the composition of the communication process includes, first, the information source -- that is, a person or a machine that chooses the symbols (letters/sounds) sent as messages to be transmitted. Second, the source-generated signals are sent to a signal encoder (e.g., a keypad or microphone) which converts them into electrical representations of those symbols. Third, the channel (e.g., radio path or telephone wire) is the medium or link over which the electrical signal is sent out. Fourth, the signal is carried through the medium to a receiver decoder (such as a modem or radio receiver). Finally, the recipient decoder converts the electrical signals to symbols understandable by the recipient.[2]

There are a number of different types of networks employed in electrical communications. Among the most common are the following:

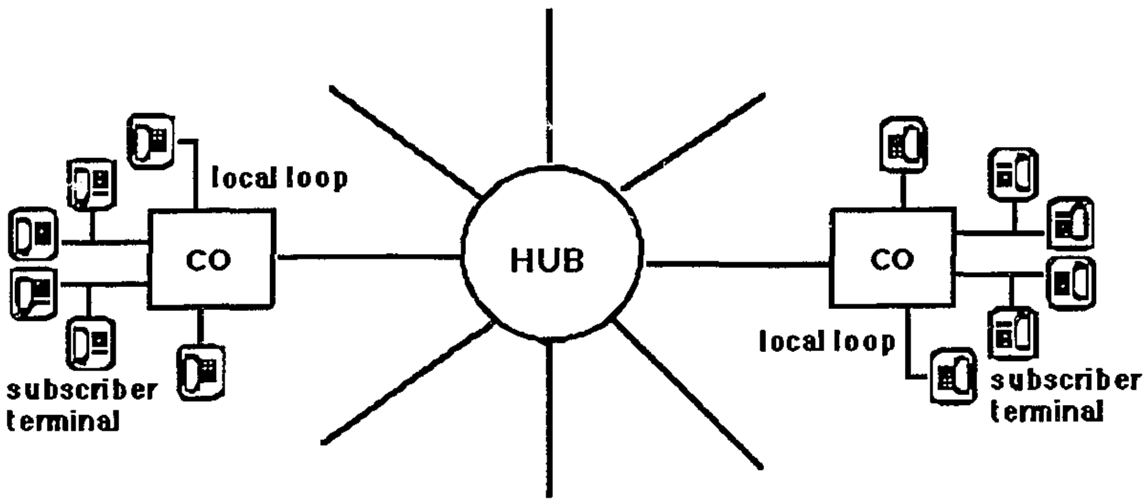
(1) The **star network** -- where links radiate from one node to other links.

(2) The **ring network** -- where communication can only occur at certain predetermined intervals by those on the ring.

(3) The **bus or tree and branch network** -- where each node shares a main link with other nodes.

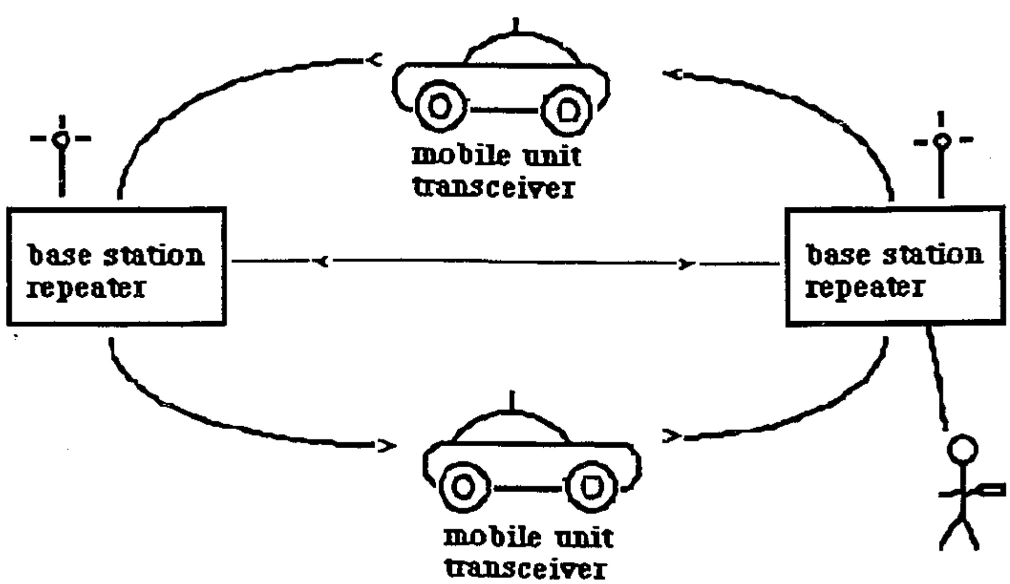
Telephone systems generally use the star configuration, with telephone company hub switching stations at the centre, connected to central offices (COs) and then to subscriber terminals. Figure 5.1 below illustrates the star configuration of the public telephone system.

FIGURE 5.1
Telephone System Configuration



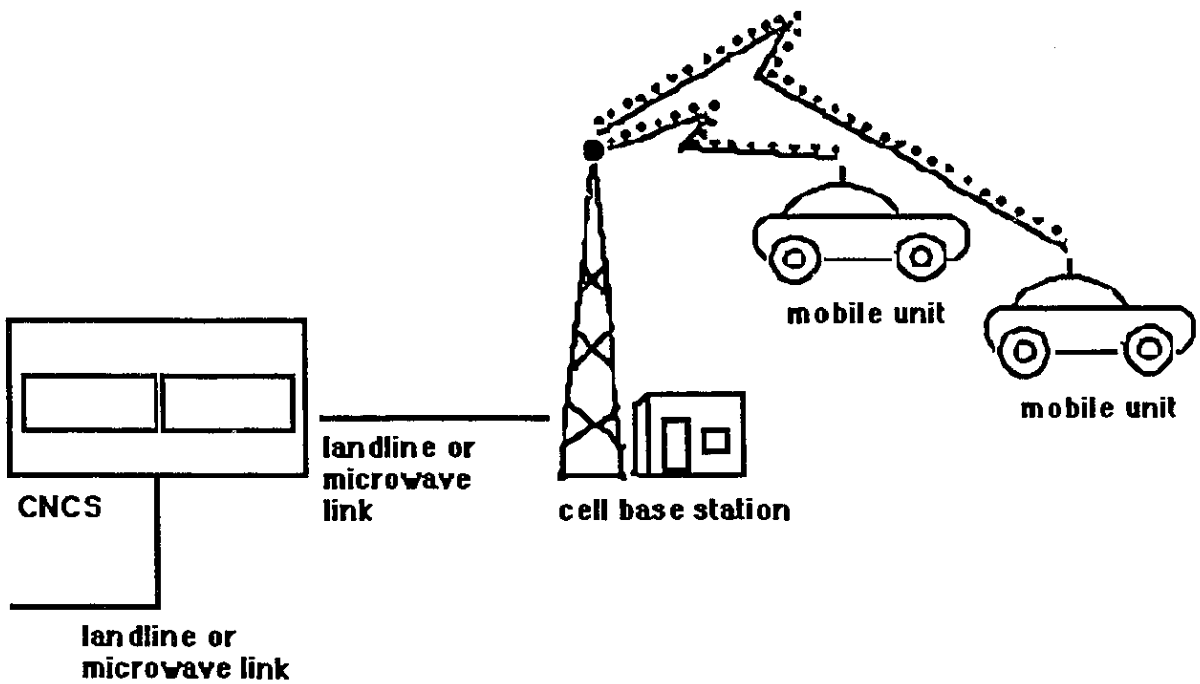
Local mobile radio systems employ a ring network configuration. Accordingly, transmissions to and between mobile units (vehicles or paging receivers) are made over-the-air, and they are always routed via a base station. Thus, direct communications between mobile units is not possible. Figure 5.2 below shows the configuration of land mobile radio systems.

FIGURE 5.2
Local (UHF/VHF) Mobile Radio Systems



Cellular radio-telephone employs a combination ring and star configuration. Figure 5.3 provides an illustration of this concept.

FIGURE 5.3
Cellular Radio-Telephone System



Cable television systems are based on a bus or tree and branch-type distribution architecture, in which subscriber lines are tapped off long feeder cables. Figure 5.4 below illustrates the cable distribution concept.

In simplified terms, a CATV system consists of the following elements:

(1) Antenna(s) placed at a site with good reception of surrounding stations.

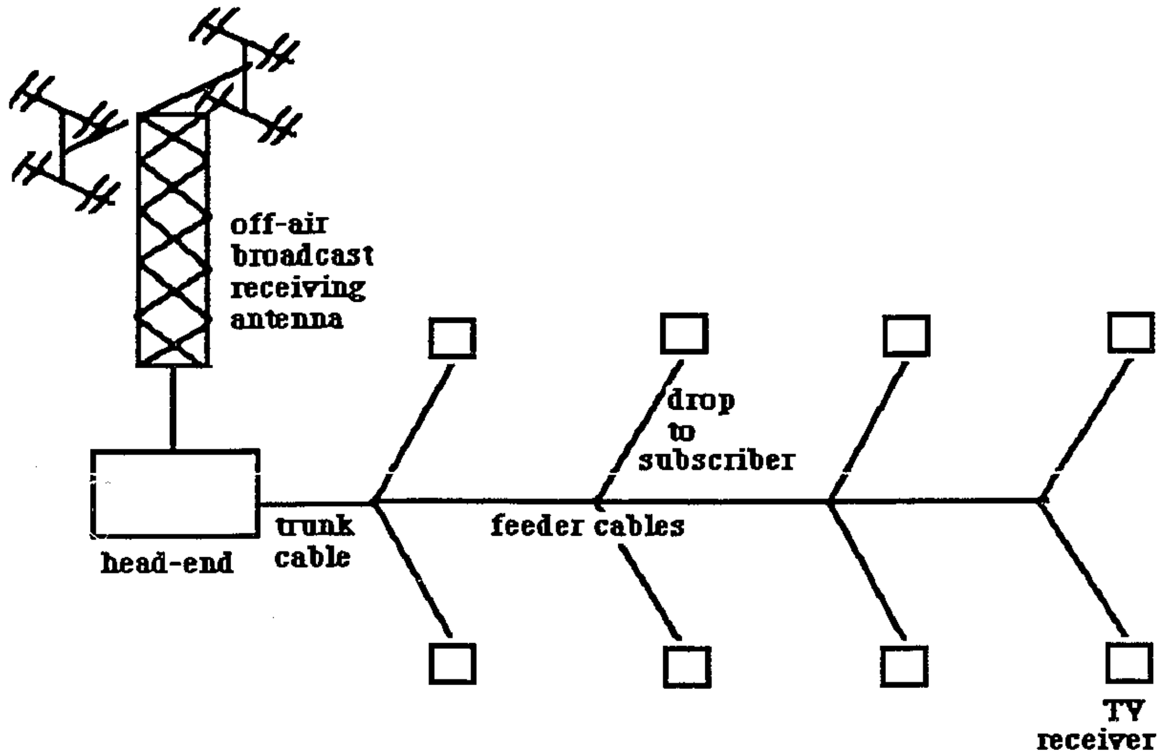
(2) A head-end, where signals received over-the-air are changed into electrical pulses that then can be transmitted over wire.

(3) Coaxial trunk cables plus amplifiers along their length used to boost the signals.

(4) Feeder cables which link the head-end to subscriber drops.

(5) A converter in systems with more than 12 channels, at the receiving end, that make television sets tunable to the channels carried by the feeder cable.

FIGURE 5.4
Cable Television System



Today we take the public switched telephone network for granted. Increasingly, however, we are coming to depend on a variety of different communications networks -- such as adaptive differential pulse (ADP), facsimile, etc. Moreover, when we think of networks, we no longer think just of the physical facilities upon which they are built. Networks include complex protocols as well -- that is, technical standards and interface computer software which permit separate operating systems to exchange information.

5.3 Electrical communications

When molecules are set in motion by a vibration, they move in waves -- at a certain rate of speed. This rate is known as a **frequency.**[3] Sound is the result of an object vibrating and causing a displacement of its environment (e.g., air, water). Sound waves result from a vibrating object compressing and stretching the substance or "medium" through which they are travelling. The speed at which sound travels through a medium is proportional to its (the substance's) elasticity. For example, sound travels through water at 3,322 metres per second (m/s), but through rubber at only 54 m/s.

While passing through the medium, if they encounter another object, the sound waves will cause it to vibrate as well. That is, if sound waves travelling through one medium, such as air, reach another medium of different elasticity, such as a wall, some of their energy will set up waves in the new medium; the remainder will be reflected or echoed. When the human ear feels these vibrations, the eardrums begin to vibrate at the same frequency and we have the sensation of hearing.

Sound waves travel through the air at a speed of 335 m/s, but they are rapidly diffused in that medium. In order to make sound travel some distance, it therefore is necessary to put it into a carrying container. Alexander Graham Bell achieved this by immersing a wire connected to a diaphragm (his telephone mouthpiece transmitter) in a sulfuric acid solution. As the wire vibrated in and out of the solution, the resistance of the device varied, resulting in an undulating electrical current which placed varying strain on the diaphragm. The consequent motion produced sound.[4]

When alternating current (AC) is introduced to tuned circuits which are resonant at the frequency of the alternating current and coupled with an antenna, those circuits radiate electrical energy in the form of electromagnetic waves.[5] These waves are used as a transmission medium for telephonic and radio communications. Conventional telephone, radio and television systems operate at frequencies between 100 hertz (Hz) and 10 gigahertz (GHz or 10 billion Hz). State-of-the-art high-capacity systems operate at between 1 and 10 GHz. As frequency is increased beyond 300 GHz, the visible light spectrum is approached. Frequencies in this range are used increasingly by fibre optic "broadband" transmission systems.

Within the radio frequency spectrum (which includes electromagnetic waves between about 10 kilohertz (kHz or 1,000 Hz) and 300 GHz), a number of frequency bands have been identified which will be referred to from time to time. They include:

VLF (very low frequency)	< 30 kHz (direct voice)
LF (low frequency)	30 - 300 kHz
MF (medium frequency)	300 kHz - 3 MHz[6]
HF (high frequency)	3 - 30 MHz
VHF (very high frequency)	30 - 300 MHz
UHF (ultra high frequency)	300 MHz - 3 GHz

SHF (super high frequency)	3 - 30 GHz
EHF (extremely high frequency)	30 - 300 GHz.

5.4 Telephony

The concept of telephony refers to the idea that sound waves can be converted into electromagnetic waves, carried for a distance, and then reconverted into sound (or audio) waves which are perceptible to the human ear.[7] The use of electromagnetic energy for communications began with the telegraph. From there communications engineers began the ascent of the radio frequency spectrum -- starting with voice frequencies on telephone lines, then radio, television and, later, microwaves, which can carry a variety of electronic communication signals. Communications engineers now are moving beyond the radio frequency spectrum into the light spectrum.

Bell's telephone had a skin diaphragm stretched over the mouthpiece (the transmitter). Attached to it was a piece of iron fastened to an electromagnet. When sound waves struck the mouthpiece skin, it vibrated and the skin, in turn, touched the iron which also vibrated, causing electrical currents to pass through the electromagnet. These currents travelled along a wire which was connected to a receiver, where they struck another electromagnet. This made the iron fastened to it vibrate, reproducing the original sound waves that had been fed into the transmitter. Thus, the transmitter converted the sound waves produced by the human voice into electric current, while the receiver reconstructed that current into the original sound waves.

Thomas Edison designed a more efficient telephone transmitter using a mica mouthpiece connected by an ivory button to powdered carbon (a good conductor of electricity) placed between two platinum plates. The modern telephone still operates on Edison's principles. Since electromagnetic waves carrying the voice message get weaker over long distances, repeaters or amplifiers are placed at regular intervals along the transmission path to regenerate the weakening energy of the waves without distorting them (Reinfield, 1963: pp.74-77).

The basic elements of telephony include the ringer, the switch hook, the dialler, the transmitter, the receiver, and the anti-sidetone circuit:

(1) The **ringer** is the telephone bell. It is activated by a series of electrical pulses generated at the telephone company switching office (CO).

(2) The **switcher hook** is used to connect or disconnect the telephone terminal to the telephone line and power sources.

(3) The **dialler** (rotary/pulse or touch tone[8]) is used to send dialling signal codes to the telephone company CO.

(4) The **transmitter** is the microphone built into the telephone instrument mouthpiece.

(5) The **receiver** is the built-in earphone or speaker.

(6) The **anti-sidetone circuit** eliminates outgoing voice echo by preventing transmitted voice signals (generated at the microphone) from reaching the instrument receiver.

Other built-in features that may be available include number memory, muting and number redial. Separate devices that might be attached to the customer terminal include computer modems, answering machines, facsimile machines, and the like.

5.4.1 Telephone network components

The public switch telephone service network is comprised of a number of components. They include:

(1) **Terminal equipment** located at the customer's premises (e.g., telephone, teletypewriter, facsimile machine, personal computer or large computer central processor).

(2) The **local loop** -- that is, the set of wires, cables, poles and related equipment (i.e., the circuit) that connects the customer's premises to the telephone company CO -- providing the customer access to the public switched network.

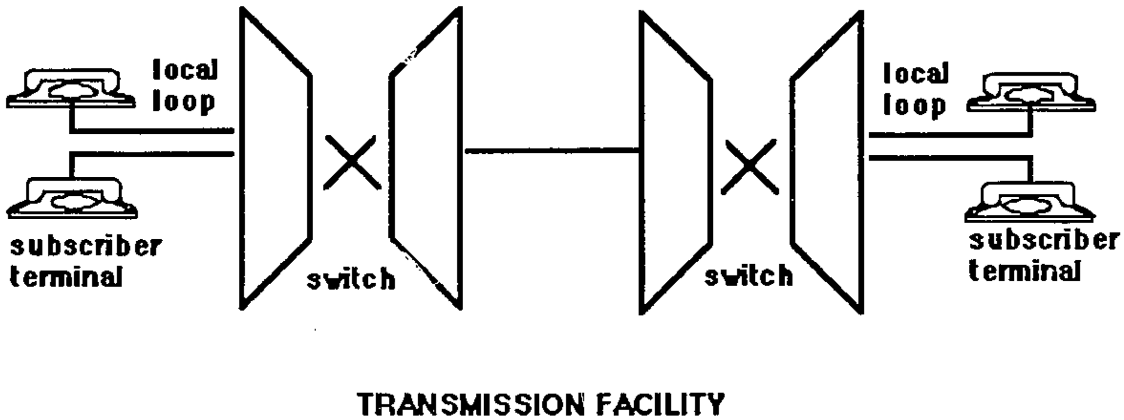
(3) **Switches** (e.g., local, tandem, toll or long-distance) located in a CO which provide the necessary connections when messages are sent or calls are made.

(4) **Trunk lines** (e.g., fibre optic or coaxial cable) that connect local or end-office COs to other COs such as hub switching stations, toll switching offices and microwave relay transmitters, etc.

(5) **Transmission equipment** which sends and receives electric signals over long distances, including higher capacity cable, microwave radios and satellites.

Importantly, for signals to be communicated effectively over these systems, there must be technical compatibility, interconnection and interoperability among all the functional components. Figure 5.5 below is a diagram of the basic telephone network components.

FIGURE 5.5
Basic Telephone Network Components

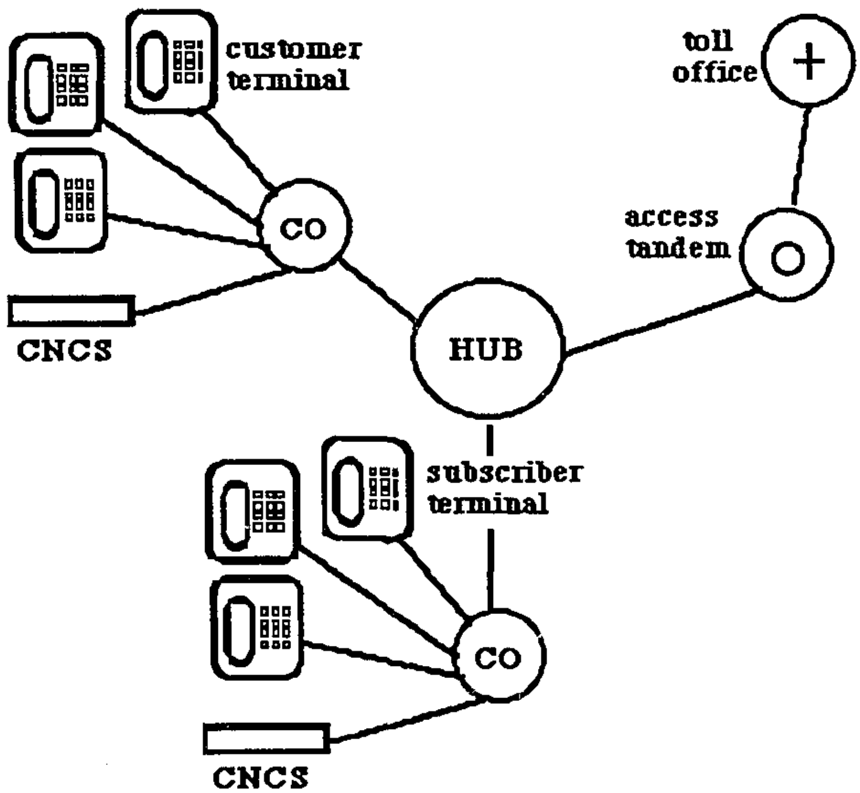


Under normal conditions, it works in the following way: when a call is made from a residential or business telephone, it is relayed over landlines (copper or fibre optic cable) to the nearest telephone company CO. The switching equipment located there sends it on to the CO nearest its destination, if the call addressee is in the same local calling area. A call to a destination outside the local calling area -- i.e., a toll or long-distance call -- is carried to the nearest access tandem office, from there to a toll office and, subsequently, across the public switched telephone network.[9] When the call reaches the CO nearest its destination, it is switched again to the local line (the loop) that goes to the address being called.

In high traffic volume areas (medium-sized metropolitan centres), customer terminals are connected to smaller COs (i.e., local or end-offices), which are themselves connected to a larger CO or "hub" switching centre. Only the hub stations are connected to other hub stations and to the switching offices that handle long-distance traffic. The hub concept is illustrated in Figure 5.6 below.

The hub configuration looks like a wheel, with the hub switching office in the centre. The rationale for running lines from a large number of COs through a single major hub station is, on the one hand, to reduce the risk of service loss resulting from cable cuts by laying fewer cables between individual COs and, on the other, to increase flexibility by providing more routing possibilities for longer-haul traffic. However, while the hub configuration may alleviate the majority of service interruption problems, when an outage occurs at the hub office itself, many more subscriber lines than previously will lose service. For this reason, in large U.S. metropolitan centres, and recently in Canada as well, because telephone traffic flows between nearby COs may be heavy, trunk lines connecting some COs to each other in addition to the nearest hub station may be laid. This allows the telephone company to "patch around" a problem situation or to reroute calls when there is an outage at a CO that normally handles large traffic volumes. In addition, in the United States, large users increasingly have some lines connected to an alternative CO to provide greater service reliability.

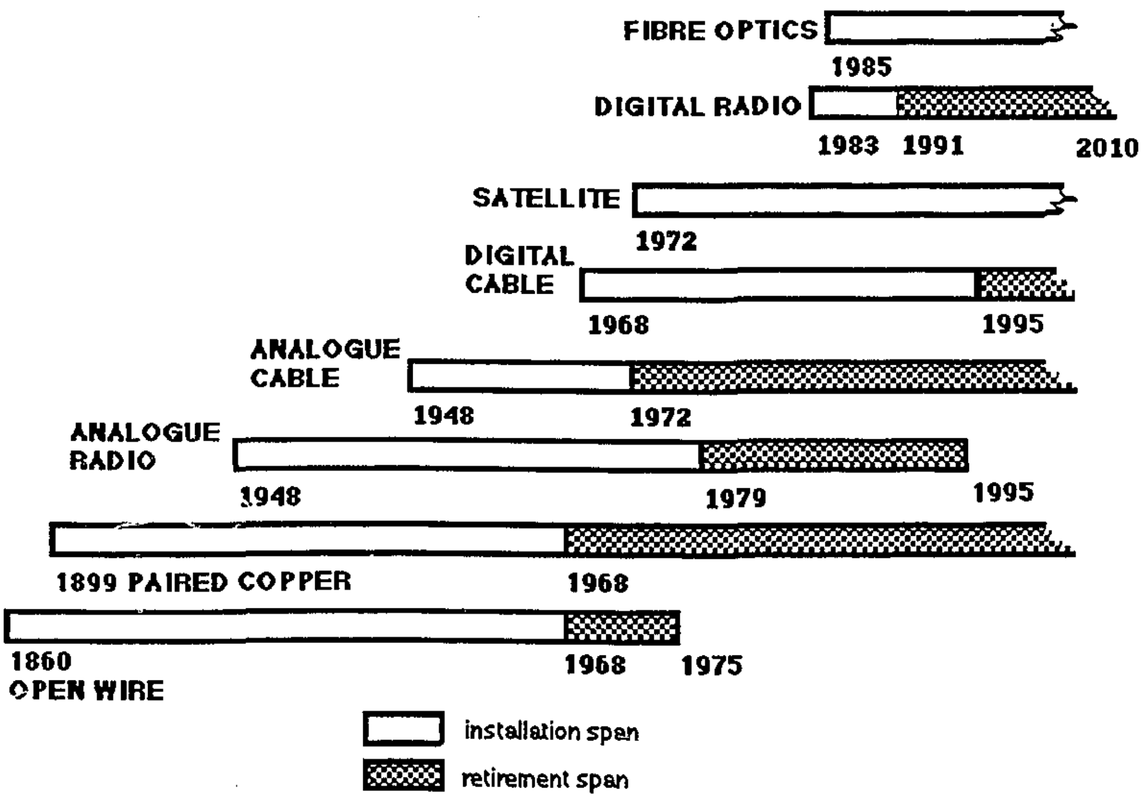
FIGURE 5.6
Hub Configuration



5.5 Voice transmission
5.5.1 Technological developments

Transmission systems refer to the facilities used to transfer something from one geographical location to another. Historically, the deployment of voice transmission technology in the public telephone system has been through a variety of transmission modes. Voice messages initially were transmitted over open wires, grounded either to the water main or to earth. From 1899, paired copper wires have been used for most local loop connections. Other transmission modes commonly used for voice transmission include coaxial cable,[10] microwave radio, satellite and lightguide or fibre optics. Figure 5.7 below illustrates the evolution of the related technologies.[11]

FIGURE 5.7
Transmission Evolution



Copper cables remain the centre of the voice transmission network. Due to improvements in cable-related technologies, transmission costs per coaxial voice circuit have declined steadily. At the same time, transmission quality and capacity have increased markedly. For example, from the L1 to the L3 and L4 Western Electric coaxial cable systems, voice circuit capacity increased from 2,000 to 17,000 to 32,000 voice circuits, while costs per circuit mile decreased from US$4.00 to $1.50 to $0.90. By the 1970s, the L5 system provided more than 80,000 voice circuits at a cost of only $0.35 annually per circuit mile (OECD, 1983: Ch.IV).

Microwave radio technology, using extremely high frequency (EHF) radio waves, was developed in the 1940s as an alternative to coaxial cable. Given that cable generally must be laid underground and cannot be emplaced on uneven terrain, microwave provides an attractive alternative transmission medium. Just the same, its capabilities are restricted somewhat due to its line-of-sight transmission path, together with high start-up and maintenance costs. In the first place, microwave repeater towers which are used to amplify or regenerate signals and relay them to the next tower usually are spaced at intervals of 30 to 50 km. Secondly, additional relays will be required in mountainous and other difficult terrains. Third, the rising costs of fuel have increased significantly maintenance costs associated with relay stations located in very remote areas. Furthermore, microwave is not reliable for transoceanic transmissions.

Some of these problems are resolved by satellite communications, which are based on the same principles as microwave radio. In satellite communications, the relay stations are located in outer space. Increases in the payload capacity of launch rockets together with the U.S. Shuttle program have brought down the annual costs of providing an increasing number of two-way telephone circuits -- from over $32,000 per circuit in 1962 to only $800 in 1979. Moreover, digital echo-cancelling microchips, introduced in the late 1970s, have doubled transmission capability. And increases in satellite transmission power, the introduction of spot beams and the development of above 11 GHz technologies also have resulted in significantly smaller satellite earth stations which cost considerably less to maintain (OECD, 1983: Ch. IV).

Perhaps the most significant advancement in telephony in recent years has been in the area of optical transmission. The introduction and rapid deployment of fibre optic cable as part of wireline telephone systems has altered fundamentally the direction of technological developments in telecommunications. Not only is the basic material used for its production much less expensive and more widely available than copper, the transmission capacity of fibre optics is more than three times greater. Among other things, one significant advantage of fibre optic cable over other terrestrial transmission media is that it can be fed through existing cable ducts. It also is more resistant to corrosion; needs fewer regenerations along long-distance routes; is immune to electrical interference; and is more difficult to tap into. The main areas of fibre optics application initially will be, first, interoffice trunks (that is, the high-capacity cables that link urban exchanges) and, second, long-haul transmission.

In terms of increasing transmission capacity using the different technologies described above, the evolution of this capability breaks down as follows:

* Single wire to carrier (3 to 12 circuits per two-wire system).
* Paired cable to cable carrier (12 to 24 circuits per two pairs of wire).

* Microwave:	analogue	- 1950 (5 x 480) = 2,400 voice circuits per route.
		- 1978 (11 x 1,800) = 19,800 per route.
	digital	- 1982 (10 x 1 344) = 13,440 per route.
* Satellite:	Anik-C	- 10,752 voice circuits (less TV channels).
	Intelsat VI	- 33,000 voice circuits and 4 TV channels.

* Fibre optics:
- 1982 (45 Mb/s bandwidth) = 672 voice circuits per FO pair.
- 1985 (565 Mb/s) = 8,074 voice circuits per FO pair.
- 1988 (1.8 Gb/s) = 24,192 circuits per FO pair.
- 1991 (2.4 Gb/s).

The first coast-to-coast analogue microwave radio route was installed by Telecom Canada's predecessor, the TransCanada Telephone System, in 1958. And in 1968, a second route was placed into service. These subsequently were modified so that today, the Toronto-Eastern Canada portion has one route that is equipped for both analogue and digital transmission while the other carries analogue traffic only; the Toronto-West Coast portion carries analogue and digital traffic on both routes. The completion in spring 1990 of a Halifax to Vancouver (7,000 km long) high density fibre optic route by the Telecom Canada and its proposed extension to Newfoundland and Prince Edward Island likely will result in an increasing domination by fibre optics as the preferred transmission mode for voice communications in Canada.[12] Unitel, formerly CNCP telecommunications,[13] similarly has constructed a nation-wide fibre optic network to provide (monopoly) telex and (competitive) private voice and data transmission services.[14]

Alternative voice telephony transmission modes, employed in areas where fibre optic placement would not be economic, include microwave radio and satellite systems. At the present time, microwave radio networks are used primarily as a backup transmission mode in the public telephone system; they also are used extensively in rural and remote areas where the very high costs of laying and maintaining cable routes preclude fibre optic deployment. Satellite transmission likely will be supplanted by fibre optics for voice telephony services in all Canadian urban centres; it will remain, the medium of choice for broadcasting until fibre optics is extended to the local loop (not expected until midway through the 1990s, given the projected 25 to 30-year lifespan of copper). The main use of satellites thereafter will be for niche applications, and for data rather than voice transmission. Satellite systems will continue indefinitely to provide most or all voice, data and video telecommunication services to the Far North and other remote communities.

As Figure 5.7 above suggests, microwave radio as an alternative voice transmission mode could be phased out in favour of very high-capacity fibre optics early in the 21st century. Analogue radio transmission similarly is scheduled to be retired from the public network as early as 1995, while digital radio -- only introduced in Canada in 1983 -- also might be retired eventually. This would have some unfortunate consequences because, for example, when it is deployed widely, microwave radio provides an excellent alternative system to an entirely fibre optic network. Just the same, where microwave routes parallel coaxial and fibre optic cable routes in close geographic proximity, the benefits of that redundancy are eroded, since a major natural disaster likely would take out microwave towers and damage antennas in the affected area in addition to destroying portions of the cable route.

Considered together, advances in communications technologies suggest a fairly robust capability. Still, the public telecommunications system remains at risk, and its survivability could be improved significantly by emphasizing a multimodal transmission capability. Specifically, while there are significant advantages in extending fibre optics in terms of lower costs and extended broadband services availability, there also are some important disadvantages. These are measured principally in terms of lost system redundancy.

In the next section, the development of lightguide systems is considered, together with the associated implications for emergency preparedness communications. This will be followed by a discussion of recent advances in switching and system software technologies, and the transition to broadband networks which is altering fundamentally traditional conceptions of the public telecommunications system. The remainder of the chapter will look at modern radio transmission systems and technologies, particularly as regards radio-telephony.

5.5.2 Lightguide systems

Terrestrial landline transmission technologies have evolved from open copper wire to coaxial cable to fibre optic cable. Indeed, fibre optic transmission dates back only to the early 1980s. It is based on a light wave communications system which uses hair-thin strands of ultra pure silica glass as the transmission medium.

Light waves are part of the spectrum of electromagnetic energy which is at the heart of all electronic signal transmission phenomena -- including, electrical current, radio waves, infrared radiation, visible light, ultraviolet radiation, X-rays, etc. Lightguide systems, it will be recalled, transmit information at frequencies beyond the radio frequency spectrum -- that is, above 300 GHz. Theoretically, the bandwidth capacity of optical communications systems is enormous. At such high frequencies, they can carry much greater quantities and types of information than electrical signals transmitted on copper wires and coaxial cable.

In addition to saving space,[15] optical systems experience lower transmission losses over distance. This makes it possible to transmit over longer distances with fewer regenerations. The result is considerable cost savings in terms of equipment purchase (fewer cables and repeaters) and maintenance. Moreover, as they are made of a non-metallic conductor substance, optical systems are nearly impervious to interference from electrical equipment, lightning and crosstalk (that is, between lines in the same cable). Optical systems also are more secure than other transmission systems because it is more difficult to "tap in" to them. A basic fibre optic or lightguide system consists of the following elements: [16]

(1) A **modulated light source or laser transmitter**, which is turned on and off millions of times each second.

(2) A **glass fibre transmission medium,** which carries injected light from the laser source.

(3) A **receiver with a photo-diode,**[17] which can detect arriving photons or light pulses.

(4) For long-haul transmission, **optical repeaters** are used to regenerate the light signals because they are subject to distortion over long distances.

In lightguide systems, voice, data and/or video messages are converted at the transmission end into pulses of light. These then are guided along the transmission path by modulating the light from either a light emitting diode or a laser source and coupling the optical beam that results into the glass fibre. At the receiving end, the process is reversed as the optical stream is demodulated by a photo-detector (i.e., a photodiode) and translated into multiplexed electrical signals that replicate the source (e.g., voice) signal (NRC, 1989: p.47).

The superior quality of the signal transmitted over lightguide systems is due to the reduced attenuation and distortion of the signal as it passes through the highly pure glass compound strand. The development of purer compounds and attenuation reduction techniques allow very high-speed information transmission rates over increasing distances between repeaters. Commercially available fibre optic systems can now support as many as 24,000 simultaneous conversations at a transmission rate as high as 1.8 Gb/s. It is expected that in the near future, fibre optic systems will be available that can handle twice that amount of traffic. Indeed, fibre optics has an inherent transmission capacity estimated to be as much as 25 terahertz (THz) or roughly 10,000 times existing systems. Thus, the capacity of fibre optic systems will not be limited to the ability to modulate the transmitted light beams at higher and higher speeds. Recent developments in (wavelength division) multiplexing will further increase fibre optic capacity by combining multiple bit streams travelling on different wavelengths through the same fibre strand (NRC, 1989: pp.47-48).

The addition of lightguide technologies as replacement circuitry on "the last mile" --that is, between the telephone company central switching office and home or office premises) will provide much greater traffic carrying capacity that could be used in a variety of ways. In contrast to the copper cable that now constitutes the local loop (often capable of handling only one telephone conversation at a time), fibre optics might be used to carry several conversations, as well as simultaneous voice and data transmissions, or even video transmission. And as the price for installing fibre optics continues to fall due to improvements in manufacturing and increased market demand, we also can expect the race to provide "fibre to the home" (electronic communications, not home-delivery of oat bran cereal) to rekindle competitive pressures between cable television and telephone companies. Moreover, fibre optics are expected to become the most commonly used transmission medium by telecommunications companies in interoffice (CO) trunking systems as early as 1995.

Concerning emergency preparedness communications, the net result of these trends will be increased reliance on a single mode of transmission. Additionally, that reliance will be on a thinner and thinner network base, since one fibre cable is able to carry so much traffic. Furthermore, given the broadband[18] capabilities of fibre optics and absent a redundant fibre optic link, an outage would affect not only circuits carrying telephone conversations, but computer-to-computer traffic as well; and that could have a tremendous adverse impact on regional and, in a prolonged outage, even national commerce. Indeed, the loss of a single very high-capacity fibre optic link could result in the loss of service to tens of thousands of calls per hour.[19]

Telephone companies, however, dispute suggestions that the public telephone system would be less reliable as an entirely fibre optic network. They point out that the use of high-capacity fibre means that there are fewer cables at risk of being either accidentally or intentionally cut. Moreover, users might not even notice a breakage when it does occur, because traffic would be switched automatically to another line. Nevertheless, if fibre optics gradually replaces microwave radio as the public network's backbone, it certainly will be more susceptible to cable cuts and the resulting widespread loss of service in the highest traffic areas.

With regard to long-haul telecommunications -- where microwave radio currently provides a fairly reliable backup system -- telecommunications service providers would face similar problems in an all-fibre system. Some redundancy could be provided by other (private or competitive) facilities-based carriers, but only if their systems are fully interconnected and interoperable with the public network. In Canada, Unitel's request to be allowed interconnection with the public long-distance voice network has not yet been granted, although it may interconnect with other companies' networks for the purpose of data and private-voice message transfers. In the United States, in contrast, the three nationally based long-distance carriers -- AT&T, MCI and U.S. Sprint -- now are fully interconnected with the regional Bell operating companies on an "equal access" (that is, transparent to users) basis. Indeed, each carrier owns its own national fibre optic network capable of providing backup service in most areas of the contiguous United States. Just the same, the continued absence of competition in local service markets, together with the lack of full interconnection and a limited availability of access tandem switches (through which all long-distance traffic is routed), restricts the redundancy benefits of the alternative carrier systems in that country as well.

Respecting short-haul communications, local calling areas (traditionally provided service by a single common carrier) would be most at risk of system failure in an all-fibre environment. This is due to the fact that any large-scale disaster in a localized area probably would cause multiple cable breakages. Furthermore, backup cables often are laid alongside primary routes, with little if any geographical separation.

Another problem of relevance to emergency communications is associated -- albeit indirectly -- with the trend towards an all-fibre network. It relates to the provision of electrical power to the telecommunications system. Historically, it has been the policy of telephone companies to provide electrical power from their own source, that is, independently of the electric utility company. This, it will be recalled, is done using storage batteries that transmit electric power using direct current, as opposed to alternating current. The latter, due to its ability to be propagated over long distances without loss of energy remains the predominant commercial electrical resource.

Additionally, today an increasing number of business customers are using key systems or private branch exchanges (PBXs). PBX systems operate essentially in the same way as larger computerized switches used by telephone companies to route subscriber calls -- that is, COs. A PBX is dedicated to a single user, and it allows a business to provide enhanced services like voice messaging, automatic call routing, etc. to each telephone or computer extension connected to it. Moreover, because modern PBXs use computerized digital communication methods, they also can transmit voice and data simultaneously.[20] Significantly, these on-premises customer equipment usually are powered by an AC power supply provided by a power utility company rather than by DC battery power provided by the telephone companies. This raises some interesting questions respecting the dependence by business users -- and indirectly by the public network -- on electric utility companies to provide power to network access points. This is because the increased reliance on power supplied from a source external to the public switched network adds a new source of system vulnerability -- namely, electrical power outages -- which in some regions are frequent and may be prolonged. In such situations, business customers who neither own a power generator nor have access to an alternate power source, will lose access to the public network. They also will lose all internal communications for the duration of the power outage.

Consequently, although fibre optic routing is not inherently more vulnerable than other methods of terrestrial transmission, the much greater traffic-carrying capacity of lightguide systems means that fewer primary routes are needed to meet transCanadian voice and data traffic requirements. The diminishing number of transmission routes, in turn, means a greater concentration of traffic, reduced use of other technologies and, in many instances, restricted spatial diversity of the alternative routes that do exist. Moreover, the trend towards sophisticated customer-owned equipment has created a situation where commercial power failures regularly disrupt service, with the associated consequences for medium and large business users. On the positive side, in situations of service loss due to a fibre optic cable cuttage, the time required to restore service overall will be reduced due to the fact that when it is repaired, service will be restored for all users at once.

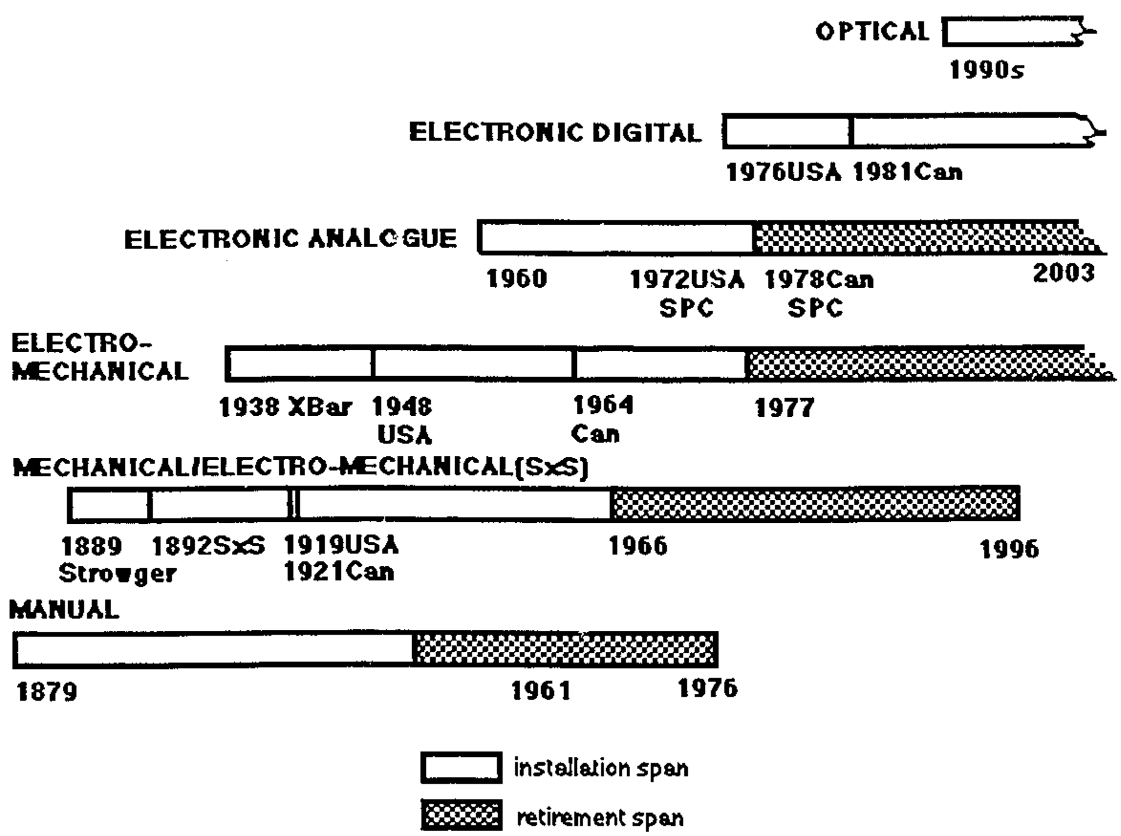
5.6 Switching technologies

Technological developments in telecommunications switching have paralleled the evolution of voice transmission technologies. They began with the development of mechanical switching technology which replaced the first manual switches. This was followed by electro-mechanical, electronic analogue and, most recently, by digital switching. Optical switching modes are now on the horizon. Figure 5.8 below summarizes the evolution of switching technologies.

Developments in switching have followed two divergent trends. In the first place, the economics of digital switching have driven service providers to build "super switches" which they have located in very large capacity wire centres. These so-called "hub" stations (the configuration of which was discussed earlier) have enormous traffic-carrying capacities. They also control an increasing amount of voice message traffic routed from remote switches which aggregate traffic originating in smaller communities.

The other major trend in switching has been driven by advances in microprocessing. Advanced integrated circuitry has made possible the use of customized network control software, the effect of which has been to transfer switching capability closer to the customer's premises. Providing the impetus for these trends are sophisticated distribution processing technologies and large-scale integrated circuit microchips.[21]

FIGURE 5.8
Switching Evolution



The first **manual switch** in Canada was put into operation in 1879. The subsequent development of battery power technology led to the consolidation of switching power sources to serve entire communities. It also led to the replacement of in-home batteries with a common battery, introduced in Canada in 1901.

The transition to high-capacity switching began with the invention of the **Strowger mechanical switching system** in 1889. The **step-by-step mechanical switch**, initially introduced in 1892, stated being used by the U.S. Bell System only in 1919 because of the high cost of providing service to large numbers of users. Its introduction in Canada in 1921 eliminated the need for a human operator to complete local telephone calls.

The next major development in switching technology came in the 1950s, with the introduction of the **electromechanical crossbar relay switch** -- really just a more sophisticated mechanical switch. Made possible by the development of the transistor by Bell Labs in 1947, the crossbar switch was introduced commercially in 1948 in the United States; it became available in Canada only much later, in 1964. Crossbar switching makes possible common control (but not stored program control), alternate routing and four-wire transmission.

Electronic analogue switching, developed about 1960, was introduced in the U.S. market in 1972. It came into commercial use in Canada six years later. Using sophisticated integrated computer circuitry capable of storing information necessary for automatic network control, stored program control (SPC) was made possible by its introduction. And as SPC providers replaced wired logic circuits and relays in their switching control units with solid-state microprocessor chips, switching equipment became vastly more flexible. Changes in functions now can be accommodated relatively easily by changing the stored program, rather than by physically altering logic parts in the equipment (OECD, 1983: p.53).

The commercial availability of **electronic digital switches** dates from 1976 in the United States and 1981 in Canada. Their introduction has removed the necessity to convert analogue (voice) signals into digital binary format on the trunk side. Digital switches also are capable of accommodating considerably more complex network control (i.e., software) features, including SPC and a time-division multiplex[22] switching matrix. This has increased switching capacity geometrically. Underlying the transition to fully digital switching has been the rapid decline in costs-per-function of digital circuits. Increasing levels of component integration have doubled not only the functional complexity of digitally integrated circuits each year, but their performance capability as well. At the same time, prices per circuit have remained virtually constant. By contrast, there has been little reduction in the cost of analogue circuitry (OECD, 1983).

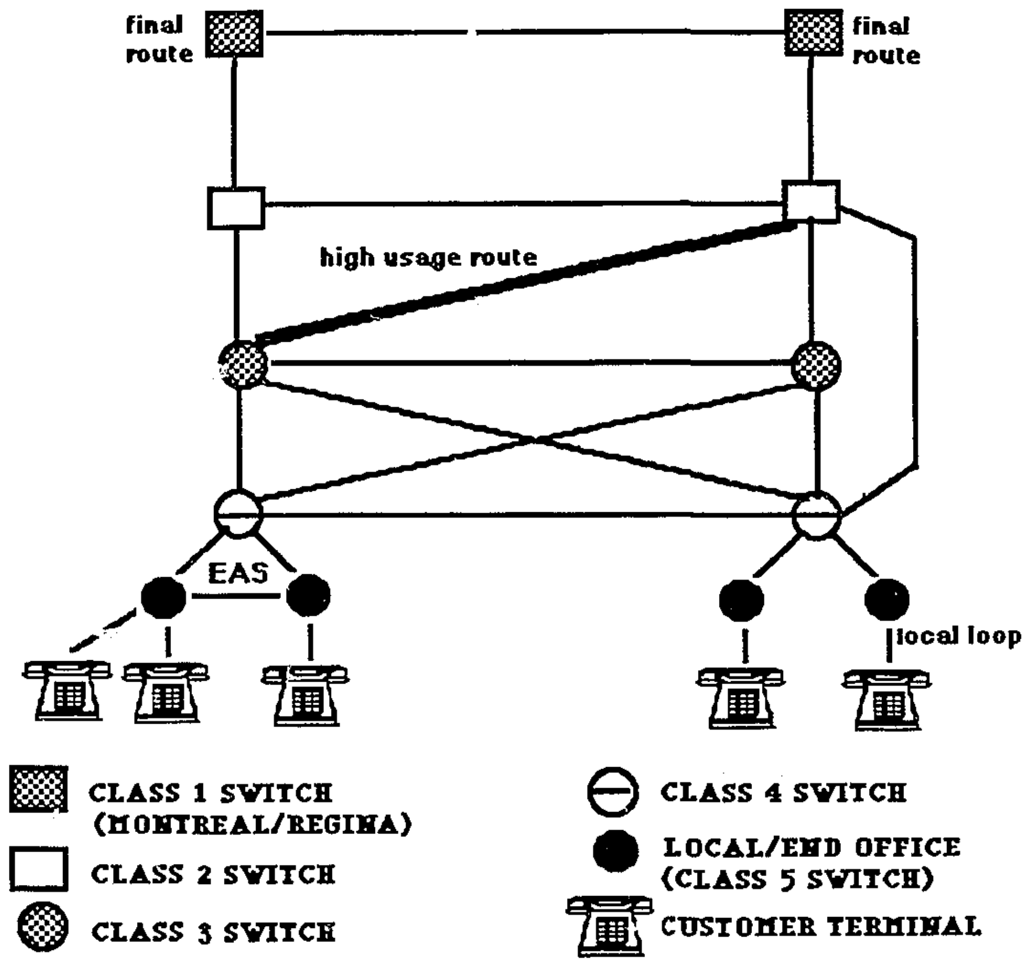
Today's digital switches are physically much smaller than earlier switches, but they have a far greater traffic management capacity. In addition, they are capable of controlling unstaffed remote switching systems, with the consequence that tens of thousands of users spread across dozens of communities may have their regional and long-distance call traffic routed through a single switching node. Indeed, it is now common to find the following equipment co-located in the same building: signal transfer points (STPs); class 3, 4 and 5 switches; packet switches (for data and signalling); cellular network control stations (CNCSs), also known as mobile telephone switching offices (MTSOs); and private line terminals.

In 1985, as many as 30 per cent of Canada's switches were still step-by-step mechanical switches; 28 per cent were electromechanical crossbar switches, while 21 per cent were SPC electronic analogue and 21 per cent were digital. In that year, Canada's domestic long-distance telephone network had a total of 133 switches. Of these, 104 were class 4 switches and 20 were class 3 switches. In addition, Canada has seven class 2 (that is, regional) switches and two class 1 switches. The class 1 switches are located in Regina (covering Western Canada) and Montreal (covering Eastern Canada), respectively. In addition, there are four international gateway switches (in Toronto, Vancouver and two in Montreal) which provide centralized switching for overseas and very long-haul communications.[23] Today, some of the larger class 5 switches located in local/end office COs, are now digital (i.e., DMS).[24] This means that they automatically can search for a direct transmission route, so that there is less need to route calls hierarchically.

As of 1991, the whole of the Telecom Canada trunk network has been converted from fixed hierarchical routing to high performance (dynamic) routing as a strategy to improve network performance. The current switching configuration in Canada, from small local switches up through the largest long-distance switches, is illustrated in Figure 5.9 below. Still essentially hierarchical, it improves on the older configuration in that it allows for more automatic rerouting options to enable subsystem points of failure -- that is, switches or transmission links -- to be patched around almost instantaneously. In this way, an improved grade of service is achieved compared to standard hierarchical routing. Finally, the ongoing transition to common channel signalling system seven discussed in the next section, in combination with the modifications to the Canadian switching configuration just discussed, will have the effect of converting this country's public telecommunications system to a geodesic one.

To summarize, there are now fewer, very high-capacity digital switches taking the place of lower capacity analogue and electromechanical switches. This trend results from the creation of "super switches" which act as traffic control hubs for larger and larger geographical areas and, correspondingly, more and more telecommunication customers. At the same time, the number of smaller remote switches installed in rural and remote areas also is growing rapidly. These are used to aggregate traffic originating in smaller communities and then route it via the host switch (a hub switching centre), which could be located hundreds of kilometres away. In order to reduce the potential effects of key point failures on the total network's performance, Telecom Canada also is converting its routing from fixed hierarchical to high performance (dynamic) routing. In this way, service loss will be reduced in the event of a major link or switch failure.

FIGURE 5.9
Canadian Switching Configuration



5.7 Software management

Another significant trend related to advances in telecommunications transmission and switching technologies that will influence the configuration of telecommunication networks in the next century is toward software rather than hardware-oriented innovations. These developments are making the public switched network increasingly "intelligent" -- at lower and lower levels of the network hierarchy. Accordingly, most general network control functions are being concentrated into fewer, centralized software databases, connected by a small number of signal transfer points (STPs). At the same time, more sophisticated software program-based distributed processing is decentralizing switching capability by making some of it available at the customer's premises -- e.g., related to key systems and private branch exchanges (NRC, 1989: p.54).

As a result of these developments, it is becoming more and more difficult to distinguish between computer technologies and telecommunications. The management of the national public switched telephone network now depends heavily upon computerized control technologies and protocols. And whereas voice distribution -- the "telecommunication" function -- was the primary focus of the telecommunications industry through the late 1970s, today we think of "information" distribution rather than just voice communications when we think of telecommunications. Information, defined in broad terms, includes anything from voice to numerical data to text to graphics and image "data streams." Thus, information distribution encompasses voice communications, data processing, batch processing and now, interactive processing (which involves going on-line and doing time-sharing). Furthermore, just as telecommunications is moving away from voice distribution and towards integrated information distribution, so too is the computer business moving away from mainframes and towards mini-computers, personal computers and, increasingly, to integrated data-processing service bureaux within organizations which aggregate, integrate and process all types of information -- e.g., data, voice and video.

Major developments in improving traffic-carrying capacity, intermodal communications linkages, and increasing to tremendous speeds both transmission and switching will be attributed predominantly to microprocessing and "network control" system improvements. As the memory capacity of microchips expands, so to will the capability of an increasingly intelligent network to execute complex functions requiring extremely detailed programmed instructions. It is expected, therefore, that while improvements and innovations in transmission and switching hardware will continue, the greatest system performance enhancements will result from dynamic routing programs, common channel signalling (CCS) and the like -- all of which are software based.

A key element in the emerging telecommunications environment that will have a fundamental impact on emergency communications relates to ongoing advancements in the area of stored program control (SPC). Dynamic call routing and common channel signalling, two aspects of SPC, will now be discussed and their implications for emergency preparedness communications considered. Subsequently, developments in radio communications will be looked at, including recent advances in cellular radio-telephony, which are of particular relevance to emergency communications.

5.7.1 Stored program control

It is anticipated that by the year 2000, some 100 million lines of software programming code will be required to operate telephone company super switch hub stations. Indeed, centralized switching nodes already need as many as 10 million lines of code. This increasingly complex software function provides the network with the flexibility necessary for both dynamic call routing and common channel signalling. Built-in software programming in digital switches also permits self-diagnosis of technical problems, thereby speeding up repairs to a damaged node. In addition, packet switching[25] technologies allow multiple messages to be sent simultaneously along the same transmission path.

On the other side of the equation is the added vulnerability introduced by the greater reliance on software and the centralization of massive software databases in a small number of very large switches. Open network architecture and the gradual introduction of ISDN will give customers access to basic network software. But, while this provides users with more control over their own internal networks by providing the needed programming information at the access point to the public network, it also may open the door to hackers.[26]

Trends in the area of SPC validate earlier predictions of a convergence of the computer and telecommunications industries. Software control will certainly affect, and may fundamentally alter, every aspect of national network configurations. Already, digital and analogue signals are becoming indistinguishable; and it probably will be only a short time before transmission and switching multiplexers are also melded and the separate functions performed by each merge. The vast storage capacity of today's centralized computer processing units suggests that there may be no meaningful limit to the kinds of programming functions possible for information processing and distribution carried out by tomorrow's networks.

Stored program control is now the dominant network control technique used by all electronic telecommunications switching systems. In a similar way, planning alternative transmission routes to cover major emergency contingencies also will be software driven. Likewise, the move towards more customer control in designing customized "virtual private networks" is reflective of advances in software made possible as a result of dramatically increased microchip memory capacity.

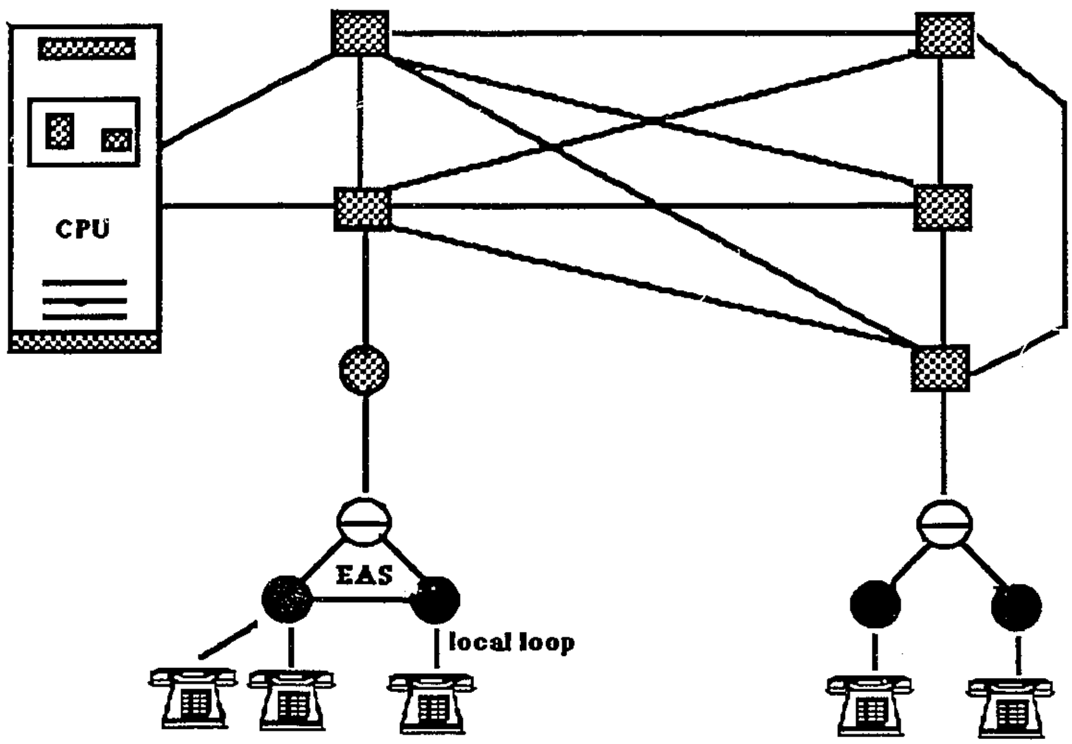
5.7.2 Dynamic call routing

Network management systems in Canada today require human intervention at Provincial Service Co-ordination Centres (PSCCs), where computer-based network surveillance and traffic management operations are centralized. Technical experts at these centres anticipate peak traffic periods and develop contingency plans to cope with equipment failures as well as disasters. In the event of a situation where certain routes are either overloaded for prolonged periods or disrupted by damage to the physical facilities of the network, on-duty staff will intervene manually to "massage" the system by (1) rerouting calls over alternate microwave and fibre optic routes; (2) restricting incoming toll calls or outgoing local and long-distance calls; and (3) co-ordinating service restoration (Bell Canada, 1986).

Under dynamic call routing schemes recently implemented (1990), execution of PSCC contingency plans has become increasingly automatic. That is, the remedial procedures now are programmed into the PSCC monitoring system. In Canada, a complex high-performance dynamic routing system for long-distance calls has been developed. It is based on a central processing computer located in Ottawa, which polls all toll switches in the country approximately every ten seconds in order to measure traffic loads on each trunk route. On the basis of the information provided, the central computer will automatically calculate and select the best alternative tandem route to be used when a direct route is busy. A theoretical schemata of the dynamic call routing configuration is shown in Figure 5.10 below.

It is anticipated that dynamic call routing will help to make the network much more resilient to switch failures and peak period overloads. It also is anticipated that it will result in more rapid real-time reaction to unanticipated traffic congestion such as is likely to occur following a major disaster, since it will not require the same degree of human intervention to recognize a problem and decide on corrective action.

FIGURE 5.10
Dynamic Routing Configuration



5.7.3 Common channel signalling

Another significant software-oriented development has been towards common channel signalling. Today, for the most part, voice communications and call signalling use the same transmission path; in the future, they will follow separate paths. This means that the voice circuit that is now assigned when a caller receives dial tone will no longer be tied up during the entire call set-up period. The time required by the system to complete a call set-up also will be reduced significantly (from more than 12 seconds for a coast-to-coast long-distance call to only about two seconds). Circuit costs, moreover will be reduced as a consequence because no switching will be involved in the signalling process.

At present, the signalling function involves the routing of each call through the public switched network from the terminal (e.g., telephone) originating the call to the receiving terminal, and reporting on its status along the way -- connected; terminated; ringing or busy. In a typical call sequence as noted above, network signalling is in-band (that is, the signal is carried in the same channel as the voice communication). The calling party dials a telephone number (the address), and this signals the telephone company central office to which the caller's line is connected. The telephone number being called then is sent on to the next CO over the voice channel that will, if the call is successfully connected, be used for the conversation. Signalling proceeds along the call route from CO to CO until it reaches the one nearest its destination. If the called subscriber line is free, the caller hears a ring at the other end. If it is answered, the call is completed and this is signalled back across the network. At that point, the voice communication takes over. If, however, the addressed line is already engaged, a busy tone message will be signalled back along the designated channel to the caller. Throughout the entire set-up time for the call, the channel assigned for voice communication at the time the caller receives dial tone cannot be used for anything else.

Common channel signalling, in contrast, is "out-of-band." With CCS, the system generates software-created signals which are carried in a communications channel that is physically separate from the voice channel. The calling party dials a specific sequence of numbers. The stored program controlled network recognizes the sequence and routes the call to an action point -- which may be the originating CO, a toll office, etc. The action point stops the progress of the call set-up; then instead of the call signal proceeding across the network from CO to CO on a voice channel link to the destination CO, the action point's central processor will create a new (data) signal message which it sends on to a network control point. The network control point is a network node containing detailed logic and data about how the call is to be handled. It will instruct the action point what to do -- that is, how to route the call signal message through the network. The call signal message will be sent over a packet switched network, through a small number of STPs, to the destination action point switch and, finally, to the subscriber line addressed. During the call set-up period (a few seconds at most), the caller will not be assigned a voice channel; indeed, the caller will not be assigned a voice channel unless and until the receiver is picked up at the other end. Figure 5.11 below illustrates the quite different network configuration employing CCS.

Common channel signalling introduces significant flexibilities to the public switched network which improve its efficiency. They include:

(1) the automatic routing of calls to different business locations;

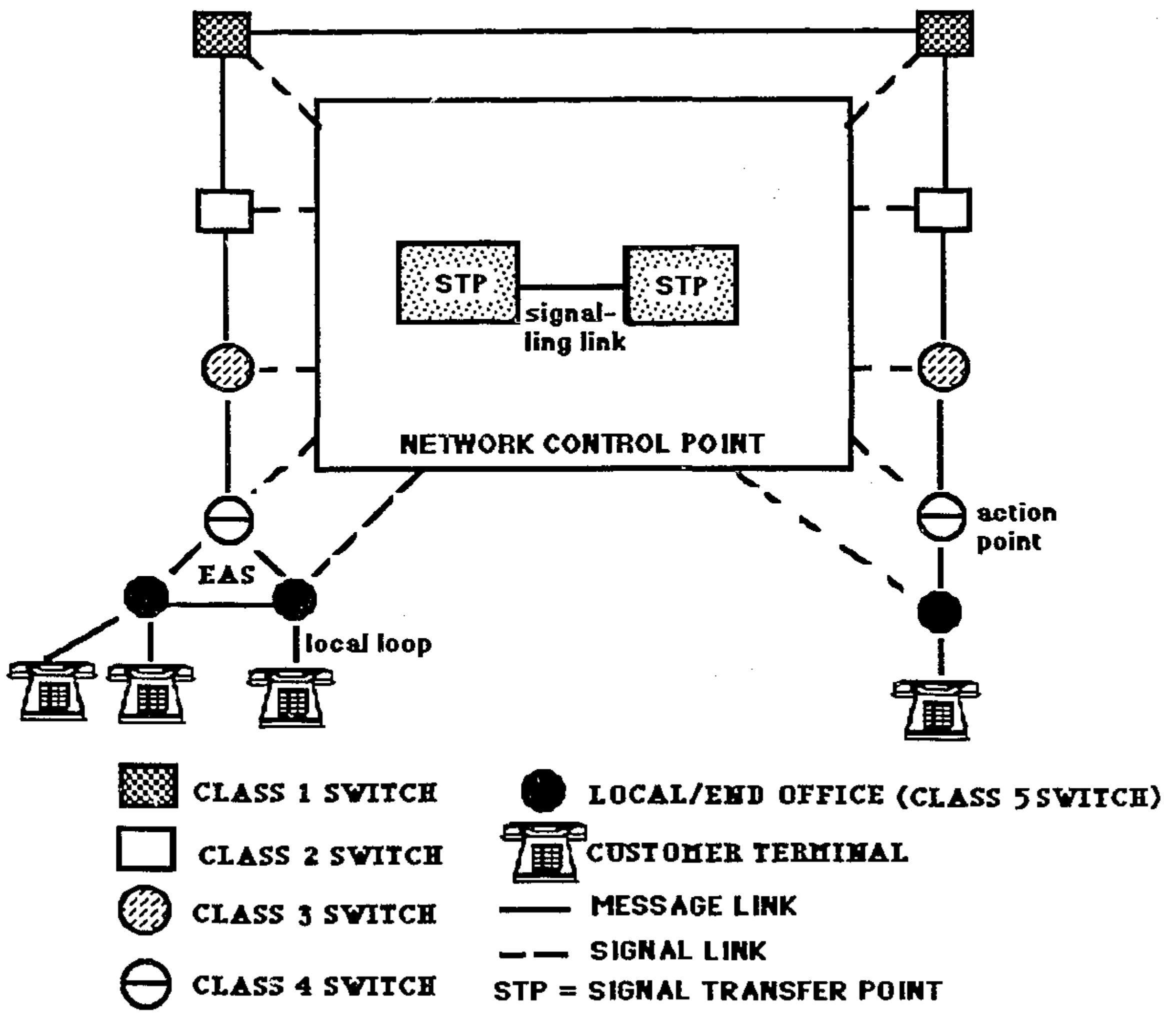
(2) allowing localized answering through a single, permanent nation-wide telephone number;

(3) reducing the amount of telephone equipment (and hence plant purchase and maintenance costs) tied up in call attempts -- since the busy signal can be given by the nearest action point rather than by the destination switch;

(4) simplifying 800-service numbering and routing; and

(5) automatic monitoring and controlling of mass calling (such as the system overload that results each time Bruce Springsteen concert tickets go on sale in an area).

FIGURE 5.11
Common Channel Signalling



Common channel signalling system seven (CCS-7), fundamental to the implementation of ISDN, is a more sophisticated version of this architecture. In addition to all the features of basic CCS systems, it will employ a set of gateway standards to permit interconnection and interoperability between public and private networks. Essentially, CCS-7 is designed to act as a secondary -- but non-redundant -- network to the public switched network. It also keeps track of detailed information about each call, such as the caller's telephone number (which users can see displayed on their terminals), etc. It is anticipated that by the late-1990s, interswitch signalling could be handled almost entirely by CCS-7 technologies (Contel, 1989).

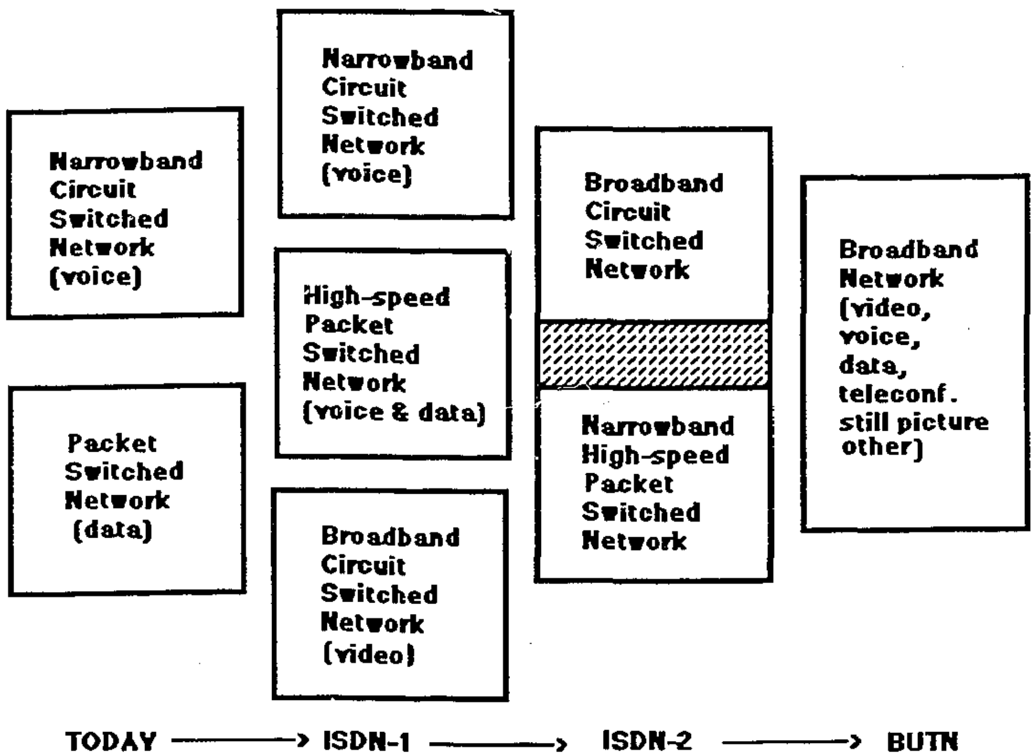
5.8 Evolution to broadband universal networks

The recent technological advancements in voice transmission and switching discussed in the sections above suggest a gradual transition to broadband universal telecommunication networks (BUTNs). These will be capable of delivering switched digital voice, data and image signals integrated over a single pipeline based on a switched star configuration. They will provide dedicated links between the nearest CO or remote switching centre (RSC) and every residential as well as business subscriber premises, on demand. All switching -- broadband, narrowband, telemetry, data, etc. -- will be provided at the CO/RCS for multiplexing onto the subscriber line. Video services (entertainment, library, etc.) will be fed on super trunks to the CO/RSC. At the CO/RSC, these services will be multiplexed into a single digitalized data stream for each subscriber line; alternatively, they might be further multiplexed for transmission to a remote subscriber-line interface (Harrold and Strock, 1987: pp.69-70). The evolution of public switched telecommunication networks toward broadband networks is outlined in Figure 5.12 below.

Separate circuit-switched[27] and packet-switched networks are used today to provide various narrowband services. These include voice, data. teleconferencing, facsimile, etc. But it is anticipated that in the next few years narrowband fast packet-switched networks (ISDN-1) will be deployed which will transport voice as well as data traffic. At the same time, broadband circuit-switched networks will emerge carrying video information. Subsequently, a single network will evolve that will be capable of carrying voice and data using fast packet-switched technologies, signalling the beginning of the integration of broadband circuit-switched and narrowband fast packet-switched networks (ISDN-2). Eventually, industry observers anticipate, broadband universal telecommunication networks will emerge as hybrid systems -- combining switched narrowband and broadband ISDN characteristics (Harrold and Strock, 1989: p.71).

As already noted, today's video and voice transmission systems constitute distinct networks utilizing quite different configurations. Typically, cable television services (i.e., video transmission) are delivered over coaxial cable on a one-way transmission path based on a bus or tree and branch distribution configuration which does not require switching. In contrast, it will be recalled, the local loop facilities of the telephone companies use a switched star network configuration. At the centre is the main CO switch; at the end points are the individual subscriber lines; calls between subscribers pass through CO switches.

FIGURE 5.12
Evolution of Broadband Networks



The key component of future broadband networks is a fibre optic cable system that will provide the "last mile" link to customer premises. Thus, no dramatic new technological breakthroughs are required to implement broadband networks. Moreover, the switched star network configuration used by the telephone companies is considered to be well-suited to broadband services distribution. Certainly, it is much better suited to two-way applications than is the bus configuration. Telephone service availability also is more pervasive than cable television in Canada (98.9 per cent as compared with roughly 85 per cent penetration levels, respectively). Finally, all the telephone companies have plans to extend fibre optics to the local loop as a replacement for obsolete copper plant over the next several years. The telephone industry consequently is at a considerable advantage over the cable television industry in terms of the costs associated with installing broadband networks. A similar undertaking by the cable television industry would require a total redesigning of that network, at tremendous cost. A similar undertaking by the cable television industry would require a total redesigning of that network, at tremendous cost.[28]

5.9 Radio communications

Radio transmission has evolved from terrestrial microwave to satellite microwave to cellular mobile radio. As mentioned earlier, where fibre optic emplacement is not considered to be economic, radio provides a viable alternative transmission mode. The principal radio transmission modes that may be substituted for landline telephone in local voice communications are line-of-sight (VHF and UHF) radio systems and, since the mid-1980s, cellular mobile radio-telephone. For communications over longer distances, including public long-distance telephone service, microwave radio provides the backbone of the present-day Canadian telecommunications system. Finally, satellite radio supplements terrestrial coaxial, fibre optic and microwave networks to complete communications links with and between remote and very distant locations.

5.9.1 Early radio technology

In **1887**, Heinrich Rudolph Hertz placed two electric coils near to each other. He then directed an electrical current into one coil, at which point he observed sparks leaping up in the other. In this way, Hertz made the electricity travel through the air, instead of via wire. The sparks observed in the second coil came in spurts or "waves," rather than continuously. By timing them, it was possible to calculate the wavelengths, measured in terms of the frequency of the vibrations. Directing them against a mirror, they were reflected back, just as light waves would have been; by deflecting them, they could be bent, also like light waves. Radio waves and light waves are of the same nature, but different frequencies.[29] The difference lies in the length of the waves.[30]

In **1894**, Sir. Oliver Lodge was able to transmit Morse code messages by "wireless" for a distance of about 1 km. An aerial attached to a receiver picked up the radio waves sent out by the transmitter. After passing through the aerial wire, the signals flowed into the receiver and moved a telegraph key which reproduced the dots and dashes.

Guglielmo Marconi sent and received the first wireless telegraph signal in **1896**; and he succeeded in transmitting the first transAtlantic signal in **1901**. The absence of transmission cable made the "wireless" the first mobile electrical communications technology. Early radio technology was used to link wireline (telephone) services to remote mobile units such as ships and, later, airplanes, and to provide communications with less accessible locations. The ability to meet these various communications needs demonstrated the potential importance of radio communication in the provision of emergency assistance.

Voice message transmission by radio, however, had to wait for the invention of the vacuum tube[31] (the audion) in **1912**. One-way speech was first transmitted over a long distance in April **1915**: from Montauk, New York to Wilmington, Delaware -- a distance of approximately 35 km. The first two-way conversation took place in **1922**, in a ship-to-shore transmission between the ship, S.S. America, and a location in New Jersey. The first transoceanic two-way radio-telephone conversation occurred between the United States and England in February **1926**; by December 1929 telephone calls could be made on the high seas to almost any Bell subscriber in the United States (Bowers et al., 1977: pp.17-18).

In the early days of radio, land mobile technology development was undertaken by local police departments rather than by telephone companies. Detroit policemen built the first automobile radio receiver in **1928**; its utility in apprehending criminals led police departments in other North American metropolitan centres to install similar systems.

Perhaps the most significant technological change subsequently was the switch from amplitude modulation (AM) to frequency modulation (FM), a transition made in the late **1930**s. Modulation is a technique that uses a link between two nodes to convey information by altering characteristics of the link at one node such that it can be detected at the other. The link is the carrier of the information; it can be a radio path, a telephone line, a fibre optic connection, etc. AM is a method of transmitting the sound signals of a broadcast by changing the strength (or amplitude) of the carrier waves to match the audio signals.[32] FM is a method of transmitting or carrying the sound signals of a broadcast by changing the frequency (i.e., the number of complete cycles per second) of the carrier waves to match the sound signals. VHF and UHF radio communication systems typically use FM, with the exception of aeronautical VHF, which uses AM. HF (shortwave), international broadcasting, and other voice communications generally use AM modes. Among the advantages of FM over AM transmission are the ability to communicate even when signals are weak, the superiority of FM's "squelch" system, and the higher level of receiver sensitivity (Noble, 1962).

Introduction of the transistor[33] by Bell Labs in **1948** allowed the manufacture of more easily transportable units with better performance reliability, as measured in terms of signal-to-noise ratio. Particular emphasis has been placed since that time on improving radio frequency spectrum use. This has involved developing standardized procedures aimed at shortening message length, channel splitting and the like.

5.9.2 Radio system configuration

As will be recalled, in basic telephony, the medium over which sound waves are carried is wire. Radio communication, in contrast, employs broadcast-like transmission technologies, making it possible for sound waves to be carried over the air instead. However, sound waves diffuse quickly in the air. Thus, in order to transmit voice or other signals over some distance through that medium, they must be strengthened or "amplified."[34] Early (i.e., pre-transistor) radio transmission arrangements consisted of an oscillator circuit[35] and one or two amplifier stages. Voice transmission was achieved by increasing the strength of the voice signal to a power level equal to that of the output amplitude of the transmitter and then connecting it, through a transformer,[36] with the output amplifier. This was done while imposing an audio signal[37] directly onto the radio frequency output of the transmitter. The result was a double-sideband AM signal.

Sidebands result from the mixing of audio and radio frequencies, in the following way: If an audio signal of, say, 1 kHz is mixed with a radio signal of 1 MHz, sidebands would be produced at 1 kHz above and 1 kHz below the 1 MHz radio signal. When two signals of different frequencies are mixed together, they produce new signals at the sums and differences of the original signal frequencies. A double-sideband AM signal therefore consists of a carrier wave and two sidebands. If the signal is being modulated with the human voice, the sidebands will fluctuate in amplitude and frequency within the limits of the carrier waves plus and minus the voice spectrum.[38] In a fully modulated signal, the carrier wave would contain as much as half the transmitter power, a considerable waste of power since its only function is to mix with the sidebands to reproduce the voice signals at the receiving end. A technique was therefore developed in the late 1930s to eliminate the carrier wave and filter out one of the sidebands. This meant that the entire transmitter power could be put into the remaining sideband; the carrier was inserted into the radio receiver, at a much lower required power level.[39]

Today's radio communication transmitters are quite different. The electrical signal is generated at a relatively low frequency and mixed with an audio signal in what is called a "balanced modulator." This produces two sidebands, with no carrier wave. One of the sidebands is then filtered out, and the remaining signal is mixed with another audio signal to produce a higher frequency signal. The process of filtering and mixing continues until the output signal reaches the desired frequency level. At that point, the signal is amplified and applied to an antenna for transmission. The signal that is broadcast over the air from the transmitter goes out as an electromagnetic wave of radio frequency .

The exact nature of radio waves is unknown. What is known is that when an alternating voltage is imposed onto an antenna at a specific frequency, radio waves are produced at that frequency. These waves then travel out from the transmission antenna at the speed of light. Radio waves can be divided into two categories: long waves (low frequency) and short waves (high frequency). Long waves are reserved for broadcasting; short waves -- reaching down into the microwave range -- are used for television, long-distance telephony, transoceanic broadcasting, radar, amateur radio, etc.

At the receiving end, the functions of the reception apparatus include: (1) screening selected broadcast signals from unwanted incoming signals; (2) amplifying weak signals; (3) separating the carrier from the voice-generated signals by a process of demodulation; and (4) converting the voice signals to audio signals through a speaker. To do these things, the receiver must first be tuned to a "resonant" frequency -- that is, one at which the circuit will show far greater efficiency than at any other. At that point, information can be isolated by the tuned circuit, and the information carried by the selected signals recovered (Hood, 1983: Ch.10).

Repeater stations are used in radio communication to relay (receive and retransmit) radio signals between the base station transmitter and destination receiving antennas. They are usually employed to overcome problems of coverage caused by surrounding geographical terrain. The base station or broadcast transmitter communicates with the repeater through a directional antenna pointed at the repeater. The repeater receives the signal on one frequency and rebroadcasts it on another, stronger frequency. In this way, the transmitted signal, which diffuses or weakens over distance, can be regenerated at regular intervals to protect the quality of the signal.

Transceivers are commonly employed in land mobile services. They are both transmitters and receivers; they may be hand-held units, under-dash vehicular units, or units designed as base stations. Often, the main difference between these various configurations is related to power supply. Hand-held transceivers, for instance, generally are operated using rechargeable batteries, while vehicular (under dash) units operate on 12 volts DC, and base stations on 120 volts AC.

As the discussion above suggests, the concept of radio transmission is very similar to that of telephony -- although without the use of carrying wires. The microphone picks up the sound waves and converts them into electrical signals; the converted waves are then amplified -- as much as 30 times -- to make them strong enough to be broadcast over the air. The broadcast antenna picks up the amplified waves from the transmitter and, by the action of alternating current, forces them out into the air.

Until recently, the type of signals most commonly transmitted over radio were analogue voice messages. In an analogue transmission, the electrical signal carries information by means of continuous variations in its amplitude or frequency. Digital transmission -- whereby the transmitter translates the signal to be sent into a binary code -- usually was limited to data messages. The transmission of digital information over analogue channels requires modulation methods that convert data inputs into streams of pulses -- either of different frequencies transmitted at uniform intervals (FM) or of uniform frequencies transmitted at varying intervals (AM). Narrowband digital mobile voice transmission systems are now available due to advances in waveform coding, multiplexing and solid state technology.

The sections that follow look at the different types of radio communication technologies used today. In addition to a brief description of each, their relevance as alternatives to the public telephone system and for emergency communications will be considered.

5.9.3 Long-distance radio

5.9.3.1 Terrestrial microwave

Considering first the long-distance element, Canada's first coast-to-coast microwave transmission route was established in 1958. It covered some 6,500 km from East to West, and provided 480 voice circuits and one television channel. It consisted of 139 microwave towers, and cost approximately $50 million. The introduction of digital microwave to the commercial market in 1983 eliminated the need to convert digital signals to analogue, as had been necessitated by the introduction of digital switching in the 1970s. It also provided much higher quality data transmission. Terrestrial microwave signals are transmitted using radio relay towers spaced 25 to 50 km apart. The radio frequencies used for these services range from 400 - 500 MHz up to around 23 GHz for the newer, digitalized microwave systems. Moreover, in 1972, Canada deployed the world's first geostationary communications satellite dedicated to the provision of domestic telecommunication services. The Anik-1 satellite and subsequent Canadian satellites are capable of relaying telephone, television, telex and data signals to or from any point within Canada.

Respecting emergency preparedness communications, terrestrial microwave radio systems in the more populated southern regions of Canada provide a fairly reliable backup system to the public telephone system. However, this apparent redundancy in some cases may be illusory. This is because microwave routes almost always parallel coaxial and fibre optic cable routes. Indeed, they frequently use the same rights of way. Thus, the possible gains to network survivability in an emergency will be limited by the extent to which alternative transmission routing is in close geographic proximity. Damage done to coaxial or fibre optic cables as a result of a large-scale environmental or industrial accident or, especially, as a consequence of a natural disaster such as a major earthquake, likely will damage or destroy nearby microwave towers and radio antennas as well.

5.9.3.2 Satellite radio

Satellite radio is the principal alternative transmission medium for remote and very long-distance telecommunications. Using this technology, radio signals are sent via line-of-sight microwave from earth station antennas to a satellite in geostationary orbit. Satellite radio is particularly economically attractive for point-to-multipoint data and broadcast transmissions because the cost of signal transmission does not vary with distance inside the satellite's coverage area or "footprint." Furthermore, terrestrial rights of way are not required, resulting in further cost savings.

Satellite transmission is less attractive as an alternative for voice communications, however. This is because of the lack of transparency to users. The tremendous distance travelled from the transmitting earth station to the satellite relay antenna, orbiting at 37,000 km above the earth's surface, and from there to the receiving earth station below, results in a signal propagation delay of roughly 0.25 seconds round-trip. And while this may seem minimal, it is perceptible to the user.

A typical satellite consists of a number of transponders,[40] each of which provides a large-capacity communications channel. Each transponder is comprised of:

(1) a **receiver** tuned to a frequency channel that has been allocated for the uplink communications signals from earth to the satellite;

(2) a **frequency shifter,** which lowers the received signal frequency to a downlink frequency; and

(3) a **power amplifier** used to transmit signals back to earth.

The communications capacity of a satellite is determined by the number of transponder channels and the volume of communications traffic that can be transmitted on each. Although they vary by type, the most commonly used communications satellites have 12 transponders, each of which has enough channel capacity to carry a colour television signal or at least 1,200 telephone voice signals in one direction. The transmitting and receiving stations on earth (i.e., "earth stations") range considerably in size -- from large stations capable of sending and receiving all types of communications signals to small, simple, disk-shaped television antenna stations used only to receive television signals.

Considering emergency communications, the most relevant satellite communication applications are for mobile communication systems. Of particular interest in this regard is the joint Canada/U.S. MSAT program, targeted for launch in 1993,[41] and regional satellite communication services such as British Columbia Telephone Company's (BCTel) Spacetel offering. These are discussed in the next chapter. Suffice it to say here that given the enormous carrying capacity of new-generation satellites, together with the much lower costs of today's satellite dish antennas -- especially very small aperture terminals (VSATs), which may be less than two metres in diameter -- satellites can provide a useful emergency communications transmission medium. In an increasingly fibre optic environment, satellites will play a significant part in the restoration of failed telecommunication ground linkages. Finally, the improved transportability of small earth stations and dish antennas, combined with much lower transmission costs due to greater capacity and an over-abundance of transponder space, enhance its attractiveness for emergency applications.

5.9.4 Short-distance radio

Turning to short-haul radio transmission, the principle alternatives for voice communications covering relatively short distances include one-way paging services and two-way land mobile radio systems such as conventional and trunked services, and more recently, cellular mobile radio. The former have been employed generally by personnel communications systems (including police and fire departments, ambulance services, etc.); cellular services, in contrast, are attractive where more private communications are desired.

The configurations of all satellite and terrestrial microwave systems are based on line-of-sight transmission. Moreover, the geographical range of reception of messages transmitted using terrestrial microwave technologies is restricted by a variety of technical and environmental factors. These include transmission power; antenna height; antenna gain; receiver sensitivity; geographic terrain; carriage frequency; and ambient noise.

The general configuration of private land radio communications systems is as follows:

(1) a **base station** -- located at a central point;

(2) several **mobile stations** capable of receiving transmissions (in the case of pagers) and, in the case of two-way systems, of communicating with other stations in the system; and

(3) **repeater stations** used to overcome problems of coverage caused by the surrounding terrain.

These systems are essentially private broadcast-type systems. If tuned to the correct frequency and within the range of the signal, their receivers can pick up any over-the-air signal transmitted within the system (Bowers et al., 1977).

Radio common carriers (RCCs)[42] are companies engaged in providing one-way paging or two-way mobile radio communications to the public. They are licensed by the federal Minister of Communications under the Radio Act. Their networks consist of a base station and one or more repeater stations located at geographically advantageous sites. Their customers are provided with leased or purchased radio equipment and coded access to the repeaters for their radio communication needs. Tone encoders and decoders are installed in all radios operating on two-way systems so that customers are provided with some degree of privacy from other users.

The range of a base station can be extended by using repeaters to amplify outgoing and incoming signals to/from mobile units. Also, signal transmission over a given distance from a higher frequency transmitter usually will be weaker than those of a lower frequency transmission with equal antenna gain and output power. Moreover, while mobile-to-mobile communications relayed via a base station generally will be highly reliable, communication between mobile units is difficult across large areas due to the limited antenna height and power output of most mobile transmitters. Similarly, ambient noise will interfere with radio transmission reception by causing delays in signal arrival or even changing the frequencies of signals received (due to the Doppler effect).

5.9.4.1 Mobile land radio

Mobile radio communications technologies used for short-haul communications can be categorized in different ways. They may be distinguished in terms of the mode of use to which they are put or, alternatively, in terms of the types of services provided. Among the most common modes of use are remote paging; dynamic routing (of vehicles or personnel); vehicle monitoring; emergency beaconing; data transmission (to mobile printout devices); and voice communication. The associated services that have evolved include: (1) mobile paging services; (2) conventional and multichannel trunked mobile radio-telephone; and (3) cellular radio-telephone.

Paging systems use a base station to transmit signals to a portable pager receiving unit. The signals are used to advise the receiver that there is a message waiting to be passed by some other means of communication. The electronic signal received by the remote unit activates a tone or a light; it also might include a very brief pre-recorded verbal message. No provision, however, is made for communication from the receiving unit back to the base station. Instead, a telephone normally is used by the individual equipped with the pager unit addressed to call a pre-established number in order to receive their messages.

Tone paging was introduced in Canada during the 1960s. Voice, alpha-numeric and display terminals are in common use today. Because allowed message lengths are short and no response from the pager terminal is required, little radio spectrum is used by paging services, and the receiving equipment is technologically very simple. It also is relatively inexpensive. More sophisticated automatic digital systems now are capable of providing service to more than 100,000 subscribers per central processing unit.

Conventional mobile radio systems are private two-way broadcast (one-to-many) systems operated in a simplex mode. That is, a single voice path is available at any given time, precluding simultaneous message transmission and reception. Usually, several mobile units are assigned and tuned to a single radio frequency or "channel." In order for the mobile units to transmit, they must queue up to use the shared channel. Users of conventional radio systems include private sector fleet-oriented companies involved in transportation (e.g., trucking, rail and taxi firms) and industrial firms (contractors, plumbers, etc.). They also include many municipal public safety agencies such as police and fire departments. The technology of conventional systems resembles that of commercial FM radio stations. In other words, anyone equipped with a receiver that can be tuned to the correct frequency can listen to any and all of the communications broadcast over the system.

Growing demand for mobile radio service has been met by increased allocation of radio spectrum frequencies to these services. Additionally, the limited availability of lower frequency bands has led to technological developments that have made operating at higher and higher frequencies economically feasible. Low-band allocations commonly refer to frequencies below 50 MHz; they include LF -- i.e., between 30 and 300 kHz; MF -- between 300 kHz and 3 MHz; and HF -- between 3 and 30 MHz. High-band frequencies are around 150 MHz. They include VHF, which range between 30 and 300 MHz. Ultra high-band frequencies are around 450 MHz, and they include UHF -- ranging between 300 MHz and 3 GHz. The allocation of frequencies in these three bands is divided among wireline telephone companies, and the (wireless) RCCs which provide mobile radio-telephone and paging services through interconnection with the public landline network (Agy, 1975).

Receivers for low-band frequencies are highly sensitive to interference from automobile ignition and the like (i.e., sources of impulse radiation). In addition, low-band transmission is susceptible to interference from distant stations operating on the same frequency, as a consequence of "skip," the reflection of signals off the ionosphere. Ultra high-band equipment, in contrast, is relatively insensitive to impulse noise and -- since radio wave transmissions using higher frequency bands pass through the ionosphere -- they are not subject to skip. As a consequence, weaker signals using the higher bands can be more easily received, even in a noisy urban environment.

Multichannel trunked radio-telephone systems are intended to allow users to access a limited number of two-way, duplex channels.[43] These systems commonly are used to provide traditional FM VHF or UHF mobile telephone service, although they may be used for point-to-multipoint dispatch services as well. When a subscriber activates the microphone of their radio, they have access to the group of frequencies assigned to that network (usually between five and 20). At that point, the system will select automatically a free frequency, and it will remain open to that particular user for the duration of the communication. Affiliated radio stations programmed to utilize that group of network frequencies will recognize the tone-signal of their frequency group and activate to tune into the frequency assigned to this particular communication.

Trunked systems make more efficient use of the radio frequency spectrum because channels are not allocated to a single user or organization. Instead, a number of channels are shared by many organizations. Moreover, in a trunked system, different types of users can use the same system, because they essentially operate independently with the shared central processing computer assigning channels on demand. Although listening in on a channel is technically possible using a scanning receiver, trunked radio communications are more private than conventional mobile radio. Moreover, transmitters and receivers are equipped to search automatically for free channels; they also can interconnect with the wired public telephone system. Mobile units of modern trunked radio systems now employ large-scale integrated circuitry to perform the control function of tone sensing (that is, to receive a call), free channel location, and "locking on" to a free channel in order either to make or receive a call. Consequently, voice service on these systems has become almost indistinguishable from wireline telephone service, except that there may be longer waiting times for dial tone, and reception is subject to fading.

In an emergency situation, a trunking system could be established to provide intercommunications capability to groups of users which in normal times operate independently. To ensure efficient use of the radio spectrum by such systems in an emergency, however, the trunking system would need to be comprised of a minimum of three channels (with two frequencies per channel) and each frequency channel would have to cover at least 50 mobile units (DOC, 1989g). Similarly, paging systems could provide a local alert/waring capability for notifying public safety emergency response personnel, and conventional mobile radio could be used by local response agencies for interorganizational emergency communications if mutual assistance arrangements are in place to allow for shared frequency use in such situations.

5.9.4.2 Cellular radio-telephone

Cellular mobile radio is the most recently introduced, and by far the most interesting, alternative transmission mode to landline telephone service. It also is the most rapidly growing medium used for mobile communications. Cellular radio-telephone is especially prevalent in hundreds of North American metropolitan areas, as well as along corridors joining high-traffic centres. Since its commercial introduction in the United States in 1983 and in Canada in 1985, cellular radio has greatly increased mobile channel capacity in major urban markets.[44] It also has brought high-capacity mobile services to many smaller communities.

The cellular concept refers to a fully automatic, high-capacity radio-telephone system capable of accommodating mobile, portable and fixed subscribers over a wide geographical area. Cellular systems are based on the ability to re-use frequencies. They specifically are designed to address the need for mobile communications, and to overcome the limitations of conventional and trunked radio-telephone systems -- which are restricted in the numbers of users that can be accommodated due to the limited availability of radio frequencies. Cellular technology subdivides a geographical area into a number of cells, each served by a low-power transmitter (i.e., base station) situated for optimal radio transmission. Cells are defined according to (a) traffic patterns and volume, and (b) optimal radio coverage. Together, they form a network co-ordinated by a separate, cellular switching office which automatically routes calls to specific base stations and which also provides interconnection to the public switched network (U.S. Department of Commerce, 1988: p.6). A diagram of the cellular system configuration is provided in Figure 5.3 at the beginning of this chapter.

The connection between separate cellular networks and with the public switched telephone network is similar to the way in which a telephone company CO switch connects to other switches and, ultimately, to individual customers. At the centre of the cellular network is a large-capacity central computer processing unit, known as a cellular network control station (CNCS) or a mobile telephone switching office (MTSO). This station is connected to the public telephone network as well as to other (competitive) cellular systems' CNCSs. It also houses the electronics that poll demand by mobile units for access to the network and determine appropriate routing for calls made within the cellular network, with other cellular systems and with the public telephone system. The functions of a CNCS include: (1) cell network traffic control management; (2) problem diagnosis; and (3) "hand off" control between cell base stations.

Transceiver units in adjoining cells always operate on different sets of frequencies to avoid co-channel interference. This allows frequency re-use even at very short distances. As a user moves from one cell into the next, the central processing computer at the CNCS automatically switches any call in progress onto another frequency band, thereby freeing the original frequency for re-use. This is made possible by limiting transmitter power and mobile antenna height, and by spacing cellular base stations at adequate distances apart: the distance is approximately 40 km for seven-km radius cells, although urban cells may be as small as one-kilometre radius. The ability to hand off calls provides the system with much greater traffic carrying capacity than that offered by conventional and trunked land mobile radio systems.

Each cell also is served by its own control system and it is assigned a specific set of operating radio frequencies for transmitting voice signals, so that simultaneous communication can take place with any mobile unit operating in its coverage area. Links between cellular companies' CNCSs and the respective cell control sites (base stations) use coaxial and fibre optic cable (in the case of nearby fixed stations) or microwave transmission facilities. The cell site controller manages communications with and between mobile units within its range. It also monitors continuously the signal strength on all transmissions to determine when handing off is required. Equipment at the cell base station consists of antennas; radio receivers; radio transmitters; computer processing equipment; cell site controllers; power amplifiers; and backup power equipment (U.S. Department of Commerce, 1988: p.6). Together they permit a kind of "public" subsystem -- similar to multichannel trunking systems -- to operate within each cell.[45]

From a user perspective, the cellular system operates in the following way: When a caller (cellular or public telephone system subscriber) wants to contact a mobile unit, the nearest cellular central processing computer will undertake a search for the unit being called. Once located, the destination cell will be identified to the CNCS computer and the call signal will be transmitted (usually over landline) to the appropriate cell base station. Then, a duplex channel frequency in the appropriate cell will be assigned by the destination cell's base station, and the message will be radioed from there to the receiving mobile unit.

In the case of a mobile unit originating a call, the search for a free duplex channel and the calling unit's (automatic) adjustment to authorized transmission and reception frequencies will be carried out by the mobile unit's microprocessor and the nearest base station, while the caller waits for dial tone. As the mobile unit passes from one cell to another, the base stations in the adjacent cells interact as instructed by the CNCS central processor to switch transmission base stations and duplex channel frequencies.

There are three kinds of cellular terminals. They include first, the fixed, vehicle-mounted model (three watts) whose power source is the car battery to which it is attached; second, the transportable model which has a battery pack (up to three watts) and a significant transmission capability; and third, the compact portable model which is much less powerful (0.6 watts) and consequently has a more limited transmission/reception range (Bell Cellular, no date (a)).[46]

Along with optional facsimile and microcomputer connection features now available to cellular subscribers, secure voice communications using cellular also are possible. For instance, CellNet companies now offer a service called Privacy Plus to security-conscious cellular users. It requires a scrambler which can be attached to three-watt unit. When the call is placed, the Enhanced Privacy Unit (EPU) scrambles the conversation. It then is unscrambled at the company's cellular switching facilities and the person being called can understand the message (coded and decoded by the central switching facility) even if they do not have an EPU. Where both parties have EPUs, Privacy Plus provides end-to-end security (Bell Cellular, 1990).

Radio equipment used by cellular base stations and mobile units uses standard FM technology. The use of FM provides static-free reception and allows receivers to "capture" signals at a given frequency, while rejecting stronger signals at nearby frequencies. Base station control equipment must provide continuous storage and updating of channels requested and channels in use. Control circuits inside mobile units contain a tiny computer capable of deciphering the various digital signals received from the base station. Then they must act upon the transmission instructions received and send appropriate digital responses -- that is, the mobile units must be able to answer a page, change transmitter power, request a channel and dial a number. In addition, the mobile unit equipment must be able to change both transmission and reception frequencies, while in use, when the unit moves from one cell into another (Bowers, et al., 1977: pp.55-56).

In Canada as in the U.S., competition in cellular service provision is mandatory. Unlike the United States, however, Canada's non-wireline carrier, Cantel, has nation-wide privileges. On the wireline side, the authorized Canadian cellular radio-telephone providers are the regional municipal telephone companies.[47] Both Canada's and the U.S. cellular networks are advanced, high-capacity systems operating in the 800 MHz band.

Canada's system is comprised entirely of an Advanced Mobile Phone System (AMPS) system design with a channel spacing of 30 kHz and an availability of 666 channels per system. U.S.cellular systems vary; they range from lower capacity systems operating in the 450 MHz band (Nordic Mobile Telephone system or NMT), with channel spacing of 20 kHz and 220 available channels, to very high-capacity Total Access Communications System (TACS) systems operating at 900 MHz which have 1,000 channels spaced at 25 kHz.

The main disadvantage of employing multiple systems is that they operate on different frequencies; they are incompatible with each other; and they are based on fundamentally different technical parameters (e.g., modulation and signalling protocols). This means that subscriber equipment designed for use on one type of system may not be able to operate on another. Similarly, roaming -- the employment of cellular radio-telephone outside the network serving area -- is limited to those cellular network areas that use the same system type (Bowers, et al., 1977: pp.39 and 36).

At present, all cellular systems are analogue -- at least for the radio portion of call signal transmission. Since most cellular systems have substantial unutilized analogue transmission capability, no difficulties in serving established demand requirements are anticipated through the mid-1990s. However, rapidly growing demand for cellular service in some urban areas and the limited availability of radio spectrum allocated to these services is driving some cellular companies toward digital cellular technology.[48] The introduction of digital technology will substantially increase channel capacity -- by as much as four or five times current capabilities. It also could make cellular service economically feasible in some smaller markets that would not be able to support stand-alone cellular systems. Those markets might even be linked via satellite to hub metropolitan cellular systems (NRC, 1989: p.51).

Significantly, cellular technology combines the features -- and to some extent, the vulnerabilities -- of public telephone and microwave radio systems. A cellular system is basically a telephone system superimposed upon a radio system. It functions primarily as an extension of the public telephone system, to which it is physically interconnected. As a result, cellular systems depend on the public switched network's facilities.[49] Indeed, given the lack of back-up central processing computers in present-day cellular systems, they are subject to almost complete system failure if a disaster knocks out a cellular network control station or a telephone company central switching office.

5.9.5 Radio communication system vulnerabilities

Generally speaking, radio communication systems are vulnerable to service disruption only at base station and repeater sites. Should a disaster disable either type of site, no communication within the coverage area would be possible because all communications pass through these points. To reduce the effects of a disaster on private mobile radio systems, a number of things can be done. First, a second channel could be added to all associated radios to enable them to transmit and receive on that frequency; in this way, the repeater could be bypassed. This is referred to as "repeater talk around." A second option would be to ensure that a "hot standby" repeater is available to take over with minimal time delay. (Of course, a standby power source would be necessary as well.) It also would be useful to establish a centralized inventory of repair or replacement components in order to speed up service restoration following a disaster. Finally, testing of backup systems through regularly scheduled exercises could be used to familiarize users with emergency plans and procedures. Loss of a base station would require its replacement as quickly as possible -- perhaps with a temporary, transportable backup unit.

Despite some serious limitations, emergency preparedness communications will certainly benefit from expanding deployment of radio-telephone technologies. This is due to the fact that they have significant capabilities with respect to providing public switched network redundancy, especially as they are increasingly deployed in smaller urban and, in the case of cellular-radio, even some rural markets. Radio systems also may be considered, in certain contexts, as more robust than terrestrial links -- since coaxial and fibre optic cable links are vulnerable to disruption along the entire length of the transmission route. Furthermore, digital radio technology, when and where available, will provide increased call security since it is more difficult to intercept and decode digitalized messages. Indeed, microwave radio and cellular radio are considered essential to effective emergency communications because they allow virtually instantaneous communication between response personnel of the same organization and, with respect to multichannel trunked and cellular systems, with those of other organizations, including the media, etc.[50]

Considering vulnerabilities associated with the introduction of cellular radio on a large scale, it is important to mention that its ability to provide redundancy to the public telephone network is limited by the creation of the very same super systems that make its expansion into smaller communities economically feasible. Cellular systems are, in fact, pseudo-redundant in an emergency preparedness context. This is because the remote cell switches serving rural and small urban areas feed all their traffic through the metropolitan cellular network control station to a telephone company central office or hub switching centre. And thus, if either the CNCS or the telephone company CO or hub to which it is interconnected becomes inoperable following a disaster, even users far away from the switching station will lose service. Moreover, unlike public telephone systems, which have redundant links to accommodate regular traffic in the event of trunk-line failures between switches, present-day cellular systems do not yet have backup central processing computers that could take over. If, however, the cellular network control station is left intact in a disaster, while one or more base stations or repeaters are lost, cellular radio service would continue to operate in those cells whose repeaters were not damaged.

Another factor limiting the ability of cellular radio in particular to provide redundancy to the public telephone network is its inability to accommodate the kind of dramatic upsurges in traffic volumes that generally accompany an emergency situation which may be either localized within a single cell or spread across adjacent cells. Both current and envisaged technologies are designed on the premise that callers will be mobile -- that is, moving from cell to cell -- and that calls will be routed via landline systems as well. The experience at St.-Basile-le-Grand, Quebec in 1988 illustrates some of the limitations of current cellular technology in trying to accommodate traffic congestion when media users and external response agents converged on the scene.[51]

Furthermore, current technologies do not permit the application of line load control or essential line treatment to restrict cellular service access in a crisis situation.[52] This limitation might be circumvented to some extent in larger urban centres by the public safety agency's requesting that some of its cellular units be assigned to a second cellular base station that does not connect to the same telephone company switching centre.

The ability to implement essential line treatment and/or to access non-local cellular base stations also will have to be accompanied by a capability (as yet unaddressed by the cellular industry or, for that matter, by the telephone companies) to assure not only dial tone, but call completion as well, to a minimum number of pre-identified public safety and response agency lines. This might be accomplished through some kind of dedicated cellular service that would tie into private federal government telephone lines and, in turn, interconnect to other private trunks to provide limited "emergency only" links between the different orders of government. However, this would require complex software -- programming that could do much more than just locate the calling and called mobile unit once a duplex frequency became available in the destination cell. It would also require establishing a priority system for allocating frequencies across the system -- perhaps utilizing a set of channels held in reserve for just such contingencies.[53]

To summarize, in terms of present and future fixed and mobile electronic voice networks in relation to emergency preparedness, it must be kept in mind that current and proposed networks are all vulnerable. Most are terrestrial based and use either copper or fibre optic cables. In many disaster situations, they could be damaged or even destroyed completely, rendering portions of the public network useless. As a result, alternative radio and satellite-based networks must be integrated in emergency management systems. Technological trends are leading to ever wider availability of at least partially integrated radio systems that could be used to provide interorganizational emergency communication links, although additional network protocols may be required to make these systems more robust. In planning fully integrated, interconnected and interoperational alternative communication systems that will provide network flexibility for large-scale disasters, the stand-alone costs of implementation also need to be taken into account. Finally, the development of robust local networks must be based on the expansion of normal-time community communications needs and the full integration of multiorganizational systems for emergency purposes.

5.10 Conclusions

In recent years, customer demand has driven competitive equipment suppliers and service providersto introduce sophisticated and, increasingly, customized telecommunications services options. This trend has affected public networks in a number of ways. For example, historically, users conceived of public telecommunications in terms of voice communications alone; today, while network usage is still predominantly for voice, future usage demands are expected to be primarily for data transmission, retrieval, storage and processing services. Indeed, Canadian business users already rely on the public network as the main real-time link connecting various computer systems used in their day to day business operations. Other significant data system uses that similarly depend on public network linkages include instantaneous financial transactions and access to remote databases.

In the area of customer premises equipment, the proliferation of hundreds of types of equipment, including private branch exchanges and local area networks, as well as all kinds of handsets, etc. have brought distributed intelligence to the user's premises. Significantly, however, equipment diversification, combined with the growing variety of non-standardized network protocols has hindered the emergence of network/premises interface standards that would guarantee interoperability. As a result, particular attention needs to be given by emergency preparedness planners to increasing private network interoperability and interconnection with the public system via the deployment of common gateway architectures. Moreover, while proliferating network configurations are the current reality, some form of preplanned interoperability cut-over mechanism needs to be designed to ensure adequate response capabilities under most circumstances and including, for example, multiple signal transfer point failures.

Additionally, lightguide transmission technologies and advances in digital switching, while dramatically increasing normal-time communications capabilities for all categories of users, also have increased the public switched network's vulnerability in significant ways. This is because fewer cable routes are now required to meet overall network demand requirements -- leading to an increased concentration of call traffic along a small number of high-volume fibre optic routes and, correspondingly, a reduced utilization of alternative technologies. In like manner, the development of "super switch" centres has created a situation in which a single hub switching node, located in a distant, perhaps even unstaffed, station may handle voice, data and cellular communications traffic for tens of thousands of users. Indeed, it is now common for the following types of telecommunications equipment to be co-located in the same building: signal transfer points for common channel signalling, class 3, 4 and 5 switches, packet switches, cellular/public switched network interface facilities and private line terminals.

Developments in cellular radio-telephone technology deployment also offer potentially significant capabilities for public network redundancy -- especially as these systems expand into smaller urban and some rural communities. Moreover, the conversion to digital cellular systems will resolve most of the problems experienced by public safety users with call security. Just the same, the potential redundancy provided by cellular technology is limited in two ways: First, they will not be able to replicate fully the traffic carrying capacity of landline networks. Secondly, cellular super systems -- which interconnect remote cellular switches with hub metropolitan cellular switching offices --are in some respects pseudo-redundant. This is because they are dependent on the telephone company hub station switch, and if that fails, they fail as well.

In the next several years, fibre optic terrestrial cable will continue to be the transmission medium of choice. In addition, digital technologies will alter radically today's public transmission and switching network architectures. Microwave radio, including private and public safety (e.g., VHF, UHF, HF), cellular and satellite systems, will provide alternative transmission modes to handle situations where the terrestrial telephone network experiences multiple failures within a localized area. At the same time, network intelligence will be distributed more widely throughout the telecommunications system, and it will increasingly reside in equipment located at the customer's premises. Moreover, software-defined customized data services rather than voice communications are expected to provide the principal driving force in the evolution of networks.

As a result, emergency preparedness communications needs likely will be met only if system backup resources of the public network are increased and communications interface standards are accepted to permit terminal as well as separate-network interconnection. Finally, because the packet switching technologies commonly used by value-added networks are well suited to alternative routing, more effort needs to be made to exploit their commercial capabilities for emergency preparedness and response, including message transmission, robust packet-switched signalling, electronic mail and the like.

What we are witnessing today is the transition to a geodesic facilities network configuration -- nationally, continentally and eventually, globally as well. This transition is driven both by new communications technologies and, increasingly, by market demand for customized services that cannot be accommodated effectively by rigid hierarchical network configurations. CCS-7 switches, for instance, will lead to direct connection at lower level switches (e.g., between class 4 switches), and the wider use of LANS will create mini-hierarchies within the evolving geodesic framework. As regards emergency communications preparedness, this transition potentially could lead to a greater capability to access interconnected and interoperable alternative communication systems -- but only where pre-established protocols and procedures exist to accommodate the special requirements of emergency responders for supplementary and backup communications.

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1 AT&T's digital optical switch, now being developed, uses light to process information rather than electricity. This may enable future processors to handle more than a thousand times as much information as the electronic devices now used in supercomputers. This is because optical technology can handle many light beams at once (*Globe and Mail*, 30 January 1990: p.B-8).

2 The Shannon model.

3 Frequency refers to the number of complete cycles per second of any type of wave motion.

4 Interestingly, the first voice message transmitted electrically over wire was an emergency call. As the story goes, after completing Bell's telephone prototype, his assistant took it into

another room. Suddenly he heard -- from the apparatus -- Bell's voice saying: "Mr. Watson, come here. I want you!" Bell apparently had spilled some acid on his hand and was calling for help.

5 An alternating current is an electrical current that reverses its direction at regular intervals (as opposed to direct current, which is a steady electrical current flowing in one direction). Resonance is the condition of a circuit adjusted to allow the greatest flow of current at a certain frequency. Electromagnetic waves result from the periodic variations in the intensity of electrical and magnetic fields vibrating at right angles to each other. They can travel through space or matter, and they include radio waves, infrared radiation, light waves, X-rays, gamma rays and cosmic rays. The electromagnetic spectrum includes the whole range of wavelengths (or frequencies) of electromagnetic waves -- from the longest radio wave (wavelength 10^5 metres) to the shortest cosmic rays (wavelength 10^{-17} metres).

6 Megahertz or 1,000,000 hertz.

7 The human ear is capable of detecting sounds ranging from about 20 cycles per second (20 Hz) to about 16,000 cycles per second (16 kHz). The ear has its greatest sensitivity at about 2,300 cycles per second. A hertz is a standard international unit for measuring the frequency or rate of occurrence of waves and vibrations equal to one cycle per second.

8 Touch tone is a push button dialling method using multi-frequency tone keying to send AC pulses to the CO equipment (or to other associated equipment such as a computer). This is in contrast to the DC pulses transmitted by rotary/pulse dialling.

9 The Canadian network is comprised of some 3,500 local and toll circuit switching centres, which are interconnected through a complex of interexchange (long-distance) circuits with automatic alternate routing, and which can access and be accessed by telephone subscribers through local loops. The public switched network is operated by the regional telephone company members of Telecom Canada and other connecting independent telephone companies; it also is interconnected with the U.S. public telephone network, principally through AT&T, and to overseas networks through Teleglobe Canada.

10 A coaxial cable is one that encloses two or more concentric insulated conductors capable of operating singly or in combination to carry telephone, telegraph, radio or television signals.

11 Figures 5.7 through 5.11, Source: Farmer, 1989; and personal communications, Teleglobe Canada.

12 A second high density coast-to-coast route is now being planned. It is to be a hybrid system using both fibre optics and high density route digital radio. It is expected that the fibre optic sections will be based on SONET OC-48 technology -- that is, 32,256 circuits per fibre pair (Hoffman, 1990: p.21).

13 In 1947, Canadian National Telegraph and Canadian Pacific Telegraph began providing private wire services jointly. In 1956, CNCP (now Unitel) introduced Telex to the North American market and in 1964 it completed a microwave network across Canada.

14 Other services provided competitively by Unitel include public switched data; switched teleprinter and other text; public message or telegram; and audio and video program transmission. Moreover, in May 1990, Unitel filed an application with the CRTC seeking approval to provide public long-distance telephone service in competition with some of the Telecom Canada member companies.

15 Transmission equipment on a half-inch optical cable containing 144 glass fibres can provide 46,368 two-way voice circuits -- as compared with 41,472 circuits provided using equipment on a three-inch, 1,800-pair copper cable.

16 See Nagel, 1987: p.33.

17 A **diode** is an electronic device consisting of a semiconductor and two attached electrodes (conductors through which an electrical current enters or leaves a conducing medium, such as an electrolyte, gas or vacuum in a battery, electron tube, etc.) used to translate electrical signals into audio or voice signals.

18 **Broadband** is characteristic of a transmission facility whose bandwidth is greater than that required for a voice-grade channel and is therefore capable of higher speed capacities for data transmission. Bandwidth refers to the required width of the frequency band used to communicate. To convey information clearly, a band of at least 2,500 Hz is required to modulate any carrier in a communications path (because when speaking the air vibrates at frequencies between 0 and 2,500 cycles per second). Broadband exchange service, for example, is a public circuit-switched communications service (offered by Unitel in Canada) which provides direct subscriber-to-subscriber transmission of digital or analogue signals, including data, teleprinter, telemetering, voice-co-ordination and facsimile.

19 The cut of a single New Jersey fibre optic cable in January 1991, for example, reduced that portion of the public telecommunications network's transmission capacity by as many as 250,000 conversations per hour; those circuits were out of service for some eight hours. Similarly, the accidental severing of Bell Canada's Montreal-Toronto primary fibre optic transmission cable on the morning of 5 July 1989 cut off 50 per cent of Eastern Canada's 70,000 long-distance circuits, and it took up to 18 hours to restore service.

20 Northern Telecom's latest enhancements to its Meridian PBX system, Meridian 1, builds on the SL-1 PBX product family launched in 1975. Introduced commercially in April 1991, it is able to handle up to 60,000 telephone lines, doubling the capacity of its predecessor. In addition, its computer processor is also faster and more efficient, enabling it to handle an estimated 100-fold increase in the volume of computer messages. See *Globe and Mail*, 31 January 1990: p.B-36.

21 By the year 2000, it is expected that ultra large-scale integrated circuit chips will be able to store as much as 100 million bits of data (as compared with 16,000 in 1980).

22 **Multiplexing** involves the use of a common channel to make two or more channels. This is done either by splitting the common channel frequency band into narrower bands, each of which is used to constitute a distinct channel (referred to as "frequency-division multiplexing," or by allotting the common channel to multiple users in turn to constitute different intermittent channels, known as "time-division multiplexing."

23 Through Teleglobe Canada's facilities.

24 As of 1990, about 73 per cent of toll switching centres in Canada were digital, as compared with 30 per cent of local switching centres.

25 **Packet switching** is a computer controlled method of data communication in which the message is split into segments or "packets." These then are transmitted over a separate network and reassembled in their original form at the destination. Specifically, packet switching only uses the channel for the duration of the transmission of the message segment. And in contrast with circuit switching, the data network determines the routing during, rather than prior to, the transfer of the packet. Examples are Telecom Canada's Datapac and Unitel's Infocall and Infogram.

26 The proliferation of worms,viruses, trojan horses, etc. in the computer industry is evidence of the kinds of risks involved in providing information that might lead logic processors to probe deeper into the public network's software system.

27 **Circuit switching** is a method of handling traffic in which the source and the destination are connected by a single transmission path for the duration of the communication by interconnecting incoming and outgoing circuits through a switching centre. Circuit-switched services include MTS, WATS, TWX, Multicom, Voicecom and Datalink (Telecom Canada), as well as Telex, Data Telex, Broadband Exchange and Infoexchange (Unitel). Packet switching, in contrast, only uses the channel during transmission of the message segment.

28 Of course, the costs associated with implementing universal broadband networks are not the only consideration. The regulatory framework within which the cable television and telephone industries operate and its orientation over the next decade also will help determine which sector controls the broadband local loop facilities, and under what terms and conditions.

29 Both are **electromagnetic waves** -- that is, waves of energy resulting from periodic variations in the intensity of electrical and magnetic fields vibrating at right angles to each other.

Electromagnetic waves can travel through space or matter. They include the full range of wavelengths or frequencies -- from the longest radio waves to the shortest cosmic rays. Radio waves range in frequency between about 30 kHz and 300 GHz, while optical or light waves have frequencies greater than 300 GHz.

30 Even the shortest radio waves are much longer than light waves.

31 A vacuum tube is an electron tube from which almost all air has been removed, leaving an almost perfect vacuum (that is, an empty space devoid of matter) through which an electrical current can pass freely.

32 A **carrier wave** is a radio frequency used to carry the audio frequency waves representing the sounds being broadcast.

33 A **transistor** is a small electronic device, similar to an electron tube (i.e., a device for producing a controlled flow of electrons) that amplifies electricity by controlling the flow of electrons.

34 **Amplification** is the distance from the top to the bottom of a wave. Louder sound increases amplitude, while softer sound decreases it.

35 **Oscillation** involves the single forward and backward surge of a charge of electricity. An oscillator is an electrical device which produces the oscillations that give rise to an alternating current (one that reverses its direction at regular intervals, as opposed to a direct current which is a steady electrical current flowing in one direction).

36 A **transformer** is a device for changing the voltage of an electrical current.

37 An **audio signal** is one that falls within the audio frequency range -- corresponding to audio sound vibrations between 20 Hz - 20 KHz; they are discernible to the human ear.

38 The voice spectrum has a range of sound frequencies from 300 to 3,000 Hz.

39 This technique is known as suppressed carrier, single-sideband transmission.

40 A **transponder** is a type of transmitting and receiving system for radio or radar. When it receives signals from earth on one frequency band (the uplink band), it amplifies and retransmits them back to earth on another frequency band (the downlink band).

41 For the Canadian share of MSAT, Telesat Canada has formed a consortium known as Telesat Mobile Inc. (TMI) in which it will have a 50 per cent stake; Canadian Pacific Ltd. will own 30 per cent and C. Itoh & Co. of Japan will own 20 per cent.

42 The Canadian Radio Common Carriers Association is a national association of over 200 licensed RCCs, representing approximately 75 per cent of the Canadian paging and mobile radio services industry. See section 4.2.4 in Chapter Four.

43 Half-duplex transmission allows both ends of a communications circuit either to transmit or receive alternately, but not both simultaneously. Full-duplex transmission allows both ends of a communications circuit to transmit and receive independently and simultaneously.

44 At the end of 1985, there were 12,000 cellular subscribers in Canada and 11 cities where the service was offered. In 1988, 3 1/2 years later, there were more than 225,000 cellular subscribers in Canada, and it is estimated that there will be more than a million subscribers by 1993 and more than 2 million by the year 2000. In the United States, there were already more than 2 million cellular subscribers at end-1988, five years after the service was introduced in that country. Moreover, it is expected that by 1993, there will be some 10 million cellular subscribers in the United States (Bell Cellular, no date (b)).

45 The predecessor of cellular radio was mobile telephone service which functions through a single high-power transmitter in each service area.

46 It is suggested that government emergency response organization personnel equipped with cellular telephones for normal-time use ought to be required to use three-watt transportable or portable models so as to ensure maximum power capability for emergency applications.

47 CellNet Canada is a national association of telephone-company affiliated cellular service providers. In this way, CellNet effectively acts as a single national enterprise. The CellNet member companies include: New Brunswick Telephone Company; Newfoundland Telephone Company; MT&T Cellular (Nova Scotia); Bell Cellular (Quebec and Ontario); Thunder Bay

Telephone; MTS Cellular (Manitoba); Saskatchewan Telecommunications; Edmonton Telephones Cellular; AGT Cellular (Alberta); B.C. Cellular; and Québec-Téléphone Cellulaire (Beauce region, Quebec). See Bell Cellular, no date (b): National); and section 4.2.4 in Chapter Four.

48 Technical standards that will enable end-to-end digitalization of cellular radio links have yet to be adopted. In addition, it is expected that the conversion to digital transmission to meet demand for cellular service will only be needed in a maximum of 20 cities world-wide. As a result, it is unlikely that cellular providers will make the substantial capital investments necessary to convert to digital until customer demand is sufficient to make it financially worthwhile for them to do so.

49 The Bell Cellular network, for example, is made up of a total of four Northern Telecom digital switches, each of which is situated in a cellular switching station at Toronto, North Bay, Montreal and Chicoutimi. They are linked by microwave and landline to approximately 160 cell base stations in Ontario and Quebec (Bell Cellular, no date (b): «Technologie»). Cantel and Bell Cellular advise that they are currently in the process of providing backup capability for their Toronto and Montreal switching centres.

50 The perceived importance of cellular radio in emergency applications is reflected in a 1988 survey of needs of federal ministries and agencies with offices in the Province of Quebec done by the regional DOC office. Of those who responded to the survey questionnaire, 70 per cent have included cellular in their planning as a communications tool in time of emergency; 70 per cent would look to cellular to fill any gaps in their communications resources inventory; and 50 per cent would employ cellular for backup communications. See CRTU-Québec, 1989.

51 See Chapter Ten. As media staff had difficulty getting through to their offices, once they did, some individuals apparently kept the line open for extended periods, thereby preventing other callers -- including response teams -- from making calls. Emergency responders and government advisers had to queue up for a free channel, along with all the other waiting cellular users.

52 BCTel advises that it might be possible to implement such controls by adding a programming feature that would redefine the cellular system database to provide priority dial tone access to pre-identified mobile terminal numbers. It might be relatively easy to alter the network architecture in this way because already, before dial tone is applied, the cellular base station must first identify the call-originating terminal in order to assign it transmission and reception frequencies. The DOC recently created a National Working Group for Cellular Line Load Control. A subcommittee of the CRTU-Québec also has been established to work on developing generic emergency plans for cellular service providers, including ways to implement emergency line treatment.

53 Cantel and CellNet have announced plans to provide cellular priority access to essential government users similar in principle to the line load control concept. In this regard, cellular technology has a superior technical capability as compared to regular telephone in that it already uses a subscriber number identification computer program for billing purposes in addition to having a handing-off capability which is managed remotely by their CNCS, thereby providing a greater potential capability for successful long-distance as well as local call completion. It is anticipated that this service will be available, on a partial or trial basis in both companies' serving territories by mid-1993.

CHAPTER SIX
Supplemental and Emergency-Only Systems

6.1 Introduction

A growing variety of communication technologies employed normally to provide specialized services can usefully be considered in terms of their possible application in emergencies. This chapter will look at a number of these supplementary and a few emergency-only communication systems.

The sections that follow discuss, in turn, emergency satellite services, high frequency (HF) radio and meteor burst communications, each of which can be used to transmit emergency messages over long-distances. Government-operated integrated radio systems are also considered, along with amateur and citizen band radio; radio-equipped couriers; taxi and other transportation company systems. In addition, facsimile and paging networks; 911 service; cable television and call-up systems are looked at in terms of their possible applications for public alert and response to localized emergencies. Together these networks enhance communications flexibility in emergencies by permitting a coupling of the various components thereof.

Under extreme duress, such as in a situation in which regular telephone service is lost, these alternative systems could be accessed by emergency organizations as an interim measure. To that end, however, prior co-ordination of communications resource listings (including equipment and operational personnel availability), and the establishment over time of formal and informal relationships with neighbouring jurisdictional authorities, equipment and services suppliers, and major public and private telecommunication users is considered to be crucial.

This chapter also reviews Canada's Emergency Broadcast System (EBS), and looks at recent federal proposals to establish a new Warning and Emergency Broadcast System (WEBS) -- a concept that has been developed by the federal Department of Communications (DOC). That system would incorporate alert/warning and emergency broadcast capabilities into a national network configuration distinct from the public telecommunications system. Under present arrangements, the Emergency Broadcast System relies entirely on the CBC radio-television networks and affiliated stations. It could, potentially be expanded to include local cable television (CATV) and other private broadcast networks as well. However, since its origins date from the height of Cold War tensions which have all but disappeared with the disintegration of the eastern block, its political saliency has been reduced recently -- to the detriment of peacetime disaster applications. This is reflected in the decision in 1990 by Treasury Board to deny the DOC's funding request to implement the WEBS. Finally, Canada's overall approach to emergency communications is considered in a comparative context by looking at related U.S. policies and approaches.

6.2 Two-way voice communication systems

6.2.1 HF radio

HF or shortwave radio communications typically are used by mining companies, trappers, prospectors, fishing vessels, etc. in remote northern and coastal areas. They also are used by licensed amateur or "ham" radio operators. In addition, many U.S. federal agencies use HF radio to support established government communication networks in crisis situations. In contrast, Canadian government entities, excluding the military, do not have easily accessible HF radio communication capability, although the DOC advises that there has been a renewed interest recently in integrating existing HF systems with other communications technologies.

In North America, public (as opposed to those allocated for government use) HF frequencies are not assigned on an exclusive-use basis. Instead, they are employed on a shared, non-interference basis. Just the same, distress, safety and urgency messages are, as a matter of common practice, always given priority over other communications, while private networks and other scheduled operations do not have an assigned priority level.

Communication with HF stations located hundreds (or even thousands) of kilometres away are possible when the radio signal is reflected back from the ionosphere.[1] But the ionosphere is unstable; it is affected by time-of-day and seasonal variations, location of transmitters and receivers, power, antenna type, and the frequency used. Moreover, during periods of intense solar activity, its makeup may change dramatically -- to a point where virtually no signals can be reflected back to earth. These HF "blackouts" can last for several days at a time (DOC, 1985b).

The National Communications System (NCS) in the United States is now developing a concept of operations for a "shared" federal HF network -- known as the "SHARES" project (Loe, 1989). That network will use existing U.S. federal-government HF radio communication assets in emergencies where regular communication links are destroyed or disrupted.[2] Underlying the SHARES concept is the U.S. government's stated belief that the HF spectrum offers a valuable resource which provides a reliable support network employing unsophisticated radio equipment that is operable over a wide range of frequencies. Among the most critical factors in establishing SHARES capability are the following:

(1) frequency selection and co-ordination (especially given the lack of common operating frequencies, varying modulation techniques, propagation anomalies, etc.);

(2) equipment that is used often;

(3) the development of easily understandable operating procedures; and

(4) regularly scheduled exercises employing as many participating HF stations as possible.

Co-operative efforts required by voluntary participants in the program include, first, the adoption of HF equipment purchasing standards and, second, because it may be necessary at times to relay sensitive information over the network, an examination of ways to incorporate protection measures to ensure network integrity. Moreover, it is anticipated that non-technical staff might need to use the equipment in a crisis situation. Thus, very simple basic operational procedures have also been established, involving something in the order of a five-minute read-through of the specially designed "SHARES Operating Manual."

Initial participants in the SHARES network will be U.S. federal departments and agencies -- non-military and military. Possible additional participants could include licensed amateur radio operators having access to HF radio equipment who are recognized by a federal agency. As of 1990, some 27 U.S. federal government entities were participating in the program. More than 600 HF stations so far have been listed in the provisional "SHARES Directory," and their numbers are growing rapidly. An Operations Manual and Directory were published in 1989, and exercises have been held regularly to test different aspects of the program.

6.2.2 Amateur (ham) radio

In natural disasters or industrial accidents, power and telephone lines can be knocked out or overloaded. In these situations, public safety agencies usually will rely first on their internal radio systems to provide an emergency communications capability. Moreover, in areas where intermunicipal radio systems exist, those networks also may be used to meet operational needs for handling localized emergencies. But, how do the Red Cross, St. John's Ambulance and other voluntary service groups communicate their needs when caring for large numbers of people affected by a catastrophic disaster or other major emergency?

For the most part, this is done by amateur radio. Significantly, amateur radio stations can be brought in and set up quickly, and they can be moved around at need.

"Amateur radio" is defined as non-commercial radio used for experimentation, personal use and public service. In Canada, amateur radio operators are required to obtain an operating licence from the federal Department of Communications. Using a broad range of assigned frequencies in combination with either high or low-power transmitters, amateur radio operators can communicate locally or internationally by employing Morse code, radio-teletype, voice, telephone, packet radio and personal computers. This can be done directly by using FM-type VHF and UHF equipment, or it may be done via their own satellite, Oscar VI.

Since as early as 1920, Canadian and U.S. Radio Relay Leagues have been involved in training members of their "Amateur Radio Public Service Corporation." These volunteers now number in the tens of thousands, and they are fully self-equipped to go out into the field to provide "on site" emergency communications. North American amateurs also run their own "National Traffic System" comprised of network operators who keep the system operational on a daily basis from early morning to late at night.

On-site emergency amateur communications involve either written record messages or tactical voice command messages. Emergency inquiries from, for example, distant anxious relatives usually are handled using a written record message circuit. This helps overcome the problems of language differences. In the aftermath of a large-scale natural disaster, such as an earthquake or hurricane, power and telephone lines often take several weeks to repair; in these situations, amateur radio also can provide (sometimes the only) communication links for the duration of the outage, both within the affected area and with the outside world.

Unfortunately, there is growing concern that the numbers of amateur radio operators in many areas of North America are falling markedly. This is due in part to the fact that so many of today's active amateurs were trained either during the Second World War or in the early post-war years. Young people today seem less interested in radio clubs; they are involved instead in personal computer clubs and playing interactive games.

Significantly, however, in areas where there is a fairly strong disaster awareness education program, there is evidence to suggest that the "greying" trend is less apparent. According to the emergency preparedness co-ordinator for Richmond, British Columbia, for example, the local amateur club in that city has a growing percentage of members among 20 to 35 year olds. This development, it is suggested, may be the result of the combination of excellent (and continuous) public education related to citizen earthquake preparedness and the location of that municipality, which is below sea level and has several toxic chemical storage sites within its boundaries.

6.2.3 Citizen band radio

General radio service or "citizen band" (CB for short) radio probably is the most ubiquitous mobile communications technology currently available.[3] This is due to the low cost of the equipment required to use the system, and to the fact that use is not restricted to a particular category of users. CB radio essentially is a party-line type broadcast system of very limited geographical range. It provides a large number of "broadcasters" within the range of the signal, and it is used mainly for private and entertainment purposes. Lack of privacy and delays resulting from spectrum congestion and interference, however, make it an inefficient instantaneous voice medium as compared with other technologies available for business and emergency use.

In various forms, citizen band radio dates back to the mid-1940s. It became a fad in North America in the early 1970s, leading to a tremendous growth in the numbers of users, with licence applications in the United States reaching as high as 980,253 during a single month (January 1973); licensing requests tapered off later in the decade. At the peak of CB radio's popularity, *Time* magazine did a marketing survey, the results of which reported that a majority of CB operators used their radios to get information on road conditions (84 per cent); and to call for help in an individual emergency such as a traffic accident (66 per cent) (*Time,* 1977).

A survey study by Drabek et al. (no date) of emergency organization executives, citizen band service organization officers, unaffiliated users, and licensees residing in the area of a severe flooding event reveals three separate emergent patterns of citizen band use in emergency situations. The first is that of "co-optation" and absorption of screened volunteers and their equipment into an expanded interorganizational emergency system controlled by the local police department and a volunteer team of citizen band users recruited by the Red Cross until the amateur radio club could get its own emergency communications system in place.

The second pattern revealed by that study is the emergence of a multi-organizational communications network co-ordinating the specialized tasks of different, relatively autonomous, neighbouring community emergency service agencies. This was achieved through a centralized flow of communications into and out of the community EOC using CB radio. Thus, while local government radio frequencies and emergency mobile telephone units provided internal communications for the various agencies, citizen band radio was the core technology employed to achieve communications between emergency service agencies and volunteer units. In that capacity, citizen band radio supplemented rather than replaced other communication technologies.

A third pattern occurred in affected rural areas where telephone service was interrupted for several days. Given the widespread use of citizen band by rural residents in the affected area, it provided a substitute to the local telephone system, allowing isolated families to relay messages to friends and relatives. The information exchanged in this last emergent system was primarily conversational in nature.

Among the benefits achieved from employing citizen band radio in emergency situations are the following:

(1) a backup for the public telephone system, especially in isolated areas;
(2) a support to other communication systems for information gathering and message verification; and
(3) low cost to local governments since this technology is not only highly flexible, but can be made available for short-term use in acute emergencies at very little if any cost.

Just the same, some significant disadvantages exist with citizen band radio which make it less attractive than some other supplemental communication systems. In the first place, its usefulness is hindered (particularly in urban areas) by technical problems associated with the small number of assigned frequencies and their shared use with other services. Additionally, it suffers from reliability problems associated with modulation, and power output capacities which are susceptible to interference and noise from non-CB users sharing the frequency band as well as from electrical motors and automobile ignition noise. Citizen band signals also are subject to the sunspot cycle, making it possible for transmissions to be picked up hundreds of kilometres away -- either as coherent signals or as noise. Furthermore, the lack of training required for citizen band licensing has resulted in some users actually disrupting emergency communications -- for example, by refusing to share channel time or congregating at a disaster site. In addition, citizen band channels are rumour-prone since information is repeated over and over on the system.

Just the same, most citizen band users want to co-operate with emergency organizations. Consequently, despite technical limitations and operational problems, citizen band radio must not to be discounted as a possible backup to other radio-communication systems in emergencies. Indeed, a significant benefit offered by citizen band radio, as with any mobile communications system, includes rapid response to requests for help made on a reserved emergency channel. Certainly, citizen band radio is recognized to have saved lives and protected property on many occasions. The services of CB operators could be particularly useful to improve emergency medical and police traffic services, debris and hazardous spills control, law enforcement, and the like.

As a result, emergency response organizations might consider developing special public training programs to involve interested citizen-band operators in preparing for emergencies and exercising local contingency plans. Additional citizen band applications in emergency preparedness and response include assisting in search and rescue missions, and weather watches.

6.2.4 Private courier and taxi networks

Private radio systems, such as those operated by taxi companies and portable radio or walkie-talkie equipped delivery services, must not be overlooked as backup or supplementary emergency communication systems. For what would happen to local communications capability if neither public telephone nor electrical power were available for several hours or even days?

Indeed, the tremendous mobility of courier service personnel, and the fact that they are usually equipped with short-range portable two-way radios, suggest that they might provide valuable communications support following a severe localized disaster. In addition, it is easy technically to restore these networks. Moreover, when the effects of the disaster are expected to result in prolonged communications outages which would make it difficult to co-ordinate relief to the affected population, these systems might be employed to help set up neighbourhood relief co-ordination centres. Furthermore, where telephone and other communications with the outside world are blocked due to damage to public networks, they could be used to provide temporary vital links between local response agencies and neighbouring communities or provincial/territorial authorities.

In a similar way, taxi companies often have been used by public response organizations to notify agency personnel of an emergency situation when they cannot be reached by another means. They also may used to transport them to the disaster site or, alternatively, to convey messages between the site and organization headquarters until such time as other arrangements can be made.

6.2.5 Integrated radio systems

The primary impetus to the development and implementation of municipal, intermunicipal and other integrated radio systems is previous disaster experience. In this regard, increasing publicity surrounding urban and industrial disasters in Canada and the United States appears to have translated into political saliency in terms of persuading governments to develop long-term strategies aimed at broader system interconnection and interoperability for the purposes of emergency management. Moreover, recent advances in integrated circuitry and microprocessing technologies have enabled engineers to make separate network interconnection possible without requiring the complete replacement of existing hardware. Additionally, the falling costs associated with the introduction of these new technologies has made it economically feasible to consider fuller system integration within rapidly expanding continental networks. As a result, several Canadian provinces have embarked on putting in place province-wide emergency communications, and meetings have been held at regular intervals since the mid-1980s to tie the growing grid across borders, including certain civil defence authorities in the United States (Larsen, 1985).

Cases in point abound. One often referred to incident occurred in Nova Scotia a number of years ago. Emergency measures authorities and police had rushed to the cliffs along a remote shoreline off of which several fishing boats were foundering. Nearby helicopter pilots who had been dispatched to the area could not see the survivors in the water, even though they were visible to those on shore. Unfortunately, the two groups had no means of communicating with each other due to radio frequency incompatibilities. As a direct consequence of that and similar incidents elsewhere, today Nova Scotia has a province-wide switchable communications grid which is accessible to all regional and municipal emergency response organizations as well as to road maintenance crews, park rangers and snow removal personnel.

6.2.5.1 Municipal and regional networks

Through the regional offices of EPC, the DOC, and provincial and territorial emergency measures organizations responsible for assisting municipalities formulate emergency response plans, Canadian municipalities are being both financially assisted and encouraged to establish interorganizational emergency communications capabilities. Specifically they are

> to provide adequate and assured communications for the municipal emergency government headquarters and the various municipal emergency services so that these elements ... continue to function throughout the period of a[n] emergency (EPC, 1985: p.151).

Originally developed in the context of wartime preparedness, the following communications requirements for emergency organizations operating at the local level are common to peacetime emergencies as well:

(1) Police department -- requires a radio network controlled from a single point.

(2) Fire department -- requires a radio network where the telephone system is inadequate for mobilization of fire services.

(3) Engineering/public works department -- will require communications between operating units and the municipal emergency government headquarters to keep essential utilities (power, water, roads and sewage) functioning.

(4) Health and welfare services -- requires mobile sets on a common headquarters network for life-saving operations.

(5) Rescue -- requires provision for communications between municipal headquarters and the operating rescue forces, perhaps on a common civil radio network.

(6) Transportation -- needs normal mobile communications, plus police communications where co-ordination is required.

(7) Other services -- are to be served by a common radio network comprising a headquarters base station and mobiles (EPC, 1985: pp.153-155).

Integrated emergency communication systems are so designed as to allow interconnection among the different emergency service agencies on either a limited or an extended basis. The underlying principal upon which they are based is the ability to monitor emergency messages transmitted over a common or shared radio channel and/or to receive radio communications from other government agencies as an alternative to the public telephone network. It has been, however, only in recent years that larger municipalities have started linking their municipal works yards with their police and fire departments to enable better co-ordination of response to emergency calls. Interestingly, in smaller communities, the different public agencies may be interconnected already on a shared radio system -- due to the prohibitively high costs of operating parallel systems.

One of the earliest intermunicipal emergency communication systems was established in the regional area of Ottawa-Carleton in 1963. Its purpose was to ensure radio communications for elected officials and emergency agencies on common protected frequencies. As the emphasis on emergency preparedness shifted after the mid-1960s from wartime to peacetime natural or man-made disasters, the emergency government network stations in that area gradually were moved from municipal offices to regional fire, police and engineering departments. Although during normal operations, those emergency services operate on their own dedicated frequencies, the intermunicipal system allows them to communicate with each other without interrupting their own networks. In addition, voluntary agencies such as St. John Ambulance, the Red Cross, hospitals and the like also have access to the network. In a similar way, provisions for amateur radio club access have been incorporated into the region's disaster response plans to back up the emergency government network.

The Ottawa-Carleton emergency system was dismantled after the Province of Ontario disbanded its Emergency Measures branch as of 31 December 1975 and withdrew financial support to municipalities for emergency preparedness. Ontario amateur radio operators subsequently were invited to organize a province-wide emergency communications network, which is now known as Comsont (Tremblay, 1980).

Since the mid-1980s, Canada's largest metropolitan areas -- namely, Vancouver, Montreal and Toronto -- have considered various cost-sharing arrangements whereby all municipal and regional authorities in their respective surrounding areas could be connected on a fully integrated and flexible regional network. The Greater Vancouver Regional District (GVRD) for instance, has an integrated intermunicipal emergency communications system which links stations at some 17 fixed sites in North Vancouver, West Vancouver, the City of Vancouver, Delta, Richmond, Surrey, White Rock, Burnaby, New Westminster, Port Moody, Port Coquitlam and Coquitlam. Subscribers to the system include the North and West Vancouver Emergency Program, the various City Halls, police and fire departments, Royal Canadian Mounted Police offices, the Greater Vancouver Regional District Public Works Yard, B.C. Gas and B.C. Hydro. The Provincial Emergency Program also has been asked to joint the network.

As currently configured, that system is intended to link all the emergency operations centres in the region over dedicated radio channels. Any station on the network can activate the system in order to give messages, warnings, alerts or requests for mutual aid. In addition, portable radio packages can be transported to the site of a disaster to allow emergency response managers to communicate with other public agencies on a reserved channel, and thereby facilitate the co-ordination of multi-agency responses (GVRD, 1987: section 1.0). The portables come in packages of six, and they are located in four different mutual aid zones.[4] Usually they operate on their own simplex channel, but under special circumstances, they can be operated on the EOC-to-EOC network as well.

Each municipality's and other member's EOC in the region also is equipped with a base station which operates exclusively on the EOC-to-EOC network using a duplex voice channel. Transmissions from any individual base station are received and simultaneously retransmitted by a repeater station to one or all other EOCs, on a selective-call basis. During an incident involving more than one jurisdiction, the first station to activate the network will manage the use of the system.

6.2.5.2 Province-wide government networks

Nova Scotia's province-wide integrated mobile radio system has been operational since mid-1980. That system, and others like it set up afterwards or now being established in other provinces, has three main objectives. First, it is designed "to provide high quality and reliable mobile radio service to all participating Public Service agencies." Second, it will "promote the ... growth of government mobile radio service." Third, it will utilize existing resources "in the most cost-effective manner" (Eastern Canada Working Group, 1986a: Appendix A). The network that has evolved from the original system in Nova Scotia is an FM high-band (UHF) duplex system; it replaces the low-band VHF-AM simplex system established in the late 1950s for exclusive use by the Nova Scotia Department of Lands and Forests.

Users of the Nova Scotia system are grouped into two categories -- namely, "individual agency" and "common user." The individual agency part consists of the separate network and equipment of a particular government agency or user. An example would be municipal systems which integrate all city departments or, alternatively, the province-wide networks of provincial ministries. In the case of Nova Scotia, the province-wide networks include those operated by the province's Highway Patrol, the Department of Health's ambulance service, the veterinary branch of the Department of Agriculture, the Department of Transportation, the Department of Natural Resources, and the provincial Emergency Measures Organization (EMO).

The various separate networks are then superimposed upon the common user part. This consists of several strategic radio sites across the province. Each of these has a hot-standby backup power supply and antenna support structures. A backbone trunk radio system also connects them with a number of co-ordination or control centres to provide inter-agency radio communication. Additionally, communication between discrete networks can be achieved through a central operator at any time of day or night.

Each provincial site transmitter has a coverage area of approximately 40 to 50 km from the transmission tower. All of an agency's units can communicate with other (same-agency) units within the coverage area by pressing a button on the unit microphone. Wider-area communications, such as to other districts -- that is, to mobile units or fixed stations located in areas covered by a different repeater tower -- are achieved by dialling a three-digit number for automatic connection. A call to another public agency can be made through an operator located at one of the control centres who manually patches the call through to the other network.

To use the province-wide system all the participating agencies must use compatible and uniform radio sets. The backbone trunk of the integrated province-wide system is composed of 26 (as of 1986) UHF microwave relay towers. On 24 of those towers, VHF repeaters are also mounted, thereby providing discrete network communications capability on a separate frequency band for the individual agency networks within the common system. By designing the system around common facilities, capital and operational cost duplications have been avoided. Finally, Nova Scotia also has a toll-free Zenith telephone line which allows the public to call in during off-hours to report an emergency such as a forest fire.

New Brunswick similarly has established a province-wide integrated mobile radio communications system. It became operational in May 1988. Like the Nova Scotia system, it links the discrete networks of the provincial Departments of Lands and Forest, Transportation, Hospital and Ambulance, Emergency Measures and General Services with municipal fire departments and offices of the Royal Canadian Mounted Police. Inherently separate in their respective operations, each user network can utilize both the common radio sites and standby power. They also can communicate with each other through a central operator connecting the control or dispatch centre of each agency with that of the others. Moreover, the integrated functions of the New Brunswick system are fully computer controlled, and they are supported by two dispatch centres to provide interconnection among the various discrete networks.

Prince Edward Island and Quebec too are constructing province-wide emergency communication networks. PEI launched its Provincial Integrated Communications System (PICS) in December 1988, to provide direct communication between municipal and provincial emergency measures organizations, fire and police departments, ambulance services, hospitals, etc. (Borsu, 1989: p.9). That network, the first of its kind in Canada, is a combined emergency and commercial communications system (EPC, 1989b: p.37). It consists of six discrete trunked radio systems linked together by six microwave towers constructed across the province. The result is an Automatic Multiple Site Selection (AMSS) system operating in the 800 MHz band which is capable of providing both local (within the coverage area of a repeater site) and long distance two-way communications across all six sites.

For example, each municipal fire department on the Island can enjoy complete privacy in fleet-wide communications, while at the same time having the ability to talk to all fire departments in the province simultaneously -- through a regrouping feature -- should the need arise. The total number of voice channels in the network is 29 (comprised of four local channels for each of the six sites, plus five island-wide voice channels). And it can effectively handle some 2,900 subscribers (Island Tel, 1988). The network is funded jointly by the Island

Telephone Company (Island Tel), the provincial government and the federal government under the Joint Emergency Preparedness Program (JEPP). Additionally, it is part of a larger system joining Prince Edward Island, New Brunswick and Nova Scotia in the "Maritime Emergency Response Radio Network."

The Province of Quebec's «Réseau inter-sites de radiocommunication» (Integrated radio network, or "RIR") will be put into service by end 1992 or early 1993. This system is designed as a strategic telecommunications network for the provincial government together with a large number of governmental and industry responders in emergencies (Communications Québec, no date (a). The RIR concept is based on linking seven already-in-place government systems through nine regional centres situated in Sûreté du Québec (SQ) offices, with a provincial co-ordination centre located in Quebec City. The system also has been designed in such a way that it will have a negligible impact on existing systems and is able to be adapted easily to various types of emergency operations (Eastern Canada Working Group, 1986b).

The RIR will be used for two kinds of operations -- "local" and "network." The local mode will regroup emergency measures operations restricted to a relatively small area (roughly 4 to 6 km). The only equipment required in this case would be portable radio and compatible mobile units. The portable units would be under the responsibility of the organization in charge of the operation; the compatible units would belong to each of the distinct networks. In the network mode, the seven existing mobile radio networks of the Province of Quebec will be divided up into sub-blocks comprised of several repeaters each. In each network, these blocks then will be regrouped by geographic region and linked via microwave to a regional co-ordination centre shared by all the separate networks, through which they will be able to communicate with each other.

At a cost of close to $35 million, the initial RIR system will have a voice circuit capacity of 192 voice circuits on the main trunks and 96 on secondary trunks. This will be provided by 116 microwave sites throughout the province arranged in seven "loops" (to ensure greater reliability), serving some 201 radio mobile base stations; northern Quebec will be linked to the network via the MSAT mobile communications satellite (Communications Québec, no date (b)).

It is worth mentioning that each of the province-wide systems just discussed is intended to complement rather than replace existing mobile radio facilities operated by individual government agencies (Eastern Canada Working Group, 1986c). This is achieved in two ways. In the first place, they utilize point-to-point radio links to provide two-way mobile communications beyond the normal coverage area of a single radio repeater (that is, at distances of more than 40 km). Secondly, these systems greatly expand transmission capacity, enabling government agencies such as provincial police to meet extraordinary communication needs for which existing facilities have proven inadequate.

Perhaps the most significant factor stimulating current trends to expand and integrate government mobile radio networks relates to cost. The shared use among the different government agencies reduces duplication of capital investment in facilities and, correspondingly, system maintenance and operational costs. Increased system capacity also can be provided at a relatively low cost to meet growing normal-usage trunking requirements. As a result, additional users can join the system with a much smaller financial commitment than would be required to establish their own separate facilities. Other advantages to establishing province-wide networks include coherent planning and improved co-ordination of field response during emergencies, and more efficient use of the radio frequency spectrum (Eastern Canada Working Group, 1986b: p.3).

Finally, given the restricted capacity and coverage area of other mobile communications systems -- notably cellular telephone -- combined with the inherent vulnerabilities of conventional telephony (cable and microwave), radiocommunication appears to provide, by comparison, much greater versatility and resiliency. And although the capacity of mobile radio remains limited in terms of the number of conversations that can take place simultaneously, it is not nearly as vulnerable as telephony-based systems to disaster-related disruption because its users are linked for the most by hertzian waves -- although, of course, radio antennae are sensitive to extreme weather conditions such as very high winds and freezing rain (Bordeleau, 1988: p.29).

6.2.5.3 Interprovincial capability

Emergency communications along interprovincial borders continue to depend, under normal circumstances, on access to the public switched telephone system. However, if telephone service is disrupted by a disaster, an alternative means of establishing transborder communications between emergency response agencies could be made available. As a result of a meeting held in Quebec City in April 1985 between representatives from the provinces of Quebec, New Brunswick and Nova Scotia, a working group was created to study alternative approaches to interprovincial emergency communications. The Eastern Canada Working Group presented its report in January 1986. Since that time, interprovincial linkages have been established among most of the Atlantic provinces, and additional efforts are now being made to co-ordinate the development of the separate province-wide networks in such a way as to ensure operational compatibility throughout eastern Canada.

The kinds of disaster or other emergency scenarios that would require interprovincial communications between provincial (and, in some cases, with federal) government emergency measures organizations include: (1) transborder forest fires; (2) mutual aid between nearby fire departments; (3) ambulance service transfers; (4) search and rescue activities; (5) environmental accidents; (6) transport of criminals and law enforcement activities; and (7) transfer of dangerous goods (Eastern Canada Working Group, 1986a: p.4). Among the solutions considered by the working group for establishing transborder emergency communication capabilities were, first, cross-network repeaters along provincial borders; second, mobile communications vehicles; and third, provincial co-ordination centre links on integrated province-wide communication networks.

Nova Scotia and New Brunswick have implemented some of these solutions. Quebec also has provided for interconnection points with New Brunswick and Ontario within its province-wide integrated radio network. Prince Edward Island's integrated network similarly provides interconnection with New Brunswick and Nova Scotia. And Newfoundland and Ontario have both expressed interest in upgrading their transborder communications capabilities as well (Tremblay, 1987).

Key to establishing interprovincial linkages to assist in dealing with various localized emergencies is the establishment of a universal (ideally, Canada-wide) frequency plan for all emergency measures organizations. It has been proposed that the four VHF frequencies assigned to Emergency Preparedness Canada be set aside to form the basis of an interprovincial, interorganizational emergency measures communications service (Eastern Canada Working Group, 1986a: p.7). Technically speaking, it would be relatively easy to equip each agency's mobile units with frequencies used by another agency or, alternatively, to assign specific common or shared channels for mutual assistance. In this way, emergency measures organizations in adjacent provinces would be able to communicate directly with each other. Moreover, public response agencies in one province could better co-ordinate, through their respective EMOs, activities with their counterparts.

The concept of establishing interprovincial emergency communications linkages is a natural part of the evolution towards fully integrated systems -- from municipal to intermunicipal to provincial and, now, interprovincial. Consistent frequency planning, the allocation of common frequencies for emergency communications, and implementation of patching arrangements among radio repeater sites within provinces and between provincial systems through provincial control centres are considered essential in order to optimise communications response capability in large-scale disasters. Additional study on new interconnection methods as well as policies and procedures that would improve interoperability and flexibility -- such as who can connect, when and how -- also needs to be done. The implementation of similar crossborder communication capabilities with neighbouring American states also needs to be looked at since, as already noted, disasters often cross jurisdictional boundaries.

6.2.6 911 service

911 service provides call-in special access code service to the general public in areas where those services are offered by the local telephone company. Significantly, the character of 911 systems is essentially local. It is, of course, at that level that most emergencies requiring public safety intervention occurs.

The employment of a universal emergency telephone number dates from the establishment in Britain during World War II of "999" as a nation-wide system.[5] In North America, introduction of "911" service began in 1967 in the United States. At that time, the President's Commission on Law Enforcement and Administration of Justice recommended the establishment of a single telephone number for reporting emergencies. In 1968, American Telephone and Telegraphy Company (AT&T) announced that the 911 number sequence would be made available nationally. The same year, Bell Canada announced that it, too, would make the digits 9-1-1 available for local emergency reporting services.[6] Given the costs associated with implementing 911 emergency service along with the requirement of a full commitment to the goals of this service by local authorities some Canadian telephone companies providing service in areas outside of those operating in the country's major urban centres (a notable exception being the Atlantic provinces) have not yet succeeded in persuading local authorities to establish this service.

The operation of a local 911 system is straightforward. First, the individual wanting to report an emergency dials 911 on their telephone. Second, the call is routed over special trunks and is answered by a central emergency reporting bureau, usually at the police communications centre.[7] The attendant then will process the call by contacting the appropriate emergency service for immediate dispatch. In the event that the call is interrupted before the attendant receives all of the necessary information to take action, a special feature built into the system allows him/her to call back; optional features include automatic display of the caller's telephone number and of the address associated with it (Bell Canada, no date).

The main goal of 911 service is to enable citizens to obtain law enforcement, medical, fire, rescue and other emergency services quickly. Generally speaking, local callers use 911 to report property damage or to request immediate assistance for a wide variety of individual emergencies. An additional goal of 911 is to allow public safety agencies to meet their own operational interagency needs more efficiently in responding to emergencies. Consequently, the implementation of 911 systems concerns individual citizens, local politicians, local police and fire departments, emergency medical services, etc. It also requires co-operative arrangements with emergency organizations in neighbouring municipalities and with the local telephone companies -- because just as disasters tend to ignore political jurisdictional boundaries, those same boundaries rarely coincide with CO serving areas.

Under a 911 arrangement, this necessitates, among other things, the establishment of dedicated links connecting all the various response agencies with each and every CO serving that municipality. The 911 concept, therefore, is based on shared dispatching facilities which link local and in some instances, regional, police, firefighters, hospitals and ambulance services, and governmental authorities through a centralized switchboard staffed 24 hours a day, seven days a week .

In recognition of the value of a centralized emergency call-in service, there are trends -- particularly in large Canadian metropolitan areas, as well as in the National Capital Region, the Atlantic provinces and British Columbia -- to expand 911 service even further. Thus, in some parts of the country serious consideration has been given to extending the service province-wide with the aim of facilitating emergency response in large-scale disasters or other emergencies requiring co-ordination at that level.

Significantly, in Canada as in the United States, the expansion and development of 911 as an emergency telephone number has resulted from telephone company rather than government policy initiative. The reason for this is related to the historical role that telephone operators in both countries have played in processing emergency calls. Industry trends related to innovations in telecommunications transmission and switching technologies, and the resulting centralization and automation of many of the tasks formerly done by telephone operators has led to their being unable to respond to emergency "O for operator" calls that may originate several kilometres away. As a result, emergency call handling has had to be transferred over to local public safety agencies.[8]

This development initially led to a proliferation of hundreds of different emergency telephone numbers across Canada, leading at times to minor delays in emergency response. Just the same, even in those areas where 911 service is fully implemented, seven-digit emergency numbers likely will remain in place. This is because there are only a small number of access lines for 911 systems, and these tend to become overloaded after even minor incidents. Due to the lack of public education on the appropriate use of 911, seven-digit numbers for police, fire, etc. therefore are considered necessary supports to supplement 911.[9]

Canadian telephone companies all support and encourage implementation of 911 service as broadly as practicable. At the same time, they cannot be expected to invest in making the physical modifications required to their central office (CO) facilities without firm assurances, first, from the public safety agencies involved that the service will be responsive to the public need and, second, from their regulators that they will be allowed to recover those costs from the rate base.

Scattered pockets of 911 service now exist across the country and they are spreading rapidly. Just the same, some local authorities perceive 911 as part of a trend towards amalgamation and regionalization, fearing any further loss of community autonomy. Moreover, municipal governments may not have the local expertise to understand exactly how the system works and, always concerned about finances, they may be worried about how the costs could be equitably shared and what amount of responsibility for service implementation lies with the telephone company.

6.3 Data, text and image transfer applications

Prior to and during a major disaster or other emergency, computer-based expert systems can be employed to transfer large amounts of textual and image data to responders. Indeed, archival, grid and related decision-support database systems are becoming increasingly important in assisting emergency managers to make the right decisions, and thereby to help prevent disasters, or when they occur, to minimize their impact on the population and property.[10]

In order to ensure their optimal employment, these expert systems must provide easy access to data banks, along with uncomplicated procedures that will enable crisis managers to display and manipulate the information so provided easily in order to facilitate expert decision making. (If the emergency manager cannot receive the needed information in an appropriate format, the system will go unused.) Moreover, specific domain knowledge, such as that used in firefighting can be reported in reference tables which allow the system to calculate changes in damage projections based on information provided by the user regarding such things as wind speed, and direction, local weather forecasts, etc. (Mick and Wallace, 1986: pp.16-20). The sections that follow provide an overview of some of the communications technologies that may be used to facilitate data and image message transfers in disaster management.

6.3.1 Meteor burst systems

Meteor burst communication systems employ a long-range radio communications technique to provide real-time data acquisition and reliable, two-way radio teletype service from remote locations covering distances as great as 2,000 km. The meteor burst concept is based on reflecting or re-radiating radio waves off the ionized trails left by the billions of meteoroids entering the earth's atmosphere each day. Continuous coded signals can be transmitted by the master station at very high frequencies -- usually in the 40 to 50 MHz range. Then, when a meteor appears in a suitable location, it reflects the signal to a remote station. The typical meteor trail is approximately 25 km long and the possible signal duration is a few 100 miliseconds -- hence the name, "meteor burst." Signal quality and transmission speed vary by distance, time of day and season of the year.[11]

The advantages of meteor burst communication systems include their ability to provide secure two-way communications capability; given the unique transmission path used by each transmission, messages cannot be intercepted or jammed. They also provide reliable, error free point-to-point digital transmission and are highly survivable systems. Furthermore, remote stations are easy to install, require little maintenance and thus can be operated at unstaffed sites. As a result, they can be located in barely accessible areas since they need only be checked a few times a year. Other advantages of this technology in emergency applications include the fact that meteors are continually entering the earth's atmosphere, and that waiting times for messages to get through are predictable. Significantly, quality of transmission is unaffected by atmospheric disturbances. Moreover, terminals can be interfaced with other systems to provide position tracking of vessels or buoys by land-based stations. Additionally, almost immediate emergency event reporting is possible. Finally, these systems are substantially less expensive than most others both to install and operate.

With regard to specific emergency preparedness and response applications, the U.S. military has used meteor burst systems extensively as a low-volume system for data transmission. For example, the SNOpack TELemetry (SNOTel) network, which is made up of more than 500 remote stations in the western United States, is used to predict runoff and flooding. After the Mount St. Helen's eruption, the SNOTEL network similarly was used to report changes in moisture and temperature levels in surrounding areas.

Also in the United States, Federal Emergency Management Agency (FEMA) operates a meteor burst-based emergency communications network to connect state capitals with Washington, D.C. The rationale behind the agency's decision to employ this technology for its alternative network relates to "its ability to continue working or recover very quickly under post-nuclear conditions" (Larsen, 1984: p.7).

In Canada, meteor burst communications are provided by Meteor Communications Network Ltd. (Canada). The Canadian network's master station is located on Saturna Island in British Columbia. It provides coverage for the four western provinces, parts of the Yukon, Northwest Territories and eastward as far as Winnipeg. A second master station is to be installed in Yellowknife, Northwest Territories. It will extend coverage to the Beaufort Sea area and the northern Arctic. Similar proposals for a separate Department of Defence system, with master stations in Yellowknife, Frobisher, Goose Bay and at a Dew Line site, would provide nation-wide transmission capability.

6.3.2 Telidon videotex and teletex

Canada's Telidon program was launched in the 1970s by the federal Department of Communications' Image Communications Research Group. They were interested in finding ways to use computers to store and process visual images which would be accessible to the public on a subscription basis. The result was a Canada-developed commercial system known as Telidon. This system generally uses either conventional narrowband telecommunications (i.e., telephony) or wideband television transmission links. It also may use cable television distribution systems or computer diskettes to transfer information. Additionally, it is capable of both videotex and teletext applications, as described below.

Telidon's videotex and teletext technologies essentially enable "the video of a normal television broadcast to carry supplementary data communication signals without any adverse effect on television reception" (Marsh et al., 1987: p.103). These signals are transmitted during the vertical blanking interval.[12] And because they "piggy back" on television signals which already cover a large geographical area -- in the case of broadcasters such as CBC, that coverage includes over 95 per cent of the population -- they provide a reliable and economic alternative to other systems for communicating graphic and text data to subscribers.[13]

Videotex is a two-way interactive system. It allows the user to access remote data banks in a way similar to that of borrowing a book from the local library. In emergency situations, videotex could be used to supply information on relevant emergency procedures based on preprogrammed computer models. Especially useful is the ability of Telidon videotex to access building floor plans or street layouts for areas surrounding a disaster site. Potential videotex users could achieve access to those plans, etc. by connecting their terminals, including personal computers, using a modem connected to conventional telephone lines and a Telidon decoder (available for most kinds of personal and microcomputers for about $750).

Teletext, in contrast, is generally a one-way textual, as opposed to image or graphics, transmission medium. Moreover, it generally is restricted to sending brief messages such as weather warnings which, for example, could be scrolled across a band at the bottom of the television screen (Vaive, 1986: pp.10-11). It also could be used in combination with a keypad, to provide access to up to 250 pages of text information. To give an idea of the speed at which that information can be made available, the *Globe and Mail* daily contains approximately 1 megabyte of text. Using four lines of the vertical blanking interval to any or all of the sites in a broadcaster's range would take roughly 160 seconds.[14]

Significantly, during a disaster, the usefulness of either Telidon videotex or teletext systems would depend on the availability of alternate current (AC) power, since no battery application has yet been developed. This contrasts with grid computer/compass systems which have optional battery packs and are highly flexible in terms of the types of mainframes to which they can interface, variable transmission speed capabilities, and the like. Consequently, the current usefulness of videotex and teletext in emergency applications would be limited predominantly to planning and preparedness -- that is, before a disaster strikes. However, as low cost decoders become available for both commercial applications and the consumer service, Telidon videotex and teletext also might provide a viable addition to the national broadcast network -- specifically, a national public alert/warning network capability. The DOC advises that this possibility is now under study.

6.3.3 Facsimile and paging systems

Facsimile -- or, more commonly, "fax" -- refers to a communications system used for the electronic transmission of documents (written text or pictorial) which is capable of rendering the image of the document into hard copy (i.e., paper form) at its destination. Use of fax is becoming more widespread every day, to the point that most lap-top personal computers now come equipped with a built-in fax modem, as do portable cellular telephone units. Given the speed at which image and text can be transmitted via this medium, it certainly will have significant implications for emergency management applications. In addition, it is easy to use, and an emergency responder so equipped would not require any more training to operate this system than, say, to operate a cellular telephone. Messages could be sent between, for example, the individual responder and the emergency operations centre, with any data manipulation -- such as calculations or projections of impact area, evacuation patterns and the like -- done centrally and then disseminated almost instantly to response teams.

Fax messages, however, are transmitted over regular telephone circuits. Therefore, unless the transmission paths over which they are sent are dedicated -- that is, they do not use dial-up exchange numbers -- these systems will only be as reliable as the public telephone system.

In the case of those facsimile machines that do use dedicated lines, when a voice circuit is lost, it may be worthwhile for the user to check the response organization's fax/datapac service numbers, because it is possible that they will not have been affected. There is, of course, no guarantee that all of the organization's fax numbers will be line dedicated, since some may be shared with voice access networks. Just the same, fax machines and computer links often are line dedicated, and they therefore might be available when regular telephone lines are jammed following a disaster.

As regards paging systems, it will be recalled from the previous chapter that these systems use a radio base station to transmit microwave signals to portable pager receivers. The messages so transmitted may be simple tonal messages; a blinking light; a brief digital text message such as a telephone number to be called or a brief instruction; or, alternatively, a brief recorded digital audio message. Significantly, there is currently no technical provision for paging receivers to transmit a reply to the base station.

As a supplementary communications medium in an emergency situation, paging systems have a number of advantages. First, most emergency services personnel are equipped with pagers and use them on a daily basis, so that they are familiar with usage procedures and constraints. Second, in an emergency situation it likely would not take more than five to ten hours (depending on how far the disaster site is from an urban centre) to obtain as many units as needed for response teams. Third, pager receivers are highly reliable and have a long battery life. Fourth, and perhaps most significantly, the cost of renting paging receivers is considerably less than other communications terminals. The approximate cost per unit would be $35 per month (minimum of one month), with no additional usage or other charges. [15]

In addition, the major Canadian paging companies are committed to supporting fully governmental response during a disaster. To that end, some have gone so far as to donate a few hundred pagers for use in an emergency situation by public safety responders. Additionally, they have stocked "reserves of pagers to be sourced by government organizations during an emergency; and triggering pagers directly through their terminals in the event the telephone system fails."[16]

6.4 Satellite-based applications

With regard to long-distance data and voice communications, satellite and fibre optic systems remain more complementary than competitive. The advantages of fibre optics, as pointed out in the previous chapter, include the very broad bandwith possible; the absence of electromagnetic interference; low error rates; secure transmission capability; and very short data transfer times. Disadvantages include the relative fragility of optical fibres; the complexity of connection; difficulty in network reconfiguration; and the reduced possibility for cost efficient point-to-multipoint service. In fact, competitive overlap between satellite and fibre optics is currently limited to high speed point-to-point and very long-distance links (OECD, 1988: p.19).

Respecting satellite communication, the most significant -- albeit merely ascetic -- weakness is a perceptible voice transmission delay. Its overriding strength is very long-distance data, and point-to-point and point-to-multipoint voice signal transmission capability.

The largest future markets to be developed for fibre optics will be those in which satellites are essentially ruled out -- such as local area networks linking terminals in the same building or between sites in a municipal region -- for competition with coaxial cable (OECD, 1988: p.21). Mobile communications (which constitute the most likely form of communication to be required during emergencies), especially in remote locations, are similarly outside the competitive sphere of fibre optics applications. And this area of service provision represents the most significant future market for satellite communication. Competition in mobile services, therefore, likely will occur between satellite and terrestrial radio services. Finally, in very remote areas and at sea, emergency communications will continue to depend almost entirely on satellites.

As of late 1985, the Intelsat system accounted for some 450 satellite transponders in orbit. The world total includes, with the exception of the Soviet Union, roughly 1,400 civilian transponders in orbit. Estimates for 1990 were for approximately 2,500 transponders in orbit, 40 per cent of which would be part of U.S. systems, 30 per cent belonging to Intelsat and Inmarsat, 6 per cent European or Japanese and 5.5 per cent Canadian (OECD, 1988: p.7).

Given the present excess capacity in satellite transponder availability, the economic viability of satellite companies likely will depend on their ability to introduce new services -- such as, for example, decentralized digital business connection; direct broadcast television; and connection between mobile units. In the field of data and voice satellite transmission, at least 17 new services also could be developed -- including such things as database updating; remote access to mainframes; inquiry and response links; mainframe time sharing; point-of-sale record keeping; videotex distribution of periodicals; remote equipment monitoring; computer-to-computer data transfer; batch processing; electronic mail; and secure voice (i.e., digital encryption and scrambling) (OECD, 1988: p.8).

Increased satellite power resulting from solid state applications now enables the use of higher and higher radio frequencies. And this, together with recent developments in antenna technology -- i.e., the introduction of smaller and flatter antennae -- has led to greatly reduced costs to users for connection to satellite networks. Indeed, the average price for on-board terminals linked to the Inmarsat worldwide satellite-based system of marine communications was US$70,000 in 1980; by 1987, it had dropped to $30,000 (OECD, 1988: p.14) and is still falling.

The discussion in the subsections below consider some of the satellite communications programs currently available which are oriented specifically to emergency preparedness and response. They include: (1) the Canada/U.S. MSAT program; (2) SARSAT; (3) Spacetel; and (4) RADARSAT. These systems provide communication services ranging from mobile data and voice applications, to search-and-rescue emergency responder location, to portable remote terminals which provide temporary telephone link-ups, to remote sensing.

6.4.1 MSAT program

The Canadian Mobile SATellite (MSAT) program was instituted by the federal Department of Communications in the 1970s in order to develop a domestic capability in the area of mobile satellite communications -- especially for rural and remote areas.[17] Proposed services include: (1) mobile radio and mobile telephone; (2) mobile remote telephone (to some 100,000 Canadian households that currently do not have basic telephone service and to exploration camps or wilderness parks); (3) in-vehicle paging, data acquisition and transmission; (4) nation-wide paging; and (5) weather forecast and agricultural broadcasting.

Target markets are government agencies and large industrial users operating in remote areas, at sea and in the air. It is expected, for instance, that about 80 per cent of system use will be for mobile radio and mobile telephone -- i.e., two-way voice services. Satellite mobile radio service will offer private communications between mobile units or between those units and a base station. The major users of this service are expected to be police forces, ambulance service, winter road maintenance crews and forest fire fighters. In addition, resources industries operating in remote locations, together with fishing fleets (for sea and weather conditions, shipping schedules, and exchanging information on fish locations and catches) are expected to use these services extensively.

Satellite mobile telephone service will connect mobile units with the public switched network and with each other. Significantly, it is not intended to compete with cellular mobile radio-telephone service. Instead, it will be used to service those areas outside cellular serving territory which, at present, is limited to major cities, along highways connecting them and in a few rural areas. Satellite mobile data services will allow two-way mobile unit to computer database connections for information entry and retrieval. In addition, MSAT can collect data transmitted from remote monitoring and alarm devices, and command automated control stations (such as from unstaffed meteorological stations) (DOC, 1985c).

The MSAT system is comprised of four basic components. They include, first, at least one satellite in geosynchronous orbit; second, a ground central communications control station to be used to monitor and regulate the satellite, and to ensure overall system integrity; third, a number of "gateway" stations providing an automatic interface with the public switched network; and fourth, several hundred base stations (in Canada alone) located across the North American continent to allow relatively low cost point-to-multipoint communication to and from mobile MSAT terminals for the provision of private telecommunication services.

In the first-generation system, up to 35,000 mobile units will be able to access the satellite. Terminals will be approximately the same size as today's mobile radio and mobile telephone units. In addition, roof-mounted antennas will be used to establish the communications link with the satellite. There also will be suitcase-like terminals light enough to be carried into the bush (under 20 kg). Mobile communications will be in the 800 MHz band, with the up-link between the gateway stations and the satellite at 13 GHz and the down-link at 11 GHz (DOC, 1985c).

The MSAT program has evolved into a broad-based Canada/U.S. mobile telecommunications system as a result of an agreement of formal co-operation signed by the two countries in December 1983. Originally scheduled for launch in 1987, the first launching is now expected to take place in 1993, at a cost to Canadian taxpayers of approximately $176 million by the year 2000.[18] The United States will spend a similar amount to launch its own MSAT satellite, and the two will back up each other. Contracts already have been negotiated to provide the Canadian government with services amounting to $126.5 million over the first six years following the satellite's launch. The project also is forecast to generate another $2.4 billion in domestic and overseas sales during the same period (DOC, 1988).

MSAT terminal equipment purchase costs to users will be between $3,500 and $4,500 each for mobile telephone/radio terminal units (including the roof-mounted antenna and a mobile radio or mobile telephone). It also is expected that MSAT terminal equipment will be made available for leasing as well as for purchase. In addition, there will be a monthly subscription fee of approximately $50, together with per call charges averaging between $1.00 and $1.50 per minute (roughly similar to those currently charged for cellular telephone service).[19]

The potential market is estimated at 450,000 subscribers by the year 2000, with some 100,000 in Canada. Canadian government agencies, through the Government Telecommunications Agency (GTA), which provides telecommunication services to federal ministries and other public organizations, will use approximately 10 per cent of MSAT's capacity. Among the other governmental and emergency preparedness services that will use MSAT are the Canadian Coast Guard; law enforcement agencies such as municipal and regional police; fire fighters; emergency medical services; disaster relief organizations; resource management agencies; and pollution control and clean-up agencies.

The remainder of available system capacity will be made available to private subscribers. On the industry side, potential users include transportation and trucking companies operating nationally or in remote areas; mining and exploration firms; forestry companies; agriculture and fishing companies; construction crews; manufacturing firms; and the service industries.

The MSAT will be Canada's most powerful satellite to date. On the one hand, it will use super high frequency (SHF) and ultra high frequency (UHF) bands capable of beaming into densely populated areas without interfering with other, ground-based transmissions. On the other, it will provide an economic option for radio communications in remote areas, and especially where either rugged terrain or atmospheric peculiarities (such as are found in the Far North) make conventional radio -- including high frequency (HF) services -- unreliable. Moreover, the system, being completely automatic, will be easy to use; no special skills or training will be required to access and use its various services.

6.4.2 SARSAT

Developments in space and satellite communications in Europe, the United States and Canada related specifically to emergency preparedness and response include the satellite-aided search and rescue (SARSAT) system. Originally promoted by France's National Centre for Space Studies (CNES), the U.S. National Aeronautics and Space Administration (NASA) and Canada's DOC, its international dimension broadened considerably when SARSAT merged with the Soviet Union's COSPAS program to form the joint SARSAT-COSPAS program. The system has been further enhanced since the mid-1980s in conjunction with international organizations such as the International Civil Aviation Organisation (ICAO), and the

International Telecommunication Union's (ITU) International Radio-communication Consultative Committee (CCIR).

The ground network of SARSAT-COSPAS consists of ten land-based stations of which four are in the United States, three in the Soviet Union,and three in Europe. The space segment consists of payloads carried aboard five satellites, three belonging to the Soviet Union and two to the United States (OECD, 1988: p.10).

Although the SARSAT program in Canada originally was developed and put into service by the federal Department of Communications, the Department of National Defence (DND) now plays the lead role respecting Canadian SARSAT deployment, in co-operation with the Canadian Coast Guard. SARSAT is considered a potentially useful tool in emergency situations. To date, however, it has been used mainly to locate downed aircraft and ships in distress.

6.4.3 Spacetel service

Other satellite services of relevance to emergency preparedness include satellite radio-telephone service to remote areas provided by regional telephone companies.[20] An example is the British Columbia Telephone Company's (B.C. Tel's) "Spacetel" service for small communities in remote areas. This service provides users with dial tone -- via small portable satellite terminals for a single channel, or much larger multi-channel units -- employing the Vancouver exchange. In this way, dial-up access to the public switched network is possible virtually anywhere in the province where it is required. Spacetel is used predominantly in construction camps and other temporary sites where landline telephone service is not available.

B.C. Tel also has tagged three trailer-mounted transportable Spacetel units for emergency use. These are situated at centralized locations in the province to ensure rapid deployment on demand. In that way, in the case of an outage caused by a natural or other disaster, some telephone service could be restored within less than a day to the majority of B.C. communities using a Spacetel satellite terminal. In major population centres, Spacetel also could be used to achieve rapid (within about one hour) partial restoration of service. Within approximately eight hours, six-channel Spacetel access could provide point-to-point links between the disaster site via the Vancouver "Master Control" earth station and another British Columbia Telephone Company (BCTel) switching centre, or to the Canadian and U.S. national public switched networks. Within 24 hours, an operator-controlled switchboard could be attached to the six-channel Spacetel satellite terminal and terminated to local telephone loops (DOC, 1986: item 11(b)).

Related developments are still in the design and planning stages. For instance, a series of ANIK-E satellites are scheduled to be launched beginning in the early 1990s. Operating on much higher power than existing Canadian satellites, these will extend considerably northern area satellite telephone coverage. Another experimental project currently underway is the SHARP program. It will employ high-altitude unmanned aircraft to provide microwave uplinks to Canadian communication satellites. These aircraft are specially designed to operate in the "flatstream" (that is, the deadspot in the jetstream) at about 20 km above the earth's surface. Weighing approximately 100 kg and operating on 200-watt power, each SHARP aircraft will have a footprint of nearly 600 km, making them ideal for regional communications usage (Hamilton, 1987).

6.4.4 RADARSAT

RADARSAT is a highly sophisticated (and Canada's first home-built) remote sensing satellite. It, too, could have significant implications for emergency preparedness communications. Initiated by the Canadian government, the RADARSAT program now is a Canadian-led international project involving the provinces of Quebec, Ontario, Saskatchewan and British Columbia. Spar Aerospace Ltd. of Toronto received a $146 million contract from the Canadian Space Agency for Phase I of the program. And, under an agreement with the United States, NASA will launch the satellite and operate a data reception station in Alaska. The RADARSAT satellite is scheduled to be launched in 1994, and it will have a five-year design life.

Its primary feature is a synthetic aperture radar (SAR) capable of transmitting and receiving signals regardless of cloud, darkness or harsh weather conditions. SAR is expected to be especially useful as a means for geological mapping of regions not previously monitored on an continual basis. Its footprint will cover most of Canada every 72 hours, and the Arctic every 24 hours. In this way, it will significantly reinforce existing remote sensing technology and provide valuable information essential for more efficient resource management, ice and oceanic surveillance, and environmental monitoring.

Specifically, RADARSAT will be able to detect strengths and weaknesses in ice. It also will assist in improved weather and ice formation predictions, thereby reducing navigational risks. In addition, it will be able to track the movement of ships through the ice; measure oceanic winds and wave swells; detect oil spills; chart renewable resources for the agricultural and forestry industries; provide regular observation of time-related phenomena such as crop growth cycles; and measure ground moisture levels and plant conditions.

6.5 Canadian emergency broadcasting and warning

It is axiomatic that an effective public alert/warning system will depend on the existence of reliable communication links between the government agencies responsible for issuing warnings and with the commercial broadcast media. The following discussion distinguishes between public alert and warning systems, and considers the role played by both in disasters. It also points to some of the problems associated with Canada's current inadequate public alert and warning capability, and recent emergency response performance in regard to high-risk, low-incidence disaster situations. The importance of flexible and reliable emergency communications systems, together with the crucial role played by the broadcast media in emergencies is underscored.

6.5.1 Alert and warning systems

"Alerting" involves obtaining the attention of a person or persons. "Warning" means providing information about the nature of an emergency situation to a potentially affected populace. Both are comprised of "progressive chains of communication among a variety of agencies and organizations which ultimately lead to the public" (Mileti, 1975: p.24).

Significantly, warning is a process that begins with identifying an abnormal situation by an observer; reporting that situation to a decision centre; analysing the information provided and determining what response action is required; formulating directives, advice or factual messages regarding preventative or mitigative action to be taken; activating the warning distribution system; and issuing the warning message. It concludes with the affected or threatened population's receiving the warning message.

Alerting, in contrast is a "process by which the warning system is brought to a condition of readiness to generate, transmit and receive a warning message." It involves gaining the attention of individual decision-makers; activating organizational warning devices; and, if necessary, even awakening the intended recipients (Dingle, 1989: slides 1 and 2). Alerting systems, therefore, in contrast to warning systems, do not require that direction for action to be taken be given to the population potentially affected by a disaster. Instead, they used to notify publicly agency personnel of a threatening development -- e.g., such as rising water levels -- so that they will report to their workplace or, alternatively, to the disaster site (depending on their organization's contingency procedures) to assist in the response operation. Table 6.1 below outlines several types of emergencies and gives an indication of how much advance notice a population would have before impact; the amount of time needed to alert the public ;and the kind of action required by the population to reduce the threat to life and/or property.

Significantly, at the municipal level, for the most part, police and fire departments are the only public organizations with alerting capability on a 24 hours-a-day-seven-days-a-week (24/7) basis. Additionally, many small communities do not have any alerting system in place at all to enable them to notify public agency personnel. As a result, they have to rely on telephone fan-out procedures to call in their staff or, alternatively, on cruising mobile units to go to the homes of on-call personnel. It is, however, widely recognized that there is a need for identifying one central agency or telephone number (such as 911) by means of which a witness to a disaster, say, could make the incident and disaster location known to local authorities. Moreover, and for obvious reasons, alerting procedures need to be established and practised beforehand in order to optimise their effectiveness.

TABLE 6.1

Speed of Impact, Population Alert and Reaction[21]

Type of emergency	**Speed of impact after recognition**	**Alert time needed**	**Required action**
Tornado	minutes	minutes	shelter
Tsunami	1 to 6 hours	1 to 6 hours	evacuation or shelter
Hurricane	days or hours	a day or hours	evacuation or shelter
Flood	hours	minutes	evacuation
Land slide	minutes	minutes	rescue
Airplane accident	instantaneous	none	rescue
Toxic gas	minutes/hours	minutes	evacuation or shelter
Explosion	instantaneous	none	evacuation or rescue
Power outage	instantaneous	none	information
Major fire	minutes	minutes	rescue and relief
Avalanche	minutes	none	rescue and relief
Forest fire	hours/days	hours/days	evacuation
Snow storm	hours	hours	shelter

Among the most commonly used alerting procedures today are automatic paging systems which give an alerting audio tone;[22] established telephone fan-out lists; and formal arrangements with local broadcast media to call in off-duty personnel by broadcasting emergency notification messages over-the-air via radio, cable and television stations serving the affected or threatened area (EPC, 1987).

Outdoor sirens fall somewhere between alert and warning systems as defined earlier. Although they convey a very limited message which is understood only by those already familiar with the audio coding scheme employed, they also might be used to direct the public at large to turn on their television or radio. In a community, for example, near to a nuclear power plant, sirens could be used to warn employees and residents of a danger. Of course, for such a system to provide adequate warning, the affected population would have to know what response action they are expected to take as well. Table 6.2 below includes several alternative public alert/warning systems along with some of their characteristics and approximate cost.

Public warning systems, since they involve action by government agencies to alert the potentially affected populace of a disaster that threatens their personal safety and property, and because they also require private citizens to take reactive measures to ensure personal safety (such as evacuation) or protect private property, are much more complex. This is especially true in large-scale peacetime emergencies due to anticipated confusion over jurisdictional authority (i.e., which public agency has authority to make warnings, and how far can they go to ensure that private citizens comply with their directives), and public liability in the event that citizens either do not receive the warning or refuse to take action.

TABLE 6.2

Public Alert/Warning Systems[23]

Type	Kind of system	Message reliability	Geographic coverage	Population coverage	Speed	Cost
Siren	general	reliable	large	variable	fast	$5-10,000/siren
Telephone network	for responders	average	medium	small to medium	slow	none
Door to door	general	high	small to medium	small	slow	$55 per door
Loudspeaker (automobile)	general general	average average	medium to large	medium to large	average	$500-$1,000 per loudspeaker
Weatheradio	special (weather)	high	large	medium to large	fast	$35 per home receiver
Commercial TV/radio	post-event public info.	high	variable	large	fast	cost of message (minimal)
Newspaper	post-event public info.	high	variable	large	very slow	cost of message (minimal)
Radio/TV alert	general	high	variable	large	fast	minimal if collaborate
Cable alert	general	high	variable	large	fast	minimal if collaborate
Church bells	general	reliable	variable	variable	fast	minimal

Social science literature on disaster behaviour suggests that the public will respond to a crisis warning only to the level of previous experience (Mileti, 1975: p.24). Consequently, a populace exposed to a unique threat will be unlikely to respond appropriately to any warning system, however adequate in conveying information about the disaster and the mitigative measures to be taken (Scanlon, 1974). According to one pioneer scholar on disaster behaviour, "the meaning of the event and the potential threat to the community may be judged on the basis of recent memories of the population and those judgments may be inappropriate to a new situation" (Dynes, 1973: p.74). Certainly, this does not augur well for high-risk, low-incidence events such as a major earthquake. And indeed, it appears that public warning systems will be effective only if the threatened or affected population understands clearly both the nature of the threat and the timeframe involved for responding to it.

In ideal terms, a public warning communications system would have to meet a number of basic criteria in order to assure appropriate public response action. The first is <u>connectivity</u>, that is, a clearly defined system of physical communication links between the network control point and all connecting points. Secondly, a reasonable degree of <u>survivability</u> needs to be ensured to provide continued operation during and subsequent to a disaster or other emergency. This is achieved by protecting communications equipment from damage that may be incurred as a result of shock, lightning, etc. Related to survivability is <u>redundancy</u> -- the ready availability of additional parts and equipment which can be used to replace damaged portions of the facilities network. A fourth criterion is adequate <u>capacity</u>, or the ability of the system to meet dramatically increased communication traffic loads. Another is <u>transportability</u> of replacement equipment and personnel to re-establish lost communications. Sufficient <u>security</u> also is required to protect against unauthorized access to the system. In addition, warning systems must be <u>multimodal</u> -- that is, using a variety of communications modes such as voice, fax and record (i.e., teletype). They also need to be <u>flexible</u>, employing equipment that can be tuned easily to various channels or frequencies. Furthermore, emergency warning systems need to be <u>interoperable</u>, that is, able to exchange information with other systems such as the public switched network. And they must be <u>responsive</u>, or able to react quickly, to disseminate alerts and warnings, with clear transmission and reception of information in various modes of operation. Finally, they have to employ <u>user-friendly</u> equipment, thereby requiring the minimum number of essential personnel and training requirements so as to optimize efficient operation and maintenance (FEMA, 1984: pp.1-1 to 1-3).

In any peacetime emergency, as noted repeatedly in the present study, adequate communications capability is crucial to help the affected community that is trying to cope. And a public alert/warning system will be only as good as its communications system -- especially as regards its ability to handle high-priority traffic over fixed or mobile telephone, and written record (teletype or fax), together with additional backup capacity provided by amateur, police/fire/utility and other networks as well as national, regional and local radio and television broadcast networks.

Of particular significance is the role of the broadcast media in warning the public at large. Of course their role in an emergency goes well beyond warning. Among other things, they have a part to play in pre-disaster public education. During or immediately following a disaster, they provide a way (often the only one) for public responders to communicate to the threatened or affected populace to inform them on how to prevent or reduce the impact of the disaster on personal safety and property, and to give them frequent, accurate reports on the extent of damage, temporary shelters and the like. They also can be used to promote volunteer disaster response efforts and to stimulate appropriate community disaster relief. Finally, through call-in talk shows, telephone hotlines and the like, they can provide a channel for the public to express their concerns to emergency managers and relief organizations.

The importance of the broadcast and print media before, during and immediately after a disaster strikes cannot be over-emphasized. It is especially significant, however, that pre-established relationships with the government agencies responsible for co-ordinating disaster response involve them in such a way as to ensure responsible coverage of the event and promote their co-operation in disseminating relevant information in a timely manner.

Common criticisms of the media during disasters include the possibility that extensive coverage may exacerbate the problem of convergence at the disaster scene by a curious public (and by external media representatives). They also may create additional pressures on crisis managers through their seemingly insatiable appetite for information and by their possible domination of limited communications resources -- for instance, overloading telephone (including cellular) circuits. Finally, irresponsible individuals who do not take the time to verify information may hinder the response effort by spreading rumours or fostering myths (such as about the likelihood of looting) which would increase rather than quell public anxiety.

Alternatively, media representatives can be instruments for effective public response to a disaster. To that end, they could be used to convey clear messages to the public in order to dispel or correct rumours, requesting people to stay away from the disaster site and instructing them not to use the telephone unless there is a genuine individual emergency. Again, the nurturing of co-operative relationships, preferably established prior to the event, between the media and public response agencies is considered essential to effective public alert and warning in disasters (Scanlon, et al., 1985).

6.5.2 History of Canadian systems

Air defence radar stations were first established along the Atlantic and Pacific coasts in **1942**; but they were dismantled in 1945. However, in **1946**, the Canadian government already was considering building a radar chain in the Far North against the possibility of attack by the Soviet Union. Available technology at the time, however, meant that full national radar coverage could not be guaranteed; nor could hostile aircraft be tracked with any degree of accuracy.

By 1949, the Soviet Union had developed an atomic bomb and was building up a long-range bomber force. This, together with increased tensions in Europe led the Canadian government to construct a radar line just south of the Arctic coast, while the United States built one along its own northern border. Canadian-U.S. consultations subsequently led to the establishment of the "Pinetree Line" radar chain, comprised in all of 33 stations -- extending from Vancouver Island, through Alberta, Northern Ontario and Quebec to the Labrador coast. Completed in **1954**, it cost a total of $450 million, of which Canada paid $150 million.

In August 1953, the Soviet Union emploded its first hydrogen bomb, further escalating east-west tensions. In reaction, Canadian defence research scientists recommended the construction of a mostly unstaffed radar warning system, known as the "McGill Fence," to be established at 55 degrees north in order to augment Pinetree Line capabilities. In mid-1954, that recommendation was accepted and the all-Canadian "Mid-Canada Line" was constructed. By **1957**, a total of 98 stations had been built at a cost to the Canadian government of $250 million.

Simultaneously, the Canadian and U.S. Military Studies Group was expressing growing concern about the Soviet Union's ability to outflank both the Pinetree and Mid-Canada radar lines. The result was a new Canada-U.S. agreement to construct the "DEW-Line" (standing for Distant Early Warning) along the Arctic coast -- from Alaska to Baffin Island. This time, the United States would bear the full cost of construction, but Canada would retain ownership of those sites located in Canada and command of the major stations.[24] The DEW-Line covers a distance of 8,046 km, of which some 5,944 km are in Canada. Comprised of 22 radar stations, it was completed in **1957.**

Construction of the DEW-Line also represented the first step towards the creation of the North American Air Defence Command (NORAD) in **1958**. This was an initiative to integrate fully Canadian air defence radar and fighter forces with U.S. military capability for the protection of the North American continent. Unfortunately, the relevance of the northern radar lines was soon overcome by advances in military technology in the area of intercontinental and submarine missile capability. As a consequence, by **1965** the Mid-Canada Line had been phased out of service and nine Pinetree stations had been closed. As of **1983**, 21 modernized DEW-Line stations and 24 Pinetree stations remained in operation, but their primary purpose is now to maintain sovereignty over Canada's airspace rather than provide early attack warning.

The development of low-level cruise missiles which are able to avoid radar detection reawakened interest in Arctic air defence capability in the early 1980s. And in 1985, Canada and the United States again agreed to put into operation a new radar line. This time to be established along Canada's Arctic coast at approximately 70 degrees north, it will be comprised of some 57 radar stations, 47 of which are on Canada territory (of which 11 will be staffed). The cost is estimated at $1.5 billion, with Canada to pay $600 million. Known as the "North Warning System," and it replaces both the DEW-Line and Pinetree Line radar chains.

The North Warning System[25] is specifically designed to detect low-level aircraft and missiles, and to pass information directly via satellite to NORAD headquarters in Colorado Springs. Additional detection capability will be provided by radar aircraft and over-the-horizon radars. Critics of the system emphasize its inability to afford radar detection and interception control over either the Northwest Passage or Ellesmere and the other islands of the Canadian Arctic Archipelago. Moreover, surveillance of the High Arctic will continue to rely entirely on U.S. airborne radar based in Alaska and at Thule.

Finally, the "National Attack Warning Siren System" is a concept developed back in the 1950s to warn the civilian population in Canada of an impending nuclear attack. It continues to be maintained and operated by the Department of National Defence and, through contract, by the regional telephone companies which operate the public switched network portion of the system. The decision to declare a national alert/warning can only be taken by the Prime Minister of Canada. The Canadian army then would be responsible for its dissemination to the general public. However, some national alert/warning responsibilities have been decentralized to geographical zones, and provincial authorities control their own civil defence organizations to handle peacetime emergencies.

At present, this system consists of a centralized Operational Centre in Ottawa; warning centres located close to each provincial and territorial capital; and an extensive network of outdoor sirens located within most Canadian urban centres. The various warning centres are linked with each other and with Ottawa via private landline telephone and radio. Unfortunately, the system's configuration provides little redundancy or survivability capability. Moreover, most of the sirens were installed in the early 1960s, and many have received only infrequent inspection and minimal maintenance over the years. It is therefore surprising that a large majority of them remain operational today.

Warning of the likelihood of an imminent attack would be disseminated to the public in two ways. The first would involve the sounding of the attack warning signal over the national siren system. The initial sounding of that system, as already mentioned, can be authorized only by the Prime Minister. The signal used is an undulating tone of from three to five minutes duration sounded on outside sirens. This tells the public to listen to a radio for instructions on what action they are to take. The initial sounding of the signal means that an attack on the North American continent has been detected; subsequent soundings indicate the approach of radioactive fallout and that survival instructions are being broadcast. Attack warning sirens in each province and territory, where operational, are controlled from provincial/territorial Warning Centres, except for those in the National Capital Region which are controlled from the National Defence Operations Centre.

DND appears to be very reluctant to continue managing this system. As a result, strong pressures are now being applied by Emergency Preparedness Canada and National Defence to transfer full responsibility for providing a national public warning capability to the Department of Communications. Although there is a certain logic to their arguments, especially given the likelihood that the system would be used predominantly, if not exclusively in practice, for major peacetime emergencies, the DOC similarly is reticent to take on the task. The department advises that its reluctance stems from the fact that Treasury Board refused in 1990 to consider an application to establish a combined warning and broadcast emergency communications capability (the WEBS, discussed later in this chapter), and this after many years of developing a concept that would provide full coverage at the lowest possible cost. Given an estimated $30 million price tag to implement such a system, unless there is a firm commitment by the federal government to replace and upgrade the existing systems, the DOC probably will refuse to accept to carry full responsibility for public warning.

The second element of the Canadian warning system involves broadcasting information and instructions to the public through the Emergency Broadcast System (EBS), based on the Canadian Broadcasting Corporation (CBC) AM radio networks.[26] This is discussed in the next section.

6.5.3 Emergency Broadcast System

In Canada, broadcasting historically has been given top priority as the primary means of disseminating emergency warnings and instructions to the public at large. This is because radio and television constitute such an important part of our daily lives. Indeed, broadcasting reaches more than 99 per cent of the Canadian population.

The Canadian Emergency Broadcast System was developed in the late 1950s with the aim of providing a reliable means for the Prime Minister and other federal, provincial and local authorities to communicate with the public during a large-scale emergency. It has been in operation since 1962. Like other warning systems, the EBS initially was designed to meet "wartime" requirements. As a result, the original interconnecting network arrangements for emergency broadcasting involved all licensed AM and FM radio and television stations. At the provincial/territorial level, additional interconnection configurations provided for decentralized control of the broadcast network from Regional Emergency Government Headquarters (REGHQs) located in hardened shelters capable of providing protection against high-intensity fallout radiation. This would enable both levels of government to continue to govern.

In wartime, all national telecommunication networks, including telephone, radio and television, would be controlled by the National Emergency Agency for Telecommunications (NEAT) -- a body to be constituted in a national emergency by the Minister of Communications.[27] The Department of Communications also is responsible to Parliament for emergency public communications in Canada, including use of all of the CBC's network and program facilities. Under the authority of the NEAT, the CBC, in turn, has been delegated responsibility by the minister for, "developing, organizing and operating the Emergency Broadcasting Plan through the facilities of all AM and FM radio and television studios in Canada, both publicly and privately owned" (CBC, 1969: p.15).

The Emergency Broadcasting Plan developed by the CBC in the 1960s emphasized the protection of key high-power radio stations associated with the regional (REGHQ) control studios. A second phase of the program developed additional protection of radio stations operating in areas of high risk from fallout -- namely, along the St. Laurence Seaway, from Windsor, Ontario to Halifax, Nova Scotia. The third and final phase of the plan involved a program of establishing priorities for hardening stations in lower risk areas; the criteria applied included non-duplication of coverage and overlapping broadcast patterns (CBC, 1969: p.15).

Inclusion of access to a broadcaster's facilities in the EBS was to be automatic. Unlike the emergency broadcast system in the United States, participation is not on a voluntary basis:

> The government authority for licensing of radio stations [DOC for technical licence approval and the CRTC for the program licence] informs each station that it will automatically become part of the Emergency Broadcasting System and that the CBC will arrange for connection and the installation of an alerting device (CBC, 1969: p.15).

An alerting device was installed in the main control room of each radio and television station, and it was tested bi-weekly. In this way, the national system would be maintained in a state of readiness through the permanent connection of all broadcasting stations to emergency networks.

The CBC English and French-language networks then as now connected CBC-owned and private affiliated stations. Together, these constituted the backbone of the original coast-to-coast emergency system. Other radio and television stations were interconnected to the CBC/Radio Canada network configuration by microwave and landline. Normal CBC network programs were fed to non-affiliated private stations by a permanent emergency line connection, thereby permitting them to monitor the program circuit which would carry emergency broadcast messages. Survivability of the national system was predicated on the following criteria:

(1) the safe routing of microwave and landline circuits maintained by the regional telephone companies;

(2) the hardening of certain key radio stations; and

(3) the professional capability of broadcasting personnel to perform their duties under adverse conditions (CBC, 1969: p.28).

CBC network broadcasting circuits are all controlled and routed by Telecom Canada regional telephone companies, through their respective "Provincial Control Centres." In addition, they have a closed radio circuit connecting the different provincial control studios to the federal Control Centre in Ottawa. Emergency provincial control studios are also equipped to continue broadcasting through connection to hardened key transmitters via safe-routed circuits which bypass likely target areas (CBC, 1969: p.15). The emergency broadcast network also can be arranged on a regional basis, to be connected together to form a wider network as required.

Today, the EBS consists of only the CBC and affiliated stations. All CBC network stations can be alerted by means of a remote alarm device to accept emergency messages (i.e., feed). Private stations not connected to the CBC radio network will be alerted by the Canadian Press and Broadcast News wire services. However, those stations without a direct connection to the emergency network are encouraged to provide a radio receiver in their studios capable of receiving a connected station in order to rebroadcast the emergency programming. Finally, once the emergency network is activated, all Canadian broadcast stations are expected to stop regular programming and broadcast or rebroadcast the programming supplied to them over the system (EPC, 1985: p.47).

In addition to the CBC/Radio Canada AM networks, the Canadian EBS network configuration easily could be expanded to include FM-VHF radio and television services (DOC, 1985a). Indeed, as the discussion in the next section indicates, any peacetime-oriented national alert/warning system if it is to be effective, would require re-expansion of the EBS to include all radio and television broadcast stations, and cable distributors as well.

Before considering some proposals being developed to that end, it is instructive to look at one regional CBC Emergency Response Plan -- that of CBC British Columbia (CBC British Columbia, 1988). This concise, 23-page plan outlines the overall responsibilities and principles of implementation of the CBC's plan at the provincial level. It also summarizes the responsibilities of individual departments and provides an organizational hierarchy for each core group which will co-ordinate response in their respective areas of activity (DOC, 1988b: item 10). The "Statement of Responsibilities" reads, in its entirety, as follows:

> The CBC, in addition to its normal broadcasting role, provides on request through a senior officer-in-charge of any CBC location, broadcasting assistance to federal, provincial and municipal authorities and officials of recognized organizations for the purpose of giving warnings, instructions, messages or advice relative to impending or actual emergencies or disasters.
>
> CBC British Columbia must be prepared should the need arise, to provide resources, and expertise and to adjust its hours of operation in order to meet its own programming needs and the needs of the above mentioned agencies during a peacetime emergency, whether provincial or local in nature.
>
> The CBC British Columbia Emergency Response Plan is a compilation of key media and support department plans to initiate a rapid and effective mobilization of resources to meet the responsibilities outlined above (CBC British Columbia, 1988: p.2).

As the plan suggests, the CBC interprets its mandate to include the provision of an emergency warning system with the emphasis on civil emergency activities.[28] The plan therefore reflects a broader trend to de-emphasize attack warning and wartime preparedness and, instead, to look at potential peacetime emergency requirements.[29] The corporation also has in place a separate "wartime" emergency response plan to cover defence communications.

The CBC acts as a consultant to the DOC in organizing and operating the EBS. In addition, it provides its facilities on a case-by-case basis for use by recognized public officials in the event of peacetime emergencies that require official communications with the Canadian public (DOC, no date (e): p.1). The EBS Network Co-ordinator's office is in Toronto, as is Telecom Canada's General Control Office from which the CBC's alarm system is rented. The alarm system used to alert CBC stations and the wire services is silent tested on a regular basis, varying by region, with the results reported to the DOC.

Activation of the system takes place in the following way: The CBC commences emergency broadcasting when instructed to do so by a direct communication from CBO-Ottawa via dedicated telephone line. When the message has been authenticated by CBO-Ottawa, that station will telephone the Network Co-ordinator at CBC-Toronto to seek authority to begin emergency broadcasting. After that authority is received and the appropriate network connections are made, CBO-Ottawa will interrupt normal broadcasting and operate its encoder to feed an alerting signal, thereby activating decoders at all CBC regional centres. This will be followed by emergency instructions to those centres. When the decoders at the regional centres are activated, a buzzer will sound and operators will begin monitoring the incoming feed from CBO-Ottawa for a period of 30 seconds. If an emergency message is heard during that time, a true emergency is deemed to exist, and operators at the various regional centres also will stop normal broadcasting. Their own encoders then will be opened to activate decoders at the provincial radio network stations which are normally fed by them, while they continue monitoring the Ottawa feed and patch-through incoming messages to provincial networks as advised by CBO-Ottawa (DOC, no date (e): p.2).

Upon receipt of a verified emergency alert/warning from government authorities, all circuits of the CBC and other broadcast stations within a province will be switched automatically into a pre-established emergency broadcast configuration. The studio broadcasting the emergency message then will be controlled either from the key CBC location or from the protected REGHQ.

6.5.4 Warning and Emergency Broadcast System concept

When the DOC inherited partial responsibility for public alert/warning and full responsibility for the EBS (which it subsequently delegated to the CBC) in 1969-1970, the latter already was undergoing a significant reduction in scale -- from a nation-wide network which included virtually every radio station in Canada to a "barebones" network comprised of only 50 CBC and affiliated AM radio stations. This down-sizing even went so far as to include the physical removal of station alarm equipment from the extra broadcast stations along with all circuitry connecting emergency government studios to CBC transmitters. As of mid-1974, the CBC operated its national radio networks based on a total of only 45 manned stations and 282 low-power relay transmitters (LPRTs).[30]

About the same time, the federal government accepted the Dare Commission's recommendations regarding the development of emergency planning concepts for "peacetime" response. During the conceptual discussions that surrounded those deliberations, the Privy

Council Office acknowledged the need to improve Canada's warning capabilities, and the DOC was asked to study the options available.

As part of its investigation, the DOC looked at several alert/warning systems either under consideration or in place in the United States and the United Kingdom. It also evaluated the possibility of improving Canada's existing siren system, telephone fan-out and power grid distribution capabilities in addition to several broadcast options. The DOC's findings were presented to the Interdepartmental Committee for Emergency Planning which, in turn, outlined the criteria to be applied in developing an improved national alert and warning system for Canada. These include: (1) the ability to provide better operational capability; (2) a system that would be useful for peacetime emergencies; and (3) one that would be consistent with the DOC's recommendations. In addition, cost estimates for implementing the different options were provided, along with a discussion of each system's limitations and associated legal implications.

Subsequently, Emergency Planning Order 1981-1305 charged the Minister of Communications with the responsibility of developing an "efficient and effective" national warning system to replace the national siren system.[31] The DOC then undertook a further series of studies to evaluate alternative alert and warning system configurations. Among others, systems were analysed that would employ power distribution grids, cable television, the public switched telephone network, and major private telecommunication networks.[32] Each was considered in terms of (1) management and control requirements; (2) social acceptability; (3) requirements for legislative change; and (4) new regulations and policies required for implementation.

The conceptual system that emerged is known as "WEBS," standing for Warning and Emergency Broadcast System. It is essentially a replacement concept; that is, with its installation, the national siren system would be phased out and the CBC-based Emergency Broadcast Service would be upgraded and expanded for use as a delivery service for both government alerts and public warnings. The proposed system not only would use the facilities of the CBC, but those of all (private and public) AM and FM radio, television and cable television distributors as well in order to provide maximum coverage. These would be organized into local, zonal, regional and national elements, and they would be combined with a separate public alerting/warning system to be superimposed on the national broadcast system.

In a briefing to a 1985 federal/provincial conference, the Department of Communications expressed the belief that a broadcast-based system would provide the most cost-effective solution, especially "when one considers that virtually any other warning system would also require an upgraded Emergency Broadcast System to make it effective" (DOC, 1985a). The CBC AM radio network remains the backbone of the WEBS, with other broadcast stations and networks to receive an alert signal via the CBC network indicating that an emergency broadcast is about to take place.[33] The WEBS also would be available to all levels of government so that, in the case of a large-scale localized disaster or other emergency a portion of the system could be activated, to the extent required by municipal or provincial authorities.

The criteria used in defining the WEBS have been outlined in a comprehensive statement of requirements agreed to by the major federal agencies involved. They include:

(1) Speed -- activation within five minutes, to full alert within 30 minutes.

(2) Maximum coverage -- the ability to warn at least 90 per cent of the national population, some groups of which are possibly better served by a particular medium.

(3) Intelligibility -- the capability to transmit alert signals, voice messages and taped messages as well as provision of alternative broadcast coverage of a locality from outside so as to enhance service reliability by alternative routing.

(4) Multimedia exploitation of existing facilities -- because such systems are tested by regular usage and their limitations are consequently well known (DOC, no date (e)).

The scope of the WEBS ultimately would provide coverage of every one of Canada's 8,765 population centres, including 23 major metropolitan areas.[34] As a result, co-ordinating its implementation would require the co-operation of no less than 15 provincial, territorial and federal governments. It also would require the participation of authorities in some 73 provincial zones, 1,600 counties or districts and 3,000 separate municipalities (Larson, 1987).

The network configuration of the WEBS involves three separate groupings of broadcast stations. The first is a "peacetime" network of 414 stations. These would be selected in association with provincial emergency measures organizations, zonal or other public agency communication network configurations so as to provide a high degree of selectivity and local access. The second is a "wartime" network comprised of some 60 other stations. All of these would be hardened, high-powered stations with very wide population coverage and auxiliary power supplies. The third is an "extended" network. It would incorporate the remaining radio, television and cable broadcasters who would be required to rebroadcast warning messages received from designated emergency agencies or from key CBC broadcast stations. These latter stations would be grouped in association with the master stations of the wartime and peacetime networks.

In developing the WEBS concept, several methods were examined for upgrading existing systems. All of them emphasize broadcast capability. This is because, regardless of the method employed, an emergency broadcasting capability is considered integral to the wide distribution of public information. Moreover, the broadcast media generally are less vulnerable to individual emergencies since they do not rely entirely on landline technology. Additionally, broadcast stations can be equipped individually with alert/warning transceiver systems. This allows for an incremental or gradual expansion and upgrading of the system.[35]

There are two distinct but essentially interdependent components to the WEBS. In the first place, there is the requirement for an alarm/alert transmission capability. Secondly, there is a need for voice message broadcast transmission capability. The alarm component of would involve two kinds of alerting techniques. One would make use of normal commercial radio receivers, but it also would employ a technical procedure for changing the volume of the broadcast signal at night-time, accompanied by a distinctive alert sound signal.[36] The other would employ low-cost special purpose receivers. In either case, the key element is a low-cost programmable electronic microchip built into the alarm/alert devices. These can be activated by radio; or they can trigger an alarm, a siren or a public address system. They also can demute a radio, turn on lights and beep a wristwatch. Thus,

> the same alarm that will alert the broadcasting station for an emergency message can be installed to alert emergency response officials and the public in a variety of configurations down to individual alarms, thus effectively making the Emergency Broadcast Service a versatile Warning System (DOC, 1985a).

The broadcast component of the WEBS would work in the following way. While continuing to rely on the CBC backbone network, the proposed system could be expanded to include all radio and television broadcasting stations as well as cable distributors so as to permit the broadcast (or rebroadcast) of instructions and information to the maximum number of affected, threatened or concerned people. The WEBS, as already indicated, would be accessible to public agencies at every level of government. This means that municipal authorities could activate the alert/warning on a selective basis for local emergencies; provincial for large-scale disasters; and federal for national emergencies or those crossing provincial borders (DOC, no date (e): p.2).

The WEBS broadcasters would be alerted by warning centre authorities through the use of a station alarm system. Special receiving devices located at broadcast stations would be activated and these, in turn, would be capable of triggering a variety of alarms. In addition, a support modulation technique could be used to alert broadcasters not equipped with those receivers. A signal would be delivered from the initiating "master station" via either a program circuit or an on-air broadcast to "subordinate stations." A similar signal also could be used to activate special alerting receivers at public response agencies, warning centres, and possibly the general public.[37]

The concept of "master" and "subordinate" stations infers a tiering of broadcasting networks and groupings of broadcasters to assist the different levels of government, thereby optimising the use of established broadcast and reception facilities. According to the DOC's plan for implementing the WEBS, a small number of commercial AM radio broadcasters would be organized as master stations. These would pick up signals directly from key CBC stations off-the-air, and rebroadcast them to other (i.e., subordinate) AM radio, FM radio, television and cable distributors. In this way, the existing CBC network capability to achieve national and regional distribution via commercial common carrier landline, terrestrial microwave and satellite circuits could be easily extended to other broadcast systems without requiring installation of interconnecting circuitry. This would reduce implementation costs substantially.

The anticipated cost of upgrading the CBC/Radio Canada portion of the WEBS, as of 1985, was estimated at approximately $4 million.[38] That would include the costs of installing transmission and reception alarm equipment together with devices such as over-modulation units and additional circuitry. The DOC also hopes to come to an agreement with the United States on a co-ordinated use of each country's emergency broadcasting system along the Canada-U.S. border to avoid confusion arising from overlapping signal patterns (Larson, 1985).

The most recent development with regard to the WEBS was the joint submission in late 1989 by Emergency Preparedness Canada/Department of Communications to Treasury Board for funding of a trial-based WEBS. Treasury Board, however, turned down the application in early 1990, ending any further activity in this area for the time being.

Treasury Board's decision is reflective of an apparent current trend in Ottawa to favour regional proposals and local initiatives to improve municipal and provincial capabilities in the area of public alert and warning. For example, Canadians have come to rely increasingly on the local broadcast media to provide all kinds of public information, including weather watches, etc. (And when they fail to do so, as occurred at the time of the 1987 Edmonton Tornado, they receive the brunt of the public criticism.) Additionally, it is possible that the name of the proposed system -- the Warning and Emergency Broadcast System -- because it connotes "civil defence" and "attack warning" may have reduced its political saleability.

The DOC advises that it has no plans to prepare a new proposal for the WEBS. Just the same, it does intend to prepare documentation illustrating ways in which it could be implemented at the local or regional level. Indeed, given the recent proliferation of local and regional public warning systems across the country, representing the outpouring of millions upon millions of taxpayers' dollars for unco-ordinated, non-standardized systems, it appears that valuable direction and guidance could be provided by the DOC in co-operation with EPC to assist provincial and municipal governments in this area. Finally, if a national warning/emergency broadcasting concept is reintroduced at some point in the future, it might be given a different name -- such as, for instance, an "All-Hazards Alert System." This might be more effective in appealing to popular concerns regarding environmental and industrial hazard risks.

6.5.5 Cable television

Cable television (CATV) technologies have significant implications for future emergency communications capability. The most obvious of these, in the light of the preceding discussion, is the possible extension of the national Emergency Broadcast System to include local cable distribution. CATV systems can be employed as a supplementary means of warning and preparedness education before a disaster occurs. In addition, they could provide an effective medium for communicating with the public during (i.e., public alarm and warning) and after disaster strikes -- to disseminate information on evacuation procedures, reports on response and relief activities, and the like.

For the full spectrum of emergencies -- from natural disasters to industrial accidents to large-scale urban disasters (and even war or the threat of war) -- emergency communications involve two broad types of information, namely, action messages and educational messages. On the one hand, action messages are those aimed at prompt and specific action. They include: (1) immediate warning signals (sirens, etc.); (2) planned evacuation messages; and (3) long-term assistance messages. Educational messages, on the other hand, are intended to prepare citizens for responding to emergency situations which may arise in the future. These involve: (1) access messages (i.e., where action messages may be found in an emergency); (2) preparations to be taken in the event of commonly occurring emergencies; and (3) training for volunteer and public response agency personnel (Gillian, et al., 1983: pp.51-53).

Significantly, however, video and voice transmission systems today still constitute relatively distinct networks. They even utilize different technical network configurations. As was discussed in the previous chapter, CATV is typically delivered over coaxial cables deployed in a tree and branch network configuration. Signals go out over trunk lines and along the branches of the tree; they then are directed to individual subscriber premises located along the branches. And each subscriber along the branch taps off a sample of the signal.

Telephone company loop facilities, by contrast, are designed using a switched star configuration. In addition, the existing public telephone network is more pervasive than cable networks -- that is, greater than 98 per cent national telephone penetration levels as compared with roughly 80 per cent of homes for which cable service is available, or 65 to 70 per cent of all Canadian homes.

Prior to the 1970s, cable and telephone systems were entirely separate undertakings -- both technically and in terms of the services offered by each. Cable was entirely one-way, while telephone was bi-directional. Telephone possessed full switching capability and offered point-to-point communication services, whereas cable was unswitched, offering only point-to-multipoint services. Moreover, the telephone companies were interconnected nationally by microwave, while the cable systems remained discrete local systems.

Two-way interactive capability was introduced in the cable industry in the mid-1970s as a new way to earn revenues. This capability has facilitated the offering of non-programming services such as burglar alarms, medical alerts, metre readings and the like. It also is leading to the convergence of the two technologies. And it is expected that telephone and CATV service offerings increasingly will overlap, as modern cable systems become bi-directional and begin to experiment with switched services. Moreover, all Canadian cable systems can now be interconnected nationally via satellite.

The rapidly growing use of high-capacity fibre optics and their gradual deployment to the local loop (i.e., between subscriber premises and the telephone company central office) suggests that fibre-based bi-directional systems may eventually enable many existing and new broadcast, voice and interactive services to be provided universally on a broadband network. Ultimately, national regulatory frameworks rather than purely technical or plant investment cost considerations will determine precisely which services and under what terms and conditions will be accessible. Cable undertakings might, for instance, be allowed to provide voice services. Alternatively, local telephone companies could be permitted to provide video conferencing, teletex and the like.

Significantly, however, the provision of bi-directional communications capability under emergency conditions requires a different approach. Indeed, the technology already exists to use local CATV networks to warn and advise the cable subscriber population. CATV may therefore be a good emergency communications medium for informing local audiences of a developing weather-related or other environmental situations, and instructing them on the action to be taken in the event that a disaster occurs.

Cable is an especially effective way to reach urban populations during late afternoon and evening hours (i.e., prime time). In smaller communities -- and assuming that the cable system will remain operational following a disaster -- it also might be possible to use the local cable distribution system to transmit voice or textual banner announcements simultaneously on all channels of the system. Additionally, the potentially large number of channels available on modern cable systems means that they can be adapted easily to fit a locality's specific emergency information requirements. Finally, CATV could be used either to access the community as a whole or to communicate to specific segments of it -- such as schools and hospitals -- or to co-ordinate communications between emergency operating centres and the local government on a selective basis.

The effectiveness of CATV in reaching a threatened or affected population, however, is restricted by the following factors. In the first place, as with the public telephone system, CATV system territories are arbitrarily defined and will only rarely match the boundaries of a major disaster or other emergency. Consequently, getting access to CATV services for the purposes of relaying action messages prior to, during and immediately following a disaster would require some form of multi-system access mechanism. Another restriction on the system's alert/warning capability relates to the fact that the trunks that distribute CATV broadcast signals are dependant on AC-based power supplies. And because these are often mounted on external poles, should a power failure occur (as well might be expected in a large-scale disaster such as a flood or earthquake) at least partial failure of the cable system would result.

A good example of the kinds of arrangements that could be made with CATV distributors to enhance public emergency preparedness and response is a program called "Direct Access" which was put in place by an agreement between the Regional Municipality of Niagara, MacLean Hunter TV and Armstrong Cable. It gives that area's regional EMO access to all channels being broadcast throughout the local cable system. Control of the system can be activated by the EMO co-ordinator through the console of communications equipment and a telephone call to MacLean Hunter. The cable company then will flip a switch, allowing direct voice communication simultaneously throughout the system (Kirby, 1986).

Another example of a possible emergency application for a cable television distribution service is that provided by the Montreal-based "Weather Channel."[39] This satellite distribution network can address one or more of some 180 cable head-ends simultaneously and flash a warning message on the screen of those viewers who are watching Weather Channel on the cable system(s) addressed. In this way, it could be used to disseminate local public alerts, warnings and other emergency information. In order to use the system for these purpose, of course, the CRTC would have to grant regulatory permission for the Weather Channel to carry that kind of information. In addition, an administrative structure would have to be established for it to obtain alert/warning and emergency information from the municipal or provincial/territorial authorities concerned. To this end, the Weather Channel probably would have to agree to pre-empt regular programming immediately upon receipt of a warning message, and it similarly would have to forego its right to edit the content of the message. In addition, it would have to take measures to define the survivability of cable systems in various types of emergencies. Finally, it is questionable to what extent local emergency authorities would be interested in spending time in an escalating crisis situation to provide the Weather Channel with special emergency messages or other information given that it can only reach those cable viewers in an emergency or disaster area who are tune into that channel (DOC, 1990).

6.5.6 Call-up alert system

Among the latest technical break-throughs that could significantly improve Canada's public alert/warning capability on a local level is a new microcomputer software application developed by a private Ottawa-based firm. It permits users to record a digital-voice message on their (IBM or compatible) computer and store it in its memory for future use. Upon activation of the program in an emergency situation, the computer then could dial up to 32 telephone lines to which it is connected, and play the message when the telephone is answered. Significantly, as many as 2,500 separate telephone numbers could be called up within an hour. Of course, the more microcomputers there are programmed in this way within the threatened or affected area, the more quickly a population that needs, say, to be evacuated, could be alerted. And because it cannot be assumed that everyone is always listening to the radio or television (one of the fundamental problems identified with respect to broadcast alert/warning systems) this provides a viable alternative to door-to-door notifications by local police in such situations.

This kind of system also could be used more selectively to contact pre-programmed lists of emergency numbers. It might, for instance, be used to alert emergency officials of an escalating situation such as rapidly rising water levels or a train derailment. It also could be used to notify the residents of a community about a road closing, and the like. And it could be combined with a radio/television broadcast message so that those tuned in could verify the validity of the call.

Besides its call-up function, this system can receive calls as well. In that way, it would be able to provide additional (again pre-recorded) information to callers on action to be taken. The caller could access that information by indicating the specific kind of information being sought using a touch-tone telephone keypad (EPC, 1988: p.34).

6.5.7 Environment Canada's alert network

Canadians usually receives warnings about hazardous weather events from radio and television broadcasts. Indeed, studies on natural disasters indicate that the principal predictor of whether "timely and accurate" weather warnings were issued prior to a weather-related disaster was the nature of communication linkages between the local weather service office and public emergency agencies (Carter, 1979: p.3). The most crucial ones appear to be those between: (1) the weather service office and emergency service agencies; (2) the weather office and broadcast media; and (3) broadcast media and the general public.

Unfortunately, those between the local emergency agencies and the broadcast media are often unreliable (Carter, 1979: p.7). Furthermore, the very general statements issued by local weather offices often do not provide sufficient detail to convince a threatened population that a potentially dangerous situation exists. And even when more detailed information is provided, it still may not persuade the public to take preventative or mitigative action -- that is, unless it comes from a recognized authority such as the local emergency measures organization. Moreover, as the 1987 Edmonton tornado experience demonstrated, the broadcast media may even decide not to desseminate a weather warning in an area that has been experiencing severe seasonal weather.[40] Consequently, even where reliable public broadcast communication systems exist, it cannot be assumed that they will be used effectively.

Weather services in Canada are organized under Environment Canada's Atmospheric Environment Service (AES).[41] Prior to 1971, that organization was called the Meteorological Service of Canada or "The Met Office." Indeed, Canada has had a national weather service since as early as May 1871, and the first storm warnings were issued in 1876. In the early days, weather forecasts were posted on Post Office and Telegraph Office bulletin boards, and they were published in the daily newspaper. They also were telegraphed to marine agents who "hoisted storm signal baskets on exposed headlands and on towers" (Miller, 1975: p.6). The advent of radio and television increased considerably the ability of the weather service to make severe weather warnings available to the Canadian population as a whole.

The Canadian meteorological reporting network today includes hundreds of surface stations and dozens of upper-atmosphere stations, radar, and weather satellites which provide reports several times a day. These are transmitted directly to high-capacity computers capable of producing prognostic information. It is then the responsibility of each of the six regional weather offices to assess warnings of expected severe weather and alert the public accordingly.

Based on the success of the U.S. National Weather Service's dedicated VHF weather broadcasts, "NOAA Weather Radio,"[42] in 1976, Environment Canada established a similar system, known as "Weatheradio Canada" to serve major Canadian population centres. The configurations of these networks are based on province- and state-wide weather bureau teletype systems. They include weather stations at local airports, which are monitored by local radio and television stations, municipal and provincial/state police departments. Nearby radio stations that do not have weather teletype monitors also can receive weather related information by telephone. Canadian and U.S. weather services also use identical VHF-FM frequencies. The present Environment Canada-U.S. National Weather Service program provides continuous broadcast of weather information at five to eight-minute intervals. These include general and marine forecasts as well as weather advisories and warnings. They also include special local weather information.

The first emergency agency notified of severe weather conditions or a "weather watch" will relay that information to the other emergency response organizations. These then will initiate the backup telephone fan-out chain, once the notification has been verified. Information so gathered then will be broadcast to the public as part of regular programming (EMO, 1971: p.7). Individual radio and television stations also may develop their own procedures to alert their listening audiences -- for example, by superimposing recorded beeps over regular programming; reading teletype statements from the weather bureau at scheduled intervals; or transmitting textual messages across the lower portion of the television screen. However, although Environment Canada since 1986 has furnished broadcast stations picking up the weather signal on VHF with upgraded weather receivers that are equipped with special alarms, a survey conducted by that department in Quebec in 1989 indicated that only 38 per cent of the stations in that area apparently were willing to interrupt their programming in order to transmit these messages. It is expected that a survey conducted in other parts of the country would arrive at similar results. (So much for the volunteer approach to pre-emption for emergency messages!)

As of spring 1992, a new service on the Weatheradio network has become available -- namely, Weathercopy. This service allows bulletins and forecast updates to be displayed automatically on a computer screen or printer.[43] Environment Canada's Weatheradio/ Weathercopy alert system broadcasts on assigned VHF frequencies at 162.40, 162.475 and 162,55 MHz. It also is capable of providing a 1050 Hz signal which turns on special receivers equipped with a tone alert whenever urgent weather information is being broadcast. Individual audio receivers are available for under $50 (without the turn-on tone alert capability) which allow the owner to receive continuous weather information.[44]

Particularly significant to this discussion is the fact that the dedicated Weatheradio facilities also can be used "to disseminate emergency information to the public and to special users" (Environment Canada and EPC, 1978: p.2). Indeed, the expansion and improvement of this program was specifically recommended by the Hage Report which reviewed the Edmonton tornado, in order to allow it to serve "not only as an alert system for weather warning, but also for other short-period warnings such as toxic cloud releases, and nuclear accidents" (Norris, 1988: p.4). That review also recommended that the CRTC take steps to clarify the responsibilities of all Canadian broadcasters (radio and television) to broadcast weather warnings, including with respect to program interruption (Norris, 1988: p.4).

Given the apparent demise of the WEBS proposals with Treasury Board's refusal to fund its implementation, countered by an increasingly recognized need for some form of national public alert/warning system for peacetime emergencies, expansion of Environment Canada's program in this area may provide a viable alternative. It main advantage is that it is a well-tested system which is used regularly by those who have invested in the required hardware. Its principal shortcoming is that it requires users to purchase receivers -- and preferably, the more expensive models which can be activated by the tone alert signal.

6.6 U.S. approaches

U.S. approaches to emergency communications differ considerably from those that have evolved in Canada. Perhaps the most fundamental difference relates to the fact that the United States does not have a publicly owned broadcast system. Instead, that country's Emergency Broadcasting System (US-EBS) relies entirely on the voluntary participation of private broadcasters. Indeed, the only regulatory obligation that U.S. broadcasters are required to meet as part of Federal Communications Commission operating licensing is to cease broadcasting when an emergency alert signal is received.

In terms of public alert/warning systems, however, the United States has almost too many to count. They range from very basic to high-tech dedicated military warning network configurations, to a variety of military and non-military dedicated government HF radio, teletype and telecommunication systems, to FEMA's National Warning System (NAWAS) and the National Oceanic and Atmospheric Administration's (NOAA) "National Weather Radio/Wire Service" networks. Suffice it to say that, despite the elaborate redundancy and employment of state-of-the-art technologies in U.S. emergency broadcast and warning systems, their record of performance, considered overall, leaves considerable room for improvement.

The main obstacles to operating an effective emergency communications network in that country include, first and foremost, a lack of clarity with respect to jurisdictional authorities, and, secondly, unnecessary duplication of sophisticated frequency scanning and patching equipment at state and federal levels. An indication of the kinds of problems experienced in large-scale disasters in that country is well documented in the literature on the Mount St.-Helen eruption.

6.6.1 Emergency Broadcast Service (USA)

The U.S.-Emergency Broadcast System (US-EBS) was established in 1964 with the mandate, "to provide the President of the United States with an expeditious method of communicating with the American public in the event of war, threat of war, or grave national crisis" (FEMA, 1987). This has since been expanded to allow it to be employed during smaller scale emergencies at state and local levels so as to ensure the prompt and reliable release of disaster or other emergency information to public safety authorities and the public. The Federal Emergency Management Agency (FEMA) advises that on a nation-wide basis, portions of the system are activated, on average, more than 100 times a month.

At the federal level, activation of the US-EBS is initiated by the President via the White House Communications Duty Officer who contacts one of two "government origination points" -- either the North American Aerospace Defense Command or FEMA. Authorized personnel at the site notified then will advise radio, television and cable network control points participating in the program. In addition, the common carriers, Associated Press and United Press International will be contacted via a dedicated (FEMA managed) teletype network. Upon receipt of an authenticated activation message,[45] the common carriers will automatically reconfigure the networks of radio and television broadcasters to provide a common program source. A two-tone attention signal then will be used by the broadcast stations on their assigned frequencies to alert non-participating stations and the public to stand by for an emergency message from the President's office.

At the state level, activation requests can be initiated by the governor or their designated representative, or, alternatively, by the National Weather Service, the state emergency measures organization or another designated state authority.[46] These activation requests may be called in using dedicated FM radio, microwave, teletype or telephone networks.

Currently, the United States is divided into nearly 600 US-EBS operational areas, each of which is comprised of one or more counties. State and local level activation requests must be directed to a key broadcast station -- either the "originating primary relay station" located near the state capital in the case of state-level activation, or to the common program control station (i.e., the CPCS-1) in a local-level activation. Regardless of the level of activation, the same two-tone alert signal will be transmitted by the key station to other participating stations within its operating area which monitor their CPCS-1 on a continuing basis. This will be followed immediately by simultaneous broadcast of the emergency announcement over all participating local radio and television stations.

At the time of its inception, the US-EBS was predominantly an AM radio broadcast network. As in Canada, this was because the nature of AM transmission allows the radio signal to travel long distances, with the potential to reach a large listening audience. Moreover, at the time (1964), most people listened to AM radio, so those stations could be counted on to inform the population as a whole. Today, however, as much as 78 per cent of the U.S. listening audience tunes into FM radio stations instead. Similarly, most Americans are not watching national network television; they are watching the local cable stations. These developments have led proponents of the US-EBS to encourage broader participation in the program by FM broadcasters and cable distributors. In all, some 15 national television broadcast networks together with about the same number of cable program suppliers are now active in the US-EBS, despite the absence of any regulatory requirement to participate.[47]

6.6.2 Non-military warning systems

As regards warning the U.S. population in the event of a national emergency, the FEMA-managed "national siren system" has been designed for use in conjunction with the National Warning System (NAWAS) for the dissemination of an attack warning on the contiguous United States. For peacetime applications, activation of portions of the outside siren system can be controlled at the local level, thereby providing a way for local authorities to issue natural and environmental disaster warnings. Moreover, with respect to public warning capability, between 1974 and 1976 the U.S. Department of Defense (DoD) developed proposals for implementation of a separate warning system called the "Decision Information Distribution System" (DIDS).

Considering first the DIDS, this concept originally was seen as a possible way to overcome problems associated with the slow response time and restricted coverage of existing systems. It would have established a number of low frequency (LF) radio stations that would transmit warning messages received from NORAD to federal, state and local government agencies, local broadcast stations, and military installations whose receivers could be turned on remotely. The system was to be comprised of two national control stations together with ten distribution stations from coast to coast, plus support facilities. In addition, a tie-in with home broadcast receivers would provide the capability of direct alert/warning to the public. If completed, it is estimated that the DIDS would have been able to reach up to 99 per cent of the U.S. national population for siren control and 97 per cent for voice messages (Mileti, 1975: p.61).

The cost of implementing the DIDS was estimated at $43 million (1970 dollars). But other than a single prototype installation site (costing some $2 million), the program was never implemented. A major problem with the DIDS was the fact that it involved an entirely separate, dedicated, "emergency only" distribution network (Patterson, 1971: p.33). Moreover, like Canada's WEBS concept, it also required special demutable receivers which would provide direct public warning capability. For reasons related to the high costs of installation and maintenance, and potential problems associated with system reliability and user familiarity, both U.S. and Canadian governments have chosen instead to concentrate their efforts on improving the performance of existing systems -- in particular, those involving broadcast distribution and (especially) local radio, television and CATV.

An alternative to the DIDS that has been implemented in the United states for the purpose of communicating warnings to Americans is NOAA's "National Weather Wire Service" system. This system provides an extensive warning capability by combining its nation-wide teletype network connecting over 300 weather service offices with an expanded network of VHF-FM radio transmitters, thereby enabling receiver owners to access weather information continuously. It also transmits weather forecasts, watches and warnings, and related meteorological data to the mass media. Based on an existing system used for routine weather reporting, these services also can be specifically tailored to meet local warning needs. Furthermore, the NOAA system costs much less than other warning systems for the same population coverage. Wide familiarity with the system and the availability of inexpensive commercial receivers has led to expansion of the NOAA system throughout the continental United States. In this way, it has become a cost-effective U.S. government-operated radio system which can be used to communicate messages ranging from local disaster warnings to national attack warnings.[48]

The NAWAS is another U.S. alert/warning system that has the capability of assisting public safety agencies at all jurisdictional levels to share information and activate local public alert/warning systems or procedures in an emergency. It is administered by FEMA and is made up of a combination of 63 state warning circuits, eight regional circuits and a few control circuits, all of which are leased from AT&T-Communications. Principally designed to provide notification of military attack, under the 1970 U.S. Disaster Relief Act, it also has been authorized to provide warning to state and local officials of the imminent impact of natural hazards.

The NAWAS alerting system is based on a selective signalling system (SS-1) private-line arrangement which provides for two-digit dialling to configure the network. It links some 2,300 local, state and federal agency drop sites on a nation-wide telephone "party line". When activated at the national level, either the National Warning Center located at Colorado Springs or the Alternate National Warning Center at Olney, Maryland can alert and send a verbal warning message simultaneously to all stations on the network. In addition, each of FEMA's ten Regional Warning Centers is equipped and staffed to take control of that portion of NAWAS in its area of responsibility during a peacetime emergency. At other times (e.g., wartime or a possible attack), the U.S. National Warning Center monitors and controls the regional portions of NAWAS. The alert/warning message received over the NAWAS at whatever level of activation would be communicated to the appropriate additional agencies by various means, including, for example, radio or telephone fan-out calls. The general public in turn would receive warning by the activation of local outdoor sirens, light and bell systems, horns, whistles or automobile-mounted loudspeaker systems. Indoor systems, including public address, radio or television station broadcasts also could be used to extend the warning capability to areas where outdoor systems are not practicable (Roderick, 1966: p.6).

Strengths of the NAWAS system include the fact that one of the requirements for receiving a dropline is that the drop site be staffed 24 hours a day, seven days a week. Additionally, the system is tested daily, and it provides alternate routing capability between all major geographic locations. Moreover, many of the NAWAS facilities are hardened, as are all major telephone switching centres.

Just the same, the NAWAS has some shortcomings. One is that the network is based on technology that is now several decades old. Another is that most of the drops were installed many years ago, and local staff may not have been trained to understand either how the system works or its importance. As a result, fan-out warning dissemination evaluations of actual alert/warnings issued using the NAWAS across the U.S. suggest that the system's effectiveness in an emergency situation has varied from fairly good to non-existent. Furthermore, the current number of NAWAS drops has long since reached the upper limit for a practical multipoint circuit. Additionally, while it generally has been reliable for most peacetime applications, the network is vulnerable to electromagnetic pulse disruption (associated with nuclear explosion and severe meteorological disruptions such as an electrical storm). Finally, the breakup of the U.S. Bell Telephone System in the early 1980s led to the destruction of many of the NAWAS records (respecting, for example, dedicated line routing configurations and the like) by the new regional telephone companies that were temporarily given responsibility for the system. The former Bell companies apparently were unaware that AT&T (the post-divestiture interstate long-distance carrier) was not in possession of a master file for the network. Consequently, when a NAWAS link is lost, it actually may be more expensive to restore it by trying to locate the problem circuit than to replace the physical link in its entirety.

Other non-military communication systems owned and operated by the U.S. federal government also have significant warning capability. For example, FEMA, the agency responsible for co-ordinating U.S. federal emergency response in both peacetime and wartime, has formulated an "integrated" systems -- voice, image and data -- concept to manage federal emergency communications. It is known as the National Emergency Management System (NEMS). If implemented, the NEMS will provide a comprehensive mechanism for handling information in support of emergency management at all levels of government, again based on existing communications networks, information systems and physical facilities.

In addition, FEMA plans to create a separate, wholly FEMA-owned and controlled system to be called the Direction, Control and Warning Communications System (DCWCS). It would consist of the following divers elements: (1) a LF groundwave radio teletype network; (2) a meteor burst radio network (as backup for data transmission); (3) satellite communications; (4) an expanded NAWAS; (5) an upgraded US-EBS; and (6) secure voice, teletype data, facsimile and video capability (Hwang, 1984: p.17).[49] Essentially, FEMA's project would provide that agency with a mini-Bell system of its own, comprised of a secure multimedia switched network with flexible protocols, mobile and rapid public information capability, and fully integrated interagency communications.

6.6.3 National Communications System and National Coordinating Center

A discussion of U.S. approaches to emergency communications would not be complete without reference to the National Communications System (NCS) and the National Coordinating Center (NCC). The NCS was created by presidential directive in 1963 as an immediate consequence of the Cuban Missile Crisis. During that period, President Kennedy reportedly had been severely frustrated by his inability to communicate quickly and reliably with key U.S. military and government agencies, with the diplomatic corps overseas and with heads of foreign governments.

U.S. government participation in the National Communications System involves representation by some 23 federal agencies and other associated agencies. More specifically, they include the Departments of State; the Treasury; Defense; Justice; the Interior; Agriculture; Commerce; Health and Human Resources; Transportation; and Energy; together with the Central Intelligence Agency; the General Services Administration; the United States Information Agency; the National Aeronautics and Space Administration; the Veteran's Administration; FEMA; the Federal Communications Commission; the Nuclear Regulatory Commission; the U.S. Postal Service; the Federal Reserve System; the National Security Agency; and the National Telecommunications and Information Administration.[50]

Originally, the NCS was intended to provide a single, integrated communications system linking together portions of selected federal government systems to meet the most critical national security and emergency preparedness (NS/EP) telecommunication needs. However, rapid changes in the U.S. telecommunications industry, including competitive entry in the equipment and, later, in the long-distance voice services, has made it increasingly difficult to ensure adequate NS/EP services during major crises.

Notable among these changes was the January 1982 U.S. federal court's divestiture order for AT&T. Following that court decision, President Reagan established the National Security Telecommunications Advisory Committee (NSTAC) (U.S. Office of the President, 1982). Comprised of high-level telecommunications industry representatives, this committee was formed in recognition of the perceived imminent need to co-ordinate federal policy with the commercial industry, which provides between 96 and 98 per cent of the U.S. government's NS/EP telecommunications.

The NSTAC provides the legal framework for joint industry-government planning in relation to NS/EP telecommunications in that country. Limited by law to 30 members, its membership includes manufactures, interexchange and intraexchange carriers, and experts in terrestrial and space platforms (Morris, 1985: pp.67-68). Major subjects of discussion in the subgroups of the NSTAC include the promotion of links between different networks; standards to enhance interoperability; standardization of procedures for restoring networks after a disaster; creation of backup power sources for circuits and terminal equipment and the like.

The first problem addressed by the NSTAC after its constitution was the need for a single point of contact representing all local and long distance carriers. The result was the creation of the National Co-ordination Center (NCC). This body was officially established in January 1984 through arrangements made between government representatives of the NCS and 11 telecommunication industry entities and the U.S. Telephone Association.

The NCC is essentially a joint industry-government "operations centre" which responds to federal government NS/EP telecommunication requirements. These include services used to maintain state of readiness or to respond to and manage any event or crisis which causes or could cause injury or harm to the population, damage to or loss of government property, or degrade or threaten the security emergency preparedness posture of the U.S. government (Belford, 1987). The NCC supports plans for a more durable national and international telecommunication system to satisfy these requirements.

A very small part of the overall U.S. government communication system, the NCC's only interest is in those communications capabilities considered vital to national security. Its activities consequently focus on co-ordinating or directing the continuity and restoration aspects of emergency communications.

Federal government staff run the daily operations of the NCC and draft recommendations and suggestions to government agencies respecting funding of operations. Industry participants include full and part-time representatives whose salaries are paid by their respective companies. These individuals are available to answer questions, as they arise, regarding the provision new and restoration of lost service. The following companies currently participate in the NCC: Contel; AT&T; Bellcore -- which represents the 23 Bell Operating Companies); Communications Satellite Corporation (Comsat); General Electric; GTE Corporation; International Telephone & Telegraph Corporation (including United States Telephone System); MCI (including Western Union International); Pacific Telecom (including Alascom); TRT Telecommunications; and Western Union. The U.S. Telephone Association (representing approximately 1,500 independent telephone companies) and Martin Marietta are also represented in the NCC. Together these companies and associations supply roughly 96 per cent of all of the U.S. federal government's telephone service requirements,.

The NCC's mandate requires it to carry out the following functions:

(1) "promptly provide technical analysis/damage assessment of service disruptions and identify necessary restoration actions";

(2) "coordinate/direct prompt restoration of telecommunications services in support of needs";

(3) "develop and exercise comprehensive service restoration plans";

(4) "develop 'watch center' type functions to work through cooperating industry operations centers (OCs) to monitor efficiently the status of essential telecommunications facilities";

(5) "maintain access to an accurate inventory of the minimum essential equipment, personnel and other resources that are available for restoration operations";

(6) "Identify liaison points in each company";

(7) "maintain the ability to transfer rapidly operations from normal to emergency operations";

(8) "coordinate/direct and expedite the installation of new orders for service [to meet] NS/EP needs";

(9) "contribute to the development of technical standards and network planning"; and

(10) "coordinate/direct network reconfiguration plans in support of NS/EP needs" (Belford, 1986: pp.61-62).

Essentially, both NSTAC and the NCC function to offset any potential negative effects of divestiture on federal telecommunications security. Their benefit to the U.S. President and federal government is obvious. It also is considered to be in the interest of the service providers for their representatives to be on hand to "guide" and instruct their largest client-user in fulfilling NS/EP communication requirements as they arise. While committee work and related advice and information is provided by the industry free of charge, government agencies do pay for any services or equipment obtained from companies through the NCC in the course of an emergency response operation (Belford, 1986: pp.61-62).

6.7 Conclusions

With regard to peacetime disaster alert and warning, Canadian approaches to date have emphasized national emergency broadcasting capabilities. Unlike Canada's EBS (and the proposed WEBS), the backbone network of which is the publicly owned CBC radio network, U.S. broadcasters participate in the national emergency broadcast program on a voluntary basis only.[51] The result in that country has been something of a haphazard approach to emergency broadcast public alert and warning but, surprisingly, it has worked relatively well in most cases.

Also unlike the Canadian approach has been the U.S. government's emphasis on dedicated voice and data systems which link federal and other public agencies under FEMA-funded and administered programs. Similar programs do not exist in Canada. Instead, in this country, municipal agencies make their own arrangements for interagency communications, and with neighbouring municipal authorities for emergency mutual aid networks. Provincial and federal agencies are able to communicate with each other in large-scale emergencies over a small number of dedicated telephone lines which originally were established for other purposes, but direct communications between municipal authorities' communications and other orders of government, in most cases, can be made only by regular telephone. Just the same, it is anticipated that in the very near future arrangements will be concluded with the telephone companies and Unitel to provide a patch-through mechanism in order to enable local emergency measures offices and other designated authorities (such as the mayor) to access federal and provincial government networks for long-distance communications in a severe emergency situation. It will be recalled that priority access already exists for local communications by emergency users through the line load control program and other telephone company-initiated programs available in areas served by digital switches.

Looking at the United States, while emergency preparedness communications represent only a very small portion of overall government needs, the various government-owned and operated networks, in combination with post-divestiture arrangements with major suppliers participating in the work of the NSTAC and the NCC provide American authorities with considerably more diversity in terms of national emergency communications capability than presently is the case in Canada. In this country, arrangements with equipment and service providers are less formal; and while Canadian governments do operate their own voice and data networks which link the national and provincial capitals with each other and with other major population centres, they use lines leased from the telephone companies. Indeed, only the Department of National Defence owns and operates a physically separate, and thus wholly redundant nation-wide network. Access by other public agencies, with few exceptions and always requiring prior approval by the minister, is not available.

Perhaps a better approach to national communications preparedness might fall somewhere between those of the two countries considered here. Specifically, it would emphasize common technical standards and an incremental upgrading of existing operational systems. It also would encourage and provide incentives for the increased interoperability of the physically separate networks -- both public and private -- for emergency purposes. Additionally, it would necessitate further development of formal and informal, including personal, relationships among representatives of government agencies at all levels and with service providers and equipment suppliers. This might be achieved through existing industry advisory committees on which Telecom Canada (now Stentor) member companies participate together with Unitel and other major data service suppliers. It also could involve expanding the role of the Regional Emergency Telecommunications Committees in facilitating similar initiatives at the regional level and, perhaps eventually, the creation of a National Emergency Telecommunications Committee.

Although it is not likely that emergency-only systems and those that focus on "warning" capabilities (as opposed to disaster alert) will become politically more saleable in the future than they have been in the past, especially in light of the easing of international east-west tensions with the dissolution of the former Soviet Union, programs that emphasize existing system flexibility, accessibility and interoperability likely will be more successful. Nor can the role of the broadcast media in issuing public alerts and warnings together with providing situation updates during a disaster response operation be neglected. The positive performance of the Canadian EBS in incidents ranging from hostage takings on Parliament Hill to the Kanahsatake and Kanawake reserve stand-offs, etc. suggests the value of refining and expanding Canada's broadcast based approaches in this area to include television and, in particular, local CATV. Similarly, greater co-operation between Canadian and American governments, whose geographical proximity and close economic integration make the likelihood of overlapping effects of any large-scale natural or environmental catastrophic disaster considerable, needs to be encouraged at municipal and provincial/state levels in order to assure an optimal response by public safety organizations.

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[1] The ionosphere is approximately 48 km above earth. It is comprised of a band of ionized particles in the earth's atmosphere which acts as a reflective surface for frequencies below 30 MHz. It can be used to achieve very long-distance radio communication by reflecting radio waves back to earth at points well beyond the horizon. At certain frequencies, this effect can be used to reflect waves several times between the earth and the ionosphere, achieving radio paths half way around the world. At frequencies over 30 MHz, the ionosphere is less effective, because it is easily penetrated (allowing for outer space and satellite communications).

[2] The NCS has expressed interest in extending that network's coverage, in co-operation with Canadian authorities, to include Canada as well.

[3] It is anticipated, however, that as the costs of cellular radio-telephone continue to fall, it may soon be bypassed by that technology. Just the same, it likely will remain popular among truckers and residents of rural areas, who prefer the on-the-air, broadcast-like aspect of CB. Moreover, it is unlikely that cellular service will be extended into those less populated areas of the country at any time soon.

[4] Zones are defined on a geographic basis as follows: North and West Vancouver Emergency Program is the host on behalf of the City of North Vancouver, District of North Vancouver and District of West Vancouver. The Vancouver Emergency Program is the host on behalf of the City of Vancouver. Delta is the host on behalf of Richmond, Surrey and White Rock. Burnaby is the host on behalf of New Westminster, Port Moody, Port Coquitlam and Coquitlam. From Greater Vancouver Regional District, 1987.

[5] Since that time, other European countries have similarly established uniform emergency telephone numbers. For instance, Belgium uses "900," while Sweden uses "9000" and Denmark uses "000." See Bell Canada, no date.

[6] Today, 45 per cent of the U.S. population is covered by more than 1,200 separate 911 systems. In Bell Canada's territory, 911 emergency reporting systems similarly serve more than 40 per cent of Ontario's population and 35 per cent of Quebec's. Those Bell Canada served communities in Ontario include Metropolitan Toronto, London, Windsor and the regional municipalities of Kitchener-Waterloo, Hamilton-Wentworth and Halton (Oakville). In Quebec, the 29 municipalities within the Montreal Urban Community together with Boucherville, Chicoutimi, Laval, Longueuil, and St.-Hyacinthe currently have 911 service.

[7] This is because approximately 80 per cent of emergency calls require police intervention.

[8] Just the same, even after 911 service is established in a community, the telephone company continues to provide back-up emergency assistance through trained operators for those citizens who dial "O" for help.

[9] In a major localized disaster, amateur radio patch-through to available seven-digit emergency numbers also can be used to reach emergency response agents in the absence of alternative operational facilities.

[10] See Drabek, 1991 for a more complete discussion on the use of microcomputers in emergency management.

[11] Operating ranges are from 0 to about 150 km, and between 200 to 2,000 km from the base station. A transmission dip occurs at distances of between 150 (where the ground wave stops) and 200 km (where effective meteor propagation begins). Transmission waiting times vary from less than one minute during the daytime in summer to about five minutes during the daytime in winter. Transmission speeds also vary from approximately 35 words (a word is equivalent to five characters or 35 bits) per minute in summer and 25 words per minute in winter. As few as two master stations can communicate in full duplex mode and achieve steady throughput rates of several hundred words per minute.

[12] The 525-line 60 fields/second North American television signal includes a vertical blanking interval or vertical hold, the purpose of which is to allow the receiver to synchronize the signal and perform vertical retrace before the active video picture begins. If it is intentionally misadjusted -- by inserting digital data signals in the lines of the analog television signal -- it can be viewed. Under present Canadian regulations, four to five of the 525 lines can be used for teletext transmission, although in future, up to ten will be used for this purpose. See March et al., 1987: P.104, footnote 1.

[13] The DOC puts the CBC's national coverage as high as 99 per cent.

[14] This can be compared with approximately 130 minutes to transmit the same amount of data over a 1200 baud telephone line. March et al., 1978: p.104.

[15] Cellular terminal rental costs for fast delivery procurements amount to $150 per month per terminal (minimum of one month), plus programming charges and administrative charges to commence the service of approximately $90, plus per call, distance sensitive calling charges. Radio-communications systems (VHF or UHF) cost in the neighbourhood of $60 per month per terminal (minimum one month). A satellite earth station, if it could be obtained at all, would cost $4,000 per month for a single voice channel! Costs for telephone line installation, HF radio were not available. DOC, 1989.

[16] RETC-British Columbia, 1990: item 6. In the Lower Mainland/Vancouver, B.C. region, for example, there are between 60,000 and 70,000 pager receivers. In large part, many of their owners are involved in occupations that would support a major emergency response operation.

[17] With the exception of the Arctic islands which could be served using fixed directional antennae. See Draper, 1984: pp.4-5.

[18] For the Canadian share of MSAT, Telesat Canada (roughly half owned by the federal government, and half by Bell Canada and the other Canadian telephone companies) has formed a consortium known as Telesat Mobile Inc. (TMI) in which it will have a 50 per cent stake; Canadian Pacific Ltd. will own 30 per cent and C. Itoh & Co. of Japan will own 20 per cent.

[19] Department of Communications, no date (a) and Department of Communications, 1988a.

[20] As was suggested in the discussion above on MSAT, when those services become available, satellite-based remote telephone service will become universally available in Canada.

[21] Source: Hindle and Milot, 1991: section 1a.

[22] Due to experienced difficulties and delays when calling back to the base station after normal business hours, tonal paging systems might be changed to upgraded systems which can provide either a data readout or a brief broadcast message.

[23] Source: Hindle and Milot, 1991: section 2a.

[24] The capital cost of constructing the DEW-Line amounted to $600 million. The United States has also paid all maintenance costs since 1957. See Greenaway and Beattiie, 1986.

25 According to the definitions provided above, this would more appropriately be named the North "Alerting" System.
26 In operation since 1962, the EBS at one time involved nearly 900 licensed AM and FM radio and television stations with the capability to provide emergency warnings and other information. In 1970, however, federal expenditures for the EBS were cut drastically, to the point where the all nonaffiliated radio stations, FM and television stations were disconnected from the CBC radio network and the EBS alerting devices removed. Thereafter, broadcast stations not owned by or affiliated with the CBC would be alerted by press wire facilities (CBC, 1973: p.3).
27 The authorities/statutes under which the Department of Communications currently acts with respect to emergency communications include: the Emergencies Act; the Emergency Preparedness Act; the Broadcasting Act; the Canadian Overseas Telecommunications Corporation Act; the National Transportation Act; the Department of Communications Act; the Radio Act; the Railway Act; Telegraph Act; and the Telesat Canada Act. See DOC, 1989.
28 Regional Emergency Telecommunications Committee -Yukon, 1988, presentation by Greg Barnes (CBC), item 7.
29 In early 1989, CBC British Columbia invoked the plan in response to a nation-wide broadcasters' strike.
30 The 40-watt LPRTs, usually remote controlled, provide CBC program coverage to geographical areas not well served by direct broadcast from manned stations. They might be the only providers of radio programs in isolated communities. The largest number of LPRTs are in British Columbia, where the mountainous terrain makes long-distance ground wave reception difficult.
31 In 1988 this Order-in-Council, along with the War Measures Act, was rescinded. Both were replaced by the Emergencies Act (1988). DOC's responsibility to develop a national warning system has been carried forward in that legislation.
32 The use of power grids for warning delivery was eventually rejected because it would require the development of expensive signal injection equipment (converters), a comprehensive command and control system, and special devices in the home. Cable TV was similarly rejected because it is subject to disruption at any point through the effects of natural disasters on transmission equipment, in-line amplifiers, end receiving equipment and cable plant, and because it is primarily suited to high-density urban areas. CATV, however, is considered a useful option as a supplementary delivery system. Warning over public and private telephone networks was rejected as an option due to problems associated with switching control from normal operations to mass calling (which requires expensive fitting of mass ringing and conferencing facilities into several thousand central offices. Additionally, problems would likely result in terms of line load control and the selective exclusion of critical lines since invocation of alert/warning would interrupt calls in progress. See DOC, no date (b): pp.20-37.
33 AM radio is still considered the most desirable backbone system primarily because of the coverage and availability of AM portable and car radios, and the extensive networking involved. WEBS would be based on a series of AM radio broadcasters organized as "master stations". These would pick up the warning message off-the-air via landline, terrestrial microwave and satellite circuits provided by commercial carriers. The warning then could be rebroadcast to other AM radio, FM radio, television and cable distributors over-the-air, without the need to install expensive interconnection circuitry.
34 Some 30 urban centres in Canada have populations greater than 100,000. And more than half of the national population resides in these centres.
35 As compared with improving the outside siren system, broadcast reception is already universal in Canada. In contrast, it would be prohibitively expensive to install enough sirens across Canada's vast territories to provide comparable coverage.
36 Known as the Crisis Home Alerting Technique (CHAT), it requires the recipient to leave a television or radio receiver switched on (at low volume to permit sleep) and tuned to a particular

broadcast station. In an emergency, an increase in modulation (perceived as an increase in volume) would be followed by the alerting signal and then a broadcast message.

37 DOC, 1985a: p.10. The DOC proposes that receivers be developed for purchase by the general public. Alternatively, they might be tied into public address systems in public buildings and highrise apartments, and to outdoor devices like sirens, whistles or bells. Tonal signals could be made area specific or group selective. Importantly, no new communications technology would be required.

38 Given overall estimates including an effective national warning capability at $30 million, and noting that some municipalities have spent that amount of money already to establish, upgrade and integrate their interorganizational communications capability, this does not seem like very much to invest in a comprehensive system.

39 The potential usefulness of Weather Channel and similar local cable service specialized channels is considered in this section rather than in the earlier discussion on satellite systems because the service offered would be limited to cable subscribers.

40 The tornado, which touched down at 3.01 pm, on 31 July 1987 and finally dissipated at 4.05 pm, killed 27 people, injured hundreds of others, and did more than $300 million in property damage. At 1.40 pm that day, Environment Canada issued a Severe Weather Watch for the area, and at 2.45 pm it issued a Severe Weather Warning for the City of Edmonton and counties to the south and west of the city. At 2.52 pm, the Weatheradio alert tone was sounded, and at 2.59 the Edmonton Weather Centre received the first eyewitness report of a tornado. This was followed at 3.04 pm (less than 5 minutes later) with a resounding of the weather alert tone and the issuance of a tornado warning on the wire services at 3.07 pm. The Hague report reviewing the tornado, including the delivery of weather warnings to the media and their dissemination to the public, noted that "while some radio stations were broadcasting the tornado warning just minutes after it was issued ... others took as long as 40 minutes and only one television station in Edmonton broadcast it at all" (Norris, 1988: p.4). Also see Emergency Public Warning Working Group, 1991; and Presley, 1991.

41 See also section 3.9.4 in Chapter Three on Environment Canada's role in communications preparedness.

42 This provides a direct link between the National Weather Service and the public. Its effectiveness, however, is limited although it potentially could play an important warning role in an emergency. This is because in those areas of the U.S. where the system has been in operation for a long period of time, only 20 to 30 per cent of the households have radios capable of receiving its frequency. These are for the most part in coastal areas where it has been operating since the late 1960s; and in areas where it has been installed more recently, the penetration level is between 5 and 10 per cent of households. See Carter, 1979: p.3.

43 It involves the transmission by modem of digital information embedded in the Weatheradio signal. The system is composed of a personal computer with a tandem link and an encoder at the Weather Office; a PC at the transmitter site; and a receiver (i.e., a 5100 baud modem) at the client's end. Each receiver costs $750. Originally conceived in 1989 and based on a similar system in place in Australia, the hardware was developed by Dataradio of Montreal, and the software is being produced by the AES. The minimum national service includes warnings, public, agricultural and marine bulletins; other services are to be decided at the regional level. Environment Canada, 1992.

44 Interestingly, at the time of the Edmonton tornado, only two local radio stations had special (with turn-on tone alert capability). This may help to explain why it took some stations up to 40 minutes to broadcast the tornado warning after it was issued by Environment Canada.

45 Authentication is provided at the control points by preselected code words.

46 The state and local EBS is compatible with other warning systems such as the NOAA Weather Radio/Wire Service and NAWAS. It is intended to supplement rather than substitute for such systems. See FCC, 1989: p.3.

47 The most recent participants are Home Box Office and Cinemax which joined the national level EBS in 1989.

48 DoD, 1975. See also Bethel Jr. et al., 1979.

49 A provision of U.S. President Directive No.145 is to secure most federal government voice communications by 1991. Canada is the only foreign country allowed to buy the system that was subsequently developed, Secure Telephone Unit (STU). Third generation units, STU-III units cost approximately $5,000, and in 1987, Treasury Board approved the purchase of 322 STU-III secure telephones. The justification for use of this new technology is that electronic surveillance technology has made telephone conversation and data transmission more susceptible to interception than before. These telephones have a special key, the security for which is the responsibility of the user, which activates the secure voice/data feature (Milot, 1990).

50 See NCS, 1988; Foster et al., 1982; and NCS, 1983.

51 Canadian law requires that following notification that the EBS has been activated, all broadcasting stations in Canada "must discontinue local programming and switch to the Emergency Broadcasting System for unified and official announcements" (Johnson, 1962: p.5; and CBC, 1969: p.15). In the United States, there is no regulatory or other formal requirement for broadcasters to monitor for or comply with an emergency broadcast activation notification.

PART IV
CASE STUDIES

Preface

Part IV includes four case studies, presented for the purpose of evaluating the appropriateness of the prevailing command-and-control model of emergency management, and the subtheses or related major themes presented in the introductory chapter. Chapter Seven is a case study of the Mount St. Helens eruptions of 1980. Chapter Eight is a case study of the Hinsdale, Illinois central office fire of May 1988. Chapter Nine is a case study of the Saint Basile-le-Grand PCB storage warehouse fire of August 1988. Chapter Ten is a case study of the Quebec Regional Emergency Telecommunications Committee.

The Mount St. Helens experience, on which there have been several studies done, including survey research on community response and response agency personnel's reactions to their own agency's performance and the overall response experience, provides a lot of insight on traditional approaches to emergency management in a catastrophic disaster situation. That experience also led directly to significant changes being made in the years after the event towards improving state and federal emergency communications capability.

The Hinsdale experience is included because it tested the established industry procedures for responding to a major telecommunications disaster and found them to be seriously inadequate. Subsequent to that event, a careful review of what went wrong led to valuable lessons being learned regarding network vulnerabilities related to the introduction of very high-capacity switching and transmission technologies. As a result, since then, some remedial measures have been taken in order to rectify those inadequacies. Other major telecommunications outages -- the most recent being that which occurred in Manhattan in late 1990 -- demonstrate, however, that a great deal of work remains to be done in this area.

The Saint Basile-le-Grand disaster provides an example of a complex situation involving multiple jurisdictions and overlapping provincial and federal departmental mandates. It also involved the evacuation of thousands of people for an extended period of time. As regards emergency communications, the convergence of hundreds of governmental and media personnel into the area led to serious difficulties for Bell Canada and the cellular companies to provide adequate additional services, including to the emergency response organizations involved. Finally, the case provides an illustration of an alternative approach to managing the relief operation which emerged during the lengthy evacuation period.

The Quebec Regional Emergency Telecommunications Committee case study, unlike the others included herein, looks at a multiple agency emergency planning forum as opposed to an emergency response operation. Its most significant contribution is as an example of an evolving, multiorganizational, multigovernmental, emergent, co-operative and co-optive approach to emergency communications preparedness.

CHAPTER SEVEN
Case Study: Mount St. Helens Volcanic Eruptions

7.1 Introduction

The central thesis addressed by the case study presented in this chapter concerns the adequacy of the "command-and-control" theoretical approach to explain behaviour in relation to emergency preparedness activities in Canada, and specifically, as regards disaster communications. The Mount St. Helens case challenges its appropriateness by scrutinizing actual experiences associated with a peacetime disaster. Empirical evidence is provided which suggests that peacetime emergencies, by their nature, require a crisis management approach that is more flexible and co-operation oriented than that provided by the rigidly hierarchical traditional model.

The Mount St. Helens case also provides evidence for a related theme -- namely, that peacetime emergencies will reconfigure prior relationships and patterns of communications among government responders and with private sector experts to establish dynamic, "geodesic" disaster networks. This case further suggests that in a major disaster, crisis managers will turn first to those whom they know personally to have the specialized knowledge needed to help them manage the response. Finally, it supports the idea that shared disaster experience will lead to increased consultative and "co-optive" arrangements, and create incentives for both industry and government to initiate programs aimed at improving emergency communications capability, and enhancing network survivability and redundancy.

7.2 Background and event description

Since the earth began, some five billion years ago or so by most scientific estimates, volcanoes have erupted on its surface. A volcanic eruption occurs when magma -- i.e., molten rock consisting of gases (principally water vapor, hydrogen, carbon monoxide and carbon dioxide) and silicate minerals -- moves towards the earth's surface.[1]

The form that an eruption takes will depend on the magma's viscosity, which is a function of its temperature, gas and chemical composition. It may take the form of (1) <u>lava</u>

flows -- the most common types being basalt, andesite, dacite and rhyolite; (2) pyroclastic flows -- masses of rock fragments; and (3) tephra fall -- including volcanic ash and other fragmented materials of any size ejected during an explosive eruption. Dome building eruptions, in contrast to explosive eruptions, involve the piling up of stiff, pasty lava around a vent, while mudflows involve the movement down-slope of rock debris mixed with water, and resembling a wet concrete mass (FEMA, 1980a, TIB No.28).

Mount St. Helens is a composite volcano located in southwest Washington State. It has a long history of explosive eruptions, almost all of which occurred before recorded history (Crandell and Mullineaux, 1978: p.C3). It is surrounded by a number of other active (though currently dormant) volcanoes: Mt. Adams to the east, Mt. Rainer to the north and Mt. Hood to the south.

According to historical geological evidence, Mount St. Helens has experienced three eruptive periods since 1800. The first, before European settlers entered the region, involved at least one large pyroclastic eruption (Harris, 1980: p.173). The second took place after the establishment of Fort Vancouver, located about 70 kilometres southwest of the mountain; it began about 1831 and ended in 1857, with major eruptions taking place between 1831 and 1835, 1842 to1843, and from the late-1840s to mid-1850s (Perry and Lindell, 1986: p.5). After 1857, Mount St. Helens remained quiet, but on 20 March 1980 the youngest of the Coastal/Cascade Range volcanoes broke its 123-year silence.

An earthquake registering 4.1 on the Richter scale was recorded on that date, signalling the beginning of a renewed eruptive phase. On 27 and 28 March, more than 130 earthquakes of greater than 3.0 magnitude were recorded and a crater opened at the summit. Harmonic tremors began on 3 April, indicating significant movement of magma under the earth's surface. These pre-eruptive activities continued through most of April, accompanied by minor steam and ash eruptions, and the ejection of 3 to 3.7-metre diametre blocks of ice from the crater (Perry and Lindell, 1986: p.7).

In view of the increasing likelihood of more volcanic activity that might endanger lives and property, a Mount St. Helens Watch Group was formed. By 4 April, the federal, state and local public safety agencies monitoring the mountain were preparing for a major eruption, and the governor had declared a state of emergency (Greene, Perry and Lindell, 1981: p.49).

Due to the tremendous devastation associated with volcanic eruptions, damage mitigation is difficult. About the best that can be done is to map out danger zones on slopes and control access to these areas by prohibiting entry (U.S. Office of Emergency Preparedness, 1972: p.105). Consequently, on 30 April, the governor's office issued an executive order establishing two danger zones in the vicinity of the mountain (State of Washington, 1980). All access was to be prohibited to the "red" zone, which designated the most dangerous areas; restricted access would be allowed in the "blue" zone, the next most dangerous area. However, according to some observers, "portions of the Red Zone bore a closer resemblance to divisions between federal lands and state controlled and lumber-company property than to defined geological hazard zones" (Saarinen and Sell, 1985: p.29).

Furthermore, when the volcano subsequently quietened down again, businesses whose normal activities were conducted in the blocked off areas began pressuring state authorities to allow them to renew operations. Many residents of the communities closest to the volcano who had been evacuated because of the risk of flooding and mudflow also pressured them to reopen the roads accessing their properties or, at least, to escort them in so they could retrieve some of their belongings.

7.2.1 The eruption

On the morning of 18 May 1980, at approximately **8 am,** a short "threat" period began as seismic activity suddenly increased dramatically, and the swelling on the north side of the mountain became more evident. The first explosive eruption occurred at **8.32 am.** At that time, an earthquake of approximately 4.9 magnitude "rumbled through the mountain, causing eleven times the ground motion of the initial March 20th earthquake and releasing more than thirty times as much energy" (Laube and Murphy, 1981: p.63).

The cataclysmic eruption of 18 May was followed by four other eruptions of ash and steam: on 25 May, 12 June, 22 July and 7 August.[2] After the first blast, the subsequent vertical eruption lasted for more than nine hours. The volcano's sustained power output during the eruption has been compared to "the serial detonation of some 27,000 Heroshima-size bombs: nearly one a second for nine hours" (Saarinen and Sell, 1985: p.11).

A thick plume of ash composed of pyroclastic material spewed from the vent, rising as high as 63,000 feet (about 19 km) into the air (Christiansen, 1980: p.531). The ash plume was tracked by satellite, radar and ground observations. "For the first thirteen miles [21 km], the impetus of the blast moved the plume at about 100-150 miles per hour [160-240 km/ph]. For the next 600 miles [965 km], the wind carried the ash at an average speed of 60 miles per hour [97 km/ph]" (Saarinen and Sell, 1986: p.26). Volcanic glass, rock, and huge uprooted trees moved downward into nearby valleys, at surface speeds nearing 160 km/ph (Perry and Lindell, 1986: p.8). Water and soil heated to over 260 degrees celsius, and solid rock reduced to a fine volcanic dust within seconds.

7.2.2 Damage

The overall effect was a hollowed out mountain surrounded by a smouldering, blast-scoured terrain. Nearly 400 metres of the mountain's north side had vanished, and the tip rim -- formerly rising to an altitude of 2,950 metres -- subsequently stood at only 2,560 metres. Trees 20 km away from the volcano's summit were felled and approximately 8,100 hectares of national forest was devastated, and another 81,000 hectares seriously damaged by the ensuing forest fires.

The U.S. Geological Survey (USGS) estimates that as much as 20 per cent of the mountain was blown away by the initial blast, and up to a cubic mile of material was dispersed. USGS hydrologists calculated that the explosion, by destroying the mountain's northern slope glaciers, also released some 174 billion litres of glacial melt into surrounding areas and the Toutle River drainage system. This caused a wave wall some 7.6 metres high comprised of meltwater, mud, ash and debris, which displaced all of the water in nearby Spirit Lake (FEMA, 1980b). In addition, more than 4,800 km of streams and as many as 169 lakes in the region were either moderately damaged or destroyed (U.S. Senate Hearings, 1980).

A freight train was also lifted off its tracks, several bridges were stripped from their footings, and many roads and homes were wiped out. The Green River fish hatchery also was devastated, with a loss of eight to ten million salmon, and the Columbia River had to be closed to commercial traffic for several days due to accumulating debris. Damage cost estimates following the first two eruptions were estimated at approximately $US 1.8 billion in lost property and crops, with short-term losses to the state economy exceeding $US 860 million (Perry and Lindell, 1986: p.8).

Rescue crews flew an estimated 577 sorties (using two helicopters per sortie) over the blast area between 18 and 29 May 1980, and nearly 2,000 rescue personnel were involved in air and ground searches for survivors (FEMA, 1980b). In the first days after the 18 May eruption, 25 bodies were recovered, and 43 other persons were listed as officially missing (U.S. Dept. of Health and Social Services, 1980, No.10). Postmortem examinations of 22 of the bodies showed that, in 16 cases, death was due to inhalation of ash -- the tracheo-bronchial tract being coated with ash particles. Another three died from thermal burns, and three more from head injuries -- in two cases caused by falling trees. Two other victims were rescued, but later died in hospital from complications related to burns (FEMA, 1980a, TIB No.32).

The exact loss of human life resulting from the eruption may never be known. Information gathered during the months afterwards suggest that as many as 85 deaths may have been attributable to the 18 May blast (Dillman, et al., 1981: p.1). What is known is that all those whose bodies were recovered, whose deaths have since been officially confirmed or who were injured had been within the area of tree destruction and mudflows; of course, no bodies were recovered in the most severe destruction area. Fifty-three of the 100 survivors -- defined as persons located within eight km of the mountain at the time or in tree destruction areas -- had been on the periphery of those areas, that is, within a 1.6 km of that boundary (U.S. Dept. of Health, 1980, No.16). Most of the other 47 survivors were further away in areas southwest and southeast of the volcano (U.S. Dept. of Health, 1980, No.19).

But perhaps the most widely felt effect of the eruption was associated with ash fall in regions to the east of the volcano. The ash content varied from a heavy sand-like material which fell around Yakima to a talcum-powder like dust (that had to be wetted down so it could be cleaned up) that accumulated near Moses Lake and Ritzville -- more than 300 km away from the mountain. Farm and other exposed machinery was damaged by the abrasive and electrical nature of the ash, and in some areas, power lines were knocked out. Those communities that received the worst of it -- 10 to 15 centimetres -- were isolated for several days.

The ash fallout made travel by motor vehicle almost impossible. Roads between major centres, including the interstate highway, were closed as a consequence, stranding thousands of travellers (Dillman, et al., 1981: p.1). Poor visibility and other ash-related problems also hindered state patrol and other emergency responders. For instance, response vehicles required oil changes every 80 to 160 km in heavy ash fall areas, and their air filters had to be replaced for every two hours of driving time (FEMA, 1980a, TIB No.2b). As a result, the public, and especially those in heavy ash fall areas, were advised not to drive unless absolutely necessary, and when doing so, to use headlights and maintain speeds of less than 55 km/ph.

Fortunately, two other problems often associated with volcanic eruptions did not have to be dealt with on this occasion. First, the acidity of rain, streams and lakes in the affected region did not exceed the normal range. Secondly, the volcanic ash carried only a small quantity of flouride -- indeed, the amounts were not significantly greater than those of many city water supplies (FEMA, 1980a, TIBs Nos. 1, 13 and 28). Table 7.1 below outlines the major events associated with the Mount St. Helens eruptions in terms of warning and response.

TABLE 7.1

Chronology of Major Events[3]

1978		
December 20	USGS notifies Washington EMA of potential volcanic hazard from Mount Baker and Mount St. Helens	
1980		
March 20	First earthquakes near Mount St. Helens	
March 25	First closure of land around the volcano	
March 26	USFS calls first planning meeting	
March 27	First eruption	
	USGS initiates hazard watch	
	60 people evacuated in Skamania County	
April 1	FAA establishes restricted airspace zone	
April 3	Governor proclaims state of emergency, establishes Mount St. Helens Watch Committee	
April 5	National Guard begins manning roadblocks	
April 30	State closure area proclaimed	
	USGS notice of bulge on the north flank	
May 14	Equipment airlifted from camps near Spirit Lake	
May 17	State patrol escorts homeowners to Spirit Lake	
May 18	8.32 am	Catastrophic eruption begins, USGS-FS receive reports
	8.35 am	USFS begins emergency response and notification of other agencies
	8.48 am	Washington EMA notified (but no details provided)
	9.00 am	Weather Service issues first ash warning
	9.45 am	Ash reaches Yakima
	10.15 am	EMA issues state-wide warning
	11.00 am	Ash reaches Spokane
	11.45 am	First Toutle mudflow reaches Interstate 5 highway
	1.20 pm	National Guard begins helicopter search and rescue (SAR) missions
	1.38 pm	EMA issues second warning
	2.00 pm	Interstate 90 closed at Ritzville
	3.00 pm	Ash reaches Missoula, Montana
	5.00 pm	Eruption begins to subside
May 21	Presidential disaster declaration, FEMA begins co-ordinating the federal response and public information	
May 25	Second major eruption	
	Ash hits west side of Cascades	
May 30	Most east side roads cleared of ash	
	Termination of SAR body recovery activities	
June 12	Third major eruption	
July 22	Fourth major eruption	
August 7	Fifth major eruption.	

7.3 Warning problems

In order to evaluate the central thesis and related themes based on the Mount St. Helens experience, it is useful to look at some of the problems reported by those involved in the response operation, and in particular, those involving emergency communications capability. Principal among these in the early stages of the developing crisis were difficulties with the dissemination of public warnings.

Preceding and immediately following the initial eruption of Mount St. Helens on 18 May 1980, several problems were experienced by government responders with respect to warning the public, and especially those communities outside the highest risk areas. On the one hand, their origins were rooted in, first, confusion resulting from unclear or overlapping mandates of the different government organizations involved and, secondly, the abdication of responsibility for public warning by some agencies. They also were related to public and emergency service organization perceptions about the gravity and the immediacy of the volcano threat. Finally, the situation was aggravated by an extended waiting period covering several weeks -- from late March through mid-May 1980 -- before the first major eruption occurred.

Regarding first the prolonged waiting period, between the initial signs of the volcano's reawakening and its eruption several weeks later, it became increasingly difficult for crisis managers to retain the interest of politicians, the media and through them, the public. It was also hard for them to keep their own staff in a "ready to go" state. Indeed, as the weeks passed and the mountain quietened, most people began to discount the threat. Long-time residents of the area insisted that this was just one of the mountain's "moods"; after all, nothing had ever happened before.

With regard to the 18 May explosive eruption, however, the actual warning period lasted only about a half hour. This very short period of time, especially after such a long wait made it impossible to move the scientists who had been monitoring the mountain, the amateur radio operators accompanying them, and residents and tourists in the area (in defiance of restriction orders) out of the area prior to impact. Moreover, although the communities closest to the volcano had long since been evacuated in anticipation of mudflows and flooding, those farther away were not prepared at all for what followed. Additionally, the lateral blast appears to have been entirely unexpected; the mountain was supposed to erupt upwards, not outwards. Finally, and perhaps most significantly in terms of public warning, adequate account had not been taken by any of the public safety agencies of the ash fallout hazard.

7.3.1 Federal warning responsibilities

Interviews with a some of the public safety personnel who were part of the Mount St. Helens disaster response and a review of some other studies on the subject -- i.e., surveys taken during and soon after the spring-summer 1980 eruptions -- indicate that one of the main reasons for problems with respect to public warning was confusion as to who was responsible for issuing them. For example, U.S. Geological Survey scientists were responsible for monitoring the mountain's activities prior to the eruption, but much of the hazard area around the volcano was national forest land and came under the jurisdiction of the U.S. Forest Service (USFS).

The Geological Survey's scientists were perhaps in the best position to be fully aware of the extent of the threat and the implications of a major eruption. Additionally, as part of its normal mandate, it had been charged by the U.S. government with the responsibility for warning the public about geological hazards. However, once Washington's governor established a hazard watch in early April, USGS staff apparently became too busy responding to requests from other public agencies and academics for information and assessments to undertake the task of public warning as well. This, combined with their perception that the Forest Service could better co-ordinate interagency communications and public information, led the USGS to (too quickly) relinquish its warning role (Saarinen and Sell, 1985: p.54-55). It erroneously assumed that the Forest Service, together with the state and local emergency service agencies would take the information it provided, correctly assess its urgency, and disseminate whatever warning was considered necessary. In this way, the USGS contributed to the failure of the public warning process.

Also unfortunately, the Forest Service and the Washington state Emergency Management Agency (EMA) both lacked technical staff capable of understanding the complex messages received from the Geological Survey concerning hazards associated with the volcano. Moreover, with respect to the Forest Service as an alternative federal warning agency, that agency's responsibility was restricted to the national forest areas located in the vicinity of the most serious hazard zones (i.e., the red zone) As a result, from late March on, virtually all of its staff were working around the clock on developing contingency plans in order to protect the communities near the mountain and in the valleys below from damage due to flooding, mudflows and forest-fire hazards. For their part, they apparently concluded, as had the USGS, that there just was not enough time to think about anything else. Furthermore, it was reasonable for them to assume that state and local authorities would undertake to warn the public -- as part of their responsibilities as first-line responders. The problem, therefore, from the perspective of these federal agencies, was one of jurisdictional confusion about the roles and responsibilities to be assumed by the different agencies and orders of government.

Indeed, instead of agencies competing with each other to gain control of the situation, including usurping the claims of other agencies in the process, the experience of the Mount St.

Helens disaster -- one that involved multiple jurisdictions and several emergency service organizations -- suggests that in a disaster of that magnitude, public agencies actually may resist taking on any new tasks. This contrasts markedly with common "bureaucratic" practices under normal conditions. It is suggested, therefore, that in major peacetime emergencies, public agencies may be reluctant to overstep their mandate and risk criticism for a lack of effective leadership. In situations like that which occurred on this occasion, the organization that emerges as the lead agency may, in fact, do so by default rather than by design. It could be the first agency to initiate government intervention or, alternatively, it might be the one that is perceived by the others as being the most competent one to do the job, and regardless of formal authorities.

During the Mount St. Helens crisis, it was the U.S. Forest Service that emerged as the central co-ordinating agency during the early response effort. After the president's disaster declaration on 21 May, the Federal Emergency Management Agency (FEMA) assumed that role. The major advantage that the Forest Service had over the others related to its normal planning activities with respect to forest fire management, including well-practised methods of gathering and disseminating information. In exercising its fire management plan, the Forest Service, by default, became the "authority" to which all the other responders turned for direction on this occasion.

A third federal agency, the National Oceanic and Atmospheric Administration (NOAA) also had a public warning responsibility. Its National Weather Service (NWS) is responsible for issuing flood and other weather-related warnings, and it has an extensive nation-wide teletype network in place to do this. In the case of the Mount St. Helens eruption, it was in fact the NWS that issued the first public warnings about the volcanic hazards.

At **8.45 am** on 18 May 1980, the Weather Service received a telephone call from the Federal Aviation Administration (FAA) advising that a pilot had reported smoke and lightning above the volcano. That report was confirmed via the National Warning System (NAWAS) at **8.50 am**, and at **9.00 am** a "flash flood watch" was issued for the Cowlitz and Skamania counties.

However, given that the eruption was not predictable in the usual sense, the NWS depended on other agencies to advise it of the mountain's activity before issuing additional warnings. As a result, it became pre-occupied with the potential flood problem; other meteorological hazards -- in particular, ash fallout -- were considered only in terms of their potential impact on aviation activities. Thus, as noted above, although warnings were issued by the NWS quickly to advise threatened communities as to the direction of the ash plumes, most people were not prepared to deal with the ashfall when it came (Saarinen and Sells, 1985: pp.88-92).

The fourth U.S. federal agency that has public warning responsibilities during peacetime emergencies is the Federal Emergency Management Agency. It is responsible for operating the NAWAS network.[4] FEMA also is usually the agency responsible for co-ordinating federal response and relief activities after a presidential disaster declaration. This includes, among other things, oversight of all federal and intergovernmental communications -- i.e., public information as well as interagency communications. Significantly, however, "because FEMA normally becomes involved after the disaster has occurred, it is mainly concerned with response rather than warning activities" (Saarinen and Sell, 1985: p.141).

Regarding FEMA's role as the agency responsible for the federal NAWAS warning system, it is worth mentioning that, in civil emergencies, the NAWAS system also can be used to issue warnings to connected agencies on a regional level. Its activation is not, therefore, restricted to a federal decision; it may be activated at the request of a state or even a municipal authority as well. Similarly, it can be used by federal authorities having jurisdiction over a particular territory. With regard to the Mount St. Helens eruption, the U.S. Forest Service was the agency that activated the NAWAS network, albeit belatedly, because it was responsible for the protection of national forest lands on the mountain.

But problems also were experienced with the NAWAS system itself during the disaster. These were due in part to equipment malfunctions; the most serious, however, were attitudinal. For instance, some FEMA officials felt that Forest Service personnel lacked the ability to handle the NAWAS -- "the Forest Service was given responsibility for warning and they blew it" (Saarinen and Sell, 1985: p.148). Others attributed fault for the failure of the system to the Washington state authorities because, for public warning beyond the territory managed by the USFS, the state is responsible for warning its citizens.

When the eruption occurred on 18 May, the NAWAS system apparently failed at the Forest Service's emergency operations centre in Vancouver, Washington. It failed again after the 25 May eruption. But interestingly, telephone company verification tests of the line on both occasions showed that it was working. When the system failed for the third time after the 12 June eruption, FEMA personnel went themselves to inspect the drop-line. They soon found and resolved the problem -- a piece of paper had been jammed between the striker and the bell of the telephone! Another problem with the NAWAS system was finding the telephone at all. --

sometimes it was tucked under a desk, to make more room for agency responders; another time it was found under a pile of coats which had been thrown over it (because the responders at that location apparently did not know what "that black phone in the corner" was for).

7.3.2 State warning responsibilities

At the state level, the agency formally assigned with the task of issuing public warnings is the Washington state Emergency Management Agency (EMA). Unfortunately, as was the case with many of the other government response agencies, it was seriously understaffed. Moreover, like some of the federal agencies, it lacked technical personnel capable of assessing data provided by the USGS in order to determine how, when and to whom warnings best would be given. Also significant was the fact that the state agency did not have the political stature needed to have its formal leadership role properly recognized by the other public agencies -- even those at the state level.[5] For years it had been neglected financially, a reflection of the general lack of interest in emergency preparedness by the state government. But perhaps the agency's most serious problem was an absence of leadership within the agency itself.[6]

Just the same, when the Washington EMA received notification from the U.S. Geological Survey on 24 March 1980 of renewed volcanic activity, its reaction was to try to contact all the organizations on its (lengthy) emergency planning list; they included every state agency having any kind of emergency responsibility and all local governments. The agency also contacted emergency services organizations in Oregon, California, Idaho and British Columbia.

Following the 18 May explosive eruption, however, the Washington EMA focussed its public warning efforts entirely on the six counties closest to the mountain -- namely, Cowlitz, Clark, Skamania, Lewis, Yakima and Kilckitat. In addition, it sent out hazard information over teletype to county emergency services directors across the state. But, unfortunately, eastern Washington emergency services departments apparently did not regard it as having a direct bearing on their communities.

As regards emergency communications and warning capability, it has already been mentioned that the Washington EMA suffered from a lack of adequate or appropriate equipment, physical facilities and personnel. This was perhaps most evident in the agency's headquarters; the agency occupied (and still does) a small barracks-like building on the outskirts of Olympia, the state capital. Indeed, the lack of space there prevented it from setting up its an emergency operations centre of its own to which other state agencies in the area could have come. Moreover, since there was very little room in the EMA's communications room, volunteers could not even come in to relieve its communications staff. As a result, the communications officer reported that he had stayed on duty for 24 hours straight after the first eruption, and had not gone home for the first four days. In addition, the communications equipment at the agency at the time was of 1950s vintage and was not particularly reliable. Finally, the lack of backup equipment forced the agency to rely on the Washington State Patrol's radio and teletype located in another building.

The NAWAS "drop" provided to the Washington EMA by FEMA gives an indication of the type of equipment available for disseminating warning information at the time of the eruption. It consisted of a single "hot line" telephone with direct connection to each state and county emergency services office. When activated, an alarm bell would ring simultaneously at every location connected to the network. Potentially an effective and easy-to-use system, it unfortunately was not taken seriously.

Other state-operated or managed warning methods available in Washington at the time of the eruption included: (1) regular telephone call-out lists -- that is, using the public switched network; (2) the Law Enforcement Teletype System (LETS) which circulates messages to every law enforcement office in the state over public and private teletype; (3) the Emergency Broadcast System (EBS) which alerts participating local radio and television stations, and provides them with prerecorded or live public messages for broadcast/rebroadcast; and (4) the Radio Amateur Civil Emergency Services (RACES) program, the members of which provided the Washington EMA with up-to-the-minute local weather, visual surveillance and related information.[7]

Just the same, despite the availability of several ways to issue public warnings, the Washington state EMA apparently did nothing with the information it had received -- for a good hour-and-a-half! This was due, apparently, to its director's insistence on having an "official" confirmation of the eruption. But almost all of the agency's attempts at verification were by regular telephone; and when the long-distance network became jammed, they just kept retrying -- needless to say, without much success. [8] Finally, at **10.15 am,** the agency sent out its first warning to county emergency service offices.[9] To do so, it used the LETS teletype system -- the only one that apparently was working that day. The decision to issue the warning was based on the combined information received from: (1) the Seattle Weather Service office of a flash flood below the mountain (received at **9.10 am**); (2) another message received from the same source, at **9.30 am,** of an ash plume trajectory; (3) reports of ash fallout at the Cispus

Environmental Camp River, received at **9.15 am**; and (4) notification of flooding and evacuation operations on the Toutle River, received at **10.00 am**; and (5) mid-morning news reports on television and radio.

As a result of waiting such a long time for confirmation of the eruption, the Washington EMA did not have enough time to warn some of the more distant communities that were also affected by mudflows and floods in time. Furthermore, like the USFS and the USGS, the agency similarly failed to warn communities in eastern Washington about ash fallout.

7.3.3 Local authorities and public warning

Considering local responsibilities for issuing public warnings and associated problems experienced by municipal and county authorities during the Mount St. Helen's crisis, the latter stemmed from a number of sources. First, local emergency service organizations found it difficult to get adequate information about volcano hazards that might affect their communities. Second, it was often not possible for them to establish direct interagency communications other than by regular telephone in order to clarify the information they did receive. As a result, they had to rely on the (non-secure) amateur radio network to transmit and receive pertinent information about developments within the disaster area. An additional problem reported by some local emergency service agencies involved persuading the broadcast media to issue warnings to their communities over-the-air.

In major peacetime disasters, among the responsibilities of all governments is the transfer of relevant information to the public in a timely manner. The public needs first to be alerted, and then to be reassured that something is being done and their security is being protected. The best, and often the only, means for communicating such information is through the mass media. Especially significant is the role played by local radio broadcasters (and where they existed, local television stations), to provide information concerning local hazards and local response activities. They also play a vital role in giving instructions on action to be taken by citizens -- such as risk prevention, evacuation and the like. Alternatively, the absence of local media coverage may cause a threatened population either to delay taking preventative or mitigative action or, alternatively, to grasp at unfounded rumours -- no matter how improbable they may be.

7.3.4 Sources of warning information

Given the difficulties experienced by public safety officials and private citizens during the Mount St. Helens disaster with regard to the dissemination of volcano hazard information and warnings, it is interesting to look at the sources from which officials and residents of the affected communities did receive their information. Survey results of public safety personnel involved in the Mount St. Helens response show that roughly 45 per cent had received their first warning through "official" channels. An additional 42 per cent received the warning via the news media.

In contrast, surveys of residents in two communities threatened by the volcano reported a wider variety of information sources for both volcanic hazards and warning. These included friends and/or neighbours; local police or fire authorities; the county department of emergency services; the county sheriff's office; the U.S. Geological Survey; the U.S. Army Corps of Engineers; the National Weather Service; FEMA; the U.S. Forest Service; and the Washington Emergency Management Agency (Saarinen and Sell, 1985: p.162).

Regarding the communication channels through which they reported having received most of their information about the volcano threat, of those residing in Toutle, a community located very close to the volcano, 41.7 per cent identified radio as their primary source of information. About one-fourth reported receiving most of their information from newspaper coverage, while 17.5 per cent mentioned personal conversations and 10 per cent mentioned television. Only a small number mentioned brochures or public meetings.[10] By contrast, residents of Lexington, a community farther away from the mountain, reported receiving most of their information from newspapers (42.4 per cent). Another 36.4 per cent mentioned television as their primary information source, compared with 17.2 per cent who listened to the radio for information about the volcano.[11]

Another survey of eastern Washington residents later the same year illustrates the pattern of public information dissemination in communities that had not expected to be affected (Dillman, et al., 1981). This time, neither radio nor television was reported as the primary source of initial news about the blast . Instead, 51.9 per cent of the respondents said they had heard of the eruption from another person.[12] This compares with 33.6 per cent whose primary source was radio, and 12.2 per cent whose source was television.[13] As the day progressed, however, most of the respondents reported tuning into either television or radio for information about ash fallout.[14] This high radio and television use, although reflective of time-of-day, suggests a strong potential for using the broadcast media to disseminate emergency information during major disasters. Finally, with regard to media "preferences," survey respondents in urban areas rated radio over television as providing better information, while those in rural areas (communities with populations under 5,000) favoured television.[15]

7.4 Other communication problems

Another communications problem reported by public safety agencies during the Mount St. Helens disaster response was convergence -- that is, too much information and too many communicators. Others included "poor communications between agencies ... lack of analysis or interpretation of data, inconsistent or contradictory information, and lack of information on eruption impacts (especially ash) and how to deal with them" (Saarinen and Sell, 1985: p.174).

7.4.1 Convergence

During the first hours and, indeed, for a few days after the eruption of Mount St. Helens, long-distance telephone circuits connecting to eastern Washington lines were jammed. This situation continued despite repeated radio and television broadcasts asking that telephone calls be restricted to those that were absolutely necessary for individual emergency assistance.

One survey of eastern Washington residents examined who had tried to call whom and why. Of the study's 1,023 respondents, 41 per cent reported having attempted to contact someone to let them know they were all right; this compares with 14.5 per cent who reported trying to warn someone else about the eruption (Dillman et al., 1981: p.6).

Eighty-three per cent of those who made "okay" calls placed them to relatives, while 59 per cent of the "warning" calls also were made to relatives. Of those respondents calling to receive information about the volcano, 11.5 per cent contacted relatives in the same town, as compared with 13.5 per cent who called relatives in other communities, six per cent were made to law enforcement agencies, 3.9 per cent to friends in other communities, and 2.3 per cent to local radio or television stations (Dillman et al., 1981: p.7). A high percentage of the information calls were reported to have been successfully completed, although long-distance calls were less often successful.

The study concluded that "primary networks of family and friends predominated as communication vehicles for information, as sources of concern, and as motivators for calls to police and media" (Dillman et al., 1981: p.19). It also concluded that the telephone utilization patterns observed during the Mount St. Helens disaster would be useful in setting guidelines about the kinds of public announcements that would be effective for keeping telephone lines free for legitimate emergency communications. These findings, together with the data provided on broadcast media use after the eruption, also suggest that disaster communications to warn and inform the public likely would be disseminated most effectively over local radio during a major disaster.

7.4.2 Interagency links

Among the most serious problems experienced by government responders during the Mount St. Helens eruptive period in 1980 were difficulties in establishing direct two-way communications among the numerous local, state and federal agencies. To a certain extent, they resulted from inadequate or inappropriate communications facilities available to the various emergency services. That is, emergency communications equipment was either in too short supply or its particular technical configuration did not allow for interconnection and interoperability with other networks using different radio frequencies.

For instance, federal civil aviation authorities were not able to communicate with military and voluntary search and rescue personnel operating in the different counties; these could not talk with each other; nor could the Cowlitz County Sheriff, for example, talk to his own officers -- or for that matter, to all the search and rescue people. In addition, the amateur frequencies were not equivalent across counties. The result of all of this was the reliance of most of the response agencies on the public telephone system. Another consequence was their dependence on non-secure amateur radio services for interagency communications.

Also contributing to problems with interagency communications was the tension between the Washington Emergency Management Agency and other state and federal agencies related to the establishment of a joint emergency operations centre and a federal/state information centre in Vancouver, Washington.[16] The state agency's director apparently took umbrage at this and refused to relocate its operations to Vancouver. Still, direct voice communications between the Washington EMA's office in Olympia and the Vancouver centre were necessary several times a day, and it did not help that the state agency relied almost entirely on the public long-distance network for those communications. Furthermore, given the requirement that local requests for federal assistance had to be approved first by the state EMA, response and relief co-ordination generally was made that much more difficult for local authorities who themselves had problems contacting the EMA.

7.4.3 Lack of information

Because of the responsibility of local authorities for first-line response and public information, lack of information also posed a serious problem during the Mount St. Helen's crisis period. Indeed, it was one of the most frequently mentioned problems reported by public safety authorities at all levels of government (Saarinen and Sell, 1985: p.172). For example, FEMA representatives who worked closely with the U.S. Geological Survey studying the unfolding situation reported feeling that they needed more practical information about volcanic impacts on health, machinery and the environment, as well as on how to cope with them. FEMA officials also mentioned problems in "obtaining the necessary information to process state and local requests for assistance and financial reimbursement" (Saarinen and Sell, 1985: p.172).

At the state level, officials of the Washington Emergency Management Agency reported difficulties with the way that information was presented by technical agencies such as the USGS. They found it especially hard to interpret a "pure scientific approach using information based on factual data without speculations going beyond the data" (Saarinen and Sell, 1985: p.168).

A related problem experienced by the state and other agencies involved delays in receiving information. An example is provided by the state agency following the initial eruption on 18 May 1980. It relates to its difficulties in confirming via official channels that an eruption had actually occurred.[17]

Regarding complaints by local authorities of not receiving enough information about the hazards associated with the Mount St. Helens eruption, the main problem reported by authorities in western Washington also related to the speed at which they received hazard warnings from the Vancouver information centre. Other complaints referred to the absence of information by organizations that rely on the NAWAS and state emergency warning systems. Eastern Washington officials, by contrast, complained that they had had no idea that the eruption would affect their communities at all. Indeed, the first "warning" that most of them had was the approach of an enormous black cloud followed almost immediately by ash fallout. They had discounted information sent over the state teletype service because reference had not been made specifically to their localities (Saarinen and Sells, 1985: p.120).

7.5 Coping

The lack of adequate telephone circuits and restrictions on interagency communications imposed by the absence of common or shared radio frequencies, incompatible radio networks and different frequencies assigned to the respective agencies' mobile radio equipment also jeopardized effective search and rescue operations during the first days after the eruption. Moreover, given the limitations of amateur radio facilities to handle search and rescue communications across such a wide geographical area, a very costly option provided the only viable solution in the short term. Thus, at the request of the National Association of Search and Rescue,

> [t]he Air Force supplied a special communications jeep designed to transmit and receive signals on most radio frequencies. Additionally, the jeep was equipped with a mobile radio set with a special antenna capable of sending and receiving signals via a satellite provided by the National Aeronautics and Space Administration. The Earth Station Laboratory of General Electric located in Rome, New York served as the relay station and completed the communications link. With this system, emergency personnel could communicate with each other in the Mount St. Helens area as well as with individuals at distant locations. (Chartrand and Punaro, 1985: p.4)

During the disaster, meteor burst technology was also employed (by FEMA) for long-distance communications. And after the mountain's first eruption, "a network of event reporting stations were installed around the mountain to provide immediate warning of sudden moisture and temperature changes (Meteor Communications (Canada) Corp., 1984: p.7). That network, as of the mid-1980s, consisted of 48 remote communication terminals, 5,000 receivers and 13 master stations. It is specifically designed to connect all the state capitals with Washington, D.C. and it provides rapid (supplemental) emergency deployment capability within the existing "SNOTEL" network.

To handle the dissemination of information to residents in communities threatened by severe flooding and mudflows, county sheriff deputies drove predesignated routes, sounded high-low sirens and used hand-held and vehicle-mounted public address systems to issue evacuation notices. In addition, the Washington State Patrol was dispatched to block eastbound traffic out of Vancouver on state highways 504 and 505, and they were used to block the Toutle River bridge on Interstate 5 because it was potentially in the direct path of mudflows.

Communicating warning information to short-term visitors in the area was more complicated. In the weeks prior to the eruption, local emergency services personnel undertook to inform tourists about local warning systems. Pamphlets and flyers were distributed to all visitors centres and places of business located near access points to the mountain. In addition, signs were posted along primary roads leading to the volcano; these explained the meaning of warning sirens, radio station broadcast information, and the pre-established evacuation routes (Perry and Lindell, 1986: p.13).

Other emergency service organization initiatives to improve interagency and public information communications emphasized the importance of co-ordinating federal and state communication, especially as regards public information. Thus when the volcano threat period began in late March 1980, the U.S. Forest Service activated its permanent emergency operations centre in Vancouver, Washington (70 km from the mountain) and invited other emergency service organizations to participate. Following U.S. President Carter's disaster declaration, FEMA similarly set up a joint federal/state disaster field office in Vancouver.

Within hours, an "800" number disaster hot line was established there, allowing the affected population to call for information about relief assistance, etc. A disaster hot line slide also was sent to television stations covering the affected areas to inform the public of the toll-free disaster line, and a word processor computer link to a direct mailing service distributed regular information bulletins to the press. Additionally, an automatic broadcast feed machine regularly updated information about the eruption and the response operation; it was used by more than 500 local and regional radio stations in their daily broadcasts. Moreover, National Weather Service teletype together with news wire service equipment installed at the Vancouver centre provided a continuous stream of information on the volume and trajectory of ash plumes after each eruption. Briefings involving all the response agencies who chose to attend were held twice a day. In addition, a brochure on the hazards of ash fallout was distributed to over 4 million residents in the area through the postal system (FEMA, 1980b).

FEMA also created a special "technical information network" to handle information requests regarding temporary housing for evacuees, etc. Its purpose was to ensure rapid dissemination of relevant technical information to the public via the broadcast media and thereby to reassure affected populations, control rumours and prevent curiosity seekers from entering the hazard areas.[18]

7.6 Command-and-control model

Considering the case of the Mount St. Helens eruption, the experiences reported by officials involved in managing the response operation suggest that the traditional model may be inappropriate for describing crisis management behaviour in a large-scale disaster involving multiple response organizations and crossing several jurisdictional boundaries. Such a situation, it is suggested, calls for an approach that is flexible and consultative rather than formalized and control-oriented.

Many of the problems that occurred in that instance which were attributed to communications similarly reflected the "mindset" of the response agency personnel involved. Reference is made again to the guiding model, the underlying assumptions of which include hierarchical patterns of communications; a perceived need by key players to come in and "resolve" the situation; and the attitude that all emergencies can be responded to in the same way as a military emergency.

The discussion below looks more closely at difficulties experienced by public safety officials during the Mount St. Helens disaster as they pertain to the command-and-control model. In the first place, the confusion that resulted from overlapping mandates and the involvement of many agencies and jurisdictions will be considered. Then, the reconfiguring of communication patterns and relationships within and between organizations will be discussed. Finally, the effects of shared experiences among responders will be evaluated in terms of the emergence of alternative approaches to crisis management and emergency preparedness.

7.6.1 Overlapping mandates

The Mount St. Helens experience suggests that control, especially early on in the response, was fragile. This was due to confusion about statutory authorities and responsibilities caused by the involvement of different levels of government as well as several local jurisdictions. The central co-ordinating role played by the U.S. Forest Service during the extended threat period and for the first three days after the initial eruption (after which FEMA took over that function), it has been suggested, appears to have resulted more by default than design. Moreover, the effectiveness of first that agency, and later FEMA, was at all times contingent on the confidence of the other agencies in their ability to manage the crisis.

Additionally, overlapping mandates and jurisdictional confusion made it impossible to impose a rigid communications/command structure from the beginning of the post-eruption response since public officials often were not clear even about their own responsibilities; nor did they know where to turn for help when their resources were exhausted. In some cases this confusion over authorities and responsibilities led to serious tensions between some officials as to whose authority would predominate.

It is worth repeating that federal rules in respect of civil emergencies in both Canada and the United States dictate that local authorities have the principal responsibility for handling them. Provincial or state and federal intervention is at the discretion of the local authorities and in both cases, it is in a support capacity only. From a federal perspective, therefore, responsibility for co-ordinating the response to this and, for that matter, any peacetime disaster consequently rests first with local and then with state authorities. In such instances, federal agencies would act only at the request of the state or local authorities (via the state). For example, local requests for federal assistance must be approved first by the appropriate state-level agency; only upon that agency's recommendation can funds be drawn from the Emergency Relief Fund.

But in this case, the designated state agency responsible for public security and civil defence in the affected region (i.e., the Washington Emergency Management Agency) was not able to discharge its mandate. This was because for a long time before the disaster it had suffered from a poor image. Consequently, at the time of the eruption, it was not recognized by other state agencies (and apparently, including the governor's office) as capable of handling an operation of that magnitude. Of particular significance in this instance was the confusion by the other responders concerning its precise role and responsibilities. That lack of clarity and foresight by the state government may be attributable to the fact that up until that time the region had been relatively disaster free. This had led to a general complacency about emergency planning, and especially as regards low-probability risks.[19]

Regarding the requirement that local appeals for federal aid go through the state EMA, FEMA and the other public safety agencies all reported difficulties in dealing with the Washington EMA. Its internal problems in trying to cope with the enormous volume of incoming requests in addition to its other emergency responsibilities in this instance were that much more difficult to resolve due to understaffing, a limited emergency (radio) communications capability, and its (consequent) reliance on the congested public telephone network.[20]

Federal personnel experienced difficulties in co-ordinating operations with other state and local authorities as well. For example, search and rescue operations immediately after the 18 May eruption involved county sheriff departments, the state-directed National Guard and Civil Air Patrol, the U.S. Army, Forest Service and the Federal Aviation Administration. In one notorious instance, interagency tensions rose so high that a military general who had tried to take control of a particular operation was confronted, allegedly at gunpoint, by the deputy sheriff who told him to get off of "his" territory. When the general complained to the State Department, he was told that the sheriff's office had jurisdiction in this situation and that federal officials, including the military could intervene only at their explicit invitation.

Local complaints about obstacles encountered in responding to requests for assistance prior to the president's disaster decree centred on the rigidity of federal rules, especially those related to the Disaster Relief Fund. After the declaration, they emphasized problems getting help from the military -- e.g., vehicles, search and rescue personnel, and communications support -- and the requirement that concrete proof be provided that all state as well as local resources, including those in the private sector, had already been exhausted or were committed elsewhere.[21]

Another problem experienced by local authorities associated with overlapping mandates had to do with trying to co-ordinate contingency planning -- both within and between jurisdictions. According to one emergency services director, for example, plans that had been laid down in consultation with several county departments and school districts were arbitrarily superseded by the sheriff (Saarinen and Sell, 1985: p.98). A related problem involved the failure by some local authorities to develop plans that were compatible with those of other jurisdictions. This failure may be attributed to the overconfidence of many officials that they would be able to cope on their own. When they found that they could not, it was too late -- equipment and other resources that might have been available earlier had already been sent somewhere else.

7.6.2 Reconfigured relationships

Also contrary to the command-and-control model, the Mount St. Helens case suggests that the nature of peacetime disasters will cause established normal-time communication patterns and relationships to be replaced by informal and personal relationships, temporary alliances and emergent, dynamic crisis management structures. It therefore can be expected that the exigencies of a particular disaster -- including the need for continuous negotiating and rapid decision-making (often relying on incomplete information and multiple players), combined with the necessity to minimize conflict in order to optimise response -- will lead to network-like (i.e., open) rather than systemic (i.e., closed) communication patterns. And while these may be based to a certain extent on pre-established relationships or linkages, they also will reflect the importance of specialized expert information sources (Drabek, 1981: p.19).

The result, described in Eisenstadst's terms, is a form of"debureaucratization". Essentially, it involves the

> subversion of the goals and activities of the bureaucracy in the interests of the different groups with which [the organization] is in close interaction ... [and] the various outside non-bureaucratic roles impinge on the bureaucratic role to an extent which tends to minimize the specificity of the bureaucratic roles and the relative autonomy of

> bureaucratic roles in the implementation of goals and in the provision of services (1959: pp.312-313).

The reason for this is that, in a peacetime disaster, the social context tends to dominate, thereby impinging on the normal-time bureaucratic role or function of the different organizations involved.

In such a situation, it is suggested, the kind of information or knowledge required to manage the response effectively will determine the specific communication patterns and decision-making structures that develop. Moreover, since each disaster differs from every other, it will lead to shifting patterns of communication and ad hoc alliances among public safety officials and with individual experts from whom they receive advice. Additionally, in large-scale disasters, perceived communication problems often will be due to the dismantling of hierarchical structures and their transformation into geodesic linkages. Consequently, reports of a "breakdown in communications" usually refer not so much to technical problems, but instead to the disintegration of bureaucratic structures. Indeed, in these instances, there usually is more information circulating within and between response agencies than ever!

During the Mount St. Helens disaster, the enormity of the response operation and the broad implications of the disaster for the many affected communities warranted a reconfiguration of established hierarchical patterns of communications and formal relationships among the various organizations and levels of government. They also necessitated adjustments to some pre-established informal linkages -- for example, those between local authorities and the U.S. military.

Indeed, some of the more serious problems that arose during the crisis period immediately after the first eruption related to attempts by individuals or individual agencies to impose normative guidelines for "appropriate" conduct and rigid patterns of communication in a highly non-routine situation. In this instance, an excessive emphasis on standardized behaviour created obstacles to effective response instead of facilitating it. Reference is made here again to the imposition from above of an additional step in the response and relief processes -- namely, that requests for federal funds be channelled through the Washington EMA.

During the Mount St. Helens disaster, temporary alliances also were created among public safety personnel operating in the different jurisdictions or levels of government. These were formed primarily among local public safety officials in the communities affected by the eruptions to assist them to obtain federal assistance -- initially for search and rescue and later, to cope with ash fallout. In that instance, dynamic, non-hierarchical patterns of communication were crucial to the co-ordination of the emergency response effort, particularly given the wide area of impact and the large number of communities affected.

In multiorganizational, multijurisdictional peacetime disasters, it is suggested, flexibility and tolerance with the different ways of getting things done are particularly important to ensure effective response. Among other things, it is necessary to recognize the emergent nature of disaster relationships between responders, together with the dynamic, non-hierarchical communication configurations that are likely to result. It also requires acceptance by the core players of the need to put aside a "scientific" approach (which seeks a standardized response for all situations) to crisis management and find new ways to deal with unique situations.

7.6.3 Shared experience

A third major theme if this study that is addressed by the Mount St. Helens case study is that shared experience will lead to increased consultative, co-operative and co-optive arrangements among public safety organizations and with industry. Furthermore, they will lend themselves to the promotion of programs and policies aimed at improving overall emergency communications capability. Indications of the realization of these expectations several years after the Mount St. Helens disaster were provided by personal interviews with FEMA and Washington EMA officials, and with private sector and media representatives who were directly involved in or observers of that response.[22]

The information provided by those interviews was supplemented by a review ofsurvey research, respondents to which included public officials and residents of several of the affected communities. Again, the results of that research, discussed earlier in this chapter, support the idea that shared experiences will lead to consultative and co-operative disaster planning and improved emergency communications capability.

Another study by the University of Delaware's Disaster Research Center looked at the impact of previous disaster experience in six communities on emergency response performance It provides theoretical insights that are relevant to this discussion as well. That study concluded, for example, that there appears to be a strong relationship between prior disaster experience and the extensiveness of response (DRC, 1987: p.50). This is attributed to two factors: saliency and visibility. Usually, emergency management agencies are not "high profile"; that is, they are not usually either as visible or as salient as other emergency service organizations such as police, fire and public utilities. Consequently, in communities with little prior disaster experience, the emergency management agency is often bypassed in response activities in favour of the higher profile agencies (DRC, 1987: p.51).

In the Mount St. Helens response, the Washington Emergency Management Agency was, to a considerable extent, bypassed -- both by other state emergency service agencies and by federal responders. Local authorities also tried to bypass the state EMA, but federal rules regarding state approval of requests for federal relief funds prevented them from doing so. The governor's establishment of a Mount St. Helens Watch Committee, to which the State Patrol chief rather than the director of the EMA was named chair is perhaps the clearest indication of the extent to which that agency was overlooked in that instance.

County emergency service organizations also were largely bypassed during the Mount St. Helens disaster. And because neither the state nor local emergency services worked particularly well due to neglect, lack of recognized authority or for whatever other reason, FEMA was often left to meet the demands of state and local officials who often were unaware of the procedures to be followed to obtain federal relief aid.

To overcome the blockages that resulted, many public safety personnel contacted directly those individuals and organizations with whom they had dealt before for interim assistance. These included private sector specialists and external public safety agencies. Similarly, the state EMA established contacts with emergency service authorities in neighbouring states and British Columbia to ask for help and advice on how to approach the unfolding situation. FEMA Region X likewise called on its counterparts in other regions, including Emergency Preparedness Canada's regional director for British Columbia (who was asked to accompany FEMA's team of observers on its first flight over the volcano after the 18 May eruption).

These actions support of the idea that "in a disaster situation where quick reactions are necessary, people and agencies tend to rely on what and who they know" (Saarinen and Sell, 1985: p.189). In this way, ad hoc communication configurations were created, ostensibly just for the duration of the emergency. The "geodesic" patterns of communications that emerged were expected to cease when the response operation concluded, although it is likely that, should another disaster occur in the same area, they will re-emerge at that time.

Perhaps the most critical aspect of the Mount St. Helens experience was the co-operative spirit or "goodwill" that emerged after an initial period of interagency tension and confusion about roles, responsibilities and jurisdictional boundaries. Once military and other state and federal emergency services personnel understood that they were subject to the authority of the various county sheriffs' departments, and after the different federal and state agencies settled representatives in the Forest Service's emergency operations centre and, later, FEMA's joint information centre, things went a lot more smoothly. Moreover, considerable effort was made to bring the media on-side. To that end, FEMA and the other agencies participating in the joint information centre arranged daily briefings for the media with senior government officials. They also brought in an experienced public information team to assist media representatives in setting up interviews with private and government experts, distribute supplemental information, etc., all with the aim of reassuring the public that, given the difficulty of coping with such a mammoth undertaking, what could be done under the circumstances was being done and as quickly as possible.

7.7 Remedial measures

In acknowledgement of the difficulties experienced by responders at all levels of government during the Mount St. Helens disaster response, a number of remedial measures were taken afterwards by the state and federal governments to improve disaster management and emergency communications capability in Washington state. As regards communications preparedness, these have involved upgrading the Washington EMA's facilities; educating the public; improving interconnection and interoperability of separate radio systems (i.e, municipal, intermunicipal and state); establishing mutual aid arrangements among public safety organizations on a regional basis for emergency communications; and improving the EBS system.

Other developments within the U.S. telecommunications industry subsequent to that disaster also have played a role (albeit indirectly) in putting emergency communications on the national policy agenda. Foremost among these was the U.S. federal court's decision to break up the Bell Telephone System.[23] It had a significant impact, in the short-term, on long-distance and local emergency communications capability in Washington state, especially as regards the NAWAS system. The attention drawn to its implications for NS/EP telecommunications, however, led the Federal Communications Commission to wave all the divestiture requirements with respect to the NAWAS.[24]

7.7.1 State initiatives

Actions taken by the Washington EMA towards improving that state's emergency communications capability have been particularly noteworthy. One such initiative was part of a more general move by the agency to pressure the state government for better funding of its operations. It relates to the establishment of the On Scene Command and Coordination Radio (OSCCR) network, a state-owned and operated system which uses a frequency offered by the Department of Transportation for the purpose of interagency mobile communications in exchange for a state plan to enable state-wide operation. The network operates on a single mobile very high frequency (VHF) managed by the Washington EMA.[25] Significantly, the frequency is to be used only as an on-scene common frequency for response agencies. That is, it provides direct voice communication capability between fire and police personnel, etc. during a disaster response operation.[26]

Another initiative with a similar objective has involved improving the survivability of and upgrading a state-owned two-way VHF radio system, known as the Communications Emergency Management Network (CEMNET). This network is controlled via seven (also state-owned) microwave sites located on mountaintops across the state. It is capable of connecting the Washington EMA headquarters with local emergency services agencies throughout the state.[27] The state's Emergency Broadcast Service subsystem is also connected via microwave to the CEMNET, as are a number of television broadcast outlets and several local cable stations which have reserved a channel for emergency traffic.

As regards state-federal communications, however, Washington state's CEMNET operates at 45 Mhz, while the federal communications system operated by FEMA and covering the same geographical area operates on a different frequency -- at 140 MHz. This makes the two systems mutually exclusive.[28]

A partial solution to handling frequency allocation incompatibilities that would facilitate interjurisdictional radio communication has since been made available by FEMA. It has installed in its regional headquarters in Bothel, Washington, a HARRISS high frequency (HF) automatic scanner system with multiple patch capability. Physically separate radio systems operating on different frequencies are now able to talk with each other via the FEMA facility. A communication, regardless of the incoming frequency, can be patched through to the destination frequency, operating on VHF, ultra high frequency (UHF) or HF, to allow virtually transparent voice communications between the separate systems.

A third initiative taken as a result of the state's recognition of the importance of public warning and education based on the Mount St. Helens experience involves changes in its management of the regional portion of the Emergency Broadcast System. During the Mount St. Helen's disaster, neither the Forest Service nor the Washington EMA activated the EBS either to issue warnings or to give instructions to threatened or affected populations. Some of the blame for theie failure to do so can be attributed to the inactivity of the Broadcasters Association of Washington, the members of which participate in the national EBS program. As a result, citizens and emergency services personnel in several municipalities outside the immediate threat area received the first indication that they might be affected when they saw the enormous black ash cloud approaching. From this it is fair to conclude that Washington state residents had been misled over the years prior to the Mount St. Helens disaster by seeing EBS test patterns on the television and hearing the two-tone test recording on the radio. They erroneously assumed that the system was operational in their area.

The EBS in the United States, it will be recalled, is a concept that is based on agreements between private radio and television broadcasters, and state and local governments. It allows designated public authorities to "take control" of participant's transmission and broadcast facilities in emergencies.[29] In fact, all that it really is, however, is a licensing requirement which requires those stations that have volunteered to participate in the program to ensure that they are technically capable of generating the warning signal (but not of actually doing so). Consequently, although the necessary technical hardware (which is paid for by the U.S. federal government) may be installed at a radio or television station, there is no guarantee that the station will be able to transmit the emergency message over the air to its audience.

Indeed, industry representatives admit that testing prior to the Mount St. Helens eruption was sporadic at best, and oftentimes it was not done at all. As a result of considerable public criticism of the Broadcasters Association of Washington and the state EMA during and after the disaster, the agency has stepped up efforts to improve the EBS program at both state and local levels. To that end, it has been working with the Broadcasters Association on an improved regional plan for warning which involves a more effective EBS capability. In addition, the state EMA now has a regular schedule for checking with broadcasters participating in the program -- to ensure, on the one hand, that the required technical capability is in place and, on the other, to verify testing. The broadcasters, for their part, have committed themselves to testing all of their EBS equipment regularly and to doing real-time on-air broadcast tests monthly.

As of 1990, the situation in Washington state with respect to emergency communications capability was as follows: The Department of Transportation has its own two-way fixed/mobile radio system which functions throughout the state. The Washington State Patrol owns an extensive microwave and two-way radio system; it also has its own telephone network connecting all state patrol offices in the state. In addition, the Washington Department of Natural Resources has its own radio system, as does the state EMA. Unfortunately, on the radio communications side, no clear provision has yet been made for full system compatibility. Thus, the Washington State emergency communications structure continues to rely on separate service systems, with little system interconnection or interoperability.

On a positive note, the Washington EMA has moved over the years since Mount St. Helens towards a co-operative approach to emergency communications. A Friday afternoon spent in that agency's communications room to observe and monitor incoming and outgoing radio communications traffic -- which, within a period of under an hour at the end of the afternoon, included reports of two dangerous goods spills and a major fire near a fuel storage site -- revealed a very different pattern of communications and relationships between EMA staff, fire officials and state transportation personnel than that reported by survey respondents (and those interviewed during the course of this investigation) during the Mount St. Helens disaster. Those radio and telephone conversations suggested, instead, a comfortable, respectful and consultative relationship between the parties. They obviously were known to one another and appeared to have had considerable experience working together. Nor was there any indication that the EMA lacked information about the resources available in the different parts of the state from where the events were being reported. Indeed, the agency seemed to have a good handle on who could be contacted over the weekend should any of the situations escalate. Its staff also appeared to be well informed as to precisely what action was to be taken and by whom. In contrast to the Mount St. Helens crisis period when the Washington EMA had been isolated from most interagency communications, ten years later, it was at the centre of the action.

7.7.2 Federal initiatives

At the federal level, similar efforts were made after to the Mount St. Helens disaster to improve communications preparedness. For example, FEMA has purchased four multiple-frequency vehicles, one of which is permanently based in Bothel, Washington. Each vehicle is equipped with six radios having a wide-range UHF/VHF capability. They also have interconnection capability and a patch panel with room for two operators. In addition, the vehicles are equipped with two HF radios, also capable of interconnection. The FEMA-owned vehicles are roughly equivalent to the Air National Guard's "super jeep," but in contrast to the super jeep's satellite-communication only capability, FEMA's mobile units' also have UHF capability. This provides a very inexpensive alternative radio link for state and local public safety users into FEMA antennae for long-distance (e.g., coast-to-coast) communications.

Also in reaction to the communication difficulties experienced during Mount St. Helens, FEMA has established protected two-way radio links between EBS broadcast stations and its own microwave transmission sites. In this way, FEMA's Region X transmission sites (located in Portland, Oregon, Tacoma and Bellingham, Washington and Boise, Idaho, respectively) can be used to provide a direct link from an emergency information centre, for instance, to the broadcast media, using the appropriate EBS frequency as a channel. This enables public safety agencies to bypass the public switched telephone network entirely to activate the EBS.

Other federal initiatives subsequent to the Mount St. Helens disaster have involved making improvements to "secure" communications capabilities, including for hand-held radios at the emergency site. In this way, a situation like that experienced during that event -- where radio communications could be monitored by anyone equipped with a scanner, including the media -- could be avoided.

Additionally, FEMA has established its own Mobile Radio System (MRS). This includes its own switches, it own power capacity and a total of 15,000 radio-telephone lines. Among them are several HF/VHF switches. They allow radio communications using a variety of transmission modes and media -- for example, line-of-site microwave, secure receiver, fax and teletype. That agency also has installed its own private telephone system. Operating nation-wide, the FEMA network is specifically designed to improve NS/EP communications capability among federal agencies in a post-Bell system era.

Just the same, a visit to the FEMA Region X communications centre in Bothel, Washington in 1990 indicated that there is still some work to be done to improve federal-state relations in this area. For example, while FEMA Region X personnel are in contact with the Washington EMA office on a daily basis, they were unaware of the state's current emergency communications capabilities. Discussions with the staff at both agencies suggest that, to some extent, the right hand is unaware of what the left is doing. Following Mount St. Helens, each organization made costly improvements to its own emergency communications facilities, but evidently without consulting the other -- let alone consolidating and standardizing their approaches (or, for that matter, purchasing compatible equipment). To some extent that has led to a duplication of efforts. It may also have served to perpetuate the myth that each agency has mutually exclusive responsibilities in disaster management. Only another catastrophic disaster, such as a major earthquake on the West Coast, for instance, could adequately test the extent to which their actions actually have improved communications preparedness in that region.

But at least they have been doing something. Furthermore, and perhaps more significantly, the major players are now better known to one another than they were before the St. Helens disaster. And some of the crucial linkages that likely would constitute an emergent disaster network during a future crisis have been established. It is therefore unlikely that a similar degree of frustration by or isolation of a key node on such a network would occur again.

7.8 Current U.S. emergency communications capability

The current situation in the United States generally with regard to communications preparedness is greatly improved over what it was in 1980. Among other things, AT&T's divestiture forced U.S. policy-makers to reconsider their national security/emergency preparedness (NS/EP) options in terms of large-scale disasters and other peacetime emergencies. In addition, alternative arrangements have evolved -- specifically, the creation of the National Co-ordination Center.[30] And these have fostered more consultative, co-operative and voluntary co-optive arrangements between governments and industry for emergency preparedness by involving the major U.S. carriers in national planning processes so that they will be able to help governments meet the challenges of major disasters effectively and rapidly.

On a less positive note, some post-St. Helens federal initiatives may prove detrimental to state-level preparedness in that there are now fewer reasons for states to improve their own emergency communications capability. This is because the regional FEMA headquarters in Washington state, for example, possesses all of the communications facilities likely to be required to handle a large-scale response operation. They include: HF radio for long-distance voice; UHF and VHF radio (including UHF/VHF patch-through) for local use; walkie-talkies for on-sight communications; and, if the disaster site is not too remote from existing telephone company facilities, a limited number of telephone lines.

Just the same, immediately following the onset of a disaster, local and state public safety agencies would have to continue to rely, at least in the short term, on their own or amateur radio facilities. Emergency support communications using amateur frequencies are provided in the United States through the Radio Amateur Civil Emergency Services (RACES) program. It is an association of amateur community members who are registered as emergency volunteers at the local level; others may be registered with the state on a limited or ad hoc basis, as was the case during Mount St. Helens.[31] In addition, in Washington state, 15 amateur operators provide direct support to the state emergency operations centre, co-located at the Washington EMA headquarters. They meet weekly (on the radio frequencies) to review procedures and discuss developments.

7.9 Conclusions

Among the lessons learned during the Mount St. Helens disaster was an appreciation of the need for a clear, but flexible authority structure and improved co-ordination among public safety agencies. This applies not only to horizontal relationships between emergency service organizations at the same level of government; it also suggests a need to clarify <u>who</u> has precisely <u>what</u> authority, and <u>who</u> is going to do <u>what</u> tasks (Reinman, 1984).

In this case, the political authority of FEMA over other federal agencies was established by the appointment by the U.S. President of its head as the federal co-ordinator. However, the relationships between the Washington state emergency management agency, other state agencies, and county and local emergency service organizations were not. This led to considerable confusion. For instance, county emergency services departments were not well integrated with the state office, and most of local agencies appeared to be acting on their own initiative.

Looked at within the broader context of overall emergency planning and preparedness, this case also suggests a need for increased flexibility in setting rules for support disaster assistance. A poignant example was provided of the consequences applying rigid rules and procedures; military personnel were not allowed to help local authorities directly, as was the common practice in localized emergencies. This led to a situation where a faster deployment of military search and rescue teams might possibly have saved more lives and property. It also led to considerable public criticism of the military's performance on that occasion.

In particular, the case study underscored the importance of effective communication links among emergency service agencies, and trained emergency service staff. It also emphasized a need for involving all levels of government in hazard preparedness planning, and for increased public and political awareness of the importance of emergency planning and mitigation.

The Mount St. Helens experience indicated a number of problems with the command-and-control model in terms of peacetime crisis management, problems that are especially pronounced in a large-scale disaster situation involving multiple response agencies and crossing jurisdictional boundaries. It will be recalled, for example, that traditional approaches to crisis management presume a stable environment predicated upon cause and effect, and a limited number of "solutions" derived from military strategic planning. In contrast to this, disasters tend to be highly dynamic environments. This calls for flexible patterns of relationships and communication linkages among the central players in order to assure an effective response. Moreover, as this case illustrates, normative or bureaucratic guidelines specifying appropriate modes of conduct may unnecessarily constrain, and could even hinder, effective response. Indeed, attempts by the Washington state EMA and other response agencies (including the military) to impose standard operating procedures and bureaucratic decision-making structures during the first days after the explosive eruption resulted in confusion, tension and led to outright confrontation among some responders. They also created obstacles to rapid resource deployment and the bypassing of the state EMA, where possible, in order to overcome them.

A modified approach, as indicated by the St. Helens experience, would involve increased participation by private firms supplying emergency services and/or equipment and the mass media, as well as representation from the different orders of government. Their involvement, moreover, would encompass emergency planning, public education and multiorganizational post-event evaluations. In this way, flexible and consultative open decision-making structures would evolve over time which would be more amenable to handling a variety of contingencies requiring multiorganizational participation.

This case challenges the thesis that the command-and-control theoretical model is appropriate for explaining the behaviour of government decision-makers and response personnel in a peacetime disaster situation. Instead, it supports the idea that previously established relationships among the organizations and individuals who become involved in managing a large-scale disaster response operation likely will be reconfigured to reflect the particular situation at hand. Perceptions about organizational competence may take precedence, and formal bureaucratic communication structures likely will bypassed if they are perceived as interfering in decision-making. In their place, temporary alliances may be formed within and between organizations, and ad hoc -- emergent -- disaster networks may evolve which link the key players in different phases or aspects of the response operation.

Finally, those shared experiences eventually might lead to the development of a more permanent expert network comprised of representatives from different public and private organizations likely to become involved in future response operations. Such a network, by definition, would be broad-based and dynamic; that is, it could easily be expanded or contracted to meet the requirements of a specific disaster situation. The evolutionary nature of the network also would allow participation in planning and post-event analysis by a larger core group of participants, thereby generating additional incentives to develop and exercise innovative strategies for coping with a variety of disaster agents.

As mentioned, the Mount St. Helens disaster response experience suggests that a modified or new theoretical framework for crisis management may be needed to describe organizational behaviour in major disasters and other peacetime emergencies. Such a framework would be rooted in a local or situationally focussed perspective, thereby allowing for planning and response structures that reflect an image of "loosely coupled systems" (Drabek, 1981: p.5). These, in turn, would constitute the nodes of a dynamic, non-hierarchical -- geodesic -- expert disaster network. This view contrasts sharply with the prevailing emphasis on so-called scientific crisis management. Unlike the emerging frameworks of which this case provides a good example, more traditional approaches appear to have failed to recognize the potential strengths of loosely coupled systems and less formal co-operative arrangements which facilitate rapid, localized improvisation and encourage innovative solutions to complex disaster situations.

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1 Approximately 79 per cent of all volcanoes are contained in what is called the "ring of fire" around the Pacific Ocean. Only 17 per cent of the world's volcanoes are found in the Pacific coastal regions of North and South America. Finally, in the populated areas of the North American continent, most of the volcanoes are along the Coastal/Cascade Range which extends from Alaska, through British Columbia and the states of Washington, Arizona and California.

2 Numerous dome-building and other minor eruptions continued through the next five years. See Perry and Lindell, 1986: p.6.

3 Saarinen and Sell, 1985: pp.2-3.

4 Discussed in Chapter Six, section 6.6.

5 Prior to the event, the Washington state Emergency Management Agency had been rated as having one of the worst disaster response programs in the United States. See Ota et al., 1980.

6 At the time of the 1980 eruptions, it was directed by an inexperienced political appointee instead of a hazards professional.

7 It was Gerald Martin -- the radio amateur volunteer on the RACES network killed in the 18 May eruption -- who sent the message that provided the agency with its first information on the eruption.

8 One respondent to Saarinen and Sell's survey reported having tried to warn no less than 40 agencies by himself, all over the telephone. It took him three to four hours to do so, and by the time he did get through, most of them already knew about the eruption (1985: p.83).

9 In addition to the amateur radio operator's report from the mountain,which the EMA received immediately, and another -- informal -- communication from the USFS just a few minutes later to the effect that there had been "a major event, and we'll get back to you," the Washington EMA received information from a number of other "official" sources as well. These included the NWS (regarding reports of flooding and mudflows in the vicinity of the mountain), and the FAA, which was tracking the ash cloud on radar. But, surprisingly, the director of the Washington EMA refused to treat these messages as confirmation of the amateur's report.

10 That community's emphasis on local radio, according to Perry and Lindell, "seems to reflect a perceived need among Toutle residents for quick responses to imminent threats from the volcano" (1986: p.70).

11 This suggests a situation of less perceived urgency about the volcano risk.

12 28.9 per cent from relatives; 20.7 per cent from friends; 17.7 per cent from neighbours; and 22.7 per cent from others.

13 Interestingly, the mass media held an advantage over interpersonal networks only among those who were aware of the eruption within a half hour of its occurrence -- 45.1 per cent of

these cited radio as their initial source, while 38.2 per cent mentioned another person (See Dillman et al., 1981: p.3).

14 Over two-thirds (69.6 per cent) used both radio and television as an information source during the late afternoon and evening, compared with 2.3 per cent who reported that they had not had contact with either media source (Dillman et al., 1981: p.5).

15 The reasons given for the greater usefulness of radio information suggest that radio stations responded more quickly to the day's events. Just the same, this may in reality be attributable to the presence of more local radio as opposed to television stations in the area.

16 Following the president's disaster declaration on 21 May 1980, FEMA was given the task of consolidating federal and state public information operations. Among other things, that involved the establishment of an information "clearing house," which was to be staffed seven days a week, 24 hours a day by experienced public information officers from each participating agency. In recognition of the role played previously by the USFS, including that agency's activation of its own (permanent) emergency operations centre in Vancouver, and given the proximity of that location both to the mountain and to the federal government telephone system toll switch in Portland, Oregon, FEMA chose Vancouver over Olympia, out of which only the Washington state EMA was operating.

17 The impression one gets is that of an agency "standing in isolation ... while all around them information is flowing" (Saarinen and Sell, 1985: p.168).

18 See FEMA, 1980a, TIBs Nos.1-33.

19 An indication of this is the fact that as of 1980, Washington state was one of only two or three states in the United States that had not established a disaster fund.

20 As soon as the eruption occurred on 18 May 1980, the state asked FEMA for monies to purchase or lease additional emergency communications equipment for the response operation. The allocation of funding, however, was delayed by several days because they had to be released from the federal government's Disaster Relief Fund, and that required a presidential declaration of a disaster. All that FEMA's Region X office could provide in the interim was "technical assistance" - e.g., their own personnel equipped with FEMA communications equipment. Subsequent to the Mount St. Helens disaster, the U.S. Senate introduced legislation that would allow FEMA to release federal funds without a presidential declaration. The draft legislation, however, got held up in Congress and the question remains unresolved.

21 The military was not allowed (as it usually had previously) to provide direct assistance to county officials for search and rescue or other localized response operations. Local responders found this particularly difficult to accept because such assistance is part of a long-established tradition. Historically, local authorities in Washington state have turned to the military for help in, say, flooding or search and rescue operations. Thus, although it is understandable that a catastrophe of the magnitude of Mount St. Helens necessitated special procedures, unfortunately in this instance it meant that by the time the military finally was deployed to help with search and rescue around the mountain (four days after the eruption) all of the survivors already had been rescued.

22 The value of discussing with career public servants policy trends that can be linked with a concrete experience such as this cannot be underestimated. Especially beneficial is the possibility it allows for comparing current emergency communication capabilities with those available at an earlier time. This, in turn, permits conclusions to be drawn as to the role played by a specific event in effecting changes in public policy. Also valuable are the views expressed by disinterested observers of the event as well as those whose personal opinions have affected public reaction to it.

23 United States v. American Telephone and Telegraph Company, 552 F. Supp. 131, 195 (D.D.C. 1982), aff'd sub nom., Maryland v. United States, 460 US1001 (1983); United States v. Western Electric Co., 569 F. Supp. 990 and 1057 (D.D.C. 1983).

24 The NAWAS network operates as an open "party-line" whereby one or several lines can be rung to receive a direct communication from any other connected line. The service is entirely federally funded, and in 1990, the U.S. government, through FEMA, paid out approximately

US$ 200,000 for the Washington state portion of the network (which is comprised of about 40 NAWAS drops.)

At the time of the Mount St. Helens eruption, NAWAS was provided by AT&T's nation-wide Bell System. It was assigned a dedicated Priority 1-F circuit, and provided to connected local, state and federal emergency organizations "one-stop shopping" in terms of two-way emergency voice capability. However, problems were experienced with the NAWAS network on that occasion, and this, combined with the over-reliance of many emergency service organizations -- e.g., the Washington EMA -- on regular telephone for interorganizational communications, led some critics (notably the U.S. military establishment) to worry about the effects of a major industry restructuring on national telecommunications preparedness.

The AT&T divestiture decision was regarded as a threat to NS/EP telecommunications capability because it transferred responsibility for the system to the local exchange carriers. Furthermore, with divestiture, AT&T did not retain any records on the system. When the FCC eventually waived all the divestiture requirements with regard to NAWAS (the new) AT&T Communications (AT&T-C) became the primary carrier for that system.

Unfortunately, due to record keeping problems at Pacific NorthWest Bell during the transition period, when AT&T-C took on those responsibilities, it received incomplete drop-line, servicing and related information. Additionally, the essential service listings (equivalent to line load control in Canada) had been lost in the pre-/post divestiture shuffle. Finally, the incoming cable connecting that state's portion of the network to the interstate toll switch apparently had been cut. As a result, for a short period after divestiture there was <u>no</u> emergency circuit operational in that state. Also with regard to the cable cut-out, Pacific Northwest Bell was, technically speaking, responsible for handling the repair. But it had not kept either the original connection plans or the priority restoration lists needed to put the system back into operation. To resolve the situation once and for all, ATT-C rewired all of that part of the national NAWAS network.

25 That agency's chief communications officer is the APCO holding the master licence for the frequency. In this capacity, s/he can issue authorizations to emergency response organizations that request it, to program the frequency into their vehicle radios.

26 In order to access the frequency their vehicles must, of course, be equipped with a VHF radio.

27 Although the system was in place at the time of the Mount St. Helens disaster, a crucial high-elevation microwave relay station was knocked out during the eruption, rendering it inoperable across the affected area.

28 Moreover, interagency frequencies are located in the 800 MHz band.

29 Those stations not participating in the program are required, upon notification that an emergency broadcast is about to be made, to go off the air for the duration of the transmission.

30 Discussed in Chapter Six, section 6.6.3.

31 Following Mount St. Helens, the State of Washington required all amateur emergency volunteers to register at the county level.

CHAPTER EIGHT
Case Study: Hinsdale Central Office Fire

8.1 Introduction

As stated in the introductory chapter, a central theses addressed in this study concerns the effects of introducing new communication technologies on national emergency communications preparedness. Of particular relevance to effective disaster response, it is suggested, are those industry developments that could have negative implications for emergency users in a disaster situation

The May 1988 Bell Illinois' hub switching centre fire provides insights on the kinds of problems that can arise when an integral part of a national public telephone system is directly affected by a disaster agent. As will be shown, the implications for all telecommunication users in such a situation are significant. Their impact on emergency response performance is even more critical.

This chapter will take a closer look at these trends and their implications for communications preparedness. In particular, some recent technological changes, specifically, in switching and transmission, have played havoc with public telecommunications network integration and cohesion. They also have led to inconsistencies in industry technical standards and operational protocols. Moreover, they have resulted in an over-centralization of network switching and transmission facilities, thereby increasing significantly the at-risk population of telecommunication users in a disaster or other emergency situation.

The impact of these developments on emergency communications capability, it is anticipated, likely will be even greater when the physical facilities of the public network are victims of a particular disaster agent. This is because a loss of network redundancy has been seriously reduced with the introduction of (1) digital switching; (2) fibre optics transmission; and (3) powerful new software programming which has automated a large portion of traffic management practices and procedures. Additionally, the concentration of call processing capability at so-called "hub" stations has enabled individual telephone company switching centres to serve users across areas of up to several hundred kilometres. Indeed, long-distance calls originating or terminating in most Canadian and U.S. communities are now commonly channelled through telephone company switching offices located outside the caller's local calling area. In this way, the potential scope of impact of a telecommunications disaster on subscriber service -- both in terms of overall numbers of users and the size of the geographical coverage area affected -- has increased dramatically.

It is also suggested that assumptions made by many emergency responders that new communications new technologies will enhance their communications capability in a disaster or other emergency situation may be incorrect. Instead, as this case study will show, reduced facilities redundancy combined with overly centralized network monitoring via computer hook-up at distant locations has led to a situation in which emergency service users cannot assume that they will be able to communicate with individuals in other organizations using normal voice or data channels. Instead, in their own contingency planning, they now must consider alternative communication technologies that do not rely on the public switched network at all -- for example, very high frequency (VHF) or ultra high frequency (UHF) radio communications using shared emergency frequencies or perhaps cellular telephone services provided by carriers other than the local exchange carrier serving the affected area.

The main question that arises from the Hinsdale case study is as follows: What happens when telecommunication facilities experience a direct hit by a disaster agent and are put out of operation for a long period of time -- that is, several hours or days? The Hinsdale fire illustrates some of the possible consequences of just such an occurrence. It thus provides a useful measure for assessing current U.S. emergency communications capability. It can also be used to evaluate Canada's own national emergency communications preparedness capability.

Another them addressed by the Hinsdale case study relates to the possible effects of liberalized competition policies respecting the provision of telecommunications services on emergency communications capability. In this regard, the Hinsdale experience points to a number of problems that can be attributed, indirectly, to these trends in public policy. In particular, it is postulated that liberalized competition has forced telecommunication providers to emphasize profits above all else in order to survive in the marketplace. This, in turn, has caused them to streamline their operations and minimize facilities duplication at every level. It is suggested that these strategies may also be related to the erosion of national emergency communications capability generally in the United States. Indeed, as the argument goes, while corporate performance and profitability may be enhanced by increased competition, disaster communications capability has been correspondingly reduced.

Also significant are public policies in Canada and the United States that permit competitive carriers to lease some of their facilities from the telephone companies for the purposes of expanding their networks. Regulatory policies in the two countries allow service providers to purchase bulk-rate service packages from the telephone companies, "enhance" them, and resell at competitive prices. Significantly, however, governments and other clients who purchase these services from the competitive carriers may think that in this way they would be protected from total service loss should one of the network's to which they subscribe become damaged. But that is not necessarily true. Indeed, all of the long-distance carriers in the United States, including the largest ones, depend on the regional telephone companies for leased transmission lines and switching capability in areas where it would not be economically practical for them to install their own. As a result, when a telephone company loses part of its physical network, so do the other carriers. None of them will be able to provide full service to their clients within the affected area.

What all of this means is that public policies that were originally designed to improve user choice have neither promoted greater system reliability nor improved network redundancy. Moreover, it will be recalled that the majority of public safety agencies -- and especially municipal services which are always on the front-line of peacetime disaster response -- often rely on the public telephone system as their only medium for interagency voice communications. Consequently, they, too, would be adversely affected by a major telecommunications facility failure. Consideration, therefore, needs to be given to building in added transmission path redundancy, while at the same time improving overall system survivability. This is especially crucial to ensure access to alternative networks by government, public, and private emergency service organizations.

Addressing this latter concern, in Canada and the United States "priority restoration" listings are now programmed into telephone company computers to allow rapid restoration of service, in the event that it is lost, to essential service users. Similarly, essential service line or "line load control" (LLC) software programming can provide dial tone to a limited number of government and public safety users in a call traffic overload situation. Significantly, however, invokation of LLC does not guarantee call completion. It only assures the caller of being able to reach the nearest telephone company central office. After that, the caller is still subject to the "luck of the draw" for the remainder of the call transmission path. At any step (or, more accurately, telephone company switching centre) along the way, a blockage at the switch would prevent call completion. In this way, priority access to dial tone may actually mean very little indeed in a disaster.

Just the same, studies are currently being done by Canadian carriers aimed at rectifying this situation. One possible solution would involve developing a software mechanism for caller identification "tagging." In that way, the essential user's telephone number would be identified as an essential service line to each telephone company central office along the call path, and priority then would be given automatically for the communication to proceed. Tagging, however, is not yet technically possible, although the concept is part of Bell Canada's, for one, strategic plan. Indeed, it is anticipated that the next generation of digital switches will be able to provide this feature without incurring an additional cost to users. Unfortunately, however, the research in this area has not advanced very far, and Bell advises that it is not a priority item on its research and development agenda.

Moreover, even if such provisions were in place, essential users still might lose service temporarily in a situation where there has been extensive damage to the physical facilities of the public network. This is because failure of the primary transmission route will cause all of the traffic carried on it to "spill over" onto alternative routes identified in the the telephone company's switching centre central processing unit. When, in turn, a very large volume of call traffic is rerouted to other telephone company central offices, such as in peak call periods or in the aftermath of a major disaster, they too will experience congestion and possibly even overload. Thus, at a minimum, when the user's own telephone switching centre is put out of commission, regardless of the cause, service will be lost during the time required to transfer over the traffic carried on the affected lines to an alternate telephone company switching centre.

In the United States, this task may be somewhat easier than in Canada, at least in some of the larger urban centres. This is because that country's domestic network architecture allows for the automatic transfer of traffic among the local exchange carrier's central offices providing coverage to a city's downtown core. Each telephone central office is connected to every other central office in the vicinity. In Canada, by contrast, the transition away from a more rigid hierarchical configuration has not been completed. Just the same, other weaknesses of the U.S. network architecture which have reduced significantly transmission route diversification are not as apparent in Canada, making this country's public switched network less vulnerable to massive outages on the scale of those experienced repeatedly in the United States -- and especially in recent years.

8.2 Event description and response

This section gives an account of the fire that broke out in an Illinois Bell telephone switching centre located in Hinsdale, a suburb of Chicago on 8 May 1988. It illustrates some of the inherent weaknesses of North American public telecommunication systems today as regards emergency response communications capability, and thereby provides an opportunity to learn valuable lessons for communications preparedness.

8.2.1 Background

Prior to the fire, the total call volume either switched directly by the Hinsdale central office's 1AESS analogue switch or transited via the toll equipment installed at the same location was approximately 3.5 million calls per day.[1] In addition to handling local calls on 42,276 subscriber lines, 50 or so other telephone company central offices were also connected to the Hinsdale "hub" through more than 50,000 T-1 lines and 13,000 special (e.g., data) circuits.[2]

The Hinsdale facility is one of five "gateway" hubs serving the high-traffic western and southwestern suburban Chicago telephone system. Before the fire, it operated approximately 118,000 trunks for local and long-distance call routing, and it supplied voice and data communications services to six suburban communities as well as several unincorporated areas in nearby South DuPage County.[3]

Local area calls to destinations within the territory served by that central office together with toll linkups to neighbouring communities are all made via fibre optic cables connected through the Hinsdale switch. In addition, the station is homed to a long-distance access tandem located in LaGrange, Illinois. Significantly, that tandem switch, which does not deliver calls directly to customers but instead relays them between telephone company central offices, did about 98 per cent of its operations through the Hinsdale hub. Indeed, most of the calls initiated and terminating in North American area code 815 transit that central office.

In addition to serving a total of ten prefixes, the directory assistance database for downstate Illinois is also housed there, as is the "Julie hotline" used to prevent damage to buried cables (by construction crews, etc.). Furthermore, Hinsdale is the main centre for "911" emergency service and "611" repair service for more than a dozen West Chicago suburban communities. Additionally, it serves as the communications apex for air traffic control between O-Hare International and Midway airports and the Federal Aviation Administration's (FAA) Aurora aviation centre (Karwath and Sjostrom, 1988). It is also the key switching point for Ameritech Mobile Communications and, as such, is headquarters for a majority of the cellular service providers in the greater Chicago area. Finally, the Hinsdale hub is a major national switching centre for MCI and US Sprint competitive long-distance telephone services (*Telecom Digest*, 1988).

Particularly significant in terms of the damage done to the facility as a consequence of the fire is the fact that the Hinsdale central office was not staffed at the time of the fire. This, however, was not unusual at the time. Given the sophistication and reliability of today's electronic switches, "it has become standard industry practice for central offices not to be staffed during non-regular work hours" (Joint Report of the Office of the State Fire Marshal and Illinois Commerce Commission Staff, henceforth "Joint Report," 1989: p.11). The last person to enter the hub station before the fire was discovered was a customer services technician who was there to correct a line problem. He did not, however, enter the area where fire damage later occurred, and he left the building about an hour-and-a-half before the fire was detected by the building's fire alarm system.

All of the communications equipment at the site operated without either human assistance or supervision. Consequently, on weekends technicians come in only to correct problems reported by customers or by equipment-generated alarm signals monitored remotely by two separate Illinois Bell systems, each responsible for different operational functions. Building and room temperature, humidity, boiler and sump pump malfunctions were monitored by the Building Equipment Status Indicating System located in downtown Chicago. But fire alarms, power interruptions and telecommunications equipment malfunction alarms were monitored by the company's Division Alarm Reporting Centre in Springfield -- more than 300 km away. Indeed, at the time, the Springfield centre monitored some 280 unattended central offices throughout the state. Moreover, the operator monitoring the Hinsdale central office on the day of the fire was also responsible for 40 other unattended offices (Joint Report, 1989: pp. 6 and 33).

8.2.2 The fire

A controversial aspect of the Hinsdale fire was the time lapse between the first fire alarm going off at the Springfield monitoring centre and the arrival of the local fire department on the scene. Early media and telephone company accounts vary considerably -- with the reported delays ranging from 42 to 72 minutes.

According to Illinois Bell, just before 4 p.m. on that Sunday (Mothers' Day, which is one of the busiest telephone traffic days of the year) alarm signals were triggered on the console in the company's Network Control and Alarm Reporting Centre located in Springfield, Illinois. They indicated a power outage and possible fire -- the first suggestion of something unusual occurring at the Hinsdale office. At **3.50 pm**, the Springfield operator logged in "an indication of commercial power failure, a fire alarm trouble alarm, a fire alarm, an air dryer alarm and a battery discharge alarm."

At **3.53 pm,** these alarms cleared as the on-site diesel generators started up. The fire alarm trouble alarm apparently is triggered when there is a loss of alternating current (AC) power. It also sends a fire alarm signal, which clears when AC power is returned. Since power fluctuations often occurred which set off the type of alarm used at the Hinsdale office, the operator interpreted them as a power interruption rather than as a fire. At **3.59 pm,** the diesel failure alarm went off, as did an air dryer alarm, a fire alarm trouble alarm and a fire alarm, indicative of a return to commercial power. Then, at **4 pm,** the battery discharge alarm went off again, while the fire alarm trouble and fire alarms cleared. At **4.14 pm,** the Springfield console showed four separate conditions at the Hinsdale station: (1) diesel engine failure alarm (signalling a return to commercial AC power); (2) fire alarm trouble alarm clear; (3) fire alarm clear; and (4) battery discharge clear.

At **4.16 pm**, the operator called the weekend duty supervisor and reported the power-related alarms. He then began getting power failure signals from other switching centres in the area, reinforcing his interpretation that the trouble indications at Hinsdale were the result of meteorological disturbances (Joint Report, 1989: pp.11-12). Indeed, storms, high winds and tornadoes in the vicinity were playing havoc with the alarm system, causing repeated malfunctioning of the Springfield board. Moreover, high winds and an electrical storm in the Chicago area also were triggering the alarm system since they kept causing power failures. These all showed up on the Springfield console, regardless of how brief or how minor they were. Furthermore, since the alarms registered on the screen merely as a bleeping light -- with no distinguishing noise or other indication as to their severity -- the console operator may not have picked them up right away, especially if (as in this instance) he was doing something else besides monitoring that console alone (*Risks Digest,* 1989).

At **4.20 pm,** the Springfield operator received the first Carrier Group Alarm in the interoffice facility system, simultaneously with a fire alarm from the Hinsdale station. This time, the fire alarm did not clear. Consequently, at **4.21 pm,** the operator reported the fire alarm to the duty supervisor. But, importantly, he made no attempt to telephone the Hinsdale fire department -- as is required by Illinois Bell operating procedures. At **4.24 pm,** the duty supervisor dispatched a central office technician to investigate, and at approximately **4.30 pm,** he attempted himself to call the Hinsdale fire department and the neighbouring Downers Grove fire department. But both lines were out of service and the calls were not completed. The supervisor's inability to contact local fire departments by telephone resulted from long-distance service failure related to damage to on-site lines inside the Hinsdale central office.[4]

Between **4.23 pm** and **4.56 pm,** the alarm signals received by the Springfield console indicated that the Hinsdale station's equipment were working, but not very well. The computer was experiencing some interoffice problems, but local services had not yet been affected. At **4.56 pm,** all signals from the Hinsdale central office ended.

An Illinois Bell field technician arrived at the switching centre at **4.52 pm** and saw smoke coming out of the building. He tried to call the Hinsdale fire department from the telephone located in the lobby of the building and subsequently from the cellular telephone in his car, but both were out of service. He then flagged down a motorist and asked him to go to the fire department -- located about five blocks away -- to notify them of a possible fire. The fire department reported having received notification of the fire at **4.58 pm,** and firefighters were dispatched immediately. They arrived at the site at **5.02 pm** -- a full 72 minutes after the first alarm had flashed on the Springfield console and 42 minutes after the fire alarm went off which did not clear. Bell personnel at the scene, however, reported that fire fighters were on the roof of the building trying to ventilate it as early as 4.55 pm, seven minutes earlier than the time indicated by the company's timesheet.[5] Just the same, by all accounts, it took almost three-quarters of an hour from the initial "fire" fire alarm until fire trucks arrived at the station.

At **7.15 pm,** the fire department reported that the flames had finally been extinguished following repeated re-igniting due to electrical arcing. The fire was declared officially extinguished at **11.30 pm,** and at **3 am** Illinois Bell personnel were allowed to enter the building to assess the damage (Joint Report, 1989: p.14).

8.2.3 Cause, damage and prevention

As to the cause of the fire at the Hinsdale switching centre, a post-event joint investigation by the Illinois Office of the State Fire Marshal and Illinois Commerce Commission staff determined that the fire had been caused accidentally. Its source appears to have been an electrical fault associated with the contact between an armored cable and a damaged direct current (DC) power cable. The exact point of origin, however, could not be determined. Other contributing factors included repeated commercial power interruptions related to storms in the area, building vibrations, cable temperature variations and the like -- although any of these alone would not have had a causal effect if the DC power cable insulation had not been damaged already (Joint Report, 1989: p.23).

The fire broke out in the ceiling of the first floor of the central office building on an aisle running between banks of the huge metal frames holding the electronic circuitry used for relaying calls into and out of the station (Swanson and Karwath, 1988: p.1). Most of the equipment that handles the hub's flow-through or transit traffic was located close to the initial blaze point, as was the machinery that processed local calls. All of this was quickly destroyed, even though direct fire damage was confined to a 30-foot by 40-foot area of power and communications cable trays suspended from the ceiling. The fire consumed most of the wire insulation around both types of cables located there. In contrast, only minimal damage occurred to the telecommunications equipment located beneath them (Joint Report, 1989: p.14).

The rest of the switch, including the central computer processor located on the second floor and the other metal frames containing local call relay circuitry apparently were not affected by the blaze. Just the same, they were severely damaged by heavy smoke and the chemicals created by the melting of the plastic casings around the fibre optic cabling. That melting released hydrogen chloride, which when mixed with the water used to spray down the fire, formed highly corrosive hydrochloric acid (*Bellcore News,* 1988: p.1).

Within just a few minutes, the fire rendered completely inoperable the 42,000-line telephone company central office switch, several banks of high-speed multiplexers, and 63 bays of fibre optic terminals connecting it to the outside public telecommunications network (Abel, 1988). Also damaged were 8,718 carrier systems which leased lines from Illinois Bell through the Hinsdale station together with 432 fibres contained inside of six fibre optic cables which were melted together by the blaze (NCS, 1988: p.2-6).

An estimated 38,000 residential and business lines lost telephone service completely, as did 37,000 trunks. Moreover, approximately 118,000 long-distance fibre circuits and 13,000 special circuits providing some 42,000 special services -- for the most part involving computer-to-computer connections -- together with cellular services were also lost. In all, the damage affected voice and data communications for more than half a million Illinois Bell customers (Joint Report, 1989: p.17).

As a result of the fire, a total of nine local exchanges were without any service for at least a week. And roughly a third of western and southwestern Chicago suburban area customers had only intermittent service for nearly a month afterwards. In addition, tens of thousands of customers served by the 50 or so other Illinois Bell central offices whose traffic normally transited the hub station were restricted to making calls within their own local calling areas. Long-distance calls could not be completed due to an inability to access a tandem switch. Thus, even those subscribers who could get dial tone could do little with it.

Additionally, problems were experienced in a number of so-called "unaffected" areas. These resulted from the strain placed on the company's other switching offices due to the spillover of Hinsdale traffic, especially during peak periods (Holton, 1988: p.6). And as technicians gradually succeeded in manually rerouting call traffic around the disabled facility, the geographic area across which telephone service was disrupted enlarged accordingly (Frisbie and Franchine, 1988: p.3).

Roughly 9,000 Chicago-area businesses reported that they had suffered significant financial loss due to the prolonged outage. The most severely affected, of course, were those firms that normally depend heavily on telecommunications to do business. Among these, some eight telemarketing firms closed shop for the duration of the outage. Spiegels Catalogue also closed, laying off all its employees serving the area affected. In addition, a major Chicago-area insurance company claims processing centre reported that it had lost between 80 and 90 per cent of its usual volume of calls while it was without telephone service.

The system shut-down similarly disrupted thousands of banking and retail-brokerage financial transactions which relied on communications routed through the Hinsdale hub station for electronic verification. For example, of the 900 automatic teller machines in the area, fully a third were unable to complete transactions. Similarly, retail stores could not process credit card transactions. Nor could banks process cheques, order cash or wire money through the Federal Reserve System (NCS, 1988: p.2-8).

Many travel agencies in the area closed, and bank automatic teller machine systems were down for close to two weeks. Restaurants and theatres, beauty parlours, florists, limousine services, fast food vendors, etc. were all unable to take reservation or delivery orders. Real estate agents spent their days driving around to keep in touch with clients. Alarm systems at jewelry stores hooked up by telephone to security firms or police stations were out of service as well.

Nor could American Airline's computerized reservation system be accessed because AT&T 800-service was not operational. Similarly, paging companies had no way of transferring messages, and telephone answering services had to relocate temporarily to provide service to clients who retained at least some telephone service. In sharp contrast, and for obvious reasons, unlike most other businesses, message service firms, express mail and cellular telephone vendors suddenly became very busy.[6]

The loss of telephone service by subscribers, including emergency services users in the vicinity of the station, jeopardized not only police and fire protection in the area, but emergency health care as well. Local public safety organizations attempted to overcome these problems by posting radio-equipped cars at busy intersections to handle emergency fire department and ambulance calls (Schmidt, 1988: p.A-12). And police officers increased their patrols of neighbourhoods and business districts. Nurses at the Hinsdale Hospital used hand-held radios for internal communications, and an emergency ambulance radio frequency was employed for interhospital communications. In this way, other hospitals could relay messages to doctors whose pagers were no longer working. Additionally, community residents received flyers in the mail informing them of emergency communication procedures, and giving the locations of emergency vehicles and mobile telephone company trucks that were equipped with telephones which they could use until full service could be restored.

8.2.4 Questions raised

Perhaps the most significant factor delaying the response to the fire and thereby increasing the damage to the switch was the fact that the Hinsdale station was not staffed at the time. Also noteworthy in this case was Illinois Bell's policy that all of the company's major central office alarms for that portion of its serving territory were centralized at a single location. As was already noted, the Springfield alarm control centre was over 300 km away from the Hinsdale hub. Illinois Bell's rationale for its policy was its apparent concern that local firefighters might, in their enthusiasm, ruin highly sensitive multimillion dollar electronic processing equipment by hosing down the site.

A related question raised afterwards concerned the absence of a fire suppressing system at the Hinsdale station. The telephone company apparently had never installed a water sprinkler system there. The reason given by the company was that activation of such a system would do the same kind of extensive damage that water used to put out the fire on this occasion did.

As a brief aside, following another fire at a telephone company central office in New York City in 1975, American Telephone and Telegraph Co., (AT&T, the predivestiture parent company of Illinois Bell) reportedly had considered, but subsequently decided against, installing equipment containing halon, a gas that effectively snuffs out fires by stopping their chemical reaction. Moreover, halon is considered very effective on electrical fires, and it is safe to humans at levels high enough to extinguish fires. Nor is it considered harmful to computer equipment. But AT&T on that occasion decided that it would not be "practical" to put halon in buildings as large as the Hinsdale station, which took up nearly half a city block. The reasons given by the company's manager of building operations after the New York City fire for not using halon in its switching stations were, first, that corporate management thought the gas might itself damage the equipment and, second, because it "depletes the earth's ozone layer" (Karwath and Winter, 1988: p.19). It is more likely that that decision was linked to perceptions about the very low probability of such an occurrence combined with the very high costs of installation. The cost for installing a halon system at the Hinsdale site, for instance, would have been between $250,000 and $350,000 (Karwath and Winter, 1988: p.19).

In order to prevent a similar occurrence elsewhere in the future, several remedial measures have been recommended by post-event investigations. They include changes to alarm signalling (i.e., a transition to "intelligent" alarms) which can differentiate better between fire alarms and power outages. Other recommendations include staffing central offices at all times and having localized, as opposed to remote, alarm monitoring centres. Alternate emergency communications systems and improved familiarity with emergency procedures by both telephone company employees and firefighters also have been recommended because they would contribute to a shorter response time.

Furthermore, it has been pointed out that the various functions executed by telephone company central offices might be compartmentalized physically in order to permit installation of appropriate fire suppression technologies for the different kinds of equipment involved. For example, sprinkler systems could be installed in areas where sensitive computer equipment is not present. Similarly, a halon system could be installed in confined areas. In this instance, had the cable trays been better insulated from the telecommunications equipment below them, a halon system potentially would have been very effective. Finally, carbon dioxide and dry chemical agents could be used in areas where the fire is not deep-seated (as it was in this case). The Hinsdale fire also demonstrates the desirability of dividing central office buildings into compartments in order to limit smoke damage. Indeed, the Joint Report of the Office of the State Fire Marshal and Illinois Commerce Commission staff stated that the most critical preventative measure that needs to be taken is the separation of power cables from communication cables and, in addition, the separation of all cables from telecommunications equipment to the extent practicable (1989: p.37).

In addition to separating the different types of cables from each other and insulating them from electronic telecommunications equipment, the Hinsdale telecommunications disaster illustrated the necessity of facilitating de-energizing procedures for both AC and direct current (DC) power systems. Particularly significant in this instance were the problems experienced with the electrical power sources which repeatedly ignited the fire. This case illustrates the critical importance of shutting off all the AC and DC power feeding the cable trays in order to be able to extinguish the fire. However, even after shutting down the AC power, the fire could not be extinguished. This was because, at the Hinsdale office, a complete power shut-down could be achieved only by individually pulling out out each fuse for the individual power cables that fed the equipment (Joint Report, 1989: p.37).

Respecting emergency communications capability, the Hinsdale fire also underscores the vital importance of being able to communicate with public safety agencies in such a situation. It will be recalled that the alarm monitoring centre's weekend duty supervisor was not able to reach the appropriate fire departments by telephone. Nor was the field technician who went to the site at the request of that supervisor able to call in the alarm -- either from the building or from his cellular telephone. Indeed, virtually all of that state's emergency communications systems -- "including the low-band statewide radio network, the National Warning System, the Nuclear Accident Reporting System and the Federal Emergency Management Agency system" -- at the time relied predominantly on regular telephone for interagency communications (Joint Report, 1989: p.31). Possible solutions may include improvement of interoffice cable trunking, whereby major telephone company switching centres would have multiple communication routes to nearby central offices and to long-distance corridors in a disaster situation. This could involve what is called "double hubbing" or improved star architectures for the public network in order to avoid the isolation of emergency communications systems and customers. It also would have to involve improved physical diversity by placing additional cables to improve transmission redundancy capability (Joint Report, 1989: p.31).

8.3 Service restoration

It is generally recognized that the source of most public network telephone service disruptions are out in the field, not at telephone company switching centres. Most often, service loss occurs because cables are accidently dug up or cut by backhoes and construction crews. as a result, given the low probability of a fire occurring in a hub station, Illinois Bell's contingency plan for the Hinsdale central office provided for only a 25 per cent backup for its circuits. In contrast, due to the very high volume of traffic in and through the downtown Chicago hub switches, these had been provided with as high as 50 per cent circuitry redundancy (Bozman, 1988: p.121). Fortunately for essential users, this meant that about one-fourth of Hinsdale's traffic, including all of their traffic, could be quickly transferred to other hub switches. Unfortunately for other subscribers, however, it took nearly four days for just half of those circuits to be switched over. Full restoration of service could only be achieved by the total replacement of the Hinsdale switch.

Bell technicians at first thought that they would be able to return the switch to service after repairs. But sensitive metal connections inside the old switch had quickly corroded as a result of their exposure to smoke, water and hydrochloric acid produced when the fire was being fought. This made telephone service unreliable, and although replacing the 60 or so destroyed bays of multiplexing equipment -- which had been used to route long-distance calls over fibre optic cable -- would be relatively easy, replacing the more than 40,000 local circuit connections would not (Bozman, 1988: p.121). The company therefore decided to install a new, fully digitalized 5ESS switch at the site and remove the damaged analogue switch from service.

Under normal circumstances, it probably would have taken as much as a year to install a new switch. After the Hinsdale fire, remarkably, the task was accomplished in only three weeks, and <u>all</u> of the affected subscriber lines had been transferred over to the new switch within a month. This was made possible by the co-operation and technical support of the other carriers, some of whom agreed to have their own equipment orders rerouted to Hinsdale. In addition to equipment -- e.g., switch and main distribution frames -- the other carriers also provided technical advice, engineering translations (analogue to digital, etc.) and related installation support. The initial conversion stage was completed by 26 May, at which time 21,000 customers were transferred over to the new switch. First among these were fire, police and hospital lines (Joint Report, 1989: p.17). The remaining customers were transferred over on 5 June.

In the meantime, until the new switch could take over at Hinsdale, it would be necessary to slow down the corrosion so that the old switch would be able to carry at least a partial traffic load with some degree of reliability. To do this, the clean-up crew had to lower humidity levels inside the facility. They did this by erecting a kind of environmental balloon which encompassed the entire building and was hooked up to gigantic dehumidifiers (*Bellcore News*, 1988).

In addition, Illinois Bell needed a microwave hookup to relieve east-west telephone traffic congestion. To that end, a transportable microwave tower was installed atop the Hinsdale station building to relay calls that were "dead-ending" there to another microwave dish set up on the roof of the Hinsdale Hospital a short distance away. The second dish, in turn, relayed the calls to the tandem switching centre at LaGrange, Illinois (Herrmann and Frisbie, 1988: p.3). In this way, the LaGrange centre would carry most of Hinsdale's flow-through traffic until the replacement switch was installed and operational (Karwath and Sjostrom, 1988: p.6). At the same time, telephone company workers were put to work splicing new connections onto the more than 300 fibre optic cables entering and exiting the station, many of which had melted (Winter, 1988: p.9). A temporary emergency telephone station was also set up outside the Hinsdale central office; some of its lines also were connected down a nearby manhole to landlines leading to the LaGrange tandem switch.

Finally, considered a good "bare bones" alternative emergency telephone system, Illinois Bell gave special priority to restoring Ameritech's cellular telephone service which, prior to the fire, had been handled exclusively through the Hinsdale station. Thousands of cellular telephones had been left non-operational by the fire because their microwave transceivers all connected to land-based switching equipment located in the burned out station (Richards, 1988). This meant that approximately half of cellular service in the greater Chicago area was lost due to the fire and associated damage to the Hinsdale switch (*Telecom Digest,* 1988). In western Chicago suburban areas, cellular service was lost completely.

But as soon as a temporary microwave relay link between the Hinsdale and LaGrange stations was in place, cellular service using the Hinsdale central office rebounded almost immediately -- from near-zero to 70 per cent effectiveness (Swanson and Karwath, 1988: p.16). Unfortunately, technical limitations precluded it from being reserved strictly for use by emergency response organizations. This was because, at the time, there were no technical protocols in place which could have imposed essential line service, otherwise known as line load control, for cellular in order to give them priority access. Indeed, business demand for cellular increased dramatically as a consequence of the prolonged landline outage, and this placed an added burden on the restored cellular system. As a result, many automobile unit-originated calls could not be completed because they had to be routed through already overtaxed alternate cellular switching centres. Furthermore, cellular users were seldom able to receive incoming calls, with only about one in five or six such calls completed successfully -- again due to traffic congestion, this time on the overburdened public switched network (Hausner, 1988: p.17).

A brief chronology of service restoration after the Hinsdale disaster follows:

9 May 1988 -- By noon, the seven most critical of the 28 out-of-service dedicated (i.e., FAA) circuits linking computer terminals at Aurora Illinois' air traffic control centre and O'Hare and Midway airports had been restored.

10 May 1988 -- Police, fire departments and hospitals, the highest priority local emergency services, were able to function with a limited number of telephone lines, a few cellular telephones and two-way radios. Trunking was restored from the Hinsdale central office to the LaGrange tandem office using transportable microwave towers (apparently provided by MCI). Temporary trunking was also established from Hinsdale to Oak Brook (supporting FAA circuits) through the AT&T Glenview facility. Of the 8,718 carriage systems initially affected, 483 were restored to service within 48 hours.

11 May 1988 -- Ameritech Mobile Communications Inc.'s cellular system, mobile telephone and paging services became operational. All FAA priority circuits also were restored, as were 15 of the Veterans Administration's (VA) circuits linking medical centres through the VA Data System. A total of 12,000 customer lines were back in service, at least on an intermittent basis.

End of the first week -- Approximately half of Hinsdale's transit traffic, that is, calls originating and terminating outside the blackout area which had been choked off at the Hinsdale bottleneck, had been restored, including suburban-suburban, city-suburban, long-distance and 800-number calls (Swanson, 1988: p.1).

16 May 1988 -- Bellcore reported that the 1AESS switch at Hinsdale was partially operational, with 16,500 of 42,276 lines back in service. Seven of 11 line networks and four of seven trunk networks were also operational. Three emergency calling centres had been established for use by residential and business customers, as well as six coin trailers -- one in each suburban community served by the Hinsdale switch (NCS, 1988: p.3-3).

18 May 1988 -- All 23 VA medical centre and eight VA Data System backbone circuits had been restored. Bellcore reported that 67 per cent of subscriber lines also had been fully restored. Some very large users had alternate routing plans in place; these allowed their traffic to be rerouted to different hubs, resulting in only minor service disruptions. Other large companies that did not have similar plans in place were supplied with direct digital radio links to the long-distance networks of AT&T and MCI. AT&T reported connecting 25 of its largest stranded customers in the area, while MCI connected another six companies through temporary microwave set-ups. US Sprint did not have any large customers in the area with direct line-of-sight to a microwave tower; it was therefore unable to do the same. MCI estimates the cost of installing temporary microwave dishes at about $60,000 per customer -- likely to be a prohibitively high expense for all but its biggest users (Carnevale, 1988: p.1). Approximately 30,000 customer lines were back in service.

Two weeks after the fire -- The 13,000 or so "special lines" used for telephone-linked computer services such as electronic cash dispensing and lottery ticket machines were back on-line.

20 May 1988 -- A total of 41,853 Illinois Bell subscribers served by the Hinsdale central office had at least intermittent local service.

26 May 1988 -- The first 21,000 subscriber lines were cut over to the replacement switch at Hinsdale.

6 June 1988 -- The remaining lines were cut over to the new switch. Full service was restored to all Bell Illinois customers previously served by the Hinsdale switch.

8.4 Restoration priority system

This section raises some major issues related to impact of the Hinsdale central office fire on national emergency communications preparedness in the United States. Of particular concern here are those that arose as a result of the prolonged service outage following the fire. They relate for the most part to (1) the U.S. government's Restoration Priority (RP) system; (2) the activities of national security/emergency preparedness (NS/EP) users and potential private-sector RP designees; and (3) the role of the National Communications System's (NCS) National Coordination Centre (NCC) -- in overseeing and facilitating service restoration on behalf of NS/EP users.

Before proceeding, it may be useful to consider briefly the history of the U.S. Restoration Priority system. In the mid-1960s, the executive branch of the U.S. government requested the Federal Communications Commission (FCC) to work with telecommunications common carriers to develop a FCC Order relating to the restoration of intercity federal private-line service. That exercise led to the creation of the RP system. A 1968 National Communications System memorandum (No.1-68, 18 July 1968) implemented the U.S. government's RP policy and prescribed procedures for its application to federal communications circuits (NCS, 1988: p.4-1). Approximately 30,000 NS/EP-identified circuits received RP certification by the NCS on behalf of the executive branch at that time.

Several years later, a FCC Order in Docket 19305, adopted on 8 October 1980, established a uniform system of priorities. It was comprised of four priority levels to be applied for the purposes of restoring vital private-line services lost in a major natural or man-made disasters as well as in national defence and security emergencies. Under the order, the first two priority levels would be reserved for federal and foreign government private-line services, and for non-governmental private-line services designated for voluntary participation in a national emergency. A third priority level would apply to government and non-governmental services considered necessary for U.S. military defence and diplomacy, law and order, and national health and safety. A fourth and final priority level would apply to all dedicated line services required to maintain public welfare and the U.S. national economy.

The Hinsdale outage showed that the RP system was only marginally effective in meeting that country's needs for priority restoration of NS/EP telecommunication services, even though it affected only a few NS/EP-identified services. The problems experienced by NS/EP users as a result of the fire were associated primarily with difficulties in identifying individual circuits that had been lost so that they could be restored quickly.

Apparently, the RP databases of NS/EP service users did not match those of their service provider. This situation led to unnecessary delays in RP certified circuit restoration due to the inability of users to identify precisely which RP circuits had been lost. Without that information, little could be done by the telephone company to restore the affected lines. Responsibility for this situation lay with the U.S. federal government, because it had failed to provide clear guidance to its agencies on the proper application of its RP criteria. The problems experienced also related to confusion among the staff of the affected agencies as to the procedures to be followed in the case of a prolonged outage. Moreover, they were, indirectly, a product of public policy trends towards reduced regulation and increased competition -- more specifically, the FCC's Computer II decision and the AT&T divestiture.[7]

Identification information on leased circuits was not always shared between service users and providers. This was because resale and sharing policies meant that vendors of enhanced and data services were sometimes competing head-on with their suppliers. Moreover, in some cases, the RP databases of the vendor or the client included only predivestiture circuit identification. Additionally, users were not required to revalidate their RP circuits, so that telephone company records were often outdated.

For the most part, however, the problems experienced by federal agencies after the Hinsdale fire were localized and relatively minor. In fact, only 59 RP-designated lines were identified as having been lost as a consequence of that event. Furthermore, no NS/EP requests for new services were initiated as a result of the fire. And the National Coordination Center took only one NS/EP action (i.e., related to Veterans Administration RP). The affected agencies included the Federal Communications Commission, the Federal Aviation Administration, Defense, Environment, Commerce, the Veterans Administration, the General Services Administration and the National Research Council.

The Federal Aviation Administration, for instance, reported the loss of 28 voice and data circuits linking its Aurora, Illinois air traffic control centre with the O'Hare and Midway airports. The loss of those lines required the two airports to use manual procedures for managing incoming air traffic, including increasing the spacing of approaching aircraft from between 5 and 8 km to 30 km. This significantly delayed flights and backed up into the continental flight patterns, causing travel delays of up to two hours on some flights. Once the FAA succeeded in contacting AT&T and Illinois Bell, however, it was able to establish its priorities for line restoration. All FAA lines were restored by the next day.

The Department of Commerce's Census Bureau Office also reported a minor disruption of Federal Telephone Service (FTS, which provides tie-line connections among federal agencies). At various times during the weeks that followed the fire, the National Research Council (NRC) similarly reported problems with several of its FTS circuits. The General Services Administration (GSA) also reported an outage of FTS service to the Argonne National Laboratories, a Department of the Environment facility, and the NCS/Defense Communications Agency assisted in the restoration of a number of MILNET circuits connecting the Argonne Labs with five separate Department of Defense installations.

The most obvious shortcoming of the RP system that became evident after the Hinsdale fire was in relation to the Veterans Administration's loss of circuits serving its data network. Initially, the VA reported the loss of some 23 VADATS lines -- that is, dedicated lines connecting VA medical centres and regional offices to the public network's switching nodes. The Veterans Administration apparently had misunderstood the purpose of RP assignments, and they were unable to identify properly all the circuit identification numbers -- specifically, those subsegments or "tail circuits" that had been provided by non-AT&T vendors. An additional eight circuits were eventually added to its RP list once they had been located and properly identified. All of these were TYMNET backbone circuits. The only circuit numbers included in the VA's database had been those for the overall AT&T commercial circuits -- i.e., for the total end-to-end path, less the subsegment purchased from TYMNET.

In addition to government NS/EP requirements, the Hinsdale experience revealed a need to look more closely at other circuits or related services which might be operated by private sector organizations, and which could be critical to national emergency preparedness. To that end, it would be useful to identify such private telecommunication systems, include them on telephone company essential service line listings, and assign appropriate FCC restoration priorities. For example, the Department of the Environment notified the National Coordination

Center of problems experienced by Commonwealth Edison Power Company's intergrid control circuits as a result of the fire. The company had reported that they had had to rely on the four internal telephone lines that remained in service to contact their generation dispatch office, their generating stations and distribution centres as well as handle all outside calls, including to neighbouring utilities. In addition to problems experienced with internal communications, damage caused by the fire also disrupted communications between Commonwealth Edison and a North American Electrical Reliability Council (NAERC) co-ordination centre (NCS, 1988: pp. 2-9 and 2-10).[8]

Considering the National Coordination Center's role in overseeing service restoration on behalf of NS/EP users, the Hinsdale fire underscored the importance of such a centralized mechanism for co-ordinating those activities so as to ensure effective and timely service restoration to essential services users. To that end, during the month following the fire, the National Coordination Center monitored Illinois Bell's service restoration activities very closely. It also prepared daily situation reports based on information received from industry representatives. These were distributed to key federal government officials, including the Manager, NCS; the Director, Office of Science and Technology Policy; the Executive Office of the President; Joint Telecommunications Resources Board member organizations; and the Assistant to the National Security Advisor for Telecommunication and National Defense.

As regards the restoration of service to private sector activities considered "essential" to the national economy, the NCC worked closely with the Department of the Environment to identify circuits providing service to the NAERC which are considered critical to the monitoring and management of the national power grid. The NCC determined that these commercial circuits would have qualified for RP assignment had they been submitted to the FCC by an appropriate federal sponsoring agency, and it authorized Illinois Bell to proceed with their restoration on a priority basis. In its post-event report, the NCS reiterated the importance of federal agencies identifying "those organizations in the private sector which utilize NS/EP telecommunication services and encourage them to seek appropriate RPs for applicable circuits through the FCC" (NCS, 1988: p.5-1).[9]

The National Coordination Center also worked with the Veterans Administration and its contractor, TYMNET, to identify the VA's subsegment circuit numbers. It then co-ordinated this information with AT&T, from whom TYMNET had purchased the circuits. The delay in implementing the VA's RP request apparently had resulted from confusion over the "customer" listed in the commercial carrier's (i.e., Illinois Bell) database. AT&T had listed TYMNET, not the Veterans Administration, as the customer, while Illinois Bell had listed AT&T as the customer. The discrepancy stemmed from the fact that AT&T had itself leased the tail circuits from Illinois Bell, and TYMNET had, in turn, leased them from AT&T. Database confusion reigned supreme!

This problem was exacerbated by the fact that RP listings at the time of the disaster included a large number of government circuits which had been granted "interim" NS/EP-RP certification by the NCS and FCC, respectively. That practice apparently had led to major discrepancies in agency, NCS, FCC and carrier RP databases. This, in turn, placed in doubt the accuracy of RP circuit identification (NCS, 1988: p.5-1). Such an undesirable situation has particular significance for emergency communications preparedness because commercial circuit identification for all segments of a circuit path provides crucial information for the successful restoration of NS/EP circuits. As the Hinsdale experience clearly showed, without the correct circuit identification number, prolonged delays in service restoration can result, and at a time when communications capability may be needed the most.

8.5 Assessment

What began as a relatively small electrical fire in an unattended suburban switching station started a chain reaction of telephone and computer breakdowns. These eventually crippled telecommunications throughout northern Illinois and, for many subscribers, several weeks passed before service was restored fully. Due to the need to reroute the large volume of traffic normally processed by the disabled hub until such time as its switch could be replaced, the consequences of the fire were much worse that any other disaster experienced up to that time by a North American telephone company. This is because while switching hubs had existed for many years in large metropolitan areas, dozens had been needed in each since the equipment used to run them could not fit into just one or two buildings.[10]

On the positive side, centralization of telecommunications switching and transmission capability has resulted in substantial economic advantages of scale for the telephone companies. Indeed, modern electronic switches can handle nearly four times as many calls as their predecessors, and the newest digital ones will be able to handle twice again as many.

Since 1984, local exchange carriers in the United States have reduced the number of their switches by an average of approximately 10 per cent.[11] Moreover, recent technological advances have made it possible to adapt quickly to overcome most call routing problems related to the sudden loss of a fibre optic cable. Several high-volume cables enter each hub station, and this means that the affected traffic can be rerouted easily and quickly over those alternate transmission channels. Since traffic in most situations can be switched to another fibre line almost immediately, cable breakages usually are not even noticeable to the user.

At the same time, however, there are some obvious disadvantages to putting so many eggs in one basket, so to speak. When an entire hub switching centre is put out of service, as occurred in this instance, the impact on subscribers can be widespread and devastating. This is because, while Illinois Bell had backup fibre cables to handle "normal-time" contingencies, both primary and backup cables fed into the same (i.e., the Hinsdale) central office. As a result, all of them were destroyed in the fire.

Loss of service, even for a few hours, will be even more worrisome to public safety and essential services organizations than it is for other users. The U.S. Defense Department is particularly concerned about the implications of concentrating telephone equipment in vulnerable centres. It especially wants to ensure that a saboteur or a nuclear attack could not disable the national telecommunications system. According to John C. McDonald (Executive Vice President for Technology, Contel Corporation and Chair of a National Academy of Sciences panel studying this issue), "the network is getting thin enough in certain areas that if a guy like Gaddafi knew where they were, he could wreak havoc with the phone system."[12] Furthermore, its vulnerability,

> has become more important now that the circuits carry not only conversations but computer data and are crucial to the nation's commerce. Companies routinely place orders, telephone money and consult computer data banks over phone lines. A halt in phone service could ricochet through the economy, causing millions of dollars in business losses (Pollack, 1988: p.D-8).

The problems that resulted from the Hinsdale station fire can be attributed almost entirely to technologically-induced vulnerabilities introduced to the U.S. public telecommunications system. They may also be partially attributed to changes in the ways that calls are now processed. This relates to the introduction, on the one hand, of highly sophisticated technologies which have allowed the concentration of call transmission capability in high-capacity fibre optic cables, and, on the other, the centralization of switching capability made possible by advances in digital technology and system programming. This latter development has, in turn, resulted in increasingly automated switching centres that often are monitored from a distance. Indeed, post-event reports prepared by both Illinois Bell and the National Communication System conclude that much of the damage to the Hinsdale station could have been avoided had it been staffed at the time of the fire.

However, besides being unable either to communicate over the public network or to access portions of several major private voice and data networks for extended periods time (and sometimes even days), additional problems were experienced by some emergency public and private essential service (e.g., public utility) organizations as a consequence of the Hinsdale outage. These were related, as was already mentioned, to problems with the U.S. government's Restoration Priority system. They are associated, specifically, with its failure to provide adequate guidance to public agencies as to the proper application of RP criteria and restoration procedures. But once again, new technologies and industry practices have contributed to making the RP difficult to manage. For instance, it is now a common practice among the commercial carriers to restore service on a broadband basis. As a result, the definition of no less than 18 subcategories across four restoration priority levels, according to the NCS, has rendered the RP system almost meaningless (NCS, 1988: pp.4-2 and 4-3).

Furthermore, the convergence of computer and telephone technologies, and the ease of sending communications signals using a variety of transmission modes is blurring distinctions between private versus public and long-distance versus local service. Additionally, the introduction of integrated systems capabilities, and improved parallel system interoperability and interconnectivity have put into question earlier notions about networks. In this way as well, the idea of prioritizing service restoration on the basis of "circuitry" -- that is, facilities -- applied under the U.S. government's RP system has become obsolete.

Recognizing the inadequacy of the RP system in light of major recent technological advances, the National Communications System, the U.S. telecommunications industry and the Federal Communications Commission have undertaken jointly to develop and implement a new Telecommunications Services Priority (TSP) system. The key aspect of the TSP system, is that priority levels are no longer to be defined in terms of circuit identification; instead, priority assignments will be based on categories of services. In this way, it is hoped that the new system will be flexible enough to accommodate future technologies. Other features of the new TSP system include: (1) revalidation of priority level assignments by the service user every three years; (2) a requirement that the primary vendor notify the National Communications System directly of all TSP arrangements made with federal agencies; and (3) a regular periodic reconciliation of databases by the NCS, the service user, service vendors and the telephone companies.

8.6 Conclusions

The experiences of large users and, in particular, those of emergency and essential service organizations after the Hinsdale fire challenge the thesis that the introduction of new technologies improves emergency communications capability. To the contrary, this case study suggests that they actually may have a negative impact on national communications preparedness because they make the public telecommunications system more susceptible to major disruptions. The Hinsdale CO disaster demonstrates, for example, that the combination of introducing high-capacity fibre optics, digital switching and sophisticated software programming capabilities led to: (1) reduced public switched network redundancy overall; (2) an over-concentration of call traffic on a diminishing number of transmission routes; and (3) an over-centralization of call processing capabilities in hub switching centres.

Therefore, while certainly high-capacity fibre optic transmission and powerful new software for digitalized computer processing units located in centralized hub switching centres enhance voice, data and image message transfer capability in normal times, in a disaster situation -- and especially when the physical facilities of the network themselves are damaged by the disaster agent -- the repercussions for all users and, in particular, for public safety and other essential service users could potentially be serious. This is because of the much greater volume of traffic that can now be transmitted through an individual hub switch. It also means that the area of impact coverage will be correspondingly greater, and the number of affected users will be much larger if a major telephone company switch is lost.

Indeed, the plethora of private and public networks that are not always interoperable or even interconnected seems to have grown out of control. And unfortunately, many public safety users operate under the mistaken belief that because there is so much capacity and sophistication out there, their communication needs, including in a major disaster, can be met easily. The Hinsdale case shows this is not necessarily true.

With regard to Canada's emergency communications preparedness capabilities, there are some valuable lessons to be learned from the Hinsdale experience as well, even though the Canadian public network has evolved differently than that in the United States due to the distribution of most of the Canadian population within 100 kilometres of the U.S. border and the slower pace of change in the network configuration in this country associated with less rapid population growth and slower increases in business user demand.

For example, Canada does not have the same kind of hubbing structure as that found in the United States. The much smaller size of the Canadian network also means that a certain intimacy has evolved among the various players in this country as regards deciding on network architectural design modifications, etc.. Indeed, the fewness of their numbers and the association of the largest telephone companies in Telecom Canada makes it considerably easier to negotiate co-operative arrangements between government and industry to avoid or, when a disaster occurs, rectify quickly problems such as those that resulted from the Hinsdale fire. Moreover, it has made it possible for the different industry players to conclude informal arrangements among themselves for mutual aid in the event that a major carrier loses a portion of its facilities.

This is not to say, however, that the Canadian network is immune to a major telecommunications outage. Indeed, there are several common elements between the Canadian and U.S. national telecommunication systems and both domestic industries have introduced technologies which have had the effect of greatly reducing network facilities redundancy on the one hand, and increasing their susceptibility to extensive service loss on the other.

For instance, although in Canada the hub switching centre concept has not been used as extensively as in the United States, there is a heavy reliance outside of the largest urban centres on remote line technologies feeding into DMS-100 (digital) switches. This aggregation of call routing means that there is less route diversity than previously. Moreover, in Canada, other network design practices may further reduce the public switched network's flexibility in an emergency situation. In Montreal, for example, all call traffic to and from Toronto goes through a single central office. Furthermore, again unlike in the United States, telephone company central offices handling local traffic in downtown city cores are not always connected to one another. As a result, if a downtown CO loses service in a disaster, all the lines it serves will lose service as well since they cannot automatically be transferred to a nearby CO (even if it is only a few blocks away).

Another major theme addressed by this case study presented in this chapter relates to the effects of U.S. public policy trends -- and specifically, liberalized competition in telecommunication services -- on emergency communications capability. Although the assertion was made in the National Communication System's post-event report, as well as by media and other observers at the time that liberalized competition has jeopardized U.S. NS/EP telecommunications capability, the Hinsdale case does not provide empirical evidence indicating any obvious causal link between the two. This is not to say that such a link does not exist. Instead, it can only be asserted that this case study does not answer that particular question. Furthermore, it is quite possible that these trends themselves are the result of successful pressures on policy-makers by large business users to expand competition in that sector.

There is considerable anecdotal evidence suggesting that the combined effects of AT&T's divestiture and competition in long-distance voice services have pushed U.S. telephone companies to put profitability before other considerations. And as a result, they have had to streamline their operations and eliminate duplication of facilities and plant wherever possible. Additionally, it is widely recognized that liberalized competition policies have had the effect of emphasizing market segments rather than systemic integrity. This, in turn, has led to a fragmented public telecommunications system that may be difficult to organize for the purposes of integrating emergency communications capabilities. Beyond this, little more can be said other than that this area requires more study.

Since 1988, most of the problems associated with the Hinsdale central office fire have been addressed, if not fully resolved. At the same time, other major telecommunications outages stemming from a variety of causes -- such as the February 1989 fire at a Brooklyn, New York central office; an AT&T switching computer failure in Dallas, Texas; and most recently, another AT&T outage which cut off all telephone service in and out of Manhattan for almost seven hours in September 1991 -- has led the telecommunications industry and policy-makers in both Canada and the United States to take steps together to improve network survivability and reliability.[13] Moreover, the co-operative efforts of industry and government, and in particular the creation of a permanent body of industry representatives to advise the federal government on NS/EP telecommunications questions suggests a gradual settling of the after-effects of divestiture. Together, these activities appear to indicate a trend towards fuller integration of communications preparedness initiatives together with the possible emergence of a modified or new framework for emergency preparedness management analysis.

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1 See the *New York Times*, 1988: p.A-3; also see Shear, 1988.

2 Joint Report, 1989: p.17; also see Bozman, 1988: p.1; Titch, 1988: p.10; and Pollack, 1988: p.D-8.

3 Joint Report, 1989: p.6; also see Karwath and Sjostrom, 1988: pp. 1 and 6.

4 See Joint Report, 1989: p.12; and Shear, 1988.

5 Joint Report, 1989: pp. 12-13; see also Huntly and Herrmann, 1988: p.7.

6 Schmidt, 1988: pp.A-1 and A-2; and Goozner and Elsner, 1988.

7 See Richards, 1988; also see Pollack, 1988; and *The Daily Herald,* 1988.

8 The NAERC is an organization of U.S. power company representatives. It co-ordinates distribution of power across the continent.

9 The FCC has indicated that it has received very few requests from private industry for Restoration Priority (RP) certification. All such requests must be accompanied by federal agency sponsorship, and almost all of those received to date have been from the U.S. Defense agencies.

10 Jerry Hopper (Illinois Commerce Commission), in Pollack, 1988: p.D-8.

11 Amos E. Joel, Jr. (Telecommunications consultant, formerly with Bell Laboratories), in Pollack, 1988: p.D-8.

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12 The panel reported some of its findings to the National Academy of Science in August 1987. Quoted in Pollack, 1988: p.D-8. On network vulnerability, see also *The Daily Herald,* 1988; and Richards, 1988.

13 In February 1992 the Chairman of the FCC formed a "Network Reliability Council" and convened a meeting of senior government officials to discuss those outages and consider remedial action. The CRTC has accepted to be a member of that council in recognition of the close integration of the two countries' national telecommunications systems.

CHAPTER NINE
Case Study: Saint Basile-le-Grand PCB Fire

9.1 Introduction

One of the things that changes the most at the organizational level in an emergency or disaster situation is the dramatic increase in the quantity of information to be assessed within a very short period of time in order to facilitate effective response co-ordination. As a result, established authority relationships and the hierarchical communication configurations associated with bureaucratic decision-making which are appropriate under normal circumstances will become irrelevant as regular communication channels become congested or overloaded. In these circumstances, formal hierarchical intra and interorganizational communication patterns will be replaced by emergent geodesic linkages. These, in turn, will foster decentralized as opposed to centralized or bureaucratic decision-making. Moreover, greater reliance likely will be placed on private sector organizations, the resources of which will be voluntarily co-opted to meet short-term demands for essential equipment and/or expert and technical services.

Significantly, the command-and-control model for crisis management assumes a <u>stable</u> decision-making environment and complete information. Yet, this is far from the case during an actual disaster or other peacetime emergency. Furthermore, as regards emergency communications, the traditional model assumes, first, that adequate facilities will be available to provide uninterrupted communications service and, second, that decision-makers will be able to access them easily. The Saint Basile-le-Grand response experience challenges both of these assumptions.

Regarding emergency communications during the Saint Basile response operation, the effects of the breakdown in centralized decision-making that occurred in that disaster were made worse by a technological consideration: an over-reliance by many responders on a single communications technology -- cellular radio-telephone -- as the preferred medium for voice communications. In that instance, there clearly were not enough cellular channels to go around. Consequently, bringing in additional equipment actually increased the burden on the two cellular networks operating in the affected region. Moreover, in order to access the alternate cellular carrier's network, the user required a second cellular unit (with a separate telephone number) and subscription to both services.[1]

Additionally, given the small size of the two cellular companies' respective customer bases in the region surrounding Saint Basile, neither Bell Cellular nor Cantel Mobile Inc. was able to handle the upsurge in call traffic that followed the fire at the PCB storage warehouse. Nor did either company have in place at the time adequate corporate contingency plans which could have helped them to take extraordinary measures in order to cope with the tremendous increase in service demand. Furthermore, prior arrangements were not in place for one company to access the other's network temporarily in order to protect emergency users from service loss related to system overload. Consequently, emergency personnel using cellular telephone had to wait along with all the other would-be callers for a connection to their network.

Just the same, Bell Cellular reports that when the company noticed increased activities on the network, and principally from the Saint Bruno cell site, its Operations and Engineering departments set up to increase the number of channels at that site, find additional frequencies, increase the cell's power capacity, change the operational data in the MTX switching computer and implement the other necessary measures to do so. In addition, the company's crew was sent to proceed with the operation during the night so as to minimize down-time for users. After it was completed, there was a significant reduction in the amount of "fast-busy" or overload.

The regular (Bell Canada) public telephone system also suffered from traffic congestion during and after the fire at Saint Basile. The situation with respect to the public switched network was worsened by a strike by Bell's technicians. As a direct consequence of the strike, considerably more time was needed than normally to install, disconnect and reconnect telephone lines to meet the needs of the various response teams. Finally, although an emergency plan did exist for the municipality of Saint Basile-le-Grand, local responders were not familiar with it. That is because it was issued only hours before the fire occurred (Thompson, 1988: p.A-3).

In this instance, while neither the public switched nor the cellular networks were themselves direct casualties of the disaster, their response capabilities were hampered just the same. Additionally, cellular radio-telephone, as the most flexible (i.e., easily transportable) communications technology available, quickly became the hottest commodity for all types of users. The burden that this placed on the two cellular networks and their inability to work together to handle it led to added delays and, at times, considerable frustration among some emergency users.

A related question also addressed in this chapter pertains to the effects of shared disaster experience on communications preparedness. It has been postulated that shared experience will give an incentive to industry to undertake technical improvements to the network in order to avoid repetition of problems encountered previously.

Another theme addressed in this chapter is the anticipated closer co-operation between governments and industry to improve emergency communications capability subsequent to the Saint Basile disaster. Reference here is made to the evolution or emergence of voluntary co-optive arrangements such as the appointment of informal government/industry study groups to address relevant questions as they arise. It could also involve initiatives, sanctioned by government, to encourage co-operative relationships among competitive carriers for service provision during an emergency.

9.2 Description of the event

This section gives an account of the fire that broke out in the PCB storage warehouse located in Saint Basile-le-Grand, Quebec on 23 August 1988.

9.2.1 Background

Over a period of several years prior to the fire at the Saint Basile warehouse, a number of events occurred which led to a situation of "an accident waiting to happen." Indeed, the media's first reaction to the fire described it as perhaps the worst environmental disaster ever experienced in Quebec (Colpron, 1988: p.B-1). An overview of those developments follows.

Polychlorinated biphenyls (PCBs) are chemical compounds with excellent insulating properties. Added to mineral oil, they create a coloured fluid that does not burn under temperatures of 1,000 degrees centigrade. Another significant feature of PCBs is their ability to inhibit electrical flow in transformers, thereby reducing the chances of their exploding. Through the 1970s, PCBs were used widely as coolants and lubricants in electrical equipment. However, research in Canada and the U.S.began raising serious concerns about their potential hazard to health, and eventually they were banned in the two countries.

PCBs, on the one hand, are highly toxic substances. On the other hand, they are very stable elements which accumulate over time in human tissue. As regards their potential effect on human health, it has been alleged that

> prolonged exposure to PCBs can lead to serious, long-term problems including respiratory ailments, skin irritations ... and liver problems, ranging from dysfunction to jaundice. Studies have also linked PCB exposure with birth defects and low birth weights in animals (Curran and Kalbfuss, 1988: p.A-2).

In 1979, the production of PCBs was forbidden in Canada, and the federal government stopped their usage in new electric materials.[2] Moreover, older equipment that contained PCBs was to be retired at the end of its useful life. Just the same, by the time the banning came into effect about 40,000 tonnes of PCBs already had been imported to Canada. And as of late 1988, Environment Canada estimated that there were more than 26,000 tonnes either still in use or in storage in this country (Curran and Kalbfuss, 1988: p.A-3).

The same year, Environment Canada began taking an inventory of PCB waste in the province of Quebec. Interestingly, one of its employees involved in that work was Marc Levy, who later purchased the PCB warehouse at Saint Basile-le-Grand. Eventually Mr. Levy was fired for conflict of interest, but he was subsequently issued a permit by Environnement Québec to store PCBs at a site owned by him at Shawinigan Sud (Francoeur, 1988b: p.1).

On 15 August 1979, the warehouse at Saint Basile-le-Grand (then owned by Mr. Paul Allain) received a permit from the Quebec environment ministry to store 1,000 gallons of pure PCBs. On 10 October 1979, the authorization certificate increased the warehouse's storage capacity to 5,000 gallons. And on 13 May 1980, the site's PCB storage limit was raised a final time to 20,000 gallons.

In April 1981, ownership of the Saint Basile warehouse was transferred to a numbered company (1845-0858), and then to SOTERC (81) Inc. It was from the latter company that Levy's Delaware-registered company, North Central Dynamics (NCD), purchased the site. When Mr. Levy bought the warehouse, it was already half-full. Shortly afterwards, he asked the Quebec government to further increase in the site's PCB storage capacity to 40,000 gallons, but the request was refused.

Over the next four years, Hydro Québec sent more than 700 pieces of contaminated equipment, condensers and transformers to the Saint Basile warehouse for storage. In addition, Hydro paid thousands of dollars to NCD to cover the costs both of their storage and their eventual destruction. According to the warehouse's records, no additional PCBs -- either in pure or liquid form -- had been stored at the site since 1984, following notice from Environnement Québec served on 28 November 1983 advising the site owner to stop accepting delivery of PCBs (*Le Devoir*, 1988b: p.8).

In May 1985, Mr. Levy asked for a renewal of the storage permit for the Saint Basile site. The request, however, was eventually refused (in October 1986) because the warehouse had failed to conform with new, more stringent provincial regulations. Indeed, later the same month, the environment minister began a proceeding against Mr. Levy to require him to apply minimal security measures at the site. Among other things he was to: (1) inspect all of the barrels stored there; (2) replace any rusted containers; (3) maintain the access route to the warehouse; (4) construct a fence around the site; (5) install an alarm system which was also to be connected to a guardpost; and (6) complete repairs to the ventilation system and install an automatic sprinkler inside the warehouse.

In February 1987, an Environnement Québec inspector visited the Saint Basile warehouse to determine whether these requirements had been met. He returned a few days later, again after a month and for a third time two months later. By September 1987, Mr. Levy apparently had conformed with most of Environnement Québec's requirements, but a fence still had not been built around the warehouse. Just the same, the permit for the site was eventually renewed.

Less than a month before the fire -- on 31 July 1988 -- an Environnement Québec inspector again went to the Saint Basile-le-Grand storage site. This time, nothing out of the ordinary was reported, although there still was no fence around the building, and a broken window at the back of the building had not even been boarded over. Nor were any security personnel found on the premises. There were not even signs posted to warn off the curious (Boychuk, 1988b: p.A-3). Thus, despite repeated complaints by local residents, politicians and environmentalists over a period spanning several years prior to the disaster, Environnement Québec apparently had been unable to resolve the security problem at the site. Furthermore, the alarm system, although installed, apparently was not functioning when the fire broke out.

At the time of the Saint Basile fire, Levy's Saint Basile and Shawinigan Sud warehouses were the only two commercial PCB storage facilities in Quebec. Indeed, the Saint Basile site was the third or fourth largest site of its kind in all of Canada (Wills, 1988: p.7).[3]

When the fire broke out at the PCB warehouse in August 1988, the building contained, according to its records, "some 22,400 gallons of askarels in 45-gallon barrels" (EPC, 1988, p.29). Le Devoir's post-event research findings are more detailed; they also suggest that the warehouse records understated the amount of PCBs actually stored there at the time. According to their investigation, the warehouse contained up to 171,000 gallons of contaminated materials, including 26,000 of pure PCBs and askarels -- fully 30 per cent more than the quantity allowed by site's storage permit (*Le Devoir,* 1988b: p.8). A government inventory of the warehouse after the fire also found more than 6,000 condensers and more than 150 transformers stored, intact. Together, they contained roughly another 6,000 gallons of liquid PCBs. Moreover, some of the condensers were found inside of barrels along with flammable items such as clothing and other materials used in the decontamination of sites cleaned by client companies of Levy and his predecessors (Francoeur, 1988a: p.1).

The poor condition of the Saint Basile warehouse building combined with the Quebec government's apparent reluctance to shut it down underscore the difficulties of disposing of PCBs. Eleven years after the ban was issued on their production in Canada, Quebec still has not licensed or developed a facility for the disposal of PCBs. This has forced the continued storage of PCBs in Quebec under potentially dangerous conditions (Boychuk, 1988b: p.A-3).

9.2.2 The fire

According to local fire officials, the fire started at approximately 8.40 pm on Tuesday, 23 August 1988 at a PCB storage site located on Road 116 at Saint Basile-le-Grand, about 50 km southeast of Montreal. It began in a small office at the front of the warehouse and spread quickly throughout the building. Fire officials allege that the fire probably would not have spread very far had the interior walls of the building been fireproofed or had there been an operational automatic sprinkler system installed (*Le Devoir,* 1988a: p.3).

The fire departments of Saint Basile-le-Grand, Saint Bruno, Chambly and Beloeil were quickly mobilized to fight the flames, even though the precise contents of the burning warehouse were not yet known. By the time they arrived, more than half of the building was ablaze. Inside they found a stock of wood and other flammable non-toxic products stored alongside barrels of PCB-laced oil, pure PCBs and residues, many of which were unlabelled.

Approximately 100 firefighters spent some six hours trying to bring the fire under control. At the height of the fire, there were reportedly as many as 45 firefighters working side by side (Curran and Kalbfuss, 1988: p.A-1). Initially, conventional firefighting equipment -- that is, water, fire hoses and monitor nozzles -- was used. But the walls of the warehouse were metal, and this prevented the water from reaching the main blaze area. Moreover, the heat apparently was so intense that firefighters were unable to go on to the roof of the building in order to ventilate it. Finally, one of the explosions inside the warehouse blew open a large hole in the roof, finally making it possible for the firefighters to reach the flames within.

The fire was eventually extinguished early the next morning following the application of some 5,500 gallons of foam provided by the Canadian Forces Base at Saint Hubert. However, on Thursday morning (25 August) smoldering was again reported within the building, though nothing more was done at that time. But when the rain stopped and winds picked up Friday afternoon, the foam truck was called back to the site. This time, the crew worked through the evening and well into the night to ensure that the fire was completely extinguished.

9.2.3 Damage and social impact

According to Environment Canada, "the main danger during a PCB fire is not the PCBs themselves, but the by-products of their combustion" (EPC, 1988: p.30). The burning of PCBs at relatively low temperatures -- as occurred at Saint Basile -- results in the generation of dioxins; their incomplete combustion produces furans. Moreover, in the presence of chlorinated organic compounds, the most toxic of the 75 dioxins, 2,3,7,8-tetrachlorodibenzodioxin (2,3,7,8-T4CDD), are produced.

Given the potentially high toxicity of the smoke and ash fallout produced by the fire, a 14 sq. km evacuation zone was delineated in accordance with a plan developed by Environnement Québec in conjunction with Environment Canada's Atmospheric Environment Service. A computer-generated model was also produced to predict the circulation and dispersion of the toxic smoke cloud based on prevailing meteorological conditions and assuming a worst-case scenario -- that the entire contents of the warehouse would burn (EPC, 1988: p.35).

About 3,800 residents from three nearby communities -- Saint Basile-le-Grand, Saint Bruno de Montarville and Sainte Julie -- were evacuated during the two to three hours following the outbreak of fire. Another 174 families were evacuated during the next five days as the evacuation zone was redefined based on, first, changing weather patterns and, second, the results of the initial field samples. The latter showed contamination levels at between six and 22 times normal levels in some sectors (Curran and Sanger, 1988: p.A-2).

Table 9.1 below provides a breakdown of the evacuation figures by municipality as of 2 September 1988 (EPC, 1988: p.14):

TABLE 9.1

	No. individuals	No. Households
Saint Basile-le-Grand	2,350	825
Saint Bruno	470	176
Sainte Julie	2,154	730
Total:	**4,974**	**1,731.**

Statistics compiled by the Quebec Emergency Preparedness Committee put the total number of evacuees at 6,029 (Denis, 1989a: p.5). Most of those evacuated during the fire spent up to 18 days away from their homes. All the evacuees were allowed to return to their homes on the weekend of 10 September 1988.

In addition, some 60 local businesses had to close their doors for the duration of the evacuation, and many others laid off employees. In both instances, this was due to the severe drop off in business caused by blockage of parts of Highway 116 and the evacuation of residential areas nearby the disaster site (EPC, 1988: p.66).

Hundreds of gallons of water had been used to fight the fire before the decision was made to switch to foam. Contaminated by the toxic by-products of the fire, all of it had to be gathered up and stored in tanks hauled onto the site by Sanivan. Eventually it, too, would have to be decontaminated (Curran and Kalbfuss, 1988: p.A-2).

Another problem experienced after news of the fire was broadcast over the 10 p.m. news on radio and television was a situation of telephone system overload. Literally thousands of calls were made into and out of the affected and surrounding areas. According to one media account, "Lines into Saint-Basile were overloaded between 10 pm Tuesday and about 2 am [Wednesday] during the fire" (Curran and Kalbfuss, 1988: p.A-2). This problem continued intermittently through most of the next day as people attempted to contact family members residing in Saint Basile and the other threatened communities in the area. Bell Canada reports that calculations were not made of exactly how many calls were attempted during that time, but it suggests that it would take tens of thousands of simultaneous communications to jam up its circuits.

Post-event estimates conclude that the fire consumed roughly 1,680 gallons of askarels, containing about 60 per cent PCBs. It also consumed between 1,000 and 5,000 gallons of contaminated oil from transformers and condensers. Fortunately, however, only 15 per cent of the pure PCBs stored at the warehouse burned in the fire -- considerably less than Environnement Québec's preliminary calculations. This low percentage helps to explain the relatively low concentrations of PCBs, dioxins and furans that were found in the various kinds of samples taken from the evacuation zone and surrounding agricultural lands. PCB contamination levels in both apparently were either minimal or nonexistent, except for the area adjacent to the warehouse. Moreover, traces of the dioxin 2,5,7,8TCDD, the most toxic of those measured, similarly appeared only in the immediate vicinity of the warehouse. Nor did the contaminants penetrate any homes in the area. Surprisingly, samples taken from inside the evacuated homes showed levels comparable with those normally found in urban areas. Indeed, the toxic concentrations resulting from the fire were no greater than maximum daily limits established by Canadian, U.S. and European authorities (*Le Devoir,* 1988c: p.10).

In retrospect, the evacuation and response operation -- which included bringing in teams of international and Canadian PCB experts, housing evacuees in hotels for almost three weeks, etc. -- may seem exaggerated in view the actual damage incurred. However, given the lack of prior experience combined with the absence of reliable information on the contents of the burning warehouse, the unavailability of the site's owner and heightened public awareness about environmental hazards, it is understandable that drastic measures were taken in this situation. Furthermore, environmental experts have reaffirmed that the evacuation, under the circumstances, was justified.

Before the fire at Saint Basile, the biggest PCB fire in Canada had taken place in 1984 at Hydro-Québec's research laboratory at Varennes, also on the South Shore not far from Montreal. At that time, some 670 litres (about 150 gallons) of PCB-laced oil were partially burned. That clean-up operation took more than a year to complete, and it produced a total of 3,200 drums of toxic waste, each containing 204 litres. The cost involved on that occasion amounted to $15.7 million. The largest PCB fire experienced in the United States occurred in Binghamton, New York, in 1981. And while on that occasion, the fire burned for only 45 minutes, it started in the basement of an 18-storey building and the ventilation system carried contaminated soot throughout the building. That clean-up took over three years to complete and cost more than US $50 million (Boychuk, 1988a: p.A-7).

After the fire at Saint Basile, almost 4,000 barrels of toxic liquids remained in the burned out warehouse. And during the weeks that followed, the local fire department was called back to the site three times to deal with small fires caused by smoldering embers (*Maclean's,* 1988b: p.16c). Eventually, a 12-foot industrial fence was built around the building and all of its contents were placed in sealed containers. These were to be removed for destruction as soon as a place could be found to send them. Many individual law suits also were filed along with three class action suits initiated on behalf of evacuated residents. Those charged include the Municipality of Saint Basile; the warehouse owner; the Quebec government; and, finally, Hydro Québec -- whose PCB-contaminated oil was stored there.

Estimates of the evacuation costs alone are estimated at approximately $4 million. Other costs associated with decontamination, overtime for police and other response workers, fire fighting, compensation for crop destruction and lost business by firms located within the evacuation zones, etc., as of August 1989, amounted to at least $30 million (Scott and Derfel, 1989: p.A-1).

9.3 Response operation

The response operation related to the fire at the Saint Basile-le-Grand PCB storage warehouse involved several elements. They include: (1) firefighting and extinction of the fire; (2) evacuation of threatened populations; (3) provision of temporary lodging for evacuees; (4) medical examinations of those individuals in the evacuated area at the time of the fire as well as of response workers exposed directly to the fire's by-products; and (5) gathering and testing samples of human blood, livestock blood, milk, vegetable products and other foodstuffs, soil, air and water in the evacuated areas. As the discussion in the subsections below indicates, the experience at Saint Basile illustrates some of the problems with traditional approaches to disaster management initially used on that occasion. It also provides evidence of their replacement by co-operative arrangements and concensus decision-making, together with the associated replacement of bureaucratic hierarchical linkages between organizations with an emergent geodesic expert network.

9.3.1 Multijurisdictional response

It will be recalled that according to Canadian law, the first responsibility for peacetime disaster response is at the local level. The Saint Basile-le-Grand fire, however, required the partial evacuation of three separate municipalities. Furthermore, PCB storage is a matter of provincial jurisdiction. In any case, the scope of the disaster quickly escalated beyond the capability of all of the municipalities to cope as the full extent of the risk to their populations and the environment was revealed.

Given the nature of the Saint Basile disaster, Environnement Québec initially assumed the role of lead department in co-ordinating provincial assistance to the affected municipalities, given its established authority regarding PCB storage and the major threat that the fire's by-products posed to the environment. At the request of the provincial government, Environment Canada also came in to provide support. In addition, a private firm, EcoRecherche, assisted with sample gathering and the contamination analyses, while another private firm, Sanivan, was contracted to gather up the water used to fight the fire in order to prevent it from contaminating the surrounding soil and water table. Additionally, the response team included participants from the three affected and two other neighbouring municipalities, various departments of the provincial government and as many as 12 federal ministries, together with individuals from the affected communities, several amateur radio operators, many Red Cross volunteers, and a number of individual environmental and PCB experts (Tremblay, 1991).

During the first hours after the outbreak of the fire, Saint Basile's firefighters joined forces with those who came from nearby communities with whom mutual aid arrangements had been established. They were later assisted by National Defence personnel as well who brought in foam trucks from the Canadian Forces air base at Saint Hubert to extinguish the fire.[4] In addition, 60 or so policemen from the Sûreté du Québec (SQ) co-ordinated traffic control along routes accessing the site. They also set up a five-kilometre long roadblock along route 116 where it crosses Saint Basile and maintained it throughout all of the next day (*Le Devoir*, 1988a: p.3).

In the meantime, municipal police, with the assistance of the SQ, began evacuating families from residential areas around the disaster site. In situations such as the one at Saint Basile, it is usually up to the mayor to declare a state of emergency and take the decision to evacuate areas at risk. But both the mayor and deputy mayor of Saint Basile were out of town at the time. Consequently, the evacuation was initiated at the instruction of the municipality's director general. It was based on the recommendation of Environment Canada whose meteorological service had employed a computer model to project the toxic smoke cloud and fallout coverage area using information from local weather forecasts, including wind direction and velocity, for the evening and night of 23-24 August.

The federal Department of Communications was requested, via the regional director of Emergency Preparedness Canada, to arrange for the provision of additional communications equipment and services to the various government and voluntary agencies operating out of the joint emergency operations centre set up at the Saint Basile City Hall. Local school authorities, the Red Cross, and hotel owners in the region also were asked to assist the operation by providing temporary shelter to evacuees -- although most of them went to the homes of friends or family members. The prolongation of the evacuation for a period of two-and-a-half weeks led the Quebec government to ask Employment and Immigration Canada to grant financial compensation to evacuated residents and affected businesses.

In addition, over several days after the fire, Environnement Québec and Agriculture Québec were involved in taking samples in the affected region so that the levels of contamination from PCBs, furans and dioxins could be accurately measured. Similarly, Health and Welfare Canada prepared a list of dairy producers in the area and took milk samples for contamination testing. In all, some 472 samples of milk, vegetable products, foodstuffs, soils, air and water were taken from the evacuated areas (EPC, 1988: p.31). Additionally, Canadian and international environmental and PCB specialists were brought in to provide expert advice about the sampling methods and analysis procedures to be applied in order to arrive at standardized results.

An embargo also was placed immediately by Quebec's Agriculture minister on all produce grown within the 14 sq km evacuation zone (Buckie, 1988: p.A-3). Following the first sample test results, however, it was revised to include only that produce grown within a 3,500-acre area immediately adjoining the disaster site. The minister also ordered the destruction of all the fruits and vegetables grown in the gardens of evacuated residences. In addition, the Quebec environment minister decided to take additional precautionary measures by decontaminating residents' homes inside the evacuation zone -- although this was not required by either Canadian or international teams of PCB experts as a prerequisite to re-entry.

The air samples were analysed by the Ontario Ministry of the Environment's Trace Atmospheric Gas Analyser (TAGA 3000) and the Department of the Environment of New York State's TAGA 6000. Samples of soil, water, etc. were sent to ten laboratories throughout Canada in order to reduce the time required to conduct a conclusive analysis.[5]

Quebec health authorities, in turn, arranged for blood sampling and medical examinations for all of the evacuees and response workers exposed to smoke and fallout from the fire. Approximately 4,000 samples of human blood were gathered and medical evaluations were done for approximately 5,500 persons who had been in the evacuated area at the time of the fire (emergency Preparedness Canada, 1988: p.31). Epidemiological follow-ups also were conducted on the 450 or so response workers who had been exposed directly to the fire's by-products (King, 1988: p.A-3).

On 28 August, Premier Bourassa unexpectedly appointed the Sûreté du Québec to assume responsibility from Environnement Québec for provincial operations with respect to the fire. At that time, new emergency operations headquarters were set up near the Saint Basile City Hall, which was not adequate to accommodate response personnel from all of the government and voluntary organizations involved. Liaison officers also were appointed at that time to co-ordinate work among the various agencies.

The first five days after the fire were characterized by the following activities. First, the evacuation of residents from the threatened area (within the first two to three hours) and lodging them temporarily -- in schools, hotels or with friends and relatives. Second, establishing security arrangements to protect evacuated homes and secure the site of the fire. Third, the circulation of rumours about the dangers posed by the fire due to inaccurate and often contradictory information provided to the public by the various agencies involved. Fourth, medical examinations and other sample testing which further increased the level of uncertainty and mistrust of evacuees toward public authorities. In addition, during that period there was a convergence to the region of politicians, bureaucrats and the media. The period also was characterized by rivalries among provincial government ministries and agencies over leadership, although this was reduced considerably over time, and ad hoc co-operative arrangements and alliances gradually emerged which were based on a combination of shared concerns and individual good will (Denis, 1989a: p.8).

The next several days were characterized by what has been called the "management of waiting" -- for sample test results and the all-clear for evacuees to return to their homes (Denis, 1989a: p.78). The waiting finally ended on 10 September. The main characteristic of this latter period was the replacement of interagency tensions and jurisdictional turf battles which had characterized the earlier period, with increased co-ordination, co-operation and consensus decision-making with respect to the various response activities (Ibid.).

9.3.2 Co-operative disaster management

Over the 18-day evacuation and response period, several measures were taken by the different levels of government as well as among private citizens which resulted in a shift away from a command-control approach towards co-operative and "co-optive" disaster management. One such measure was the activation of a ministerial committee led by the Quebec premier's cabinet chief. It was comprised of the provincial ministers of the Environment and Agriculture together with the Bureau de la Protection civile du Québec (BPCQ, now Sécurité Publique du Québec). Also invited to participate on that committee were Emergency Preparedness Canada's (EPC) regional director for Quebec, and the mayors of Saint Bruno, Sainte Julie and Saint Basile (until the latter's return, that municipality's director general).

Additionally, an intermunicipal co-ordination committee was established which was led by the director general of Saint Basile. This committee included representatives from each of the affected municipalities, and from Quebec's Environment and Agriculture ministries, the BPCQ, Environment Canada and EPC.

A federal representatives committee was also created to co-ordinate the federal government's intervention. Chaired by the EPC's regional director for Quebec, it included participants from the federal ministries of Agriculture; Communications; Employment and Immigration; the Environment; Health and Welfare; and National Defence. Also participating on the committee were the Canadian Housing and Mortgage Corporation; CN Rail; and a Bell Canada representative. Quebec ministries, and in particular the BPCQ, were invited to sit on the committee as observers, but only a single representative from Environnement Québec attended one of the federal discussions.

In addition, citizens groups were formed by evacuees and concerned residents from each of the affected municipalities. Their primary function was to pressure government authorities at all levels to provide more complete information concerning the disaster and its potential effects on their lives. They also worked together to get financial compensation for evacuated residents and shut-down businesses.

Finally, an ad hoc committee of Canadian and international PCB experts was set up to evaluate the results of the sample testing, and assess the immediate and long-term environmental risks associated with the fire. The group issued its recommendations on 9 September 1988;

they included an "okay" for the evacuees to return home. At the same time, the need was expressed for a meticulous cleaning of the air intakes of all the air conditioners and fans that had been operating during the fire as well as of any surfaces exposed to smoke and soot from the fire -- such as the outsides of resident's homes, automobiles, etc. The group recommended first, the destruction of vegetables, fruits, etc. grown inside the contaminated zone; second, the establishment of an environmental monitoring program to prevent similar situations in the future; and third, the creation of an epidemiological and medical follow-up program (including veterinary). It also pointed to the need for measures to be taken aimed at improving the preparation of response groups for dealing with chemical accidents, including a clear definition of the tasks and responsibilities of each person and agency that might become involved with sample test analysis. Finally, it urged the decontamination of the warehouse site, and the removal and destruction of the associated contaminated waste (EPC, 1988: p.39).

9.3.3 Problems encountered

Regarding the response co-ordination in this instance, Emergency Preparedness Canada reported on 2 September on some of the problems that had developed to that time. They relate primarily to information exchanges among the different agencies and levels of government. Specifically:

> the Federals are feeding all they have to their provincial counterparts and no feedback seems to be available (the same is happening between municipal to provincial). The reason for this is that internal directives have been passed down in the provincial departments that all information is to be sent to the Ministers and Premier's offices and they will decide what is good to be said (EPC, 1988: p.15).

Just the same, according to EPC, for the most part federal/provincial liaison problems were recognized and resolved before they became serious, and federal representatives "strove to ensure that all our services and support to the province caused as little difficulty as possible." The objective, in their view, was "to encourage the provincial and municipal representatives to call on federal agencies for any needs that they could not fill themselves" (EPC, 1988: pp.115 and 116). As far as could be determined, no criticism was made afterwards by either provincial or municipal authorities of the assistance provided by any of the federal agencies.

The same, however, cannot be said for the province's performance. Indeed, the media and residents of the affected communities have been very critical of the premier and Environnement Québec -- especially for having allowed the risk to exist in the first place. The Quebec government also has been criticized for its failure in the early stages of the disaster to provide adequate information on, first, the precise nature of the disaster and, second, the associated risks to public health and the environment resulting from it.

It is suggested that the majority of the problems experienced at the provincial level during the Saint Basile response operation can be attributed in part to lack of experience with major environmental or technological disasters. They also may be partially attributed to the Bourassa government's decision to call upon the Sûreté du Québec rather than the BPCQ oversee the provincial response.

9.3.4 Command-and-control model

It will be recalled that Canadian law has mandated Emergency Preparedness Canada with oversight responsibilities regarding federal intervention in peacetime disasters -- regardless of the nature of the emergency. With respect to the Saint Basile disaster, Quebec's premier assigned similar responsibilities to the Sûreté du Québec. Consequently, in addition to its traditional security role, the SQ was given an entirely new one to play -- as co-ordinator of governmental intervention.

A particularly difficult duty associated with this role involved handling all questions related to public information (Denis, 1989a: p.24). As might be anticipated, the agency's unfamiliarity with the task led to criticism by the public and the media that the government was holding back information about the risks associated with the fire, and that it was not telling the public what was being done to rectify the situation. Similar consequences might be expected if, say, the federal government gave responsibility for handling public information in a national emergency to the Royal Canadian Mounted Police or the Canadian Armed Forces. At Saint Basile, the result at first was an emergency management approach of the "command-and-control" type -- one that, it has been argued throughout this study, may not be appropriate for peacetime emergency or disaster management. That is because events of this kind require specialized and interdisciplinary expert advice as well as carefully orchestrated co-operation among divers response organizations in order to ensure an effective response and relief operation.

As was mentioned earlier, the support roles played by the federal departments and agencies involved in the Saint Basile response were clearly articulated to all the responders and to the public. In contrast, those played by the Quebec government were perceived by the other responders, media observers and the public as vague, overlapping, confused and confusing.

Adding to these problems was the frequent substitution of some of the provincial representatives, notably, those from Environnement Québec. Another factor that contributed to perceptions of confusion at the provincial level was the inability of the regional representatives of provincial ministries to take decisions in joint meetings without first obtaining approval from Quebec City. As a consequence, the establishment of informal co-operative relationships with provincial participants, which it has been suggested is crucial to effective multijurisdictional disaster management, was much more difficult to accomplish than was the case with either the municipal or federal responders.

Another practice that discouraged informal, non-hierarchical linkages with and among provincial participants at Saint Basile was a policy imposed by the premier's office a few days after the fire to keep information about provincial activities under wraps and centralizing it at a single point of entry and exit -- namely, the Sûreté du Québec. That policy was particularly difficult for some provincial and most other interested parties to accept, especially since previously information related to the fire and the response effort had been shared freely by Environnement Québec and other provincial players. An important effect of this decision was that reliable alternative information sources that serve to enhance trust relationships and prepare other agencies as well as the public (via the media) for the implementation of government assistance programs could not be established. Instead, everyone but a few information brokers -- and including other provincial departments that were expected to implement them -- appeared to have been left in the dark as to what the next move by the province would be.

Additionally, three separate municipalities had been directly affected by the event, and several provincial ministries had active roles to play in the response -- the Sûreté du Québec in helping with the evacuation of affected communities and blocking road access to the evacuation zone; Environnement Québec and Agriculture Québec for sampling and testing to determine contamination levels: Santé et services sociaux for testing human blood samples and giving medical examinations to those exposed to toxic smoke and fallout. Occasionally these roles overlapped, and sometimes it was not clear which agency was responsible for what specific intervention. This, in turn, led to problems with the flow of information among government agencies -- again supporting the idea that hierarchical communication configurations, which may work well under normal conditions, are too cumbersome to permit rapid exchanges of information that are essential to crisis decision-making. The response experience at Saint Basile demonstrates, therefore, that effective peacetime disaster management relies on effective horizontal in addition to vertical, and flexible inter and intraorganizational as well as interjurisdictional communication linkages.

Some of the problems experienced during the Saint Basile-le-Grand disaster also suggest the need for a clearer definition of mandates together with the associated tasks and responsibilities of each agency involved in a multijurisdictional response operation. In addition, they underscore the importance of co-operative relationships among responders within and between organizations, and among government and private sector participants. They also emphasize the necessity to involve the media and, through them, the general public by sharing information which on the one hand may help to alleviate anxiety, and, on the other, will serve to educate the public on ways to reduce the impact of the disaster on their own lives.

The conclusion drawn here is that the Saint Basile-le-Grand response provides empirical evidence suggestive of the emergence of an ad hoc geodesic disaster network. That network, over the course of the disaster response and relief operation which on that occasion spanned several weeks, gradually replaced formalized bureaucratic linkages and, thereafter, facilitated effective response, including public education about the risks involved and measures being taken to lessen them. It also served to foster a spirit of good will and a willingness to co-operate in the future among the various response participants. Finally, evidence of tension and conflict among the various response agencies in the first days after the fire in their vying to gain control of the situation, and their gradual replacement by co-operative arrangements based on individual good will and an over-riding desire to resolve the situation as quickly as possible also supports our thesis that the guiding model for emergency management is not appropriate for disasters such as occurred at Saint Basile-le-Grand.

9.4 Emergency communications support

The role of the federal Department of Communications (DOC) during and after the Saint Basile-le-Grand fire, as in other major disaster situations, was to provide support to federal agencies and, at the request of provincial authorities, to provincial and municipal response organizations as well respecting the acquisition of additional communications equipment and services required for the response operation. Significantly, activation of the DOC's emergency plan for telecommunications allowed the department to identify quickly the communication requirements of the various agencies involved and to co-ordinate with industry suppliers the resources the necessary resources to meet them.

Fortunately, at the time of the fire, Saint Basile was already well served in terms of communications. This was due primarily to the proximity of the community to Montreal. As a result, cellular radio-telephone units, repeaters, pagers, etc. were available locally. Moreover, the nature of the disaster was such that existing communication facilities were not affected directly.

Soon after the fire broke out, the regional director of Emergency Preparedness Canada placed the DOC regional officer responsible for emergency measures on alert. What transpired subsequently, from that officer's perspective, is summarized below in an excerpt from a personal record of the event. As will be seen, it provides a good illustration of the role played by informal and personal relationships among responders, particularly in terms of processing requests for emergency support communications and facilitating their provision -- in spite of the limited availability of communications equipment locally and a shortage of cellular channels and landlines in the affected area.

23 August

8 pm	Fire broke out in the PCB warehouse at Saint Basile-le-Grand. More than 4,000 persons were evacuated. The danger relates to the release of dioxins and furans, two highly toxic gases produced when PCBs burn at low temperatures. 20,000 gallons of PCBs are stored at this warehouse.

24 August

1 pm	Call received from Emergency Preparedness Canada [Regional Director, Quebec]. I was informed of the situation, the federal involvement and was asked to prepare our emergency plan in case it is needed.
11 pm	Asked by Environment Canada to install at the City Hall of Saint Basile-le-Grand (204, rue Principale) four independent telephone lines and a fax machine. Requested for 06h00, 25 August.

25 August

12.10am	The director of the Saint Basile Central Office advised that no lines are available in the vicinity of the City Hall. Similarly, Bell Canada could not supply fax machines.
12.15am	Call placed to the home of the Bell Cellular contact to have four cellular telephones.
12.30am	Call placed to fax suppliers in Montreal to obtain a machine. No success.
1.10 am	Call to the Emergency Operations Centre, CNCP [now Unitel] in Montreal for a fax machine. The order was taken, but I was asked to find a free line at Saint Basile.

On 25 August, DOC staff went to Saint Basile to evaluate the situation in order to determine more precisely the kinds of support communications that might be required in addition to those already asked for. Given the very limited communications equipment available locally and the large number of federal, provincial and municipal agencies (17 in all) together with telecommunications industry representatives involved in the response effort as well as the convergence of hundreds of government officials and the media on the area, the department

anticipated that it would have a significant role to play in helping with the response co-ordination.

The needs of the various government response teams included, in addition to two-way voice communications, the ability to transmit and receive images and data, and to send (secure) confidential status reports to the provincial premier and senior provincial and federal bureaucrats. During the course of the 18-day response and recovery period, the DOC:

> co-ordinated the installation of 31 telephone lines, including three "In-watt" lines, the rental and operation of seven facsimile machines, the rental of 17 cellular telephones, the rental of a pager network and the repair of a VHF radio communications system (EPC, 1988: p.58).

The department also considered the possibility of establishing a temporary microwave link between Saint Basile and Montreal to accommodate the dramatically increased demand for long-distance communications. This could not be done, however, because it would have required the installation of a repeater station on Mount Saint-Bruno, and it was located inside the evacuated zone.

Just the same, local telephone lines included in the line load control program maintained their priority access to the public switched telephone network. Furthermore, in order to satisfy the need for additional telephone lines at the Saint Basile emergency operations centre at City Hall, Bell Canada was asked to recover non-priority lines and reassign them to the different response agencies as needed. The reassigned lines had to be taken from among those located within the evacuated zones. Then, when the temporary emergency headquarters of several of the responding agencies were moved out of the Saint Basile City Hall on 27 August (because the building was unable to accommodate all of them), the DOC was asked to co-ordinate the transfer of lines and equipment to several vans brought in to handle the overflow.

Some of the main difficulties reported by the DOC with respect to providing support emergency communications during the disaster included, first, the complexity of establishing priorities in co-ordinating communications service and equipment provision to such a large number of responding parties; second, the unavailability of fax machines on very short notice; and, third, the overloading of the public switched and the two cellular networks. Of course, it did not help that Bell Canada technicians were on strike at the time, or that on the same day as the fire, a major cable on the Victoria bridge had been sabotaged, cutting off communications between the Island of Montreal and south shore communities for several hours the same evening. As a consequence, on the evening of the fire it took more than an hour of trying to reach Bell Canada in Montreal in order to ask for help. Calls could not get through, and in this instance, the message had to be passed along to the Bell Canada offices in Montreal over a police radio communication network patch-through. Nor did it help that Bell Cellular, for instance, was unable to gain access to its cell site covering the disaster area due to the fact that it was located within the evacuation zone. (The company had to wait four days before it could access it.)

After the event, the DOC reported that three vital communications tools, in addition to regular telephone, had been used during the Saint Basile disaster and for the response operation. They included: (1) facsimile (fax) machines; (2) pagers; and (3) cellular radio-telephones (EPC, 1988: p.59).

Fax machines, in this instance, provided a useful means for distributing instantaneously maps, graphics and reference materials, including background information on PCBs, etc. In this way, the response teams could be advised quickly of changes in, for instance, evacuation zone delineations based on meteorological updates and computer-generated smoke dispersion and fallout models. Similarly, government officials could be apprised of the situation as it unfolded from details on the response operation outlined in status reports prepared right at the disaster site. The availability of fax also enabled government officials and politicians temporarily relocated to Saint Basile to keep abreast of public reactions as indicated in newspaper reports and the like. Finally, information regarding sampling results and PCB toxicity could be distributed quickly to interested parties.

Pagers were also used extensively during the Saint Basile response. Their particular appeal lay in their portability. Operations personnel so equipped could maintain contact with their supervisor or office without having to call in at scheduled intervals. These systems were particularly useful as a backup to telephone and cellular given that the latter two were in short supply and subject to intermittent service disruptions. Another advantage to pagers in support of governmental response during a disaster is that the paging companies can trigger pagers directly through their terminals in the event that the telephone system fails.

Digital display pagers provide a particularly attractive option when used in combination with cellular telephones by respondents in the field. This is because they have a considerable advantage over cellular in that their batteries are good for approximately one month, as compared with cellular, whose batteries generally last for seven to ten hours of normal use, and probably less if a lot of communications are being made during a crisis.[6] In this way, respondents equipped with both a pager and a cellular telephone, could receive their calls on the pager (one that identifies the caller's telephone number), and then call back on their cellular. This combined service is now offered by the cellular companies.

As regards the difficulties reported by the DOC with respect to cellular radio-telephone technology during the Saint Basile response, the worst involved network overloading after press conferences. At those times, calls from the media to their Montreal offices tied up most or all of the available channels on both cellular systems, and other users -- including emergency response personnel -- were unable to complete their calls. Given the potential importance of this technology in emergency response, the next section looks some of the strengths and weaknesses of cellular as an emergency communications medium which came to light as a result of the Saint Basile experience.

9.5 Cellular communications

Cellular radio-telephone has several advantages and disadvantages which are pertinent to emergency communications preparedness. These are discussed in the subsections below

9.5.1 Advantages

One of cellular technology's main advantages is the transportability of cellular telephone units. They can be either vehicle-mounted -- that is, installed permanently in the user's vehicle -- or handheld (three-watt attached to a battery pack, or 0.6 watt cordless). Their easy portability allows emergency responders to take their communications medium along with them -- to the disaster site, the emergency operations centre, wherever. Moreover, the telephone number assigned to an individual cellular unit is valid throughout the serving area of the service provider (and in the case of Canadian telephone company affiliates, those of the other telephone companies through Cellnet). This means that regardless of where the responder is located at a given time during the emergency or disaster response period, if the unit is within receiving range (and, of course, if it is turned on), the user can be reached.

Another advantage of cellular is its good record for reliability. Certainly it is as reliable as other two-way voice technologies. Cellular provides a backup to both the local and long-distance network in situations of congestion. This is because the microwave networks operated by each of the two cellular companies operating in Quebec are (for the most part) physically separate from that of the public telephone system. It is, however, necessary to qualify this statement because the experiences of some emergency responders (such as occurred after the earthquake in the Chicoutimi region in late 1989) have shown that when a cellular unit is registered in a region other than the disaster or emergency site, it may be difficult to contact that unit by telephone.[7] For example, if the user of a unit registered in Quebec City is responding to an emergency in the Montreal area, callers from the Montreal area who want to contact that person have two options. They may contact the cellular unit via its network entry point at Quebec City, which involves a circuitous call transmission routing and, additionally, incurs two long-distance charges (one for the caller and and one for the cellular receiver). Alternatively, the caller may compose two numbers; using this option, the caller would dial the first number to access the network entry point of the cellular at Montreal, wait for dial tone, and then compose the cellular number. Both options seem unnecessarily complicated; it would be more useful, particularly in an emergency situation, to simplify the process by allowing the user to transfer temporarily the unit registration (that is, its automatic identification to the cellular system computer) to the affected region.

A third advantage of cellular radio-telephone in emergency situations is the fact that this technology enables responders so equipped to communicate with one another -- both intra- and interorganizationally -- instantaneously. Furthermore, that ability extends beyond the disaster site to local and long-distance calls connected through either the public switched or the user's cellular network.

Finally, facsimile and computer communications can be transmitted from and received by cellular units equipped with these optional capabilities. In this way, response teams can be notified of changing meteorological conditions, such as expanding or shifting flood areas, etc. as soon as that information becomes available. In the case of the Saint Basile PCB fire, for instance, updated maps indicating wind direction and velocity shifts and the corresponding projected fallout coverage area could be transmitted instantly to evacuation teams to expedite the evacuation of the communities at risk.

9.5.2 Disadvantages

Unfortunately, there are also some significant disadvantages associated with cellular technology which came to light during the Saint Basile disaster response. Many of these have not yet been resolved, and they therefore need to be taken into account in communications preparedness planning.

One of the most significant of these is the restricted geographical coverage area for cellular service. At the present time, cellular service is available only in those urban areas considered by the service providers to be large enough to create a potentially profitable client base. In small towns and villages and along sparsely populated corridors linking the small number of urban centres in Quebec (areas where there would be only a minimum number of cells and a correspondingly small number of cellular call channels available), it may be difficult or impossible for cellular subscribers to place or receive calls.[8]

Additionally, would-be emergency users of cellular require some basic theoretical knowledge of the system and a certain amount of training in order to use the network properly. This means that in a situation such as the fire at Saint Basile-le-Grand, response personnel who were not familiar with the technology had to learn how to use it on the spot, and telephone company and government communications staff had to go there to train them -- in the middle of the emergency. For obvious reasons, it is not desirable to take responders away from their operational duties at such times in order to teach them new skills.

Thirdly, as noted earlier, portable cellular units rely on batteries. At the time of the Saint Basile fire, those units could only be used for a few hours at time before their battery had to be recharged. Moreover, to do so, the unit had to be turned off completely -- for a period of 12 to 16 hours! Today, by contrast, a standard Motorola unit, for example, can provide reliable service for approximately 18 hours on "stand-by" or 75 minutes of "talk time." Generally, this means that the battery is good for between seven and ten hours of normal use. In addition, batteries now clip on to the smaller units (0.6 watts), and a second battery can be provided which makes it possible to use the unit virtually indefinitely. A recharge rack can also be mounted in the cellular user's vehicle to facilitate the battery switchover and recharge process. Similarly, for the larger (3-watt) portable units, two or more batteries of the same type can be provided and recycled between use and recharge.

Fourthly, as was mentioned in an earlier section, in a major emergency or disaster, cellular service may be disrupted by traffic overload. During the Saint Basile disaster response operation, for example, emergency call blockage related to cellular system overload occurred on several occasions, in particular following press conferences. At those times, delays in accessing the cellular network sometimes lasted for 15 to 20 minutes.

Indeed, after the October 1989 earthquake near San Francisco, GTE California reported that its older technology VHF mobile radio-telephone system, though less effective under normal conditions, had outperformed cellular during the first few days of emergency conditions:

> Hand-held and vehicle equipped TM (Telephone Maintenance) VHF radios worked very well and were used extensively for critical communications. Community Emergency Coordinators were supplied with hand-held units and VHF radio equipped vehicles were parked at designated Emergency Centres. Hand-held and VHF radio equipped vehicles were also used for critical communications within the telcos (BCTel, no date: p.69).

This situation is worsened by the fact that cellular systems are still unable to guarantee network access to essential users. That is, there are no priority access or service restoration programs currently in place for cellular. To provide that capability for emergency communications, the cellular companies would first have to create, and then maintain updated listings of essential service cellular numbers which would be programmed into their cellular control computers. Preference could then be given automatically to emergency users to access the cellular network or to recover lost service before other subscribers. Technically speaking, it appears that it would be a relatively simple matter to put such a program into place. Indeed, cellular already employs "handshake" recognition of the unit requesting a call channel by the base switching unit that provides it. Consequently, in order to provide priority access to essential users, the cell base station simply would accept the priority call and refuse others, based on the extent of network congestion at the time.

Northern Telecom is currently working at developing software that would provide the cellular companies with something called an "Access Overload Class"; this would take care of the priority access issue. Cantel, for instance, advises that it expects to have in place by spring 1993 a new computer software application program that will allow priority calling based, to begin with, on a listing of emergency service numbers for federal and provincial government users (i.e., similar to line load control for regular telephone service). Bell Cellular similarly has plans to put in place a priority-calling program. In addition it may eventually add on a "bumping" capability to handle prolonged non-priority calls already in progress in an emergency situation. It is important to note in this regard, however, that call bumping would be neither automatic nor instantaneous. Instead, the caller would receive a message warning that they have another five or ten minutes before losing their connection. In that way, non-priority users would be protected to some extent at least by being allowed to complete their call, rather than being cut off without warning.

A related solution also being considered by the cellular companies operating in Quebec to reduce the likelihood of cellular network overloading would involve the creation of a new customer group number -- say group No.58.[9] In this way, a small number of emergency service units could be modified physically and reprogrammed to operate on a special "code 3," for example, in contrast to other users who would operate on a "code 2" mode. This would mean that activation of one of those units would signal the cellular switching control computer to give it priority access to its network.[10] In a disaster situation, some of the channels available within a given cell could then be set aside for the special customer group (No.58 or code 3) callers, while the remaining channels would be available to other cellular users on a first-come-first-served basis. Of course, there then would be fewer channels to go around and the regular cellular channels would become congested more quickly.

The cellular companies report that if such a mechanism were in place, within a period of just a few hours, as many as half of the channels allocated to a particular cell could be reserved for these pre-identified numbers and specially programmed emergency units. It would, of course, be up to the various government departments or bureaus to decide which of their units are to be designated for priority calling, and subscriptions would have to be taken out on both networks for those units. It needs to be emphasized that it is important to keep the numbers of units to be so designated as small as possible. It is also important not to wait until a disaster occurs before asking the cellular company to make that changeover. This is because it takes time to (re)program the units, and it is not within the financial interests of the cellular companies to stockpile them for emergency applications.

The creation of a special customer group and code 3 programming could also provide a partial solution to another problem with cellular experienced by emergency responders at Saint Basile, namely, the restricted number of channels available in non-urban area cells. The cellular companies advise that while it is possible to increase the number of channels within a cell covering a disaster site within several hours in most cases, arrangements have not yet been negotiated with the Quebec government to determine who would assume the costs of doing so.

Each cell in a cellular network currently has a maximum capacity of 45 channels. In large cities, of course, there likely always will be plenty of channels available, even during a major emergency. For instance, if a disaster were to occur in downtown Montreal, it is not expected that either Bell Cellular's or Cantel's network would become overloaded. That is because demand for cellular service has been sufficient to warrant that each company invest in many cells covering the city core (each of which has the maximum channel capacity). The risk of system overload, therefore, is small since a free channel could easily be borrowed from a nearby cell.[11] By contrast, in less populated areas cells have fewer channels and the risk of overloading the system in a disaster situation becomes correspondingly higher.

There are two possible ways to increase channel capacity to provide or improve cellular service at a disaster site. First, an entirely new cell site could be added to extend the area of service; this solution would be prohibitively expensive. Alternatively, the channel capacity of a particular cell could be increased -- to the maximum of 45 channels; this would allow the same number of simultaneous conversations as numbers of channels available. Again, it is very expensive to do this, especially within a short timeframe. Cellular companies usually increase the number of channels in a cell only as normal subscriber demand warrants. Just the same, a government could ask the company to do so in an emergency situation. But it then could be expected that the associated costs would be defrayed by the agency requesting the increase.[12]

A transportable cell site could provide the ideal solution for cellular service provision at a disaster site not already served by cellular. Just the same, a transportable cell site could not guarantee coverage of a disaster area if it cannot be connected to the cellular company's microwave network (see endnote 8). Cellnet recently advised that it is planning to purchase a transportable cell (at a cost of roughly $1.8 million).[13] They also advised that while it is expected to be used mainly to replace defective cells, it is also their intention to make it available for disaster response.

Another limitation of cellular service in emergency applications is the fact that it may not be possible to access the alternate network if the subscriber's own network becomes overloaded. Only recently have cellular units capable of operating on both networks become available on the market. Significantly, however, interconnection between networks apparently is still difficult -- unless the unit has been programmed with two telephone numbers, a different one for each network. Emergency services organizations, as was already mentioned, need to be encouraged to have on hand at least a few units that are able to access the two networks. The users of units that are so equipped would, of course, have to subscribe to both networks.[14]

Another shortcoming of cellular technology concerns system redundancy. The cellular switching centres (i.e., control computers that manage call traffic within and between cells), together with the microwave systems linking the different cells, require backup capability. According to Cantel and Bell Cellular, both companies now have plans for backup computer capability for their serving areas in Quebec. In the case of each, two separate switching systems will operate side by side; consequently, if the primary one breaks down, the other will be able replace it almost immediately. Additionally, both networks' control computers and cells are now equipped with their own generators and/or batteries to back up the commercial power supply.

Unfortunately, the microwave systems of the cellular companies remain vulnerable should a tower be sabotaged or fall in an earthquake, for instance, or be lost in a mudslide. To overcome this weakness, co-operative arrangements are in the process of being negotiated among the several of the commercial carriers to provide short-term relief should some portion of any communications (including telephone, cellular or radio communication) microwave system fail, regardless of the cause.

A further inadequacy of cellular technology in emergency applications that became apparent during the Saint Basile crisis is the impossibility of conference calls. At the present time, the most that can be achieved is a three-way call. Just the same, conference-like calling might be achieved between private branch exchange (PBX) lines and individual cellular units. With respect to alerting emergency response cellular users, in the absence of a conference-calling capability, the cellular "mailbox" feature (i.e., an electronic mail system) can be used to send a large number of (one-way) messages simultaneously.

In light of all of these shortcomings of cellular technology, it is obvious that cellular cannot be regarded as a panacea for meeting emergency response communications needs. Indeed, it would be a serious mistake to regard it as a potential replacement for other emergency communication systems that are usually employed in disasters. Just the same, cellular does provide an attractive alternative or backup medium for very short-term emergency requirements (e.g., in the first hours after a disaster occurs) -- such as providing on-site communications until telephone lines can be installed, emergency radio communications established and the like. Subsequently, cellular would revert to its more appropriate role as a supplementary rather than primary emergency communications medium.

9.6 Lessons learned

Several lessons can be learned from the response to the Saint Basile-le-Grand PCB fire. In particular, it provides evidence of a trend towards co-operative disaster management, refuting the central thesis and suggesting instead a shift away from traditional military-style command-and-control approaches. Moreover, with regard to emergency communications, it reinforces the notion of emerging ad hoc, non-hierarchical linkages based upon informal and personal relationships among the response players. Those relationships may exist prior to the event or, alternatively, they may develop during the response operation itself. At Saint Basile, some of them resulted from negotiations with neighbouring communities before the fire to establish mutual aid arrangements; others evolved during the 18-day response period after the fire; still others have emerged over the period since that disaster -- in particular, those that are still being forged between government and the telecommunications industry.

The Saint Basile experience also supports another idea expressed in this study that telecommunication systems can be expected to become overloaded quickly in an emergency. It is therefore essential for emergency responders to be familiar with alternative communication technologies (including knowing how to acquire them) as a complement to pre-established relationships with their counterparts in other agencies and industry.

9.6.1 Consensus disaster management

Bureaucratic decision-making and hierarchical communication configurations are unlikely to be effective in disaster situations such as occurred at Saint Basile-le-Grand. This is because normal-time relationships, both organizational and interorganizational, are too rigid to permit rapid decision-making and resolution of problems arising within the highly dynamic context of a major disaster.

Furthermore, technological or environmental disasters require the assistance of technical and scientific experts and the co-operation of the public at large to implement disaster management decisions once they are taken. At the time of the Saint Basile fire, the only Canadian precedent (i.e,. a major disaster requiring the immediate evacuation of thousands) was the 1979 Mississauga train derailment. In that instance, as at Saint Basile, established procedures for normal-time contingencies were inadequate to meet the extraordinary demands imposed by a disaster of such magnitude. As a consequence, on both occasions innovation and consensus decision-making predominated the response operation.

After Saint Basile, a post-event report was commissioned by the Quebec government to assess its performance (Denis, 1989a and 1990). In that report, three conditions were considered crucial for effective disaster management in situations of this kind. First, while there is certainly a need for expert advise to government in disasters of this nature, in situations of prolonged uncertainty such as occurred at Saint Basile, value judgements will play a central role in decision-making relative to, for example, "acceptable" levels of contamination. Second, it is essential for individual responders to respect the different approaches of other participants; they must also be open to spontaneous negotiation in order to facilitate rapid decision-making and implementation. Finally, a mediatory approach -- in this study referred to as the command-and-control approach -- is necessary; it would be based on co-operation and mutual support. In other words, elaborate disaster management structures likely will prove ineffective if the will of the responders is not oriented towards co-operation, and regardless of pre-established rules and practices (Denis, 1989a: pp.77 and 78).

9.6.2 "Communications"

Dr. Denis' (1990) assessment of the Quebec government's response to the Saint Basile-le-Grand fire involved interviews with 84 individuals who had been involved in that operation. Those interviewed included six municipal and provincial politicians, 68 civil servants from three levels of government, and ten representatives of private industry and the media. Her report concluded that "communications" was one of the weakest factors of crisis management during Saint Basile. Under the term communications, specific reference is made to interagency linkages and public information messages -- rather than to telecommunications per se.

The report also makes several recommendations for remedial action based on the Saint Basile experience. Particular emphasis is placed, in the first place, on developing a knowledge of and a "trust relationship" with other responders, "thereby permitting ad hoc adaptations at the disaster site at the moment of the emergency" (Denis, 1989a, exec summ, translation).

Similarly, Emergency Preparedness Canada, in another post-event analysis, this time of federal performance during the Saint Basile-le-Grand response operation, concludes as follows:

> One cannot make the acquaintance or determine the credibility of persons adequately during a crisis period. The responding parties and managers should establish links and relations during normal conditions. Meetings to exchange information and discuss problems related to emergency operations should be organized regularly. The persons concerned should make an effort to participate (EPC, 1988: p.119).

In that way, trust relationships will already be in place when an emergency occurs, and aggressive rivalries among response organizations will be less likely.

Returning to Dr. Denis' report, the need is also expressed to establish a co-operative liaison between politicians and the community in emergency situations. In addition, more involvement by Communications Québec (in conjunction with the BPCQ) and in addition to providing technical support is recommended with regard to co-ordinating public information -- rather than, as occurred at Saint Basile, assigning that function to the provincial police. Also considered important is a close professional analysis of message content in order to avoid issuing contradictory and confusing information which might cause unnecessary anxiety among the affected population and the public at large.

Considering "telecommunications" during the Saint Basile response operation, a number of specific recommendations were provided by Emergency Preparedness Canada. They address primarily some of the difficulties experienced with interagency communications.

> Communications systems quickly become overloaded during an emergency such as Saint-Basile-le-Grand. It would be beneficial to list and retain a bank of additional resources. The protocols for using equipment should already be known by the responding parties. They should strive to learn how to use these new tools before being forced to do so by events (EPC, 1988: p.119).

EPC emphasizes, in particular, the need for prior knowledge of and familiarity with the alternative means of communicating during a disaster -- as a complement to pre-established personal relationships among potential responders.

Significantly, no mention was made in the EPC report of making more communications equipment available to responders. Instead, the point is made that improved communications preparedness would include the preparation of (detailed and geographically specific) resource inventories so as to expedite the provision of communications equipment during an emergency. The preparation of such an inventory would facilitate the creation of a network of relationships among equipment suppliers, service providers and a core of emergency managers and responders. This, in turn, would expedite the provision of additional communications capability during a disaster.

9.7 Post-event developments

Developments subsequent to the Saint Basile disaster in the area of emergency communications planning also support for the thesis that shared disaster experience will lead to improved emergency preparedness. As a result of the many problems experienced during that response operation, companies providing telecommunications services in Quebec have taken several significant steps to improve their emergency communications capability.

For example, the two cellular companies, Bell Cellular and Cantel Mobile Inc., advise that they have each been working to improve their contingency plans on the one hand and, on the other, have co-operated to develop an overall regional emergency plan for cellular services. In addition, each company has been actively involved in a government/industry working group, under the auspices of the Quebec Regional Emergency Telecommunications Committee (CRTU-Québec). That group is involved in resolving problems and raising issues related specifically to cellular service provision in emergencies.[15] In addition, they have looked options such as purchasing a transportable cell site (i.e., a cellular switching centre) that could be made available to provide new or additional cellular service at a disaster site. Another possibility considered by the cellular companies would involve stockpiling a small number of pre-programmed cellular units which could be dispatched quickly to a disaster site for distribution among responders.

A third activity undertaken by the cellular companies since, and as a result of, their experiences related to Saint Basile PCB fire has been the training of municipal authorities on emergency cellular applications. A final activity by the cellular companies has involved conducting research on the creation of a permanent mechanism that would enable them to give access to both networks and service restoration on a priority basis to emergency responders. This, of course, also would involve resolving technical and regulatory questions related to full system interoperability and interconnection between the two networks in emergencies.[16]

In addition to actions taken by the cellular companies to improve emergency service provision, cellular technology has also made advances which have been positive for emergency cellular service. One of the most significant of these relates to power source improvements and cellular units that can connect to both networks (albeit using a separate telephone number for each). As was mentioned earlier, portable cellular units, including the smaller 0.6 watt cordless ones, can now be operated virtually continuously. Batteries can be clipped on and off the unit, enabling them to be changed easily and allowing the the user to use the unit while they are recharging. Moreover, the time required to recharge cellular batteries has been reduced significantly, from 12 to 16 hours to about six.

With regard to other activities initiated after Saint Basile aimed at improving emergency communications capability in the Quebec region, the CRTU-Québec has played a key role as a catalyst for stimulating discussion and initiating studies on questions pertinent to emergency communications users and service provision. In addition to the cellular group, another ad hoc working group also has been established under the CRTU-Québec to investigate ways to improve long-distance communications in emergencies. One of the options being considered by this group would involve developing a mechanism to allow pre-identified users, such as mayors and local emergency measures personnel, to access the federal and provincial governments' private long-distance networks in an emergency or disaster situation.

Another, longer-term program to improve emergency communications capability is being worked on at Bell Canada as part of that company's plan to upgrade local switching capability by converting most of its switches to digital. It is anticipated the conversion will eliminate the need for special programs to allow priority access to the local network (such as line load control). These more efficient, higher-capacity switches would be able to protect pre-identified essential line numbers automatically even during the heaviest call load periods following a major disaster, and without depriving other users of access to the network.

In addition Bell Canada also advises that it now has a fully equipped mobile central office which could be transported to a disaster site by truck or helicopter. Bell also could make available a transportable microwave tower and a generator. Significantly, the company would be willing to make these transportable facilities available to other telephone companies in Quebec and Ontario in the event of a major telecommunications failure. Telesat Canada similarly advises that an MSAT earth station could be dispatched quickly to a remote disaster area were other communications services are not available, and that it could be operational within minutes of being delivered to the site.

Two post-Saint Basile activities of the federal DOC are also relevant to this discussion. The first relates to the CRTU-Québec, the function and activities of which are the subject of another chapter. Briefly, theat committee has used the Saint Basile experience to stimulate emergency communications planners to come up with new ideas (and ways to realize them) which could enhance communications preparedness in Quebec and, ultimately, elsewhere in Canada.

The second involves the DOC's ongoing work to develop an emergency communications curriculum to be used in training municipal emergency measures personnel on how, for example, to develop their own disaster contingency plan for communications. Courses are now being offered through the EPC College at Arnprior, Ontario, on a regular basis, including in the French language, and arrangements are being worked out with Communications Québec to offer similar courses at the regional level. These courses serve another purpose as well; they bring together small groups of emergency measures officers for a few days during which time there are many opportunities to work together, relax and get to know each another. In this way, relationships are established which may evolve into an ad hoc geodesic expert network that could be activated in a disaster situation. At the same time, the shared experience of learning together will increase the likelihood that some of them will keep in touch and continue to share their experiences over time -- what they have read; successful budgetary requests for emergency communications equipment; the establishment of a common frequency shared among local government agencies; negotiating communications mutual aid arrangements with neighbouring municipalities; setting up an intermunicipal emergency communications system, and the like.

Considered together, the post Saint Basile-le-Grand activities in the area of emergency communications preparedness just discussed suggest that shared experiences during and as a consequence of that disaster have significantly improved emergency communications capability within Quebec. In the first place, the incident brought to light some of the major weaknesses of cellular technology, previously considered by many disaster managers as a panacea for resolving any emergency communications problem. Secondly, it has stimulated ongoing discussions and studies to find solutions to some of the major problems experienced during that response operation. It has also led service providers to retain an interest in improving services for emergency users as part of normal corporate strategic planning.

9.8 Conclusions

The evidence provided in this chapter refutes basic assumptions of traditional approaches to emergency management and suggests that it is inappropriate for describing what occurred during and after the Saint Basile-le-Grand disaster. In addition, the thesis that new communications technologies will enhance disaster communications capability also is challenged by the evidence, especially when it leads to over-reliance on a single medium (in this instance, cellular telephone).

In a similar way as that suggested by the Hinsdale case study presented in Chapter Eight, the experiences of emergency responders during the Saint Basile disaster raise serious questions about whether new technologies such as cellular telephone have, in fact, promoted emergency telecommunications service reliability and enhanced public network redundancy. It will be recalled that most public safety agencies, and especially emergency services organizations which are always on the front-line of peacetime disaster response, continue to rely almost exclusively on telephone, including cellular, for interagency emergency communications. Consideration, therefore, needs to be given to improving transmission path diversification by, for example, allowing -- or perhaps even requiring -- intercarrier interconnection in an emergency situation. At the same time, work needs to continue on improving existing public switched network survivability.

In both Canada and the United States, "priority restoration" listings are programmed into telephone company computers to permit rapid restoration of lost service to essential line users, regardless of the cause. Similarly, essential line treatment or line load control software programming can guarantee dial tone to roughly a tenth of government and public safety users in a severe local traffic overload situation if they are served by a digital central office switch.[17]

Significantly, however, current Canadian network architectures are not able to ensure interoffice call completion.[18] It will be recalled that line load control assures only that the caller will be able to reach the nearest telephone company central office switch. After that, they are subject to the "luck of the draw" for the remainder of the call transmission path. That is, at any transfer point or transit switch access point along the way, a blockage at the telephone company switch will prevent call completion. As a consequence, guaranteed dial tone for LLC subscribers may actually mean little in a disaster situation because that portion of the public switched network beyond the caller's end office may become congested very quickly and it could remain that way for hours.

The situation is no better for cellular service. Indeed, it may be worse, since this medium, too, depends on telephone company switches to access the terrestrial telephone system. Moreover, a restricted number of radio frequencies have been allocated to cellular service. This means that within a given cell, a maximum of 45 calls can be made simultaneously. And many rural cells, without physical modification of the cell base station facilities, cannot accommodate even that many. Additionally, there is currently no technical way to cut off a call in progress or to give priority access to the cellular network to an emergency response user.[19] Furthermore, arrangements have yet to be worked out that would allow emergency cellular users to access the alternative carrier's network automatically in an overload situation in order to improve their chances of successfully completing their call. At the present time, the only way to do this is to be dually equipped, and even then, the only way to access the other network is by hanging up and trying again on the user's second number.[20]

Studies also are under way presently to look at the problem of en route toll or long-distance call blockage on the public switched network in an overload situation. Little progress has been made so far in this area, however, and Northern Telecom advises that the project is not a priority one on its research agenda. One possible solution, it has been suggested, would be to develop a mechanism similar to the "travelling class mark" -- that is, a way to "tag" an emergency call and identify each central office switch along the way that the caller is to be granted priority access.[21]

Another question addressed in this chapter relates to the effects of prior disaster experience on communications preparedness. It has been postulated that disaster experience will provide an incentive to industry to make technical improvements in order to avoid repeating problems encountered in an earlier disaster. It also has been suggested that shared disaster experience will induce governments and industry to work more closely together to improve their disaster preparedness capabilities.

The post-Saint Basile initiatives of Cantel Mobile Inc. and Bell Cellular support this thesis. Since that incident, each company has worked to develop a corporate emergency plan. In addition, they have co-ordinated their efforts for the joint provision of disaster cellular communications. And they are looking at new ways to improve their separate and combined emergency capabilities. This process has involved studying options such as (1) the purchase of a mobile cellular switching centre; (2) stockpiling a small number of pre-programmed units that could be delivered to a disaster site for use by emergency response teams; (3) providing training to municipal authorities on emergency cellular applications; and (4) creating a method for providing priority network access and service restoration to public safety and other pre-identified subscribers.

As regards increased co-operation between governments and industry, certainly the Saint Basile disaster experience appears to have significantly increased response agency and industry awareness of the need for closer collaboration in order to ensure better management of technological and environmental disasters. To that end, two government/industry study groups were created after the disaster by the CRTU-Québec to address questions related to, respectively, cellular radio-telephone in emergencies, and long-distance network overload. These groups are made up of experts from the telecommunications industry, government, and academia, and the tasks performed by them provide examples of co-operative and co-optive emergency planning. Furthermore, it is anticipated that the next time a large-scale disaster occurs in Quebec, the relationships among the various responders participating in the CRTU and its subcommittees likely will form the basis of an emergent geodesic expert disaster network, and thereby will enhance emergency communications provision.

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[1] Dual-network units are now available on the market. But all that this means is that they can be programmed by each cellular company to access its own network. Crossing over to the other network automatically is not possible since only one network at a time can be used. In addition, two monthly subscriptions would be payable, even if the user only wants to access the alternate carrier if service is lost on their primary network.

[2] Their production was prohibited in the United States a year earlier.

[3] Hydro-Québec also has five major sites of its own. It has approximately 1,000 tonnes of PCBs (about one-fifth of the provincial total) stored in over 100 locations in Quebec. Environment Canada reports that within the Montreal area alone there are more than 350 companies or institutions storing some quantity of hazardous oil, while waiting for a disposal facility to open. In all, there are an estimated 700 storage sites for PCBs in Quebec (see Hamilton, 1988b: p.A-7).

[4] Based on the Saint Basile Fire Chief's assumption that the fire was a structural one and should be fought with water, several hours passed before the decision was made to switch to foam. Advocates of water saw foam as useless because of the large space involved; advocates of foam, in contrast, argued that the addition of water to a PCB fire would increase the level of furans emitted (Denis, 1989a: pp.13-14).

[5] An analysis of furans and dioxins samples requires on average between three and five days to complete.

[6] Cellular units draw from their battery power source whenever they are turned on. Consequently, even if they are only turned on to "stand-by" (so that they can receive calls), this uses up charge time.

[7] This observation is based on a personal communication from DOC, Ottawa.

[8] There are ways, however, to provide special users with cellular service, even though the service network is far away. For example, during hte response to the Baie Comeau forest fire on Quebec's north shore during the summer of 1991, the Sûreté du Québec relied on cellular as a backup to their regular VHF network. The SQ was provided with yogi antennas which were able to capture the signal from Québec Téléphone Cellulaire's network located on the south shore, in Matane. In addition, cellular telephone equipment was installed in a number of vehicles that arrived at the disaster site without their regular VHF radio and repeater capabilities. The distance from those units and the Matan cellular network ranged from 40 to 55 km.

[9] Bell Cellular advises that its police unit subscribers are assigned to group No.53 (at the cellular switching centre level), while an average user would be in customer group No.52.

[10] For obvious reasons, a simple modification of the cellular unit without some other access protection would be ineffective since any good technician could modify a cellular unit without notifying the cellular company.

[11] For this reason, it is a good idea to equip emergency service cellular users with three-watt rather than the smaller 0.6 watt units. This is because the greater power capacity/range of the larger unit makes it possible for it to search out a free channel from a greater distance. Unfortunately, many emergency response users prefer the fancier small (now, in some cases, even pocket-size) units.

[12] Bell Cellular advises that on eight separate occasions since Saint Basile, it has itself decided to increase the channel capacity of a cell covering a disaster site in order to alleviate overload problems. No bill was sent out on any of these occasions -- perhaps because without an agreement on who would assume the cost, there was no one to whom it could be sent!

[13] Cellnet is an association of the cellular companies affiliated with the regional Canadian telephone companies (i.e., Bell Canada, BCTel, etc.). In a similar way to the Telecom Canada association of telephone companies, Cellnet companies work together to provide standardized services on a national level. See section 4.2.4 in Chapter Four.

14 The monthly subscription cost for each network is reasonable; it amounts to approximately $15, plus usage charges.

15 That committee is the subject of the case study presented in Chapter Ten.

16 Although cellular service provision is not regulated by the Canadian-radio Television and Telecommunications Commission (CRTC) emergency interconnection with the public switched network of Bell Canada (which is regulated by the CRTC), for instance,would require CRTC approval.

17 Modern digital switches such as Bell Canada's DMS-100s are tremendously efficient at handling heavy call traffic loads. Indeed, recent developments in digitalization of that company's network, it maintains, has effectively rendered the line load control concept obsolete -- in the sense that it has become unnecessary to invoke LLC in areas served by high-capacity switches. Just the same, untill all of the older electromechanical and analogue switches are replaced by digital switches capable of dynamic call processing, provisions such as those provided by ELT/LLC will need to continue to be made to give emergency subscribers priority access to the local network.

18 That is, traffic between telephone company central office switches. Line load control/essential line treatment only ensures dial tone -- that is, access to the nearest central office.

19 Cantel and Bell Cellular advise that by mid-1993, they expect to have in place priority access capability for a small number of pre-identified government users. Initially, it will be similar to line load control in that call completion outside of the cell within which the caller is located at the time will not be guaranteed. However, given the different cellular network management computer applications program as compared with landline telephone, it probably will be easier to modify the application to ensure intercell call completion as well, as long as the call does not have to pass through the public switched network -- such as, for example, a call placed to another cellular user on the same network. In addition, Bell Cellular reports that it has plans to introducea call bumping capability as well. This would advise non-essential users that their call will be automatically terminated in, say, five minutes.

20 Dually equipped cellular terminals have only recently become available on the market, and two separate subscriber numbers -- one for each cellular company -- are programmed into them. In this way, callers wishing to place a call on the Cantel network would use their Cantel cellular number; to place a call on the CellNet network, they would use their CellNet company-assigned number. Crossover is not possible; that is, there is no mechanism for attempting a call first on one network and then on the other, without reinitiating the call (personal communications, Bell Cellular).

21 A modification to the public switched network to prioritize interoffice, including long-distance calls for pre-identified essential users would require a new North American standard and a new network architecture. In any case, the high costs just to research possible solutions by Northern Telecom, for example, means that they will not put it on their R&D agenda unless a directive is received from senior management, at the request of government (Personal communications, Northern Telecom and BCTel).

CHAPTER TEN
Case Study:
Comité régional des télécommunications d'urgence - Québec

10.1 Introduction

The case study presented in this chapter looks at the establishment and operation of the Comité régional des télécommunications d'urgence - Québec (Regional Emergency Telecommunications Committee - Quebec, hereafter, CRTU-Québec).[1] The other case studies included in the previous three chapters assess thecentral thesis and related themes on the basis of reports of actual disaster response operations. In contrast, the CRTU-Québec provides a model of a planning mechanism for communications preparedness. Significantly, the CRTU-Québec along with its RETC counterparts in the other provinces and territories does not have a direct operational or response function in disasters or other emergencies. Just the same, member organizations may be asked to provide emergency communications services and/or equipment if the needs of responders surpass their existing capabilities.

As will be seen, this case study provides empirical evidence of a shift away from the traditional model towards more co-operative, consultative and, as regards private sector expertise, co-optive behaviour in Canadian communications preparedness planning activities. This is especially evident when the planners have shared experiences -- either from previous involvement in disaster response operations or by participating o advisory planning committees such as the one presented in this chapter.[2]

In addition, the CRTU-Québec provides evidence which supports the idea that established normal-time hierarchical communication patterns and formalized structural relationships among public safety and industry experts with respect to communications preparedness increasingly are being replaced by more flexible, non-hierarchical, "geodesic" communication configurations. The latter are determined to a large extent by the informal and personal relationships among the participants.

Significantly, disaster managers also appear to favour a move away from centralized planning and towards the formation of joint services planning committees on which, for instance, fire, police, ambulance, hospitals, public utilities and local authority organizations are represented. Indeed, many experienced disaster planners and responders are of the opinion that private organizations which play a significant support role by providing essential emergency equipment or services ought to be "co-opted" by being invited to participate at the meetings of regional emergency planning committees, such as the RETCs/CRTU (Fisher, 1977: p.12).

Also lending itself to the emergence of alternative frameworks or approaches to emergency preparedness and planning is the nature of technological and environmental disasters that pose a serious threat to urban populations. As was mentioned in the other case studies, effective response to (and this can be extended to planning or preparing for) disasters such as these requires the intervention of multidisciplinary teams of experts to guide government agencies. Much of the groundwork for an effective response, it is argued, is accomplished best beforehand -- through continuous planning and regularly exercising procedures for normal-time contingencies.

In this way, planning is viewed as a process, the primary goal of which is to practise decision-making and exercise different aspects of existing plans in order to assess their practicality and improve them. It is not the goal of this kind of planning merely to complete a written emergency plan, for such a plan likely would be shelved and dusted off only if disaster strikes. Indeed, it is suggested that so-called "paper plans" are unlikely to be effectively implemented if they are not used frequently.

The RETCs/CRTU, therefore, are planning bodies which challenge traditional systemic approaches. With this in mind, the CRTU-Québec case study challenges the command-and-control model and the following premises upon which it is based.

First, the traditional approach assumes a hierarchical, top-down decision-making and implementation structure. The CRTU-Québec, as will be seen, instead demonstrates an approach to communications preparedness planning that involves instead decision-making through concensus arrived at by regular consultation among representatives from several different organizations. In this way, this case supports one of the subthemes of the present study -- namely, that governments will initiate co-operative arrangements with divers public and private interests so as to enable them to meet extraordinary demands in emergencies.

Secondly, the guiding model assumes clearly defined, known and recognized authorities. The CRTU-Québec, in contrast, emphasizes informal and personal relationships among its membership. It may even appoint ad hoc working groups made up of a small number of experts brought together to address a specific question or issue. In this way, precise authorities and mandates are not the focus of the CRTU's activities. Instead, the emphasis is placed on sharing information and personal experiences so that everyone involved has, to the extent practicable, a common basic understanding of, first, the resources and, second, the capabilities of the other member organizations their representatives.

A related sub-theme addressed by this case study is that in a forum such as this, government and industry will work together closely to develop policies and programs aimed at, for instance, enhancing emergency communications capability through voluntary co-operative arrangements (e.g., ad hoc study groups set up to look at problems associated with cellular radio-telephone). Another consequence of these activities is that potential responders and emergency service suppliers over time will become better known to each other. This is especially significant because it is widely recognized that regardless of the formal authority structures in place prior to a disaster event, crisis managers faced with an actual disaster will turn first to those individuals whom they know personally to have the competence to help them. Similarly, relationships among commercial carriers also will be co-operative and non-competitive in order to assure adequate emergency communications quickly following a disaster or other emergency.

Thirdly, the command-and-control model assumes centralized control at the top -- in both planning and response activities. The emphasis of that approach in an emergency or disaster is on taking command and maintaining control in a presumed hostile situation. In the CRTU-Québec forum, by contrast, leadership is often shared and participation by all the members is encouraged, regardless of their position within their parent organization or the level of government for which they work. The latter format, it is suggested, reflects more closely than the former, Canadian law and policy which give principal responsibility for peacetime disaster management to local authorities, to be supported by the provincial/territorial and federal governments (in that order) if the scope of the emergency or disaster exhausts the resources that could be made available locally or within a reasonable timeframe.

Fourthly, with regard to emergency communications, the traditional model assumes that there will be adequate facilities and equipment available to meet the requirements of public agencies and, furthermore, that they will be accessed easily. Significantly, it does not allow for the possibility of disrupted service which in peacetime emergencies such as major disasters almost always occurs due to system overload. The CRTU-Québec gives a lot of attention to such occurrences in order, first, to minimize its impact on effective response and, second, to reduce the time required to restore lost service, with priority given to essential service lines.

Finally, a related sub-theme addressed by this case refers to the effects of shared experiences on communications preparedness. The present study, as will be seen, provides empirical evidence supporting the idea that this gives an impetus to the industry to improve emergency communications services. It also can be expected to increase the political saliency of emergency communications issues generally and, in turn, specific policies and programs which emphasize system survivability and network redundancy.

10.2 Background

According to the Canadian Department of Communications (DOC), government planning for communications preparedness is expected to be more effective "when the responsibilities, resources and aspirations of the federal, provincial and local government are merged through joint co-operative planning" (DOC, 1991c). To this end, the DOC has established Regional Emergency Telecommunications Committees (RETCs) throughout Canada. In Quebec, the RETC is known as the Comité regional des télécommunications d'urgence or the CRTU-Québec. The aim of the DOC in setting up those committees was to facilitate consultation among interested parties representing federal and provincial/territorial agencies together with industry, and to develop a co-operative approach to communications preparedness. As regional elements of the NEAT, the main purpose of the RETCs/CRTU is to advise and assist "in the determination of requirements, in the development of plans and procedures, and for the preparations necessary to ensure that the national requirements of the NEAT."[3] At the regional level, their activities are oriented towards effectively meeting "requirements within the region for telecommunications support during an emergency."[4]

"Regions," in the context of these committees, are defined in accordance with provincial and territorial boundaries. In this way, they provide provincially and territorially located federal departments or agency staff, as well as provincial, territorial (and in the case of the British Columbia RETC, some municipal authorities) a channel for assembling and communicating regional data and related information to the national emergency communications planning process. This decentralized structure has the added benefit of enhancing effective support to response authorities involved in managing a localized emergency or major disaster.

Meetings of the various RETCs/CRTU are normally scheduled twice a year in each province and territory. Only recently, however, has the program been fully constituted across the Canada. The Ontario RETC, for example, held its first meeting in October 1991; a preliminary meeting in the Northwest Territories also was held in late 1991; and the first meeting of the Alberta RETC has been scheduled for mid-1992. Just the same, in British Columbia, that province's RETC has met regularly for many years, and in Quebec it has been meeting since early 1987. Subcommittees and working groups of the respective RETCs/CRTU meet as often as they consider necessary.

10.2.1 Evolution of RETC/CRTU concept

Chapter Three provides a historical overview of the evolution of the concept of Regional Emergency Telecommunications Committees within the context of the Emergency National Telecommunications Organization (ENTO), the creation of the DOC and the ENTO's replacement by the National Emergency Agency for Telecommunications (NEAT) under the direction of the DOC. Significantly, it will be recalled, the activities of the NEAT, in contrast to its predecessor, emphasize peacetime as opposed to wartime emergency communications preparedness planning and response capability.

With the activation of the NEAT, a series of committees automatically would be called upon to provide input to the NEAT executive to assist in establishing national policy and developing macroplans. Those committees include the National Emergency Telecommunications Committee (NETC), the National Advisory Committee of Commercial Telecommunications Agencies (ACCTA), the Regional Advisory Committees of Commercial Telecommunications Agencies (R/ACCTAs) and the Regional Emergency Telecommunications Committees (RETCs), one of which is the subject of this case study -- the CRTU-Québec. Additional committees and subcommittees or ad hoc working groups also may be formed to support the planning work. Generally speaking, planning requirements emerge from the work of the NETC and RETCs, while solutions to the associated issues or problems are to be found through the activities of the ACCTA, the R/ACCTAs, other subcommittees and working groups (Ibid.: pp.18-19 and 5).

The NETC, according to the DOC's proposals for the NEAT, would be made up of telecommunication experts from the Department of Communications, and other federal departments and agencies at the assistant deputy minister or director general level (DOC, 1983b). They would represent the federal government emergency user community. The ACCTA would be comprised of a cross-section of commercial telecommunications carriers at the vice-president level. They would represent the service provider and equipment supplier community. The function of the NETC, like that of the RETCs/CRTU, is to provide expert advice on technical capabilities and resources for emergency applications. The RETCs/CRTU and R/ACCTAs have similar functions, respectively, but at a regional level. More recent DOC documents suggest that the NETC/ACCTA and RETC/RAACTA memberships have been combined. This simplifies the consultative structure considerably (Interprovincial Emergency Communications Committee, 1988: p.2).

The tasks of the NETC would include developing plans and measures for the implementation and operation of the NEAT. The tasks of the NEAT, in turn, involve several duties and responsibilities. They include:

(1) to control, regulate and maintain all essential telecommunications resources, facilities and services in Canada, other than those operated on behalf of the Canadian Armed Forces, the Department of External Affairs or the Royal Canadian Mounted Police;

(2) to ensure the provision, maintenance and co-ordination of an Emergency Broadcasting Service;

(3) to conduct effective liaison to maximise the compatibility and co-ordination of telecommunications networks and systems with those of the United States and North Atlantic Treaty Organization member countries; and

(4) to determine the nature and extent of any damage to the Canadian telecommunications system and establish priorities for its repair, replacement or reactivation (Interprovincial Emergency Communications Committee, 1988: Annex C).

Significantly, the NEAT would be activated fully only in a national emergency.[5] It might be, in theory, partially activated to meet the demands of a large-scale peacetime disaster or other major emergency -- such as, for instance, a catastrophic earthquake on the West Coast of Canada. As a consequence, the planning functions of these regional elements are considered to be crucial to the national planning process. This is because in emergency preparedness planning, everything that can be foreseen must be taken into account and documented (to the extent practicable) in advance of a crisis or disaster. In addition, every necessary action that reasonably can be taken must be taken ahead of time.

The addressing of telecommunication issues related to emergency preparedness in Canada is currently achieved for the most part within the deliberations of the RETC/CRTU. The NETC and the NEAT, in contrast, remain in large measure "paper" concepts. Still, it is anticipated that at the national level the DOC's leadership in this area eventually will culminate in the establishment of an active NETC (but perhaps not a NEAT as currently conceived), and that it will function along lines similar to those currently practiced by the RETCs/CRTU.

The RETCs/CRTU, like the NETC, although they have a somewhat different emphasis, provide effective mechanisms for "isolating needs plus providing the basis for identifying solutions through commercial carriers and other communications members" (DOC, 1988a: p.5). In the absence of an operational national planning committee for communications preparedness, therefore, they are a practical model for the structure and operations of the future NETC/NEAT.

10.2.2 Roles

The main role of the RETCs/CRTU is to encourage co-operation and an open exchange of information among member organizations and to work to develop broad-based plans for communications provision in peacetime emergencies such as major disasters, including the identification and resolution, where possible, of priority communication problems or issues. The work of the RETCs/CRTU and their membership in fulfilling that role involves:

(1) regularly scheduled round-table discussions among members in plenary session;

(2) receiving guest speakers invited to inform the membership on a particular topic;

(3) undertaking research in response to the needs expressed by members, or actual and potential technical problems that may affect emergency communications service provision; and

(4) evaluating the results of exercises related to emergency and disaster communications (RETC-B.C., 1987: item 5).

Significantly, these committees have no statutory or legal authority in Canada to establish public policy. Just the same, they can and often do make suggestions and recommendations to those organizations participating in the consultative process through their representatives. Moreover, because in emergency situations time is of the essence, they can contribute in a very positive way towards effective response. This is achieved partly by the establishment of informal interagency and intersectoral contacts, and partly by facilitating the activation of broad-based contingency plans as a result of joint consultation on generic aspects of those plans.

Another role of the RETCs/CRTU is to support each member organization's broader responsibilities for emergency preparedness and planning. To this end, for example, while healthy competition among commercial telecommunication carriers is considered appropriate under normal circumstances, in a disaster or other emergency situation, mutual aid and co-operation, including among commercial service providers and equipment suppliers, is essential for effective response. (RETC-B.C., 1987: item 6). For instance, a lot of communications equipment could be made available by public utilities and government agencies not directly revolved in the response operation to help provide emergency communications at and with the disaster site. Unfortunately, sometimes that equipment cannot be used in those circumstances due to a lack of pre-planning and co-ordination -- especially as regards systems compatibility (RETC-B.C., 1987: item 6).

An additional role of the RETCs/CRTU is to provide an intergovernmental liaison -- such as between the federal government and provincial/territorial agencies (and possibly municipal ones through the provincial or territorial government) by "identifying priority communications problems, determining the resources available to resolve those problems and making appropriate recommendations" -- to the agency/ies and to the DOC (RETC-B.C., 1987). A significant aspect of this liaison role involves advising and assisting the RETCs/CRTU executive on an continual basis in preparing multiorganizational plans. It might also involve suggesting issue study topics, inviting guest speakers to address the committee and promoting joint exercises to test established procedures.

10.2.3 Objectives

As regional elements of the NEAT, the RETCs/CRTU are considered crucial to the Canadian communications preparedness planning process. Their work derives predominantly from an increasingly recognized need for coherent and harmonious national planning for federal communications support to the peacetime disaster plans of the provinces, territories and municipalities (DOC, 1986a: p.11).

As a result, the activities of the CRTU-Québec, the subject of the present chapter, as the other Canadian RETCs have a number of common objectives. First, they each attempt to identify as thoroughly as possible all the special government and emergency service communication needs that could occur during a crisis period after a major disaster. Correspondingly, they try to determine what communications resources are available locally and within the province or territory that can be used to meet those needs. Additionally, they identify telecommunications vital points -- that is, those portions of major public and private networks that would be particularly vulnerable to damage or service disruption from a disaster agent. They also try to determine the possible effects of different peacetime disaster agents on telecommunications plant facilities in order to direct subcommittees and other ad hoc government/industry working groups to develop plans for coping with a wide range of situations. Finally, they create opportunities for discussion among those individuals who are not likely to become involved in responding to a peacetime emergency or disaster at the regional level.

Usually, planning requirements emerge from the meetings of the RETCs/CRTU. The search for solutions to individual problems normally is undertaken by RETC/CRTU subcommittees established for that specific purpose.

10.2.4 Structure

Regions, in the context of the emergency communications preparedness planning undertaken by the RETCs/CRTU, as noted earlier,[6] are defined in accordance with provincial and territorial boundaries. The precise structure of the individual RETCs/CRTU, therefore, will vary according to the specific requirements of each province or territory and the communications resources available therein. There are, however, common elements. These include a core membership or executive steering committee which sets the agendas for meetings. Because of the relatively large membership of the RETCs/CRTU, it is its steering committee's function to set priorities and co-ordinate the activities and direction of the full committee. Its membership, in each case, includes representation from the Department of Communications, Emergency Preparedness Canada, and the provincial/territorial emergency measures organization.

Typically, their overall structure resembles that of the proposed National Emergency Telecommunications Committee mentioned earlier. That is, they may have full or part-time members from the following federal departments and agencies:

(1) the Canadian Broadcasting Corporation;
(2) the Department of Communications;
(3) Emergency Preparedness Canada;
(4) Employment and Immigration;
(5) Energy, Mines and Resources;
(6) Environment;
(7) Industry Trade and Commerce;
(8) National Defence;
(9) the Royal Canadian Mounted Police;
(10) Supply and Services; and
(11) Transport (Air and the Canadian Coast Guard).

Additionally, the provincial department responsible for government telecommunications together with the provincial emergency measures organization normally also would participate on the committee, as would the telephone company/ies operating within the province or territory together with Unitel, Telesat, Teleglobe and other telecommunication firms operating regionally. Finally, individual telecommunications experts might be invited either to attend a specific meeting of the committee or to become a permanent member. Each RETC/CRTU is chaired by DOC regional officials.

Another significant aspect of the RETC/CRTU structure is their subcommittees. These may be established by the committee itself or, alternatively, by a provincial/territorial emergency measures organization on which other members have been asked to participate. An example of the latter type of subcommittee is the Earthquake Preparedness Subcommittee in British Columbia. It was established by the British Columbia Provincial Emergency Planning office. Other subcommittees include those set up by the CRTU-Québec, one of which was created to develop a regional telecommunications resource inventory. A second is currently studying questions related to the use of cellular radio-telephone in disasters. A third is seeking answers to questions related to public long-distance network overload in disasters. Each of these will be discussed in turn later in the chapter.

Table 10.1 below outlines the membership of the RETCs/CRTU across Canada.[7] As it shows, British Columbia's RETC has by far the largest membership, although it conforms with the majority of RETCs in that half of its membership is made up of federal agency and department representatives. Manitoba and Saskatchewan, in contrast, have the smallest memberships (15 each), with federal representation dominating and minimal representation from the province. Quebec has an average sized membership but, significantly, it has the smallest percentage representation from the federal government and the largest from the telecommunications industry.[8]

TABLE 10.1
Regional Emergency Telecommunications Committees

Region	No. members	% Federal	% Prov/Terr	% Industry
Newfoundland	20	50	10	40
Prince Edward Island	20	50	10	40
Nova Scotia	20	50	10	40
New Brunswick	20	50	10	40
Quebec	20	35	10	55
Ontario	28	50	10	40
Manitoba	15	71	8	21
Saskatchewan	15	71	8	21
British Columbia	44	50	20	30
Yukon	22	60	25	15

10.2.5 Meeting agendas

The meetings of the RETCs/CRTU deal with a variety of subjects. Some typical agenda items include: (1) amateur radio in disasters; (2) cellular radio-telephone; (3) emergency broadcasting; (4) emergency legislation, regulations and orders; (5) emergency plan development; (6) exercises; (7) integrated crisis management; (8) line load control; (9) long-distance; (10) new technologies; (11) personnel training; (12) priority service restoration; (13) radio-communications system development; (14) satellite communications (e.g., the MSAT program); (15) system survivability and vulnerabilities, including the federal vital points program; (16) telecommunications equipment inventory; and (17) region specific programs (e.g., earthquake preparedness).

Agendas for individual meetings, as mentioned earlier, are set by the steering committees of the RETC/CRTU. Items for inclusion may be suggested by individual RETC/CRTU members, or they may form part of a permanent agenda -- such as, for instance, subcommittee or working group reports.

10.3 CRTU-Québec

According to the minutes of the first meeting of the CRTU-Québec, that committee's «raison-d'etre» is "to bring together individuals from different organizations and disciplines to discuss communications problems in emergency situations and propose solutions." The role and responsibilities of the CRTU-Québec are outlined in the same minutes. They include assuring that the means of telecommunications are available -- and operational -- in an emergency or disaster situation. This is to be done by studying identified needs for telecommunications in such situations, considering at the contingency plans of the different response agencies likely to become involved, and recommending solutions or ways to improve telecommunications preparedness at the regional level. Additionally, the Quebec committee, like the other RETCs, has been set up to allow the programs of the DOC in the area of emergency planning -- such as line load control, telecommunications vital points, etc. -- to become better known among response agencies, and service and equipment suppliers.

To these ends, it is crucial that members of the committee exchange personal knowledge about emergencies, telecommunications and disaster telecommunications. Additionally, individual research or investigations by subcommittees created by the CRTU also may be undertaken with the aim of meeting the special needs of member organizations. Finally, the results of emergency communications exercises are routinely evaluated -- either in subcommittee or in plenary session -- in order to identify inadequacies in existing plans, programs and policies (RETC-B.C., 1987: item 4).

Another objective of the CRTU-Québec is to identify telecommunications-related problems experienced in actual disaster or other emergency situations. A third objective is to study possible solutions to those problems, present them to the committee, and approach the appropriate organization(s) to have them implemented.

10.3.1 Membership

At the time of its creation, the CRTU-Québec was expected to be made up of approximately 15 members representing federal and provincial ministries and agencies, together with the telecommunications industry. In addition, the committee membership, ideally, would include representatives not only from a number of different public safety organizations, but from different disciplines as well. In this way, the knowledge base of the members about emergency preparedness and management in general and specifically with regard to telecommunications would be broadened.

At the time of its first meeting held in January 1987, the CRTU-Québec membership represented a relatively small number of federal departments and agencies operating in the province of Quebec. It also included just one representative from the Quebec provincial government, together with spokespersons for some of the largest telecommunications companies operating in the region. At the federal level, representation at that meeting included two members and four guests from the DOC, one member and one guest from National Defence, and a member each from the Canadian Broadcasting Corporation (CBC); Emergency Preparedness Canada (EPC); the Royal Canadian Mounted Police (RCMP); and Transport Canada (Air). From the province of Quebec, the Bureau de la Protection civile (BPCQ -- now Sécurité Publique) also sent a representative to the meeting. Finally, Bell Canada, CNCP (now Unitel) and Québec Téléphone represented the telecommunications industry.

By October 1991, the committee's membership had grown considerably. The list of permanent members present at the ninth meeting of the CRTU-Québec, according to that meeting's minutes, included the following:

(1) Department of Communications (five full or part-time members);
(2) Canadian Broadcasting Corporation;
(3) Canadian Coast Guard;

(4) Emergency Preparedness Canada;
(5) Employment and Immigration Canada;
(6) Environment Canada (AES);
(7) Government Telecommunications Agency (GTA);
(8) National Defence;
(9) Royal Canadian Mounted Police;
(10) Transport Canada (Air);
(11) Communications Québec;
(12) the Association des compagnies de téléphone du Québec Inc.;
(13) Bell Canada;
(14) Bell Cellular;
(15) Cantel Inc.;
(16) Télébec Ltée;
(17) Telesat Canada;
(18) Unitel Communications Inc.; and
(19) the author.[9]

Two other permanent members from Sécurité Publique du Québec (20) and Québec Téléphone (21) were absent from that meeting. Thus, today the permanent membership of the CRTU-Québec includes representatives from no less than 21 separate public and private-sector organizations.

In addition to its permanent members, individual crisis management and telecommunications experts are regularly invited to address the committee. The decision to invite outside consultants rests with the steering committee, although members are asked to suggest guest speakers. The costs of participating on the committee are defrayed either by the individual participants or by the organizations they represent.

Subcommittees and working groups are also formed from time to time to study specific questions or issues. These are made up of CRTU-Québec members. Alternatively, they may include external public or private sector experts. Members of the CRTU-Québec may, of course, participate in any of the meetings of the subcommittees should they wish to do so. Some examples of subcommittees formed under the auspices of the CRTU-Québec include the Subcommittee on Federal Telecommunications Resources, the Subcommittee on Cellular, and the Subcommittee on Long-Distance Overload. Each of these will be discussed later in the chapter.

10.3.2 Meetings

The CRTU-Québec usually meets twice a year, although the interval between the first and second meetings of the committee was more than 15 months. Committee meetings to date have been held in January 1989, and then in April and September 1988, February and September 1989, February and October 1990, and April and October 1991. A summary of the discussions at those meetings is provided below.

The **first** meeting of the CRTU-Québec included a welcome message by the director general of the DOC for the region of Quebec outlining the meeting's aims. The objectives of the committee were then presented by the chair. The meeting also included a presentation by the regional director of Emergency Preparedness Canada on to the nature of the committee as a federal mechanism for information exchange and consultation among users and suppliers of telecommunications services and equipment who likely would be called upon in an emergency or disaster situation to identify and resolve telecommunications problems. Another item on that first agenda dealt with an explanation of the roles of the DOC in general and, specifically, in terms of Canadian telecommunications preparedness.

At the **second** meeting of the CRTU-Québec held in April 1988, two new member organizations were added to the committee -- Telesat Canada and the Canadian Coast Guard. At that meeting, a presentation was made by the BPCQ representative on emergency measures in Quebec. A plan for the development of regional emergency telecommunications was also distributed to members; in it was outlined the Quebec government's program to convert its private telecommunications network to a "veritable emergency network". Also discussed at the meeting was the creation of another working group on emergency telecommunications as a complement the work of the CRTU-Québec which would operate at the provincial level. Other topics discussed at the meeting included the preparation of a telephone list of first responders in the area of emergency telecommunications; the identification of broadcast stations that might make up a kind of regional public warning/alert network; the creation of a subcommittee of the CRTU-Québec to create a federal emergency telecommunications resource inventory for the Quebec region; the importance of developing a public warning system; and the use of satellite communications in emergency situations.

A **third** meeting of the committee took place in August 1988. At that time, another permanent member organization was added -- Environment Canada. The discussion at this meeting focussed on the preparation of a questionnaire to be used to determine federal department and agency needs for emergency telecommunications and available resources in the

Quebec region; creation of a computer applications program to allow the identification of broadcast stations covering a disaster site; the responsibilities of the DOC regarding alert messages --namely, that it is not its responsibility to transmit such messages, but instead to provide support to those agencies having that responsibility by assisting them to identify AM, FM and television broadcast stations covering a specific geographical area affected by a disaster. Also discussed at the meeting was Quebec's emergency preparedness committee and its associated study groups, including the new emergency telecommunications working group; and the line load control program administered jointly by the DOC, the BPCQ and the 17 telecommunications enterprises in Quebec. A presentation was also made by Communications Québec on that government's proposed integrated radio network (i.e., the Réseau intersite de radio-communications or «RIR»).

The **fourth** meeting of the CRTU held in February 1989 added four more members to the committee, bringing the total up to 17. The new members included representatives from Bell Cellular Inc., Cantel Inc., Employment and Immigration, and the author. Topics discussed at this meeting included a report based on the resource questionnaire results on emergency telecommunications needs and capabilities in the Quebec region. For instance, it was reported that on three occasions in 1988 the inventory had proven useful, and that as many as 45 suppliers had accepted to participate in the emergency preparedness effort. Again, a resumé of the provincial working group on emergency telecommunications was given together with an update on the RIR. In addition, a presentation was made on the EPC's exercise committee, and the DOC was encouraged to participate in the activities of other federal agencies interested in adding a telecommunications aspect to their exercises. The potential importance of cellular radio-telephone in emergency situations was also discussed at length, and a subcommittee was formed to look at related issues. Finally, an overview of individual research work on Canadian emergency telecommunications policy and preparedness was given by the author.

The **fifth** meeting of the CRTU in September 1989 added another two members -- the Government Telecommunications Agency (GTA) and Télébec Inc. Subjects discussed at that meeting included the federally administered line load control program; the development of contingency plans by the cellular companies, and the creation of a subcommittee to prepare a new resource inventory questionnaire. An update on the service restoration capabilities of Bell Canada in emergencies using mobile units which are capable of restoring a lost central office was also presented. Additionally, problems associated with public long-distance network overload following a major earthquake near Chicoutimi were discussed and another subcommittee was formed to try to find solutions. The use of transportable MSAT earth stations in emergencies was also discussed, together with the DOC's proposals before Treasury

Board at the time to establish a modern Warning and Emergency Broadcast System (WEBS) which would replace the aging siren system, and upgrade CBC broadcasting capabilities in the area of emergency broadcasting. Finally, a presentation was made by CNCP Telecommunications (now Unitel) of the services offered by that company, including some that might be used in an emergency or disaster situation.

The **sixth** meeting of the CRTU was held in Rimouski in February 1990; at that time, no new members were added to the committee. The discussion included a summary of the results of a CRTU evaluation questionnaire sent to members and the decision to work more closely with the provincial working group on emergency telecommunications. A report on the cellular subcommittee's activities was also given in which some of the major shortcomings of that medium experienced during the Saint Basile disaster were mentioned. A partial solution was suggested; it would involve assigning a small number of ("code 3") units to a special user group in order to allow a portion of the channels available in a cell covering a disaster site to be reserved for emergency calls originated by those units. Another presentation to the meeting looked at the possibility of modifying the line load control program in light of new digital switches now being installed in Bell Canada central offices. A status report was also given on the federal inventory of telecommunications resources for the Quebec region. Other topics discussed at the meeting included the rejection of the WEBS proposal by Treasury Board; the availability of Bell Canada's mobile emergency central office and microwave tower for emergencies (including their availability for use by other telecommunication companies); and a presentation on the International Decade for the Prevention and Mitigation of Catastrophes.

The **seventh** meeting of the CRTU-Québec was held in October 1990. At that meeting, the DOC discussed its own plan of intervention in emergencies, and participants visited the Emergency Preparedness Canada emergency operations centre in downtown Montreal. The cellular subcommittee also summarized alternative ways to reduce or avoid overload on cellular networks in an emergency or disaster and the long-distance subcommittee reported on the questions that would be raised at its next meeting -- such as the use of alternate routes parallelling the public network. A status report was also given on the Quebec government's integrated radio network, and a presentation was made by Environment Canada's Atmospheric Environment Service (AES) on its «Radio-météo» network. That network, it was noted, uses three VHF frequencies and, with the help of 12 stations (and another four soon to be added), it will be able to cover most of the populated areas of Quebec. It was also reported that in the Montreal area a broadcast system for transmitting data digitally -- known as "data radio" -- is also being developed in co-operation with the Montreal Urban Community.

In April 1991, the **eighth** meeting of the CRTU-Québec held at Teleglobe Canada's earth station site in Weir, Quebec considered revisions to the DOC's plan of emergency intervention for Quebec and the federal vital points program. The cellular subcommittee reported that new techniques would soon be available to improve significantly that medium's emergency capability; they include transportable cells and signal amplification improvements. The long-distance subcommittee, in turn, proposed that one solution to relieving congestion on the public switched network would be to allow access by local disaster managers, such as municipal mayors and emergency measures organizations, to private government networks. A presentation also was made to the meeting on federal programs for telecommunications preparedness (e.g., line load control, vital points), and the president of the Association of Radio-Comm of Canada discussed the different kinds of resources that could be made available by that association's members in an emergency or disaster situation. Teleglobe Canada also made a presentation on its overseas telecommunications network, and on that company's survivability plans for its three international "gateways" -- located in Vancouver, Toronto and Montreal.

At the **ninth** meeting of the CRTU-Québec held in October 1991, a 20th organization was added to the list of permanent members, namely, the Association of Telephone Companies of Quebec, Inc. At that meeting, Environment Canada's AES provided more details on its new "data radio warning system" which is now operational in the Montreal area. That system allows responders to be alerted and informed of approaching potentially dangerous atmospheric phenomenon. This is done with the aid of a data radio link operating in the 15 - 62.44 MHz band. The committee also decided to create a subcommittee to study the problem of common radio frequencies for intercommunication among emergency responders. Other presentations included information provided by the DOC on a new line load control computer program being developed at the regional level, and the sharing of the personal experiences of some of the committee members who had been involved in restoring service to Maskinonge after a recent tornado. The meeting ended with a visit of Télébec's installations at Trois-Rivières and the Gentilly II nuclear power plant.

The **tenth** meeting of the CRTU-Québec was held in April 1992. At that meeting, the roles and mandate of the CRTU were reviewed as regards regional telecommunications preparedness. One of the central concerns expressed by industry representatives was the need for the CRTU (perhaps through DOC, Ottawa) to convey its "recommendations" to the telecommunications companies as regards improving emergency capabilities in such a way as to make it easier to sell their executive boards on the idea of investing more research and development dollars so that they can better meet the needs of their government clients in an emergency. For example, the Subcommittee on Long-Distance Overload mentioned that it has arrived at an impasse with Bell Canada with regard to "tagging" long-distance calls. Bell advised that it would cost upwards of $200,000 to consider the question, and without an authoritative recommendation to do so from the DOC, nothing further will be done by the company in this regard. Cantel and Bell Cellular expressed similar concerns respecting making special arrangements for government emergency service users (such as priority access). Other subjects discussed at that meeting included post-exercise evaluations which pointed to significant weaknesses as regards emergency telecommunications and possible ways to address them; Environment Canada's weather alert system (Weather Radio); line load control schedules and the still outstanding problem of PBX priority access and restoration; updates on the activities of the subcommittees; and improvements to cellular's emergency capabilities.

10.4 Subcommittees

10.4.1 Subcommittee on federal telecommunications resources

In order to facilitate the work of the CRTU-Québec, as has been mentioned, subcommittees are established from time to time to which specific tasks may be assigned by the larger committee in the pursuit of its objectives. The work of these subcommittees includes raising and investigating issues on a particular topic, and making recommendations to address them. Alternatively, it may involve resolving a specific technical or other problem of a practical nature. Finally, a subcommittee may be assigned a particular task such as, for example, establishing a method for determining an organization's emergency telecommunications needs and resources.

The CRTU Subcommittee on Federal Telecommunications Resources was created at its second meeting held in April 1988. The mandate assigned to that subcommittee was to develop a questionnaire to be sent to federal ministries and agencies so that their emergency telecommunications needs could be determined along with the availability of telecommunications equipment and services locally and regionally to meet them.

In order to face the challenges of emergency situations, including major disasters, federal ministries and agencies must know their telecommunications needs and the extent of their resources. If the scope of the emergency is greater than the capacity of available systems, or if those systems are incompatible, the organization can ask the DOC to co-ordinate the procurement of supplementary telecommunication services and equipment.

The information provided by the completed questionnaires is intended to be used by government emergency planners to help them prepare an overall federal emergency telecommunications plan for the Quebec region. Just the same, responding agencies may request that specific information about their organization be kept confidential. A summary of the information asked for on the questionnaire follows. Among other things, federal ministries and agencies are asked whether they consider their current telecommunications systems adequate to meet their priority needs in an emergency situation. They are also asked to indicate the kinds of services or equipment that might be required to supplement existing systems -- for instance, additional mobile radios, walkie-talkies, base stations, repeaters, a separate system operating on an existing frequency or on a new frequency, etc. If the organization thinks that it may find it necessary to add to its internal communications system in an emergency, it is also asked to indicate whether it intends: (1) to rent cellular telephones or an additional radio system; (2) to share a new system with another response agency; (3) to request additional telephone lines; or (4) to rent new or additional telex, Envoy network services, facsimile, satellite communications and the like. If the organization intends to call upon another organization to help it to meet its emergency telecommunications needs, it is also asked whether those arrangements are already in place.

Concerning interconnection and interorganizational communications, respondents are asked to indicate the kinds of organizations -- federal, provincial, municipal and private -- with whom they consider it might be necessary to interconnect or establish direct communications in an emergency. Related to this, they are asked to identify the ministries and agencies with whom they likely would need or want to establish communications in an emergency as well as the specific kind of communication -- such as a radio link, a telephone link or system interconnection.

The questionnaire also asks for information on the kinds of telecommunication services that the organization would be prepared to make available to another organization in an emergency situation -- first, if the respondent's organization is involved in the response operation and, second, if it is not involved. In this regard, they are asked to provide contact names and telephone numbers, and to suggest appropriate procedures to facilitate access to those services.

On a more general level, respondents are asked to specify the nature of their participation in regard to emergency measures -- be it in planning, direct intervention, in a support capacity, with respect to public information, or for post-event recovery activities. Additionally, they are asked to specify the nature of their communications in emergencies -- that is, for decision-making, operational information exchange, personal messages, confidential messages, communications with the media, reports to senior bureaucrats or ministers, etc.

Other questions relate to the priority of the information that would be transferred by the organization in an emergency -- i.e., "urgent," "priority" or "routine." Additionally, questions are asked about the means by which emergency telecommunications would be established, such as telephone, cellular, fixed mobile (HF, VHF, UHF), microwave, amateur radio, General Radio Service (GRS or "citizen band" radio), fax, Telex or Envoy, satellite, broadcast or interconnection with other radio systems via telephone.

Finally, those respondents that have an emergency operation centre are asked if they have considered the possibility of interference among the different radio systems that would be operated at that emergency operation centre, and whether provisions are in place for secure communications in the event of an outage. Additionally, they are asked if they have adequate telephone lines to support their own operations or those of their emergency operations centre in a crisis situation. Other relevant questions involve the identification of lines and telephone terminals for emergency operations; their identification in organizational emergency plans; participation in the federal line load control program; and identification of a contact person responsible for emergency communications within the ministry or agency.

In late 1988, the questionnaire developed by the DOC regional office with the help of the subcommittee was sent to 31 federal departments and agencies operating in Quebec. The responserate was about 77 per cent. Table 10.2 below shows the distribution of the questionnaire.

According to the questionnaire results compiled by the DOC, 86 per cent of those who responded considered their current telecommunications capability adequate to handle priority needs in an emergency. Of the various telecommunication services that could be used in such situations, 100 per cent would use telephone; 90 per cent would use facsimile; 70 per cent would use cellular; and 60 per cent would use VHF or UHF radio. Additionally, 40 per cent would use electronic mail (Telex or Envoy), while 30 per cent would use HF radio. Moreover, 20 per cent of the respondents would use microwave, amateur radio, satellite, and/or a radio broadcast system; 15 per cent would use citizen band radio. Forty-five per cent would also interconnect with other networks.

As regards supplementary equipment and services, 70 per cent of the respondents stated that they would rent cellular telephones, while 50 per cent would install additional telephone lines. Thirty-six per cent would rent portable radio equipment; 35 per cent would share a system with another emergency user; 23 per cent would add base stations; 14 per cent would add mobile radio facilities; 10 per cent would install more electronic mail facilities and/or rent an additional system; and 5 per cent would rent a satellite system.

TABLE 10.2
Federal Departments and Agencies Sent Questionnaire on Emergency Telecommunications Needs and Resources

Agriculture Canada
Bank of Canada
Canada Mortgage and Housing Corporation
Canada Post Corporation
Canadian Broadcasting Corporation
Canadian Coast Guard
Canadian Mortgage and Housing Corporation
Canadian National
Canadian Security Intelligence Service
Communications Canada
Correctional Service
Emergency Preparedness Canada
Employment and Immigration
Energy, Mines and Resources
Environment Canada (Meteorological)
Environment Canada (Protection)
Fisheries and Oceans
Health and Welfare Canada
Indian and Northern Affairs
Labour Canada
National Archives
National Defence
Ports Canada
Public Works Canada
Regional Industrial Expansion
Revenue Canada/Customs and Excise
Royal Canadian Mounted Police
St Lawrence Seaway
Secretary of State
Supply and Services
Transport Canada (Air)
Transport Canada (Dangerous Goods)

Respecting arrangements with other organizations to meet emergency services or equipment needs, more than a third (35 per cent) of those federal departments and agencies that responded already had concluded agreements with other public or private organizations. Among others, arrangements had been made with telephone companies, radio equipment suppliers, cellular and paging companies, Telesat Canada, the provincial emergency measures organization and the DOC.

Concerning system interconnection, 65 per cent of the respondents said that they would need to interconnect with other federal agencies during an emergency. Sixty-five per cent would need tc interconnect with provincial agencies, and 50 per cent would need to interconnect with municipal agencies. Forty per cent of the respondents also reported that they would need to interconnect with private agencies in an emergency situation.

Significantly, 14 federal departments -- or approximately 60 per cent of the questionnaire respondents -- have an emergency operations centre in Quebec. Of these, four have done studies on the possibility of interference. Four others reported that they do not have a back-up system in place should the communications system at the emergency operations centre fail during an emergency. Ten have cellular telephone back-up facilities, two would use amateur radio, and three would use citizen band radio. One has access to an external radio system.

Regarding emergency telephone lines, 85 per cent of respondents consider that they have sufficient regular telephone facilities to handle an emergency situation. Seventy-five per cent have identified their essential telephone lines, and 70 per cent have identified the equipment that would be used in an emergency. Seventy per cent also are involved in the federal line load control program.

Finally, with respect to their ability to provide other agencies with emergency telecommunications, 20 respondents reported that they could provide access to their private telephone networks in the field, and 15 could provide access to their electronic mail services. Eight respondents would be willing to lend radio and other equipment -- either by allowing connection to their system or by lending out equipment such as cellular telephones. Two respondents could lend generators; three would provide access to their emergency operations centre; three would lend vehicles equipped with radio communications; four would supply radio operators, and two would provide emergency broadcasting services.

The information derived from the responses to the questionnaire has been used to compile an inventory -- first, of existing federal emergency telecommunications resources; second, of regional and local suppliers of telecommunications equipment and services; and third, of regional and local suppliers of non-telecommunications equipment and services necessary for emergency telecommunications. (The latter include such things as generators and electronic mail services.)

At the meeting of the CRTU-Québec held in the fall of 1989, another proposal was made by the DOC to update the inventory by distributing a new questionnaire to the same organizations along with the results of the earlier survey. An ad hoc subcommittee of representatives from the CBC, the Canadian Coast Guard, EPC and Transport Canada (Air), was established to critique the new questionnaire which would again be prepared by the DOC regional office.

As of February 1990, 84 per cent of those federal departments and agencies contacted on the second round had responded. Of these, 81 per cent reported that they would ask for additional telephone lines should they require additional telecommunications capability in an emergency; 81 per cent would also ask for cellular telephones. Sixty-nine per cent would ask for facsimile equipment, while 50 per cent would ask for VHF or UHF radio networks, and 35 per cent would ask for satellite services.

The revised questionnaire also included a question concerning the Quebec government's RIR. Fifty-four per cent of the respondents would like to receive more information about or be integrated as part of that system. No further updating of the resource inventory has been done since 1990.

10.4.2 Subcommittee on cellular

The creation of the Subcommittee on Cellular resulted directly from concerns expressed by CRTU members about some of the inadequacies of cellular in a disaster context. Specifically, these had to do with problems experienced by emergency cellular users after fire at the PCB storage warehouse in Saint Basile-le-Grand the previous year.[10]

Representatives from the two cellular companies operating in the Quebec region, Bell Cellular Inc. and Cantel Inc., had been invited to address the CRTU at its February 1989 meting, and answer questions about the use of cellular radio-telephone in emergencies or disaster situations. That invitation had resulted from a combination of factors. First, there were the anxieties expressed by committee members related to the Saint Basile response just referred to. Second, inventories of the telecommunication needs and resources of federal departments and agencies discussed in the previous section illustrated that most of those organizations consider cellular telephone to be very important in emergencies. As many as 70 per cent of the questionnaire respondents had included cellular in their planning as a communications tool to be used in emergency situations, and 70 per cent said that they would ask for cellular if existing emergency telecommunications facilities proved insufficient.

Following the meeting, Bell Cellular and Cantel both wrote to the CRTU-Québec executive asking to be allowed to participate with interested committee members on a cellular working group. They also expressed their willingness to work together to prepare a contingency plan for cellular for the Quebec region.

It was decided at the next meeting of the CRTU to create such a subcommittee. Its task would be to work in co-operation with the cellular companies to develop a regional cellular emergency plan. The subcommittee also would be asked to investigate the identified technical and operational limitations of cellular technology with the aim of resolving them. Additionally, it would inform the cellular companies concerning the special needs of government response agencies during emergencies and disasters in the hope that this would encourage them to improve emergency service provision generally and implement corporate programs allowing priority access to both cellular networks to emergency users. A proposal was also made by the meeting to the Quebec government's working group on emergency telecommunications inviting it to participate on the CRTU cellular subcommittee.

The first meeting of the Subcommittee on Cellular was held in December 1989. Participants included representatives from the DOC, Communications Québec, Santé et services sociaux Québec, Sécurité Publique, Sûreté Québec, Cellnet Canada (of which Bell Cellular is an associate member company) and Cantel Inc. Meetings of the subcommittee have been held approximately twice a year since that time.

The goals and duties of the cellular group areas follows:

(1) To see how the cellular companies can participate in regional emergency telecommunications preparedness.

(2) To learn about current technical and operational constraints on the cellular companies to provide cellular communications in emergencies -- such as the amount of time required to provide new services or to increase the channel capacity for a cell covering a disaster site;

(3) To evaluate the needs of emergency responders and, generally, to facilitate the use of cellular technology.

(4) To clarify what, precisely, is wanted by government cellular users in emergencies if existing technical limitations can be overcome.

(5) To sensitize the cellular companies to the special needs of emergency responders.

(6) To exchange information and encourage discussion on technical innovations in the area of cellular telephony that could have an emergency or disaster application.

(7) To transmit pertinent information on new technological and service provision

developments to public response agencies via the provincial working group on emergency telecommunications and the CRTU.

During the first meeting of the cellular subcommittee and subsequently, the cellular companies and the emergency user community have repeatedly emphasized the need to put cellular in a proper context as an emergency communications medium. For one thing, it must be remembered that cellular coverage in Quebec is still restricted predominantly to urban centres such as Montreal, Sherbrooke, Quebec City and, recently, Chicoutimi. Additionally, the proper use of cellular technology by emergency personnel requires some degree of understanding of the theoretical basis of cellular systems. Significantly, cellular cannot be used in the same ways as either regular telephone or conventional radio systems in emergencies. Furthermore, cellular has its own set of inherent vulnerabilities which are associated with the need for backup cellular network management computers, the use of microwave, etc. Consequently, the cellular service providers envisage the use of this medium as a supplementary rather than a primary communications technology in disasters or other emergency situations. This is because, given the limitations just mentioned, it cannot substitute for other communication technologies (e.g., telephone or radio). Just the same, it is widely agreed that cellular can be used very effectively, for example, for communications at a disaster site during the first hours following its onset -- that is, until sufficient time has elapsed for additional regular telephone lines, etc. to be installed.

At the first meeting of the Subcommittee on Cellular also has raised a number of questions also were raised which, since then, have been the subject of research and discussion among its members. Among others, there is the question of channel capacity. As was noted in the case study on Saint Basile, the current capacity of a single cell is 45 channels. This means that a maximum of 45 cellular calls to, from and within a given cell can occur simultaneously. Given the large number of cells covering city cores, the risk of overload would be unlikely to occur, even in a large-scale disaster, since the cellular unit would automatically search a free channel in a nearby cell. But in the corridors between cities and in the country, cells have fewer channels since market demand does not warrant allocating extra radio frequencies where there is not yet an established demand for them. As a result, the likelihood of cellular network overload is correspondingly increased if a disaster strikes in those areas. Bell Cellular advises that the lessons from Saint Basile were well learned and that both companies have worked hard since then to rectify the situation. In subsequent emergencies -- e.g., the Masinonge tornado, the St. Léonard de Aston derailment -- one of the first actions taken by the cellular companies has been to go in physically and modify the cell management computer covering the disaster site to increase its channel capacity. Moreover, no charges have as yet been made to government response agencies to cover the costs incurred for doing this (perhaps because there is no agreement in place specifying how such charges would be made).

Another issue studied by the cellular group concerns the possibility of buying a transportable cell which could be brought to the site of a major disaster and put into operation to provide cellular communications in areas not already served by cellular. This, like most of the other questions being addressed by the cellular subcommittee, probably is not something that will be resolved quickly. That is because transportable cells have just recently become available on the market, and they are consequently still very expensive (in the order of $1.8 million each). Moreover, it is anticipated that there might be some technical difficulty with interconnecting them to other networks. It is expected, however, that as early as the next two years, Cellnet will purchase a transportable cell. And while it will be used mainly to replace defective cells within that transCanadian network, that association also has expressed its willingness to make it available to help meet emergency demands in large-scale disasters.

An additional question being addressed by the group involves giving priority to certain cellular units over others to access the network in a disaster or emergency situation. This again relates to the discussion in the case study on the Saint Basile disaster involving the creation of a new user service group whose units would be modified in such a way as to allow them special consideration in overload situations. The way that this works is that those units would be identified on a priority access list (i.e., the line load control listing). Then, in an overload situation some portion of the channels available in a given cell would be reserved for that user group. Indeed, it is anticipated that within a relative short time up to half the channels allocated to the cell could be reassigned for the exclusive use of those units identified as part of the special user group.

Another issue being looked at by the cellular group involves the mutual aid support that could be offered by Cellnet and Cantel in an emergency situation. More specifically, it concerns the ability of emergency cellular users subscribing to either of the two networks to access the other network if their own is overloaded due to a disaster or emergency. Technically speaking, the switchover apparently can be done easily. However, in normal times, federal regulatory restrictions preclude such interconnection. According to the cellular companies, therefore, the easiest way to handle emergency interconnection requirements would be first, for response organizations to purchase equipment capable of accessing both networks and, second, for a very small number of those units to be specially programmed so that they can be protected in a situation of overload or other outage on their primary network.[11]

Other initiatives evolving out of the discussions of the cellular subcommittee are similarly aimed at improving cellular service provision (and easy access thereto) in emergencies or disasters. These include the identification of specific cellular needs in emergency situations by those responsible for handling response management on behalf of their organization. They also involve, on the part of the cellular companies, knowledge of the precise location of every cell -- their own and the other carrier's -- so as to expedite increases of channel capacity or the reservation of a portion of the channels available in a given cell for emergency responders.

Additional topics to be looked at by the subcommittee include the availability of private branch exchange (PBX) on cellular. At the present time, up to four cellular units can be connected to a PBX-like office on the cellular network. The PBX, in turn, can be connected to a large number of conventional telephones. Another is the possibility of conference calling on cellular. Technically, the cellular networks do not allow for conference calling, although three-way call capability is now in place. One way around this limitation which is especially important for rapid alert call-outs in an emergency would be to address the alert message to the appropriate cellular "mailboxes".

Integral to the process of improving cellular preparedness being worked on by subcommittee members on behalf of the CRTU-Québec membership is the gradual development of a larger interest base within the various public safety organizations and in the two cellular companies. It would be comprised of individuals who have been sensitized to the special requirements of disaster and emergency communications both generally and in terms of their respective organizations. Another aspect of this process involves an awareness among subcommittee members of individuals working in other organizations who share their interest and would be willing to assist them in an emergency. Indirect reference is made here to the emergence of an informal geodesic network of emergency cellular users and experts.

10.4.3 Subcommittee on long-distance overload

It was reported at the September 1989 meeting of the CRTU-Québec that in the hours following a major earthquake in the Chicoutimi area on 25 November 1988, approximately 472,000 long distance calls between Quebec City and Chicoutimi were refused by toll switches in both cities due to an overload on the public telephone network. Federal emergency responders contacted afterwards said that they had not had any "privileged" way to establish emergency communications either into or out of Chicoutimi.[12]

Before introducing this subject to the CRTU, a small number of emergency users and telecommunications experts met together in June 1989 to discuss the problem, learn about possible causes, and determine whether technical solutions are available which could be applied to rectify the situation. Those attending that meeting included representatives from the federal Department of Communications and the Government Telecommunications Agency, Communications Québec, and the Bureau de la Protection civile du Québec (now Sécurité Publique). On the industry side, Bell Canada, Québec-Téléphone, and Télébec Ltée. also attended the meeting.

Staff at Bell's Provincial Surveillance and Co-ordination Centre for Quebec (PSCC) reported at that preliminary meeting on how the problem had been handled on the evening of the Chicoutimi quake. For example, they had monitored the traffic load reporting boards at the centre and then manually controlled all outgoing calls from Montreal. Those destined for Chicoutimi were blocked at the Montreal end. In this way, they could not access the Quebec City/Chicoutimi trunk; nor could they contribute to the congestion problem on the Montreal/Quebec City trunk. Additionally, it was pointed out that the risk of overloading the local network -- which occurred in Chicoutimi just after the earthquake -- must always be considered for the purpose of establishing a reliable link between the long-distance switch covering a disaster or emergency site and the exterior.

The PSCC staff also advised that the problems experienced by emergency users with long-distance communications after the Chicoutimi earthquake -- and, for that matter, after most major disasters -- stem in part from current Canadian industry practices related to the configuration of the public switched network. That network is not designed to presuppose a need for priority access by a small group of emergency users. Consequently, a more specific issue that requires resolution is how, given the design of the existing public switched long-distance system, to allow authorized emergency users to "short-circuit" the system, so to speak, and what exactly would be the degree of priority accorded to those users over others.

A related question concerns finding ways to allow multiple responders calling in from the outside to speak with the same person -- for instance, the mayor or emergency measures officer -- when that person's telephone line is engaged. The normal course of action -- interruption of the call in progress -- may not be appropriate (since the mayor, for example, may be talking to the premier!).

When the problem of public long-distance network overload was brought to the table at the CRTU meeting, the committee immediately agreed to create a subcommittee to look into the problem and study alternative solutions. CRTU members accepting to participate on the subcommittee included representatives from the DOC, the Government Telecommunications Agency, Communications Québec and Sécurité Publique. The author was later asked to join, and the telecommunications companies represented on the CRTU-Québec agreed to work with the subcommittee in its investigations.

The emphasis of this subcommittee's work is on finding solutions which are based on common sense. Secondly, they need to be relatively simple to implement (both technically and procedurally). Finally, where possible, they must exploit existing telecommunication infrastructures.

A partial solution involves developing a method for identifying emergency users to telephone company operators. These then would be asked to take the necessary measures (established by the telephone company) to pass the communication on by following the call from central office to central office until it reaches its final destination. Unfortunately, today's powerful switching and transmission technologies have led to an undesirable situation as regards priority calling capability in that operator services have become so centralized that they are more often than not provided from a distant location. As a consequence, this option might not work effectively in an emergency or disaster since the caller might not be able to get through to an operator in the first place in an overload situation.

A more attractive solution, therefore, would involve routing emergency calls from and to the disaster or emergency stricken area using private networks such as those belonging to the federal and Quebec governments. The kinds of questions that need to be answered in this regard involve giving access to those networks in an emergency. Different procedures, for example, would need to be established depending on whether government services in the specific area are connected to major population centres via digital switches; whether they use centrex service; whether they are connected by tie trunks or by foreign exchange service, and the like. Each of these has significant implications for emergency access.

A related problem involves the question of identifying legitimate emergency callers. The solution likely would involve some form of special identification authorizing access for emergency purposes only. For instance, an emergency response agent or a municipal mayor needing to access the federal private network could be given a direct inward system access (DISA) code number in order to connect to that network via a federal DISA "porte" or access point. Once on the network, they would enjoy several advantages. Among others, they then would be able to bypass blocked public trunking switches en route to the destination local switch. Moreover, requests for assistance from provincial or federal authorities could be put into the works very quickly, thereby optimizing emergency assistance to the affected community.

Another solution to problems associated with public long-distance network overload also uses dedicated or private line service. This time, it would involve the establishment of communications centres in every municipality or, alternatively, at regional airports. All the telephone lines at those centres would be reserved for emergency communications and the routing of outgoing emergency calls would be predetermined. Additionally, dedicated end-to-end lines would link provincial (and possibly federal) emergency response organizations to those centres, thereby facilitating emergency requests for assistance and interagency communications generally.

Other ways of communicating with stricken municipalities following a disaster or in an emergency could involve using cellular technology. The cellular networks, as just mentioned, operate their own microwave links -- between, for example, Montreal and Quebec City and between Quebec City and Chicoutimi. Significantly, given the still relatively small number of cellular subscribers in Quebec combined with the fact that most cellular communications are short-haul as opposed to long-haul calls, the long-distance cellular routes connecting these centres likely would not be overloaded as quickly as the public switched network.[13] Similarly, companies like Unitel, Hydro Québec or Telesat might be asked to look into new cost-efficient ways to improve emergency long-distance communications.

Bell Canada, in co-operation with Northern Telecom and AT&T in the United States has been studying various technical solutions which would allow priority transmission of emergency calls along the public long-distance network. However, it is anticipated that this could take several years to resolve these questions since it would involve costly research and development investment for something that would improve service only for a small percentage of the telephone company's customers. Just the same, Bell has assured that if precise emergency requirements can be articulated, in the long term just about anything is possible technically along the lines of priority routing. In the interim, other possibilities also need to be considered. Ultimately, an integrated solution involving a combination of private and public as well as satellite, regular telephone, cellular and radio networking is expected to emerge

.

A second meeting of the Subcommittee on Long-Distance Overload was held in November 1990. At that time, it was noted that the problem can be approached in two distinct ways. First, there is the question of priority access to local service because, of course, in order to access the long-distance network, the emergency user must first be able to get a dial tone.

The second approach is to ensure priority access to pre-identified emergency users, thereby allowing them to bypass local networks and connect directly to a long-distance switching centre. The subcommittee has decided to concentrated on the second approach and, more specifically, on finding ways to allow local emergency responders access to private government networks.

A subsequent phase of the subcommittee's work will involve making new arrangements with, first, Bell Canada, and later the other telecommunications companies operating in Quebec. Among other things, they will be asked to include government user specifications for meeting emergency service needs in mind for their future corporate strategic planning. Eventually, it is envisaged that federal arrangements with Telecom Canada member companies dating back to 1978 will be renegotiated to take into account proposals to provide priority routing for emergency users via the public switched network. The subcommittee recognizes that a crucial aspect to the successful execution of its mandate is achieving the full co-operation of the various parties concerned. For this reason, the telephone companies will not be asked to make unwarranted special provisions or offer new services that would require a substantial commitment of capital. Instead, they are just being asked to keep it in mind that their government clients are the largest users of their services. Consequently, it is considered reasonable to exhort them to improve emergency services.

A later meeting of the subcommittee met with Bell Canada representatives for an update on developments related to that company's new digital switching and transmission capabilities which, they claim, have surpassed the federal government's requirements for line load control. Also discussed were the needs of the Canadian and Quebec governments to ensure that emergency responders would be able to access, first, the local telephone network; second, the public long-distance network and, third, their respective private networks.

Regarding local telephone service, for instance, it will be recalled that the line load control program originally was initiated in order to reduce the impact of network overload on emergency users, albeit as a last resort. Respecting digital switches such as the new DMS (digital) switches currently being installed to replace older electro-mechanical, step-by-step and other switches, Bell advises that these have the capability of giving priority access to the same group of emergency users, but without invoking line load control.[14] Pre-identified emergency users in areas where the local switch is a digital one now are automatically identified to it as an "essential line number" when their telephone receiver is lifted to place a call. Once that identification has been made, dial tone is assured -- but, unlike line load control, without cutting off service to other users. New computer applications programs installed in these switches, therefore, provide all of the benefits as line load control, but without significantly reducing the quality of service to the general public. In this way, the telephone company suggests, the line load control program has effectively been surpassed by new technology. Just the same, it is suggested, that program's listings continue to serve a useful purpose and thus they must be maintained and updated regularly. In this way, the telephone companies will be able to ensure that when other new capabilities become available, they can be applied automatically to the emergency user group.

In Bell Canada service areas not yet served by this latest digital switching technology, line load control will have to do for the time being. However, Bell advises that it is in the process of converting virtually all of its local switches to digital. Full conversion (in the order of 99.9 per cent) is expected to be completed before the end of this decade. Table 10.3 below outlines Bell Canada's proposed conversion schedule.

Bell also has provided a list of all of its local service areas now served by digital switches. This will enable emergency responders in any locality within Bell service territory to known whether they enjoy the associated advantages. In return, the GTA and Communications Québec have provided detailed documentation describing their respective private networks so that Bell can look into the technical possibilities of allowing access to the government networks in emergency or disaster situations on the one hand and, on the other, providing some form of priority routing on those networks.

Other questions discussed by the subcommittee with Bell include a request for more information on the kinds of call traffic problems that could be experienced by a locality served by a remote digital switch. To this question Bell advised that the distant locality would have access to the same services as all other subscribers accessing that switch. In the event of a loss of the communication line to the host switch, the locality would default to "emergency stand alone" mode; this would allow only local communications among subscribers in that locality, but not with the outside.

Another subject discussed with Bell Canada concerns the application of line load control to a private automatic branch exchange (PABX), say, one belonging to a hospital. Precisely, the question asked of Bell was whether it would be possible to give priority to some (but not all) of the lines connected to a PABX in a disaster or emergency situation, and how would this priority be passed on to the telephone company switch? It appears to be the case that if the main telephone number of the PABX is included on the priority listing, the telephone company could include all the outgoing lines from the PABX for priority access. However, it was recalled that a maximum of 10 per cent of the lines connected to or transiting a switch can be assigned to line load control. Moreover, it is important to understand that the closer that the maximum capacity is approached, the less effective line load control becomes.

TABLE 10.3
Bell Canada Switch Conversion Schedule

YEAR:	**1990**	**1995**	**1999**
Area Code 514 (Montreal)			
No. lines on line load control listing (LLC)	1,791	4,259	5,408
Percentage LLC lines accessing digital switch	33.1 %	78.8 %	100 %
Area Code 418 (Quebec City)			
No. lines on line load control listing (LLC)	1,588	3,223	4,191
Percentage LLC lines accessing digital switch	37.9 %	76.9 %	100 %
Area Code 819 (Hull)			
No. lines on line load control listing (LLC)	856	2,192	3,111
Percentage LLC lines accessing digital switch	27.5 %	70.4 %	99.9 %

10.4.4 Subcommittee on intercommunications

In recognition of the need for government response personnel to be able to communicate with each other -- both at the site of a disaster and for the purposes of multijurisdictional response operations, the CRTU-Québec decided at its October 1991 meeting to create a new subcommittee on intercommunications. This subcommittee met for the first time in March 1992. It brought together representatives from federal, provincial and regional/municipal (i.e., the Montreal Urban Community) governments.

The following mandate was adopted by the subcommittee at that meeting: In response to the specific needs expressed by the members of the CRTU, the subcommittee will evaluate and make proposals with regard to ways to allow in the short, medium and long-term, intercommunication by radio communication among designated individuals from the different organizations on the site of a disaster or for the purposes of multijurisdictional responses to a disaster.

The DOC, for example, has proposed the utilization of five channels in the new 821-824

MHz band as a medium to long-term solution to the question of emergency radio intercommunication among public safety response agencies. In this regard, the subcommittee has recommended that those channels be made available for local use at the site of multijurisdictional emergencies using mobile and transportable equipment to be purchased by interested government agencies. It also has recommended that the same channels be used throughout the Province of Quebec. In addition Sécurité Publique Québec has been asked to consider the possible integration of its own mobile radio network into a multiagency system, and EPC's four national VHF frequencies (148-149 MHz band) also are to be liberated for the purposes of co-ordinating localized emergencies. Apparently one of those frequencies currently is not allocated in the Quebec region and it therefore might be used temporarily until such time as the five channels in the 900 MHz band can be put into service.

One of the first activities of the subcommittee will be to look at the technical and other implications of using that frequency band for emergency communications. Members of the subcommittee also have been invited to study together the associated document published in the *Canada Gazette*, and to submit their formal observations to DOC-Ottawa in that regard. Further information on the subcommittee's work is not yet available.

10.5 Planning as process

As the above discussion illustrates, the CRTU-Québec provides evidence in support of the thesis that trends in planning as well as in response activities in Canada in the area of emergency telecommunications indicate a clear shift towards consensus decision-making and to flexible approaches to disaster and emergency management. The goal of the committee is not to set down emergency telecommunications policy per se. Rather, it is to enhance the knowledge and awareness of the various players participating at its meetings and on its subcommittees by making them more sensitive to the peculiar dynamics of crisis management and the associated implications for emergency telecommunications.

Consequently, while ad hoc study groups may be formed to address specific issues or questions, dissolving once a satisfactory solution has been found or their task has been otherwise completed, it is anticipated that some of those groups will be regenerated from time to time in order to update the file, so to speak, and thereby ensure that the earlier solution to an issue or problem remains the correct approach. The likelihood of slipping into a complacent attitude regarding, for example, cellular's improved capabilities in a disaster situation thereby will be lessened. Moreover, the accumulation of knowledge and experiences that underscore the inadequacies of traditional approaches to emergency management and telecommunications preparedness makes it more likely that emergency users and, specifically, those involved in the CRTU, will approach new response situations with an awareness that at some points during the disaster or emergency their telecommunications system likely will prove inadequate. This, in turn, hopefully will keep them on their toes and encourage them to be creative in terms of seeking new ways to look at old problems such as loss of or inadequate emergency service. At the very least, they will have a better understanding of their options in an emergency or disaster -- especially as regards whom to contact to rectify the situation and how to borrow or rent additional equipment.

There are two factors in particular that demand this flexibility and an attitude towards telecommunications preparedness which views planning as process. The first is the almost constant introduction of new and improved telecommunication technologies. The second, related to the first, is the fact that their introduction also leads to new players in the process, affecting in turn the dynamics of multiorganizational group planning. These two factors are discussed in the subsections below.

10.5.1 New technologies

New telecommunication technologies, including such things as digital switching and cellular radio-telephone, have significant implications for emergency communications capability -- both locally at and near the site of a disaster or other emergency, and connecting the affected area with the outside world. On the one hand, they may provide new capabilities for immediate communication. On the other, over-reliance on a single medium or mode of communication can lead to problems like public switched network or other system overload and call blockage, possibly delaying crucial communications.

For these reasons, it is essential that potential emergency responders and emergency service providers work together to develop flexible contingency plans which can be modified easily as new technologies and the associated new capabilities become available. In this way, the limitations of technologies such as cellular telephone will be known before they are actually experienced in an already stressful situation. Moreover, it is possible that ongoing participation in the planning process by those entities most likely to be involved in the use or provision of emergency telecommunication services and equipment will help public safety and other essential users in disasters or other emergency situations to apply pre-established procedures in order to avoid or reduce call traffic congestion and overload. Additionally, the sharing of personal planning and response experiences may help the participants to expand their own plans to encompass a widening spectrum of contingencies, thereby helping them to become better prepared for low-probability, high-risk events with which they may one day have to deal. It might also help them to be better prepared if called upon to provide assistance or backup equipment to other emergency responders.

Technology, it is worth repeating, is not the main driving force in current planning activities aimed at improving Canadian emergency telecommunications preparedness. It is one factor among others, and although certainly it is a significant one, concensus decision-making, interorganizational co-operation and the voluntary co-optation of private expertise and resources are, it has been suggested, more important to those processes.

The central role of advanced technologies in telecommunications preparedness and planning is to support the players in that process. Moreover, without the new technological innovations being introduced almost daily, telecommunications planners might become complacent and tempted to settle for established paper plans. As a result, new communication technologies may be regarded best as a catalyst. Their presence or, for that matter, even the possibility of their future introduction, stimulates consideration of ways in which they could contribute to enhance or, alternatively, disrupt or hinder emergency capability. Their presence in some areas and absence in others also inspires consideration of ways to provide equivalent if not equal service in areas where they are not yet available. The discussion above on digital switching is a case in point. Indeed, as long as there are new technologies being introduced that could affect the way that telecommunications service is provided, there will be a need for service users and providers along with emergency planners to come together to investigate their impact on disaster and emergency communications.

10.5.2 New players

Another dimension to the introduction of new technologies that may affect emergency telecommunications preparedness and consequently needs to be taken into account in the planning process is the set of new players that comes along with them. Considering the earlier discussion, reference is made here to the addition of new members to the CRTU-Québec -- more specifically, the two cellular companies and Telesat Canada.

The cellular companies were originally invited to make a presentation to the committee about their experiences during and after the Saint Basile PCB storage warehouse fire. They were subsequently asked to join the committee as permanent members in recognition of the significant role played by cellular technology on that occasion and the likelihood that it will continue to be used in future in responding to major disasters and other emergencies.

Telesat Canada, for similar reasons, has also joined the CRTU-Québec as a permanent member. Its participation on the committee relates primarily to the implementation of the federal government's MSAT program which, it will be recalled, makes available portable earth stations that can be used in remote areas not served by regular telephone service to provide two-way long-distance voice and data communications to assist in emergency or disaster response operations.

While it is not expected that the CRTU-Québec will grow significantly during the coming years as a direct result of the introduction of new communications technologies, new members are expected to join the committee from time to time as new areas of service provision open up which could affect emergency telecommunications service provision. The committee's membership, however, is expected to expand to the extent that liberalized competition policies and new technologies result in the introduction of new players into the Canadian telecommunications marketplace. This is because the nature of the committee's work requires full participation by all the major service providers and equipment suppliers operating in the region so as to guarantee access to them within the shortest time possible in an emergency or disaster. A reassuring note to this point is the fact that the large size of Quebec's counterpart in British Columbia, which already has 44 permanent members, does not appear to be as cumbersome as might be expected. Instead, the larger membership is reflective of a growing interest in emergency planning generally in that region, probably due largely to the threat of a major earthquake in that area. Also on the positive side, growing participation in that forum will provide more resources to undertake investigations aimed at resolving the growing list of telecommunications preparedness questions.

Certainly, no paper plan can be expected to make adequate provision for the nuances of ever-changing technological capabilities and the market forces that accompany and in some instances drive them. New players likely will join the game regularly. Therefore, ongoing planning, including exercising plans regularly, sharing experiences and investigating new issues and questions as they arise is the order of the day -- both today and for the foreseeable future.

10.6 Conclusions

The case study presented in this chapter looked at the establishment and operation of the CRTU-Québec as part of an assessment of the central thesis and related themes. In that regard, this case provides empirical evidence indicating a shift away from the prevailing command-and-control model and towards more co-operative, consultative and as regards private sector expertise, voluntary co-optation in Canadian telecommunications preparedness planning.

In addition, it supports the idea that established hierarchical communication patterns and formalized structural relationships among public safety and industry experts with respect to communications preparedness gradually are being replaced by more flexible, dynamic and non-hierarchical communication configurations. These, in turn, appear to be determined in large part by the informal and personal relationships that emerge over time among participants in the planning process.

It will be recalled that the traditional model assumes a hierarchical, top-down decision-making and implementation structure. The CRTU-Québec, instead, demonstrates an approach that involves decision-making through concensus achieved by ongoing consultation among representatives from many different private as well as public sector organizations.

Another challenge to the prevailing model made by the CRTU-Québec relates to the former's assumption of clearly defined, known and recognized authorities. The CRTU-Québec, in contrast, illustrates a decided preference for and emphasis on informal relationships. This is seen perhaps most clearly in the structure of its subcommittees, which are comprised of small groups of experts coming from the various member organizations to address a specific issue or resolve a particular problem. Their activities reflect a "networking" as opposed to a "systemic" approach. Thus, stringent, formal authorities and mandates are not the focus of CRTU activities. Instead, its meetings and study groups are designed to facilitate the sharing of information and personal experiences. In this way, everyone involved has an opportunity to expand their knowledge base and increase their familiarity with the resources and capabilities of the different participants to the process.

Third, the command-and-control model assumes centralized control at the top -- in both planning and emergency response activities. In the CRTU-Québec, leadership is shared. Active participation by all the members is strongly encouraged, and regardless of their position within their parent organization. The sense that one gets from the committee's consultative process is one of decision-making among equal partners. The federal DOC chairs the meetings of the committee, but it does not attempt to direct the activities of the committee in any formal way. Instead, the agenda of each meeting, it will be recalled, is set by an interorganizational steering committee, and all the members are encouraged to offer suggestions on topics to be addressed. Moreover, participation at the meetings of the subcommittees is open to all CRTU members.

Fourth, as regards emergency telecommunications specifically, the traditional model assumes that there are adequate and easily accessible facilities and equipment to meet the needs of public safety responders in any emergency situation. Furthermore, it does not allow for the possibility of disrupted service -- something that almost always occurs after a major disaster as a result of network overload related to the convergence phenomenon. The CRTU-Québec, however, anticipates such occurrences, and it gives a great deal of attention to finding solutions to them -- first, by looking at ways reduce their impact and, second, by cutting the time required to restore lost service to essential service users by utilizing alternative communications media.

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[1] The author has been a member of the CRTU-Québec since February 1989. As a result, the description and analysis of that committee's structure and functioning is based primarily on personal experience with the process. A serious attempt has been made, however to maintain an intellectual distance -- to the extent possible -- although certainly the author's role as a participant observer has influenced this work.

[2] Advisory planning committees are usually small in size, and they are most often used to address specific emergency management topics. According to Perry and Nigg (1985: p.74), they are recognized as providing "valuable, timely information on specific points of planning interest and can also serve a strong support-building function in the community."

[3] Government of Canada, 1981. Also see DOC, 1983b.

[4] The RETCs/CRTU are the main committees of the regional elements of the NEAT, established under the Emergency Planning Order 1981-1305 and reiterated in the 1988 Emergency Preparedness Act.

[5] See Government of Canada, 1988a for a description of the four types of national emergencies.

[6] See section 10.2 in this chapter.

[7] DOC, 1991. Information on the memberships of the Northwest Territories and Alberta RETCs, respectively, is not available, since the Northwest Territories RETC has only met once and the Alberta RETC at the time of writing had not yet met.

[8] Information recently received from the CRTU-Québec indicates that number of organizations represented on that committee has risen to 23, and that of the 27 permanent members, 52 per cent are from the federal government and 35 per cent from industry (CRTU, 1992: Annexe 1).

[9] The author sits on the committee in an individual capacity.

[10] See the case study presented in Chapter Nine for a discussion on the use of cellular telephone during that disaster.

[11] Reference is made here to the concept of a special user group category (also referred to as user group No.58 or "code 3" users).

[12] The same overload phenomenon was experienced following the air crash at Drydon, Ontario on 10 March 1989.

[13] At the time of the earthquake on 25 November 1988, the Chicoutimi area was not yet served by cellular.

[14] The latter, it will be recalled, in the process of protecting pre-designated lines from losing dial tone (up to roughly 10 per cent of the local switch's capacity), blocks all other outgoing calls. As a result, it is almost never applied and, according to informed sources within the company, apparently it has never been formally applied. Instead, other manual network management techniques have been used in overload situations to protect line load control listed telephone numbers.

PART V
SUMMARY OF CONCLUSIONS
AND ASSESSMENT

Preface

Chapter Eleven comprises Part V of this dissertation. It draws a number of conclusions with regard to the central thesis and related themes and points to the future direction that research in this area might take. It also assesses the major challenges and difficulties experienced during the investigation relative to the type of research methodology used -- specifically, the sequestering of a large portion of the information required to do the study and the author's role as observer-participant. It is suggested that the evidence provided by the case studies included in Part IV, the results of over a hundred personal interviews with career emergency planners and senior response agency personnel, combined with indications of an trend towards a growing concensus among disaster researchers regarding problems with command-and-control model suggest the evolution of other frameworks or, alternatively, some modification of the guiding model for peacetime emergency management.

In recognition of the complexity of modern disasters -- which invariably involve multiple response organizations and intervention by different orders of government -- there appears to be a trend afoot towards more co-operative and co-ordinative as opposed to a control or command oriented military-style approach to preparing for and responding to peacetime emergencies such as large-scale disasters. With regard specifically to evolving emergency communications configurations, they similarly appear to anticipate dynamic and non-hierarchical (i.e., geodesic) patterns of relationships and less formal information exchanges among the participants as opposed to more rigidly hierarchical and formalized organizational and interorganizational communications patterns.

CHAPTER ELEVEN
Conclusions

11.1 Central thesis and related themes

The central thesis was derived from the literature on crisis management. Other major themes or secondary theses considered were questions raised by the author prior to the investigation reported herein which appeared to warrant closer study within the context of the stated goals of this work. Alternatively, they suggested trends or common threads that came to light as a result of reviewing the literature, during the case studies or from personal interviews.

The central thesis addressed by this investigation was that the prevailing command-and-control theoretical model implicit in the literature applies to Canadian peacetime as well as to defence-related emergency planning and response activities. The findings of this study indicate that the situation is more complex than appeared initially to be the case. As a result, it is suggested that a refinement or modification of that model or may be needed to explain better the nuanced context within which peacetime crisis management occurs.

The 1980 Mount St. Helens volcanic eruptions, the Saint Basile-le-Grand PCB storage warehouse fire and the CRTU-Québec planning committee case studies all provided empirical evidence supporting the conclusion that the traditional model is inadequate as a theoretical framework in the search for explanations of the behaviour of government decision-makers and emergency organization response personnel in peacetime disaster planning and response activities. Additionally, the evidence provided by those case studies has been supported by interviews with a large number of individuals directly involved either in planning for or responding to disasters.

Briefly, the following assumptions made by the command-and-control model have been challenged by this investigation. First, the prevailing model assumes adequate communications facilities and easy access to them -- even under severe disaster conditions. Second, it assumes clearly defined, known and recognized authorities. Third, it assumes centralized control at the top as regards both planning and response and, correspondingly, top-down hierarchical communications patterns.

The findings of the present study, however, suggest that communications facilities in the first hours after the onset of a large-scale disaster likely will be inadequate and/or inaccessible. Indeed, technical communications lifeline infrastructures themselves often become victims of the disaster agent. Furthermore, there appears to be a clear preference among government decision-makers and public safety responders for simplified and less bureaucratic decision-making approaches in crisis situations. Indeed, in the specific situations looked at, the activities of responders and government officials suggested a predominance of non-hierarchic and informal communications patterns, particularly among those individuals with previous disaster experience. Furthermore, in terms of the preparedness planning and response activities considered, the findings suggest that leadership in such situations likely will be broad-based and it will be determined by the known technical and other specialized expertise of the participants. These findings imply a network as opposed to a traditional systemic approach to peacetime emergency management.

One of the subtheses addressed by this study was that established relationships among emergency responders will be reconfigured in an actual disaster situation. Related to this, once again, is the idea that there seems to be a trend by public safety organizations to move away from hierarchical communications patterns and formalized structural relationships. They are moving instead towards more flexible, dynamic and non-hierarchical or "geodesic" communication configurations based on interpersonal relationships established prior to or evolved during the course of a shared disaster experience. Empirical evidence was provided in support of this thesis by the Mount St. Helens and Saint Basile-le-Grand experiences. It also was confirmed by several interviews with public safety response personnel involved in managing those two disasters.

Another major theme considered relates to the effects that new technologies will have on emergency management capability. It has been suggested that the introduction of new communications technologies will improve national disaster communications capability. This theme was not substantiated by the experiences associated either with the Hinsdale telephone company central office fire or the Saint Basile-le-Grand PCB fire. The results of both case studies indicated that disaster planners cannot assume that new technologies automatically will improve their emergency communications capability. The Hinsdale case, for example, demonstrated the devastating impact on telecommunications users across a wide geographical area when the telephone company's facilities suddenly were destroyed. Many of the problems encountered on that occasion were attributed to common industry practices of centralizing switching capability at distant "hub" stations -- thereby reducing facilities duplication and, with it, system survivability and network reliability. The Saint Basile case also demonstrated some of the undesirable consequences of relying on a single (previously untested) communications medium -- cellular radio-telephone -- in an emergency situation. That experience underscored some of the serious limitations of existing cellular technologies in a disaster context. It should be noted, however, that a lot has been done as a direct result of that experience by the cellular providers to ensure rapid upgrading of individual cell capacity on very short notice. The cellular companies also now can provide a line load control-type service to give priority calling capability to pre-identified emergency subscribers.

A related theme considered was that liberalized competition policies in the United States have jeopardized national emergency preparedness communications capability. Interestingly, while several studies undertaken around the time of the U.S. federal court's decision to split up the AT&T Bell system (early 1980s) all concluded that emergency communications capability had been seriously reduced as a consequence, the results of the present investigation indicated that there was insufficient evidence to draw that conclusion. Instead, a look at some earlier studies, and of the Mount St. Helens (which occurred before AT&T's divestiture) and Hinsdale response operations, as well as interviews with most of the major industry representatives on the National Security Telecommunications Advisory Committee (NSTAC) indicate that most of the negative effects of introducing competition in that sector have been offset by co-operative arrangements established through the U.S. federal government-industry National Coordinating Center mechanism.

As regards the Canadian situation, the establishment and operation of Regional Emergency Telecommunications Committees across Canada similarly can be expected to mitigate any adverse effects of competition in long-distance public voice services in this country. This is because, in these fora, the major industry and government players have acquired shared co-operative experience through predominantly informal arrangements in the area of communications preparedness. Additionally, a number of formal arrangements concluded in the late 1970s between Stentor's predecessors and the Canadian Department of Communications regarding the federal line load control programme, priority service restoration, vital points, etc. recently were reaffirmed and now are in the process of being brought up to date as regards present-day technical capabilities. It also is anticipated that given the June 1992 decision by the CRTC to allow competition in long distance telephone service, those arrangements will be extended and refined to accommodate public service provision in addition to private line services.

Extensive anecdotal evidence from the U.S. experience has pointed to liberalized competition as the main cause of decreased national emergency communications capability -- measured in terms of over-centralization of switching and reduced transmission route redundancy. That relationship, however, may be an extraneous one. It is suggested instead that another variable, market demand for customized (e.g., virtually private networks) services, needs to be looked at more closely as a factor associated with potentially decreased national emergency communications capability.

A third major theme considered by this study is that disaster experience will lead governments to establish co-operative arrangements with divers public and private interests in order to enable them better to meet extraordinary service demands in major emergencies. Additionally, disaster experience will cause them to encourage commercial service providers to make informal co-operative mutual aid arrangements among themselves and, in this way, national communications preparedness capability will be enhanced. This thesis was supported by the evidence provided by this investigation. Specifically, a review of some of the measures taken at the regional level after the Saint Basile-le-Grand fire suggests that a concerted effort was made subsequently by federal and provincial authorities to work more closely with the carriers, including the cellular as well as the regular telephone companies, to resolve the problems experienced on that occasion. Similarly, consideration of policy changes by the State of Washington after the Mount St. Helens disaster as regards its approach to civil emergency management and especially with respect to interagency communications, indicate greatly increased co-operation between the agencies involved and with industry to redress the problems experienced during that event. In a like manner, post-Hinsdale measures taken by the industry and supported by the Illinois Commerce Commission, together with the Federal Communications Commission's (FCC) creation of a multiorganizational (extending to Canadian representation) special council established to study major telecommunications outages with the aim of reducing their impact on telecommunications preparedness also provide evidence in support of this thesis. Finally, many of the RETC/CRTU activities, and especially the establishment of ad hoc subcommittees to address pertinent questions as they arise and make formal recommendations for follow-up by the members in their respective organizations, suggest that Canadian governments are learning from their experiences with large-scale disasters. They apparently have used them to improve interorganizational co-operation as well as to facilitate industry input to communications preparedness planning.

11.2 Communications in disasters

While the role of communications in disasters generally is recognized as integral to effective emergency preparedness and response, certain assumptions made by emergency organizations regarding the ability of the communications infrastructures to meet increased and specialized demands for communications during and after a major natural or industrial disaster have been challenged by this study. In the first place, it often is assumed that an adequate technical communications infrastructure is in place to handle even the most extreme upsurge in communications traffic after the onset of a major disaster. Secondly, it is assumed that public telecommunications networks will function satisfactorily in a disaster. The findings of the present investigation suggest instead that it may be more appropriate to presume that neither will be the case in the event of a large-scale emergency.

Additionally, this study has concluded that the human factor in emergency communications is a crucial element throughout every phase of preparedness planning and response. This is because emergency organizations operate at different jurisdictional levels, and disasters are notorious for ignoring political boundaries. Consequently, pre-established relationships among individuals working in public safety organizations that become involved in a particular response operation together with those industry representatives providing technical expertise, emergency services and equipment will help determine the extent to which existing communications resources are deployed effectively in a disaster situation. Additionally, efforts to meet extraordinary demands for communications in disasters will be co-operative rather than competitive if the alternative suppliers and service providers have concluded informal or formal mutual aid arrangements prior to the event.

11.3 Government approaches to disaster preparedness

Considerable progress has been made in Canada towards more effective national, and especially regional, emergency preparedness and planning. A shift in federal policy away from civil defence planning which had been preoccupied with wartime preparedness occurred after the mid-1960s. Since that time, greater attention has been given to preparedness strategies related to natural and industrial disasters. Those trends reflect, on the one hand, the growing public awareness of the risks associated with natural and other disaster agents in their immediate -- and today predominantly urban -- environment. On the other hand, they suggest a growing consciousness among municipal and provincial decision-makers of their respective response and support roles in disaster situations, accomplished by more policy initiatives taken at those levels, and with fewer and only very broad guidelines being established by the federal government.

Clearly the threat of a nuclear attack on North America appears more unlikely than previously. It is not surprising, therefore, that the Canadian military establishment has experienced substantial cutbacks in terms of the closing of many overseas bases and reducing the size of its combat forces. Emergency Preparedness Canada's close association with National Defence similarly has placed it at a disadvantage in terms of selling civil emergency preparedness as a political issue. Just the same, the increased incidence of widely publicized disasters affecting large population centres during recent years, combined with strategic public education initiatives during and after recent earthquakes in California which have emphasized that there is a high probability that a catastrophic earthquake will occur along the coast of British Columbia have caused many Canadians to look more closely at the possible effects of such an occurrence on their own lives and to seek information on other kinds of disasters that could pose a threat to their communities. In particular, they have served to emphasize the importance of local planning -- especially as regards emergency communications.

Ironically, municipal authorities -- who in any localized incident would be responsible for managing the front-line emergency response -- have the fewest resources (in terms of human expertise and equipment) to cope with a disaster. As a result, provincial and territorial governments can help them to improve their response capability by assisting them in preparing and exercising local emergency plans, encouraging the establishment of mutual aid arrangements and training crisis managers.

It has been suggested repeatedly in this work that peacetime emergencies differ in significant ways from defence-related crises -- in terms of both the degree and the kind of involvement they require from private citizens, industry and elected officials. As a result, this study has concluded that a modified approach to emergency management is required. While it may be appropriate to take a military style command-and-control approach to preparing for and managing a defence-related crisis, the evidence suggests that, in a peacetime disaster context, less hierarchical and more co-operative approaches are required. That is because, in contrast to a military operation, it may be less important that someone "take charge," and more important that private citizens look after themselves to the greatest extent possible.

Additionally, public perceptions about how a given response operation has been managed may be more important politically than maintaining established formal authority structures. For this reason, interorganizational pre-planning together with the development of informal relationships among public officials at different levels of government, and with private sector experts and essential service providers or equipment suppliers cannot be overvalued. Indeed, it often is these non-hierarchical linkages that work best in a crisis situation.

Finally, as regards communications preparedness, decentralized planning also has led to the emergence of some new approaches to policy-making in this area. For example, the establishment by DOC of Regional Emergency Telecommunications Committees throughout Canada has facilitated the development of informal relationships among the major players at the regional level, including representatives of different federal and provincial/territorial departments and industry. In addition, it has served to create an informal mechanism for those individuals likely to become involved in a regional response operation to work out ways to reduce the costs of meeting their communications needs in a disaster and, more generally, to ensure an effective response.

11.4 Industry initiatives and government/industry programs

A key element in the transition towards a modified approach to emergency planning and response has been the co-ordination of industry and government initiatives through a variety of joint programs. These programs similarly have encouraged formal and informal linkages between public safety and other government users and their suppliers. In addition, they have stimulated Canadian telecommunications carriers to develop co-operative arrangements with each other aimed at ensuring the survivability of national networks and improving reliability in essential as well as regular service provision. Moreover, private sector involvement in emergency communications planning also has paved the way for increased co-operation for the purposes of network planning -- including, for example, the acceptance of common technical standards, operating procedures, interconnection protocols and other shared arrangements which will protect the public switched network in the event of physical damage to telephone company landline or microwave facilities.

Since communications are crucial to effective emergency response, pre-planning, including the voluntary co-optation of private sector expertise in government emergency preparedness activities, is considered to be especially important. Therefore, while in other areas of policy-making it may, in fact, not be desirable to involve the industry providing the equipment or service under consideration in the development of public policy, as regards communications preparedness, it appears that their continuous involvement is vital to the success of the process.

11.5 Impact of industry trends

In recent years, market demand has driven communications equipment suppliers and service providers to introduce sophisticated and, increasingly, customized telecommunications service options. This has affected public networks in several ways. For example, historically, users conceived of public telecommunications in terms of voice communications alone; today, while network usage is still predominantly for voice, user demands are expected to be increasingly for data services. In fact, Canadian business users already rely on the public network as the main real-time link connecting various computer systems used in their day to day business operations; other data system uses that rely on public network linkages include instantaneous financial transactions and access to remote databases.

In the area of customer premises equipment, the proliferation of hundreds of types of equipment, including private branch exchanges, local area networks and all kinds of handsets, etc. are bringing distributed intelligence to more and more users' premises. Significantly, however, equipment diversification, combined with the growing variety of protocols has hindered the establishment of network/premises interface standards that would allow full interoperability. As a result, attention needs to be given to increasing private network interoperability as well as greater interconnectivity (with each other and with the public switched network) via common gateway architectures. Moreover, while proliferating stand-alone network configurations are the current reality, some form of preplanned interoperability cut-over mechanism needs to be designed to ensure adequate response capabilities under a variety of contingencies, and especially to allow for the effects of multiple signal transfer point failures.

Also regarding technological improvements that are in the process of radically transforming the related industries are advances in lightguide transmission and digital switching. A negative consequence of these developments has been that of reducing network redundancy and thereby increasing the vulnerability of the public switched network to major outages in the event of damage to telecommunications physical facilities. This is because fewer cable routes are now required to meet overall network demand -- leading to an increased concentration of call traffic along a decreasing number of high-volume fibre optic routes and, correspondingly, to a reduced utilization of alternative technologies. In like manner, the development of "super" switching centres has created a situation where a single hub switching node, located in a distant, perhaps unstaffed, station may handle voice, data and cellular communications traffic for tens of thousands of users (e.g., the Hinsdale central switching office). Indeed, it is now common practice for the following types of telecommunications equipment to be located in a single building: signal transfer points for common channel signalling, class 3, 4 and 5 switches, packet switches, cellular/public switched network interface facilities and private line terminals. How much system redundancy is there when so many key elements of both switching and transmission capability are co-located?

Developments in mobile cellular radio-telephone technology deployment also offer potentially significant capabilities for network redundancy -- especially as these systems expand into smaller urban and, eventually, rural centres as well. Just the same, that redundancy remains restricted in two fundamental ways: First, they will not be able to replicate fully the traffic carrying capacity of landline networks. Secondly, cellular super systems -- which interconnect remote cellular switches with hub metropolitan cellular switching offices -- are pseudo-redundant in that they depend on the telephone company hub switch into which they feed in order to access the public switched network; thus, if it fails, they fail as well.

It is expected that fibre optic terrestrial cable will continue to be the transmission medium of choice for a long time to come. In addition, digital transmission technologies will determine the shape of future network architectures, while microwave radio -- including fixed and mobile private and public safety, cellular and satellite systems, where they are interconnected and interoperable -- will back up regular localized transmission capability. Moreover, software-defined customized data services rather than voice communications are expected to provide the main impetus for the network's future evolution.

As a result of all of these changes and the anticipated continued highly dynamic nature of the telecommunications sector, Canada's emergency preparedness communications needs will be met only if system back-up resources for the public network are increased significantly and co-ordinated by the establishment of industry protocols that allow improved terminal and network interconnection. Additionally, because the packet switching technologies commonly used by value-added networks are well suited to alternative routing, more effort needs to be made to exploit their commercial capabilities for emergency preparedness and response purposes, including message transmission, robust packet-switched signalling, electronic mail and the like.

Today we are witnessing the transition to a geodesic facilities network configuration -- nationally, continentally and, ultimately, globally. That transition is being driven both by new communications technologies and, increasingly, by market demand for customized services that cannot be accommodated effectively by rigidly hierarchical network configurations. CCS-7 switches, for instance, will lead to direct connection at lower levels of the switching hierarchy (e.g., between class 4 switches), and the wider use of local area networks will create mini-hierarchies within the emerging geodesic framework. As regards emergency communications preparedness, this transition potentially could lead to a greater capability by emergency responders to access alternative communication systems. Alternatively, it could result in the further fragmentation of national networks, decreased redundancy and the erosion of existing emergency capabilities.

11.6 Public alert/warning communications

With regard to civil emergency alert and warning, Canadian approaches historically have emphasized national broadcasting capabilities. The United States, in contrast, has focused on two-way voice communications. As regards national emergency broadcasting capability, unlike Canada's Emergency Broadcast Service, the backbone network of which is the government-owned CBC radio network, U.S. broadcasters participate in that country's national emergency broadcast program on an purely voluntary basis. The result in the United States has been a somewhat haphazard approach to emergency broadcasting which has worked remarkably well in most instances.

The U.S. government's emphasis on developing government-operated dedicated voice and data systems linking public agencies under FEMA-funded and administered programs differs markedly from the Canadian approach. Indeed, the various federally owned and operated networks in that country, in combination with arrangements with major telecommunications suppliers through the NCC and the NSTAC appear to provide American public safety authorities with considerably more diversity in terms of national emergency communications capability.

In Canada, arrangements between governments and with telecommunications equipment and service providers are less formal. And while the federal government in this country does operate a dedicated network linking provincial capitals and other major population centres, it uses lines leased from the telephone companies and, therefore, is not a truly redundant system. Only the Department of National Defence owns and operates separate voice and data networks, but access to them by other public agencies is not possible without ministerial approval.

Additionally, in Canada, municipal governments make their own arrangements for interagency communications and with neighbouring authorities for intermunicipal emergency mutual aid networks. Moreover, provincial and federal agencies are able to communicate with each other in a crisis situation over a small number dedicated telephone lines, but municipal authorities' communications with the other orders of government, even in a disaster situation, currently can be made only by regular telephone (and in some cases, over radio). It is anticipated, however, that in the near future (in some areas of the country as early as a year or two) arrangements will have been concluded with the telephone companies and Unitel to provide a patch-through capability that will allow designated local government authorities to access federally and provincially operated private networks for long-distance emergency communications. Priority access for local communications, it will be recalled, already exists in areas served by digital switches through the line load control program.

An optimal approach to emergency communications preparedness might fall somewhere between those of Canada and the United States. It would, for example, emphasize improved technical standardization and an incremental upgrading of existing operational systems. It also would make provisions for full interoperability of some separate major networks -- public and private -- for emergency purposes. Additionally, it would require further development of formal and informal relationships among representatives of government agencies at all levels, together with their private industry suppliers. This could be achieved through: (1) existing industry advisory committees made up of Telecom Canada member companies, Unitel and other interested telecommunication firms including major data service suppliers; (2) new policies aimed at enhancing the educational and information exchange functions of the RETCs/CRTU; and (3) the establishment of the proposed National Emergency Telecommunication Committee in order to incorporate and, where practicable, standardize practices on a national level so as to benefit from the lessons learned in different areas of the country, thereby reducing the time and the resources expended to improve Canada's national communications preparedness capability.

As regards emergency-only systems and those emphasizing public warning capability, these are not expected to become politically more saleable in the near term given the end of the Cold War. Those aimed at improving existing system flexibility, accessibility and interoperability likely would be more successful in the light of increased public awareness about the importance of early warning for weather-related and other rapid onset disasters. Nor can the role of the CBC-based Emergency Broadcast System in issuing public warnings and providing regular situation updates in a disaster be neglected. The overall positive performance of that system in incidents ranging from hostage takings on Parliament Hill to the Kanahsatake and Kanawake Reserve stand-offs, etc. suggests a clear value in refining and extending Canada's broadcast-based approaches in this area to include television and, in particular, local cable stations. Finally, improved co-operation between Canadian and American governments -- whose geographic proximity and economic integration make the likelihood of overlapping effects of major disasters considerable -- also is to be encouraged, most particularly at municipal and provincial/state levels in the area of emergency communications, so as to assure mutual aid emergency response in large-scale disasters.

11.7 Mount St. Helens and the command-and-control model

Among the lessons learned during the Mount St. Helens disaster was a greater appreciation of the need for clearly defined, but flexible authority structures and improved co-ordination among public safety agencies at different levels of government. This applies not only to horizontal relationships between emergency service organizations at the same level of government; it also suggests a need to clarify who has precisely what authority, and who is going to do what tasks.

The Mount St. Helens case also suggests that there are problems with the command-and-control model as a theoretical approach to peacetime crisis management. These become particularly evident in a disaster situation which involves multiple response agencies and crosses political boundaries. It will be recalled, for example, that traditional approaches to crisis management presume a stable environment predicated upon cause and effect, and a limited number of "solutions" derived from military strategic planning. In contrast to this, peacetime disasters are invariably highly dynamic environments and they call for flexible communication linkages among the central players in order to assure an effective response.

As that case illustrated, normative or bureaucratic guidelines specifying appropriate modes of conduct could unnecessarily constrain and even impede the response effort. Attempts by the Washington state emergency management agency and other government agencies (including the U.S. military) to impose standard operating procedures and bureaucratic decision-making structures during the first days of the post-eruption crisis resulted in confusion, tension and confrontation between some responders. They also created obstacles to rapid resource deployment and led to the bypassing of the state agency in order to overcome them.

The experience supports the idea that previously established communications patterns and relationships among the various players involved in managing a disaster response likely will be reconfigured to reflect the situation at hand. In addition, perceptions about organizational competence will take precedence and formal authority structures may be perceived by response participants to interfere with multiorganizational decision-making. Where this is the case, temporary alliances will be formed and emergent disaster networks will evolve, linking the key players in each phase or aspect of the response. Their shared experience eventually could lead to the development of a more permanent expert network comprised of representatives from organizations that are likely to become involved in future response operations. Such a network, by definition, would be broad-based and dynamic; that is, it could easily be expanded or contracted to meet the needs of the situation at hand. The evolutionary nature of the network also would allow participation in planning and post-event analysis by a core group of active participants from different disciplines, thereby generating a dynamic to develop and exercise innovative strategies for coping with a variety of disaster agents.

The Mount St. Helens disaster response also provided evidence suggesting that a modified approach to crisis management may be needed to explain organizational behaviour in major disasters and other peacetime emergencies. It would be rooted in a local or situationally focussed perspective, thereby allowing for planning and response structures that reflect Thomas Drabek's image of "loosely coupled systems." These, in turn, would constitute the nodes of an emergent, non-hierarchical and dynamic -- geodesic -- expert disaster network.

This view contrasts with the prevailing emphasis on so-called scientific crisis management which is derived from the traditional command-and-control model. Unlike the alternative emerging frameworks for which this case provides evidence, traditional approaches fail to recognize the potential strengths of less formal arrangements which, it is suggested, are more conducive to rapid improvisation, localized adaptation and innovative solutions to highly complex modern disaster situations.

11.8 Hinsdale and telecommunications preparedness

The experiences of large telecommunications users and, in particular, those of emergency and essential service organizations during and after the Hinsdale fire challenge the thesis that the introduction of new technologies has improved emergency communications capability. To the contrary, this case study suggested that they actually have had a negative effect on national communications preparedness because they have made the public telecommunications system more susceptible to major disruption. The Hinsdale telephone company central office disaster demonstrated that the combination of introducing high-capacity fibre optics, digital switching and sophisticated software programming capabilities led to: (1) reduced public switched network redundancy overall; (2) an over-concentration of call traffic on a diminishing number of transmission routes; and (3) an over-centralization of call processing capabilities.

Therefore, while new communications technologies have enhanced voice, data and image message transfer capability in normal times, in a disaster -- particularly when the physical facilities of the network themselves are damaged -- the repercussions for all users, and especially public safety and other essential service users, could be serious. This is due to the much greater volume of traffic that now can be transmitted through a single switch. It also means that the area of impact coverage and the number of affected users will be much greater if a major network node is lost. The situation will be that much worse if multiple system transfer points fail.

With respect to Canada's emergency communications preparedness capabilities, there are some useful lessons to be learned from the Hinsdale experience, even though the Canadian public network has evolved somewhat differently from that in the United States. This is due in part to the distribution of the Canadian population in a narrow band along its long southern border and the slower pace of change in the network associated with less rapid expansion of Canadian business user demand for customized services.

On the positive side, an advantageous feature of the Canadian telecommunications system in terms of emergency preparedness is that its much smaller size makes possible a certain intimacy among the various players as regards network architecture modifications, etc. The fewness of their numbers and the association of the largest telephone companies in Telecom Canada (now Stentor) also has made it easier to negotiate co-operative arrangements between government and industry to prevent or, when a disaster occurs, rectify quickly problems affecting the public switched telephone network. Additionally, it has made it possible for industry players to conclude informal arrangements among themselves for mutual aid support in the event that a major carrier loses a significant portion of its facilities. This is not to say, of course, that the Canadian network is immune to a major telecommunications outage. Indeed, there are several common elements between the Canadian and U.S. national telecommunication systems which have had the effect of greatly reducing network facilities redundancy on the one hand, while increasing their susceptibility to extensive service loss on the other.

Another theme addressed by the Hinsdale case study relates to the effects of public policy trends -- and specifically, liberalized competition -- on national emergency communications capability. Although the assertion was made in the National Communication System's post-event report, as well as by media and other observers at the time that liberalized competition had jeopardized U.S. NS/EP telecommunications capability, the evidence provided by the Hinsdale experience leads to the conclusion that it does not provide sufficient empirical evidence indicative of a clear causal relationship between the two. Moreover, it is possible that those policy trends themselves have been the product of pressures from an alliance of business users to open up competition in that sector. Certainly, there is anecdotal evidence which suggests that the combined effects of AT&T's divestiture and competition have pushed U.S. telecommunications companies to put profitability before all else, streamline operations and eliminate duplication wherever possible. It also is now widely recognized that liberalized competition policies have had the effect of emphasizing market segments rather than systemic integrity. This fragmentation of the public telecommunications system may, in turn, make it difficult to organize its different elements for the purposes of integrating emergency communications capabilities. Beyond that, no more can be said without additional research.

Since 1988, most of the problems associated with the Hinsdale central office fire have been addressed, if not fully resolved. At the same time, other major outages stemming from a variety of causes have led the North American telecommunications industry and policy-makers to take steps to improve system survivability and network reliability. These initiatives suggest a trend towards greater integration of North American communications preparedness activities and, possibly, the emergence of a modified theoretical framework for emergency preparedness management.

11.9 Saint Basile-le-Grand and cellular telephone

The evidence provided by the Saint Basile-le-Grand response refutes some basic assumptions of traditional approaches to crisis management. In addition, in a similar way as was suggested by the Hinsdale case study, the experiences of emergency responders during the Saint Basile-le-

Grand disaster raise questions as to whether the introduction of new technologies actually has promoted emergency service reliability and enhanced network redundancy.

It will be recalled that most public safety agencies, and especially municipal emergency organizations -- which are always on the front-line of peacetime disaster response -- continue to rely almost exclusively on telephone (including cellular) for interagency communications. Consideration, therefore, needs to be given to adding transmission path diversification by, for example, allowing (or even requiring) intercarrier interconnection in emergency situations.

In Canada and the United States, priority restoration listings have been programmed into telephone company computers in order to allow rapid restoration of service to essential service users when it is lost, regardless of the cause. Similarly, line load control software programming can guarantee dial tone to roughly a tenth of government and public safety users in a severe local traffic overload situation. Significantly, however, no provision has been made to ensure call completion -- on either local or long-distance calls. Line load control only assures that the caller will be able to reach the nearest telephone company central office. Thus, at any transfer point along the way, a blockage at a telephone company switch will prevent call completion. As a consequence, priority access to dial tone may mean little once the network becomes congested -- and that is likely to happen very quickly following the onset of a disaster and could remain that way for hours.

The situation is even worse for cellular service. This is because, first of all, it is dependant on telephone company switches to access the public telephone system. Secondly, only a limited number of radio frequencies have been allocated to cellular service. Third, there is currently no technical way to give priority access to the cellular network to an emergency response user. Fourth, arrangements have yet to be concluded that would allow emergency users to access the competitive carrier's network automatically in an overload situation in order to improve their chances of successfully completing calls. The only way to do so at the present time is to be to be dually equipped.

Another theme addressed by the Saint Basile experience concerns the effects of shared disaster experience on communications preparedness. It has been suggested that those experiences will give an incentive to industry to make technical improvements in order to avoid repeating problems encountered previously. The post-Saint Basile activities of Cantel Mobile Inc. and Bell Cellular support this thesis. Since that incident, each company has worked on establishing a corporate emergency plan and co-ordinating jointly their efforts for the provision of disaster cellular communications. They also are looking at ways to enhance their separate and combined emergency capabilities by studying options such as: (1) the purchase of a mobile cellular switching centre; (2) stockpiling pre-programmed units which could be dispatched to the disaster site to equip response teams; (3) providing training to municipal authorities on emergency cellular applications; and (4) creating ways to provide priority network access and service restoration to pre-identified emergency subscribers.

An additional theme related to prior disaster experience refers to the anticipated increased co-operation between governments and industry to improve communications preparedness. Reference is made here to voluntary co-optive arrangements such as the establishment of informal study groups to address pertinent issues as they arise. Certainly, the Saint Basile disaster experience created an increased awareness of the need for that kind of collaboration in order to ensure better management of a major environmental disaster. Since that time, and as a direct consequence of Saint Basile, government/industry study groups have been created under the auspices of the CRTU-Québec to address questions related to, respectively, cellular radio-telephone, long-distance network overload and interagency communication. Each is comprised of experts from the telecommunications industry, government and academia, and the projects in which they are involved provide examples of co-operative emergency planning.

11.10 CRTU-Québec and preparedness planning

The CRTU-Québec case study similarly provided evidence of a shift at the regional level away from a traditional hierarchical approach and towards more co-operation and consultation, and as regards private sector expertise, voluntary co-optation in communications preparedness. In addition, it supported the idea that established hierarchical communication patterns and formalized structural relationships among public safety and industry experts with respect to telecommunications preparedness increasingly are being replaced by dynamic and non-hierarchical communication configurations. These, in turn, appear to be determined in large part by the informal and personal relationships which have evolved over time among participants in the planning process. Like its counterparts elsewhere in Canada, the CRTU-Québec's planning activities challenge systemic approaches to emergency preparedness planning. Instead, planning in the context of that forum is viewed as process, the goals of which include the practice of consultative decision-making.

A further challenge to the guiding model relates to the assumption of clearly defined, known and recognized authorities. The CRTU-Québec, by contrast, demonstrates a preference for and, indeed, an emphasis on informal relationships by the participants, suggestive of a networking as opposed to a systemic approach. This can be seen most clearly in the structure and operation of its subcommittees which are comprised of small groups of experts coming from different organizations and academic disciplines to address a specific issue or resolve a particular problem. Thus, precise authorities and mandates are not the focus of CRTU activities. Instead, the purpose of its plenary meetings and the various study groups is to facilitate the sharing of information and personal knowledge among members. In that way, everyone involved has an opportunity to expand their knowledge base and increase their familiarity with the resources and capabilities of the different participants to the process.

Another theme addressed by this case relate again to the effects of shared experience on telecommunications preparedness. The CRTU-Québec provides empirical evidence supporting the idea that joint participation in the planning process will give industry an incentive to improve emergency communications service provision. It also is expected to increase the saliency of pertinent issues on the public policy agenda and, in turn, stimulate new programs within industry which emphasize system survivability and improved redundancy.

11.11 Assessment

"Communications" has been identified in much of the North American disaster literature as the number one problem experienced during peacetime emergency situations. But what does this mean? This study has concluded that it may have less to do with communications equipment facilities than previously thought and more to do with interpersonal communications -- that is, the communications linkages and patterns of relationships among the individuals who are involved in emergency preparedness planning and response activities.

A significant finding of the study is that traditional approaches to emergency management based on the implicit military style command-and-control guiding model may not be adequate for explaining the behaviour of government and other participants in actual planning and response contexts. The evidence provided by this investigation suggests the emergence of other, non-hierarchical approaches which may provide a better explanation. Indeed, while the findings reported herein are preliminary, since they are based on a single-country study (albeit an exhaustive one), they do suggest an evolving framework that eventually may provide either a substantially modified or perhaps even an entirely new theoretical model for crisis management.

It is suggested, therefore, that the direction to be taken by future research in this area ought to be towards exploring the existence and evolution of other research frameworks based on the conclusions drawn by the present study. To that end, for example, more case studies could to be undertaken of specific Canadian disaster experiences and, on an international level, of telecommunications-related disasters, in order to determine whether trends that appear to be emerging, as is indicated by this study, are limited to the specific response operations and planning activities considered by the author or whether, in fact, they reflect a broader phenomenon. Investigations also could be undertaken to consider the possible short, medium and longer term effects of public long-distance voice competition in Canada and the United States as regards national emergency communications capability. Other areas of research that could be pursued in order to establish the determinants of Canadian national emergency communications preparedness include taking a closer look at the different Regional Emergency Telecommunications Committees operating across Canada. Another area of study that could contribute to a better understanding of Canadian trends in emergency preparedness planning would involve doing a follow-up study, say five or ten years after, of major disasters such as Saint Basile-le-Grand to see whether and what remedial measures have been taken.

The present work perhaps best can be viewed as a prologue, or preliminary discourse, to a broader comparative effort of addressing questions related to communications preparedness in peacetime emergencies. As already noted, the investigative tasks of this study included the choice to undertake an extensive, in-depth look at a single country case, namely, Canada. That choice rested upon a recognition of the methodological difficulties and challenges associated with attempting to deal with the combined effects of an emerging and dynamic configuration of institutional players, new technologies and residual government policies. The inclusion of references to U.S. emergency management structures and policy approaches, as a rider to the Canadian experience, was based on a recognition of the usefulness of such an exercise to orient the active category or context -- that is, the Canadian experience. Moreover, it was decided to analyse the prevailing implicit command-and-control model of emergency management in terms of this country's structures and practices, particularly as regards emergency communications, as part of a larger process towards the achievement of a broader vision of communications preparedness generally.

Significantly, the international, and especially the American, situation has become vastly more complex than during the time period of the disaster case studies included herein (1980-1988). This has been due to the combination of disaster management experiences associated with several telecommunications outages having serious economic consequences for commercial activities in the affected centres and an increasing number of large-scale national and industrial disasters affecting urban centres. Additionally, other international events -- such as the dissolution of the former Soviet Union, and the declaration and commencement of the United Nations' International Decade for Disaster Reduction -- also have, to some extent, overtaken this research. The result has been a greater awareness generally by business telecommunications users, service providers and regulatory agencies of the necessity both to ensure system survivability and rectify the problems associated with the introduction of new technologies. Another consequence has been the recognition by European and North American governments of the need to reassess The North Atlantic Treaty Organization's (NATO) role and mandate, including civil emergency planning and, as part of that process, the alliance's communications preparedness capabilities.

For these reasons, the usefulness of a study such as the present one is underscored. Certainly it is reflective of a wider recognition today than previously of the crucial role of telecommunications generally and, more specifically, of the regulatory community's current activities to enhance public switched network reliability and multimodal system survivability through improved and fuller interconnection and interoperability for emergency applications.

As regards some of the methodological challenges and difficulties of this investigation, the major initial obstacles that had to be overcome related to the sequestering of much of the information required to meet its objectives. This was due in part to customary practices to sequester government-commissioned studies and departmental documents due to the overlapping of military, national security, diplomatic and disaster management considerations associated with a "civil defence" mind set which, until very recently, has predominated in Canada. As a result, information was received in bits and pieces, with no coherent pattern; and meeting the objectives of this research exercise was, therefore, a lengthy process requiring considerable patience. As time went on, however, it became apparent that, in fact, the information sought was held by a small number of individuals working in specialized knowledge areas. Moreover, it would be necessary to find a way to resolve conflicts between legitimate national security concerns and peacetime disaster considerations. On several occasions, I was advised that a security clearance would be required to access any departmental files; I refused, however, to seek that clearance because I feared that I would be unable to use much if not most of the information so acquired. To overcome these obstacles, I approached the project as an observer-participant, reassuring the information brokers regarding my non-journalistic academic credentials, and underscoring the potentially constructive role that the results of this research could play in terms of public safety education. I particularly wanted to see what kind of information I could acquire as a private citizen and work from there within the disaster community to clarify the issues, etc.

Another obstacle encountered was the military background of many of the major players cum information brokers. With the passage of a few short years, however, several of the most security-conscious players retired; they had been part of a generation of Second World War and Cold War communications operational staff recruited by municipalities, provincial, territorial and federal government to take on the task of civil defence preparedness. Gradually they have been replaced by more peacetime-oriented emergency planners and trained crisis managers. That transition facilitated my information gathering considerably.

I also obtained personal introductions to meet with the individuals to whom I needed access from other players previously contacted who had responded favourably to my research. Ultimately, I found that the security issues could be relatively easily sidestepped to a certain extent, and access to unclassified files was given readily once my credentials had been verified, together with a great deal of confidential background materials to help me to place events in a historical and political context, and which I was told could be used "with discretion."

Eventually, I was invited to participate in in-house meetings, at national, U.S. and intergovernmental symposia and even to become a member of a regional government-industry committee set up specifically for the purposes of studying emergency telecommunications issues. Through my participation in those fora, I was able to share some of the information obtained from Canadian and U.S. government authorities, exchange ideas and explore new avenues with the other participants. These activities also helped to establish an ongoing dialogue among the various participants within which everyone involved has contributed to a dynamic process of information exchange and personal education with the aim of enhancing public, including academic, awareness of the issues. Overall, the result has been the creation of an informal transborder expert information exchange network, further contributing to the evolution of the kind of geodesic process described in this work.

In addition to seeking information from a wide variety of sources, including federal government authorities in Canada and the United States, provincial and state agencies, and even municipal organizations, this study also has looked at a number of specific events in an attempt to get around the problems of sequestered information. Since those events had been tracked publicly, it was possible to determine who the major players were and contact them directly in order to try to determine the specific dynamics of each disaster incident and the patterns of relationships among those involved.

In summary, this study has contributed to the literature on disasters by giving an environmental scan of some of the major peacetime consequences of a sample of divergent conditions suggestive of the complexity of modern disaster crisis situations such as volcanoes, toxic waste and the like. It also has provided an exhaustive study of the various telecommunications technologies and emergency management structures and practices in Canada, and particularly as regards communications preparedness, in terms of the prevailing guiding model. It suggests the recognition of greater needs of responders and planners in an increasingly complex and nuanced planning and response environment that are infrastructurally communicational, and it has been able to establish these implicit needs as a pattern for organizational response in relation to peacetime disaster preparedness.

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