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A thesis submitted to the Faculty of Graduate Studies and Research
in partial fulfillment of the requirements
of the degree of MASTER OF LAWS (LL.M.).

Institute of Air and Space Law,
Faculty of Law,
McGill University,
Montreal.

Henry Addison, 1996.

August 1996.

DEDICATION

To My Parents.

ABSTRACT

Global Navigation Satellite Systems (GNSS) are a key technology underpinning the International Civil Aviation Organisation's (ICAO's) communications, navigation, surveillance/air traffic management concept. The fact the *de facto* GNSS, the Global Positioning System (GPS) is a military system owned, operated and controlled by the United States raises many legal and institutional issues for civil aviation.

This thesis will discuss the nature of GPS/GNSS as a global utility, ICAO's evolutionary path toward a civil GNSS (ie one independent from GPS) and trace the development of the institutional debate within ICAO. Reliance on navigation by GNSS in terms of the principle of State sovereignty over territorial airspace and the Chicago Convention will be considered. The three major institutional issues in respect of a GPS based GNSS (ie charging, non-discriminatory access and liability) will be examined.

This thesis will also examine past and present State practice in respect of radionavigation systems of an international character in considering whether a legal framework for GNSS is necessary, and if so what form it is likely to take. The conclusions reached on these issues will be summarised in the final chapter.

RÉSUMÉ

Les GNSS (Global Navigation Satellite Systems) représentent une technologie clef mettant en oeuvre les systèmes de communication, navigation, de surveillance/gestion du trafic aérien de l'Organisation de l'Aviation Civile Internationale. L'actuel GNSS, le Global Positioning System (GPS), en tant que système militaire appartenant, mis en oeuvre et contrôlé uniquement par les Etats-Unis souleve de nombreuses questions jurisdiques et institutionnelles pour l'aviation civile.

Cette thèse analysera la nature du GPS/GNSS en tant que service universel, l'évolution suivie par l'OACI vers un système GNSS civil indépendant et mettra en lumière l'évolution du débat institutionnel au sein de l'OACI. Nous examinerons quelles sont les conséquences de l'utilisation d'un système de navigation GNSS sur la souveraineté nationale sur l'espace aérien et sur la Convention de Chicago. Les trois questions institutionnelles importantes relatives au GPS basé sur les GNSS (c'est-à-dire la tarification, l'accèss non-discriminatoire et la responsabilité) seront ensuit débattues.

Cette thèse mettra en evidence la pratique présente et passée des Etats en matière de systèmes de radionavigation à vocation internationale, en essayent de determiner l necéssité éventuelle de la création d'un cadre légal pour les GNSS, et en cas de réponse positive, quelle en serait la forme. Enfin, nous résumerons les conclusions auxquelles nous sommes arrivées dans le chapitre final.

ACKNOWLEDGEMENTS

I am sincerely grateful to the Department of Transport of the Australian Government for giving me the opportunity to develop and broaden my legal horizons.

I would also like to thank my supervisor, Dr Michael Milde, for his advice and assistance in respect of this work.

H.A.

26 August 1996

Table of Abbreviations and Glossary of Terms

I. Abbreviations

AASL	Annals of Air and Space Law
ADS	Automatic Dependent Surveillance
AMSS	Aeronautical Mobile Satellite Services
ARINC	Aeronautical Radio Inc.
ATC	Air Traffic Control
ATM	Air Traffic Management
AW&ST	Aviation Week and Space Technology
CAA	Civil Aviation Administration
CNS	Communication, Navigation and Surveillance
COMSAT	Communications Satellite Corporation (USA)
DME	Distance Measuring Equipment
DOD	Department of Defense (USA)
DOT	Department of Transport (USA)
ECAC	European Civil Aviation Conference
EUROCONTROL	European Organisation for the Safety of Air Navigation
FAA	Federal Aviation Administration (USA)
FANS	Future Air Navigation Systems
FIR	Flight Information Region
HF	High Frequency
IALA	International Association of Lighthouse Authorities
IATA	International Air Transport Association
ICAO	International Civil Aviation Organisation.
ICJ	International Court of Justice
ILS	Instrument Landing System

IMO	International Maritime Organisation
INMARSAT	International Mobile Satellite Organisation
INS	Inertial Navigation System
GLONASS	Global Orbiting Navigation Satellite System (Russian Federation)
GNSS	Global Navigation Satellite Systems
GPS	Global Positioning System (USA)
LF	Low Frequency
LORAN	Long Range Navigation (a particular radionavigation aid)
MLS	Microwave Landing System
NDB	Non-Directional Beacon
PPS	Precision Positioning Service (GPS military mode)
SA	Selective Availability
SARPs	Standards and Recommended Practices
SPS	Standard Positioning Service (GPS civil mode)
SSR	Secondary Surveillance Radar
UN	United Nations
VHF	Very High Frequency
VOR	VHF Omnidirectional Range
WMO	World Meteorological Organisation

Glossary of Terms

"Category I (II, III) Landing": Designations for successively more difficult classes of aircraft precision landings (with difficulty determined by visibility and weather conditions).

"Required Navigation Performance" (RNP): A statement of the navigation performance necessary for operation within a defined airspace.

'"Sole means of navigation" is a means of navigation of the aircraft where position determination is provided by a system which satisfies the RNP for a particular phase of operation. A sole-means navigation system meets all four navigation system performance requirements - accuracy, integrity, continuity and availability (the latter two must be close to 100 per cent).

"Primary means of navigation" - the navigation system must meet the integrity and accuracy requirements for a given phase of flight, but need not meet the availability and continuity of service requirements. Safety is achieved through appropriate procedural restrictions and operational requirements.

"Supplemental-means of navigation" is a means of navigation where aircraft position determination is provided by a system which has to be used in conjunction with a system which satisfies the RNP for a particular phase of operation.'

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Appendices

Chapter I: Introduction

This topic is, and has been since June 1992, the item with highest priority in the general work programme of the Legal Committee of the International Civil Aviation Organisation (hereinafter ICAO) as set by the Council of ICAO and as approved by the Assembly. Global Navigation Satellite Systems (GNSS) have been the subject of intense discussion and debate in all ICAO fora as they raise many complex technical, geopolitical and institutional issues. A number of these issues that the writer considers most relevant in determining whether a legal framework for GNSS is necessary will be examined in this thesis.

As GNSS represent a quantum advance in radio navigation systems and as "law follows technology,"[1] a brief but comprehensive description of the salient technical features of the technology is a prerequisite to any discussion of legal and institutional issues.

What is GNSS?

Background:

In the early 1980s the increasing limitations[2] of the existing air navigation systems and their inability to deal with forecast rates of international air traffic growth was recognised. 'In 1983 ICAO set up the Future Air Navigation Systems (FANS) Committee to lay the foundations for "the development of air navigation for international civil aviation over a period of twenty-five years". Four years later the FANS Committee (later known as FANS Phase I) concluded that "the exploitation of

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[1] Henaku BDK, 'The ICAO CNS/ATM System: New King, New Law?', Air and Space Law, Vol XIX, Number 3,.1994, p146.

[2] "The shortcomings of the present system amounts to essentially three factors:
(a) the propagation limitations of current line-of-sight systems and/or accuracy and reliability limitations imposed by the variability of propogation characteristics of other systems;
(b) the difficulty, caused by a variety of reasons, to implement CNS systems and operate them in a consistent manner in large parts of the world; and
(c) the limitations of voice communications and the lack of digital air-ground data interchange systems in the air and on the ground." ICAO Doc 9623, FANS (II)/4, Report of Fourth Meeting of Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System (Fans Phase II), Montreal, 15 September - 1 October 1993, Appendix A to the Report on Agenda Item 8, p8A-5, para.1.2.1.

satellite technology to provide communications, navigation, and surveillance (CNS) services to civil aviation on a global basis is **the only viable solution** that will enable one to overcome the shortcomings of the present air navigation system and fulfill the needs and requirements of the foreseeable future". The proposed FANS system embraced the satellite-based CNS concept and greatly improved arrangements on the ground for the purpose of air traffic management (ATM).'[3]

GNSS is the term given to the satellite navigation component of the FANS concept. GNSS is the cornerstone of the ICAO CNS/ATM concept, formulated by the FANS Committee.[4]

The ICAO Council established the "Special Committee for the Monitoring and Co-ordination of Development and Transition Planning for the Future Air Navigation System", (hereinafter referred to as the FANS II Committee) also known as "Fans Phase II", in July 1989 to advise on the steps needed to implement the new CNS/ATM concept.

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[3] FANS(II)/4-WP/9, p2, para.1.2.1.

[4] Supra 2, Appendix A to the Report on Agenda Item 8, at p8A-10, summarises the benefits of GNSS as follows:
"1.6.3.1 GNSS will provide a high integrity, high accuracy, world-wide navigation service, suitable as a sole means of navigation for en-route, terminal, non-precision and possibly near Category I precision approach and landing operations. The system will be able to be used in conjunction with other systems (eg inertial navigation systems (INS) to support RNP requirements, and will offer four-dimensional navigation accuracy).
1.6.3.2 The implementation of the system will enable aircraft to navigate in all airspace environments in any part of the world, using satellite-based navigation avionics. Thus, existing ground-based navigation aids will find diminishing utility and may eventually be withdrawn, offering significant savings to provider States. Additionally, the new system will permit any runway to be a non-precision, and perhaps a precision approach runway, opening the vista for improved air transport services in many regions of the world. Finally, GNSS will enhance airport capacity by providing the basis for a precision surface movement guidance and control system."
Further, "In addition to GNSS being used for navigation, it may be incorporated into the surveillance function, since...the position of aircraft will be obtained by air traffic control (ATC) through automatic position reporting of aircraft systems. The airborne element of a GNSS will be capable of providing such positional information." Supra 2, Appendix I to the Report on Agenda Item 4, p4I-1, para.1.5. This surveillance technique is known as Automatic Dependent Surveillance (ADS).

The report of the FANS I Committee was submitted to the 10th Air Navigation Conference held in September 1991 which endorsed the satellite-based CNS/ATM concept. At that Conference the US and the Russian Federation offered to provide their military satellite navigation constellations (ie GPS and GLONASS) to civil users free of charge for the next ten and fifteen years respectively. These offers were referred to the FANS II Committee, which submitted its report to the Council in September 1993, and its findings in respect thereof will be discussed subsequently.

The FANS concept was redesignated the ICAO CNS/ATM system at the 134th Session of the ICAO Council (11 December 1991).

Definition:

"The Global Navigation Satellite System will be the key feature of the future navigation system and it will evolve to be a sole means of navigation, eventually replacing the current long-range and short-range navigation systems. The system will provide global coverage and without additional ground based augmentation will be accurate enough to support en-route navigation and meet non-precision type approach needs.

GNSS is a world-wide position and time determination system, that includes one or more satellite constellations, aircraft receivers, ground monitor stations and systems integrity monitoring. GNSS provides the user with the capability of performing on-board position determination referenced to a standard geodetic reference system, independently from its geographic location. It has the potential to be augmented if necessary to support a specific RNP for the actual phase of the flight.

The GNSS satellites radiate unique signals whose arrival timing can be measured with high precision by GNSS receivers. The satellites also broadcast information from which their locations and the timing of their transmissions can be accurately determined. By measuring the arrival timing of signals from three satellites, a receiver with an exact clock can determine its range from the three satellites and hence its

position. A precision timing and frequency control is essential as one nanosecond of time error is equivalent to approximately 0.3 meters. In practice, since exact clocks are not readily available, the receiver makes an additional measurement from a fourth satellite, and calculates its three position co-ordinates and the offset in its clock timing. Apparent ranges from satellites measured with receiver clock error are called pseudo ranges.

GNSS must be able to provide timely warning (integrity monitoring) to users when the position error exceeds a specified limit. To provide this integrity, it is necessary that at least five satellites be in view, with all combinations of four satellites having acceptable geometry. There are two methods of integrity monitoring currently under evaluation. Receiver Autonomous Monitoring (RAIM) and multi-sensor monitoring which are both on-board methods, and GNSS Integrity Channel (GIC) which monitors the satellites on the ground and transmits the information to the aircraft.

There are currently two satellite-based navigation systems available that together could be used for the GNSS - the United States Global Positioning System (GPS) and the Russian Federation Global Orbiting Navigation Satellite System (GLONASS)

GPS. The Global Positioning System comprises a constellation of 21 satellites plus three spares. These satellites operate in a 12 hour orbit at an altitude of 20,183 km and transmit on the same L-band frequencies which are modulated with two codes - the P (precision) mode and the C/A (Coarse Access) mode. Only the C/A mode, which provides the Standard Positioning Service (SPS), is currently available to civil aviation. The SPS provides a level of accuracy of 100 meters in the horizontal plane with a 95 per cent confidence level.

GLONASS. The Global Orbiting Navigation Satellite System comprises a constellation of 21 satellites plus three spares. These satellites operate in a 11 hour and 15 minute orbit at an altitude of 19,100 km and each satellite transmits on a unique

frequency using the same pseudo noise code. The level of accuracy for GLONASS is similar to GPS operating in the C/A mode. The measuring of the GLONASS broadcast information to determine position and range, is similar to that for the GPS."

The above quotation is taken from the FANS CNS/ATM Starter Kit,[5] which is an implementation guide to assist governments and Air Traffic Services (ATS) providers and airlines. It reflects the findings of the FANS Committees. Accordingly, it (not surprisingly) represents a definition of a GNSS tailored to meet civil aviation requirements. It is important to bear this in mind as other international organisations representing other sectoral users of satellite navigation have their own user specific definition of 'GNSS', most notably the International Maritime Organisation (IMO). In its broad sense GNSS is "A generic term for an emerging satellite radionavigation system that provides global coverage; in current use, GNSS often refers to GPS, its augmentations and enhancements and GLONASS."[6] In this thesis I shall refer to the 'ICAO GNSS concept' whenever I consider it necessary to differentiate the ICAO vision of 'GNSS' from the more generic use of that term.

The following features of the 'ICAO GNSS concept' are apparent from the above quotation: because it is a satellite based system it has all-weather capability and gives global coverage; satellites form only one element of the system ('the space segment') to which must be added aircraft receivers and ground monitor stations; integrity monitoring is necessary for GNSS to be a safe, reliable system; the unaugmented system is accurate enough for en-route navigation and non-precision approach, augmentation will be necessary for the more stringent phases of flight such as precision

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[5] FANS CNS/ATM Starter Kit, 1995, International Air Transport Association/International Civil Aviation Organisation, Section 2, Chapter 3, pp21-23.

[6] 'The Global Positioning System, Charting the Future', by a Panel of the National Academy of Public Administration and by a Committee of the National Research Council for the Congress of the United States and the Department of Defense. MAY 1995, pXLIII. Hereinafter referrd to in the text as the NAPA/NRC Report.

approach; and that the existing GPS and GLONASS systems could jointly form the basis for the GNSS. These technical characteristics of the 'ICAO GNSS concept', will feature throughout this thesis as they shape the legal and institutional debate within ICAO.

A final point to be made here is that GNSS alone will not generate major operational benefits to carriers or ATC authorities. Such benefits will accrue from use of a combination of GNSS, advanced automation and digital data link.[7] The latter two elements are an essential part of the FANS infrastructure, but are beyond the scope of this thesis to discuss. However, they are of course fully described in the FANS documentation.[8]

Preliminary Remarks:

It is not possible to comprehensively deal with all aspects of GNSS in this thesis. I will therefore discuss in general terms those GNSS developments and related legal and institutional issues that I consider to be relevant to an understanding of this topic.

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[7] "....satellite navigation is not the most critical element of the needed system modernization. As important as GNSS/GPS is, it is not an air traffic control system but only a sensor that a good Air Traffic Control system can use. Better navigation by itself is of limited value if the Air Traffic Control automation and digital communications are not there to make it useful to improve the ATC system.....While satellites are very important and they are certainly glamorous, the major benefits to the users will come from the marriage of satellite navigation and communications with ATC automation and integrated flow management, a real-time digital communications system and with exploitation of the airport capacity technologies which the industry has long pressed." Statement of Mr S Poritzky, senior vice president, Airports Council International, former Director, System Engineering Management, FAA, US nominee on FANS I Committee, 'Future Uses of Satellite Technology in Aviation', Hearing before the Subcommittee on Aviation of the Committee on Public Works and Transportation, House of Representatives, 103rd Congress, 1st Session, July 28, 1993, ISBN 0-16-041774-0. at p216. In 1984 Mr Protzky introduced to the FANS Committee the concept which became GNSS.

[8] There is also a fulsome coverage in Ghonaim, Mahmoud A., 'The Legal and Institutional Aspects of Communication, Navigation, Surveillance and Air Traffic Management Systems for Civil Aviation', McGill University Doctorate Thesis, 1995.

As previously mentioned since June 1992 this topic has had the highest priority in the general work programme of the Legal Committee of ICAO. However, in my opinion, to date the Legal Committee (which is essentially a political forum, although made up of representatives of States who are supposed to have legal expertise) has made no substantial progress on the above topic and will not do so in the foreseeable future (indeed is unlikely ever to do so) for two principal reasons:

1. GNSS is a global utility. International civil aviation is, and will remain, a minor sectoral user of GNSS services. There will not be a satellite network dedicated to civil aviation because the putative market (ie domestic and international airlines and general aviation users) are not prepared to pay the immense capital and operating costs involved in essentially duplicating the present 'free' GPS system. Similarly, contracting States are not prepared to use public funds (ie subsidise aviation users) to procure and maintain such a network. This is merely stating the obvious to anyone familiar with the evolution of the 'ICAO GNSS concept.'

Accordingly, whatever GNSS evolves will serve all sectoral users. In this respect the Legal Committee of ICAO is an inappropriate forum in which to attempt to formulate 'ground rules' to regulate a global technology. GNSS is not a 'discrete' technology which can be legally regulated on a sectoral basis (technical standard setting is a different matter). ICAO has no mandate to formulate a legal framework that would have far reaching implications for all GNSS users but this in effect is what those States with institutional concerns wish the Legal Committee to produce.

The fact that GNSS is a global utility is also why it would be inappropriate for a specialised body such as ICAO (which inevitably reflects the needs and concerns of its constituency) to own, operate or manage the GNSS space segment (this has been suggested by certain contracting States) on behalf of all users.

Further, as already noted, "law follows technology."[9] It may be that as experience of operating GNSS accumulates institutional problems may emerge (although none have to date with GPS as far as I am aware) which can only be dealt with through legal rules ie institutional arrangements cannot be finalised until a body of State practice with the technology has developed. In this sense the deliberations in the Legal Committee of ICAO may be premature or unfocussed. An alternative view is that GNSS is a ubiquitous, universal technology, part of the 'information superhighway', whose very character defies regulation. In this regard GPS is a passive system used by millions of consumers worldwide.

I shall discuss these points in considering the character of GNSS as a global utility.

2. Intertwined with 1. is the fact that legality follows social agreement and in respect of GNSS there is no political consensus among contracting States that a legal framework is necessary to regulate the 'ICAO GNSS system', let alone the form a legal framework should take.

Institutional concerns and lack of consensus in respect of a legal framework both essentially flow from the reality that GPS, a system subject to the control of the military establishment of the USA is presently the *de facto* GNSS. Further, GPS will be the core system of 'GNSS' for the foreseeable future (ie to 2010 at least). GPS is a strategic military asset and for this reason the US has made it clear to the international community that it is not prepared to cede any degree of control over the system. Russia has adopted a similar position in respect of GLONASS (although Russia is more circumspect than the US in this respect). Those States with institutional concerns believe that a binding legal framework, a multilateral convention being the preferred mechanism, is necessary to provide the guarantees they require on such institutional

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[9] Henaku, supra 1.

issues as governance and control of the GPS/GNSS space segment and they have sought to promote this agenda in ICAO fora.

This lack of consensus is evident in the deliberations that have taken place within ICAO, both in the Legal Committee and other fora. I shall review and comment upon the institutional debate within ICAO to demonstrate this.

As regards 'a legal framework' the attitude and interests of the USA as the initial GNSS provider, largest user of GNSS services and (in the ICAO context) the foremost aviation power is crucial. As the Representative of India on the ICAO Council noted during a discussion of the ICAO GNSS concept: "it would be inconceivable to launch a global initiative in any area - whether it was CNS/ATM, technical co-operation for civil aviation or safety oversight - without the full and active co-operation of the Government of the United States."[10] In regard to GNSS the USA is clearly a State "whose interests are specially affected"[11] in terms of international law.

Consequently, I will examine US policy in respect to GPS/GNSS as this will strongly influence how 'the ICAO GNSS concept is likely to evolve. This is the *realpolitik* of the situation. I shall also briefly comment on current US policy towards agencies in the United Nations system (such as ICAO) as I believe this is of relevance in determining what role ICAO will play in implementing CNS/ATM.

The institutional debate within ICAO involves competing sovereignty interests - certain user States are loath to curb their sovereign right to control navigation in their airspace by relying on GPS, without an acceptable degree of institutional control over the system, but this would entail a dilution of US control (ie sovereignty) over GPS, which

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[10] ICAO Doc 9645-C/1114, C-Min.143/1-22, p60, para.12.

[11] *North Sea Continental Shelf Case* [1969] ICJ 3, at p8, para.74.

the US to date has refused to countenance. I will comment on these conflicting sovereignty interests in the context of the Chicago Convention.

The reference above to 'certain user States' having institutional concerns is deliberate. These are particularly some European, Latin American and developing States. On the other hand it appears that a significant number of States are relaxed about GPS governance and control and are prepared to utilise the system without formal legal guarantees (e.g. this appears to be the case in the Asia/Pacific Region where commercial aircraft have already been certified by certain States to fly across the Pacific using GPS). If whole ICAO Regions are prepared to approve operations using GPS/GNSS without a legal or institutional framework being in place then this obviously has implications as to whether a formal legal framework for GNSS is necessary. I will therefore examine current State practice in respect to GPS to judge the actual strength of institutional concerns.

The FANS II Committee formulated a possible evolutionary path toward a fully civil, international GNSS by 2010. I shall discuss current progress in the development of this evolutionary path in this thesis and the fact that funding is the primary institutional issue in the development of an international, civil GNSS.

In denying the need for a legal framework the US has consistently argued that institutionally GNSS is no different than other radio navigation systems (specifically Loran-C and Omega) which have been used by the international civil community for decades and operate under bilateral and regional technical cooperation agreements. Accordingly, I will examine the international arrangements pertaining to Loran-C and Omega to see if these examples of State practice have precedent value in respect to GNSS.

Major institutional issues involving GNSS are liability, availability/non-discriminatory access and charging for using the system. I will examine these issues in respect of GPS and GLONASS, but particularly concentrating on GPS as it is the *de facto* GNSS.

Accordingly, this topic is essentially a geopolitical issue (albeit one with legal elements[12]) and I shall treat it as such. This paper is therefore more of a functional policy critique, rather than a legal analysis. However, this is inevitable given the nature of this topic. A reader may consider this leads to stark, utilitarian conclusions.

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[12] In this context certain legal issues are presented as irreconciliable, preventing a 'legal framework' from being agreed eg legal liability in respect of the space segment. However, in my opinion there is no legal issue which is a 'showstopper'. If there was the political will for a 'legal framework' all legal issues would be worked through as a matter of course.

Chapter II: The FANS II Committee's Evolutionary Path

GNSS Options

The FANS II Committee developed a list of proposed GNSS navigational and operational requirements[13] and concluded: "Neither [GPS nor GLONASS] in themselves either constitute or meet the requirements of a civil GNSS. GLONASS and GPS are sub-systems and when either of them is combined with other sub-systems designed to augment their shortcomings the resultant system will meet the necessary GNSS requirements. Additionally, it is possible that GPS and GLONASS combined together will also meet GNSS requirements."[14]

The FANS II Committee developed five options for GNSS, each of which could meet the technical requirements:

"a) Option 1: GPS or GLONASS;

b) Option 2: GPS and GLONASS;

c) Option 3: GPS/GLONASS plus overlay;

d) Option 4: GPS/GLONASS plus several civil GNSS satellites; and

e) Option 5: civil GNSS satellites."[15]

Option 5 is "defined as the long-term provision of new GNSS satellites by an international body"[16] ie a satellite constellation independent of GPS and GLONASS and controlled by the international community. The FANS II Committee developed an evolution table (reproduced as Appendix 1) showing these GNSS options and associated implications and concluded: "This table pointed out the incremental nature of starting with [GPS or GLONASS] and progressing over time to a civil GNSS. It noted that any

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[13]Supra 2, Appendix I to the Report on Agenda Item 4.

[14] Supra 2, Report on Agenda Item 4, p4-13, para. 4.3.4.8.

[15] Supra 2, Executive Summary, pp4-5, para.4.3.

[16] Supra 2, Appendix A to the report on Agenda Item 8, p8A-75, para.8.5.4.

option would provide acceptable GNSS service provided the respective institutional issues were resolved and safety regulations were satisfied."[17]

The 'respective institutional issues' are discussed in Chapter VIII. In terms of 'safety regulation' the FANS II Committee considered that the preparation of Standards and Recommended Practices (hereinafter 'SARPs') for GPS and GLONASS was not cost effective. "However, there is a need to prepare SARPs for any future satellite-based position determination system, and also for augmentations of the current systems, e.g. differential applications, integrity monitoring, etc."[18] The Committee considered these SARPs should be expedited. ICAO has accepted this recommendation, there will be no SARPs for GPS or GLONASS, SARPs for a future civil GNSS are presently being formulated with a target completion date of 2000.[19]

Implementation of GNSS

1. Phased Strategy

The FANS II Committee also stated "the implementation of GNSS will be accomplished through a phased implementation strategy:

a) Phase I, to allow for early operations use of GNSS, as a supplemental means system;

b) Phase II, to allow the transition to a sole-means system; and

c) Phase II, to facilitate the withdrawal of obsolete navaids."[20]

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[17] Supra 2, Report on Agenda Item 6, pp6-4 50 6-5, para.6.2.5.3

[18] Supra 2, Report on Agenda Item 4, p4-14, para 4.3.6.5

[19] This is in respect of 'system specific SARPs in support of longer-term satellite navigation systems'; 'system specific SARPs for the mid-term use of existing satellite navigation systems with augmentation sub-systems' have a target completion date of 1998. See ICAO Doc. A31-WP/40,'Overview of ICAO CNS/ATM Planning and Implementation Related Activities', pA-2.

[20] Supra 2, Appendix A to the Report on Agenda Item 8, p8A-74, para. 8.5.2.

As will be discussed in Chapter XII the number of States that have approved GPS as a supplemental means of navigation is expanding rapidly. GPS in the process of being certified in the US and elsewhere as a sole means system.[21] Plans for withdrawal of obsolete navaids are well advanced. For example, ICAO's "protection date" for VOR/DME (the primary system for en route through nonprecision approach) is 1 January 1998, the US expects to begin phasing out VOR/DME from 2005. The US has already withdrawn from its overseas Loran-C chains and will not support Loran-C domestically after 2000; Omega should be discontinued on 30 September 1997 etc.[22] Other countries such as Australia, Canada and New Zealand have formulated similar plans.

2. The Global Plan

It is also relevant to mention that the FANS II Committee established a Global Plan to guide and co-ordinate world-wide implementation of the future CNS/ATM system in a timely and cost-effective manner. The plan provides the overall system design, information on the global infrastructure and how it would be used, the institutional and legal guidelines, transitional guidelines and finally the time lines for implementation. In the latter respect the plan outlined 4 implementation periods as follows:

Intermediate term	-1992
Near term	1993 - 1995
Middle term	1996 - 1999
Long term	2000 - 2010

[21] For example, 'The European Joint Aviation Authorities has certified a hybrid Litton GPS/INS navigation system with software integrity monitoring for sole-means of navigation on the Airbus A340/A330. With this ground-breaking airworthiness certification, those aircraft could fly en route and execute a nonprecision instrument approach to 250ft. above the ground without reference to terrestial navigation aids, so long as the national authorities who own the airspace approve." 'Sole-Means GPS Approved', AW&ST, April 29, 1996, p37.

[22] US plans for its infrastructure of radionavigation systems is set out in the 1994 Federal Radionavigation Plan, Published by Department of Defense and Department of Transportation, DOT-VNTSC-RSPA-95-1/DOD-4650.5, particularly at Chapter 3.2 'Existing and Developing Systems-Status and Plans.'

It was agreed at the 10th Air Navigation Conference that detailed planning had to be done on a regional basis where groups of States develop and coordinate their implementation plans. However, actual implementation has to be done by the contracting States and airlines. This will be done by the State acting alone from its own resources, acting as a group of States or States and group of States using the resource of 'third party' service providers. Consequently, the implementation of the ICAO CNS/ATM concept involves three layers of planning: Global, Regional and State/airline.

Realisation of Option 3: GPS/GLONASS plus overlay

Arrangements are in place which will see the FANS II Committee's 'Option 3: GPS/GLONASS plus overlay'[23] in place by 2000. INMARSAT[24] has, in its own words, "taken the financial risk"[25] of equipping its third-generation communication satellites with subsidiary navigation transponders that will broadcast to users on the L1 (1575.42mhz) frequency used by GPS and GLONASS. The first of five Inmarsat-3 satellites was launched in April this year and completion of the constellation is due by the end of next year. These satellites are the first civil, internationally-owned contribution to GNSS.

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[23] "A solution which is attractive for the near and medium term is to have in orbit a set of satellites that emit in the GNSS frequency band both differential corrections that provide enhanced precision for the GPS/GLONASS satellites, and which also emit a spread spectrum signal providing additional pseudo-range measurements. This kind of solution is generally referred to as an overlay, since by itself it does not provide world-wide navigation, but does improve the navigation of the other systems." Supra 2, Appendix H to the report on Agenda Item 4, p4H-5, para.5.1. (In essence a 'overlay' is a satellite with a GPS navigation payload.)

[24] The International Mobile [formerly 'Maritime'] Satellite Organisation is a major provider of satellite communication and radio determination (ie navigation) services. The provisions of the Inmarsat Convention and Operating Agreement, the organisation's objectives, structure etc are fulsomely discussed in Magdélenat, J-L, 'INMARSAT and the satellites for air navigation services', Air Law, volume XII, number 6, 1987, pp266-281.

[25] ICAO Doc. C-WP/9482, 13/2/92, Appendix C-2.

The navigation transponders on the Inmarsat-3 satellites will be used to establish two overlay systems providing differential GPS - the US Federal Aviation Administration's (hereinafter 'FAA') Wide Area Augmentation System (WAAS) and the European Geostationary Navigation Overlay Service (EGNOS).[26] The transponders will be leased by service providers.[27] The FAA's timetable calls for WAAS to be operational in 1997 while "EGNOS is planned to achieve initial operational capability (IOC) in 1999 and full operational capability (FOC) in 2002."[28] Institutionally, the provision of these overlay service will involve joint participation by three independent entities ie Inmarsat as provider of the satellite navigation capacity; Inmarsat Signatories as the operators of the navigation land earth stations, and the FAA and EGNOS as the service providers.[29] Thus, for WAAS the required differential corrections would be determined at FAA facilities and transmitted to Inmarsat-3 satellites via Comsat Earth stations in the US.

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[26] "WAAS will use ranging signals from transponders aboard the [Inmarsat-3] Pacific Ocean and Atlantic Ocean West satellites, while EGNOS will use information from their Indian Ocean and Atlantic Ocean East counterparts." AirNavigation International, Vol.2, No.7, 10 April 1996, p4.

EGNOS is based upon a memorandum of understanding approved in July 1995 between the European Union (comprising 15 States), the European Space Agency (comprising 14 States) and EUROCONTROL (which deals with air navigation on behalf of its 17 Member States), the organisational structure of EGNOS is described in ICAO Doc. A31-WP/113 'Evolution of GNSS Institutions in Europe and in the World'.

[27] The partners in EGNOS have concluded leases with INMARSAT, see Flight International, 10-16 July 1996, p12. As far as the writer is aware leases for WAAS have not yet been concluded, probably because that program has being reorganised with a new prime contractor recently appointed (discussed in Chapter V).

[28] ICAO Doc. A31-WP/113, 'Evolution of GNSS Institutions in Europe and in the World', para. 2.3.

[29] "The transmission of signals to the navigation transponder (which then broadcasts to mobile users) is the responsibility of Navigation Land Earth Stations (NLES), which are expected to be operated by Inmarsat Signatories. The NLES operator must ensure that the trasmitted signal has the precise and stable characteristics required of any GNSS satellite. This signal cannot provide navigation ranging unless the proper data messages are carried on it. The generation of these messages, including their integrity and other information...is the responsibility of a service provider, which, in most instances, will be one, or a group of governmental or internationally recognised agencies who have the authority and responsibility to provide navigation services and navigation warnings (eg civil aviation authorities)." Sagar D.,'International Organisations - Inmarsat', 1994 AASL, Vol.XIX-ii, p684 at p 687.

Further, Japan is planning to launch two Multi-function Transport Satellites (MT-SAT), [30] the first in 1999, to provide to domestic and international users both an aeronautical mobile-satellite (route) service (ie communication and surveillance functions) and an overlay to GPS.[31] MT-SAT will be part of the mooted Asia-Australia Augmentation Service,[32] to which Australia and China may also contribute overlay systems in due course.

EGNOS, WAAS and MT-SAT will offer similar capabilities based on a common signal-in-space format.[33] The objective being that these three systems will be fully interoperable to ensure a seamless service from one to the other.[34] "Most populated areas will be able to receive at least one of the EGNOS, WAAS or MT-SAT signals with the result that a global supplemental capability should be available."[35] Accordingly, "there will be at least three satellite-based augmentations to GPS and GLONASS by the year 2000 (EGNOS/WAAS/MT-SAT) and in some regions users will be in a position to receive signals from all three."[36]

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[30] See ICAO FANS(II)/4-WP/28, 'The Decision on the Multi-Functional transport satellite (MTSAT) in Japan'.

[31] 'Japan has launched a $1 billion project to loft two multifunctional transportation satellites (MTSATs) into orbit to assist in air-to-air and air-to-ground relay and monitoring of GPS positioning information. The satellites will operate as differential GPS relays, covering an area including Alaska, northeastern and central Russia, China, southwest and southeast Asia, Australia, and the central Pacific Ocean. The transport satellites will increase air traffic capacity and facilitate air traffic control and will also have a meteorological mission.' NAPA/NRC Report, supra 6, p236.

[32] Avionics Magazine, January 1996, p32.

[33] WAAS, EGNOS and MT-SAT will broadcast the GNSS Integrity Channel (GIC) ie both the data format and signal format will meet agreed and common specifications. - see ICAO Doc. LC/29-WP/3-5, 'Inmarsat Satellite Navigation Programme'.

[34] "...EGNOS and WAAS will be linked, and EGNOS and the Japan's MTSATS will be made interoperable." CNS Outlook (periodical), September 20, 1995, Vol.3, No.12, p3. Report of statement given by Mr Luk Tytgat of the European Commission to a meeting of the US Coast Guard's Civil GPS Service Interface Committee.

[35] ICAO Doc. A31-WP/121, 'European Activities Related to Satellite Navigation', p3, para. 6.2.

[36] Ibid, para. 7.1.

Further, there are several mobile satellite communication systems in development[37] that have been suggested as candidates to deliver wide-area GPS augmentation information. These systems may be candidates for a third satellite the EGNOS partners are considering.[38]

Whether the FANS II Committee's evolutionary plan toward an independent civil GNSS will come to fruition by 2010 will be examined in the penultimate chapter.

Required Navigation Performance and GNSS

The FANS II Committee presented a menu of options from which users and airspace managers could choose those elements which best met their individual CNS requirements. This approach allows States the maximum flexibility to select systems appropriate to their needs and, of course, accords with the principle of State sovereignty over territorial airspace (to be discussed in Chapter VII) ie States cannot be directed to use specific CNS systems. It also recognises the reality that introducing FANS in its entirety world wide is unlikely - it is not cost effective for some ATS providers, who already have a well developed CNS infrastructure (Western Europe being an obvious example).

Different airspace (e.g. en-route, terminal, non-precision approach etc.) requires different navigation capabilities. For navigation the FANS Committee therefore developed the concept of Required Navigation Performance (RNP) which "will define the performance required in a particular airspace or phase of flight, and enable that

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[37] For example, Motorola's Iridium 66 satellite system, Loral Qualcomm's Globalstar 48 satellite system and TRW/Teleglobe's Odyssey 12 satellite system. It has been mooted that these private commercial systems could offer position determination services but I have come across no reports confirming any will incorporate a navigation package. This would be purely a commercial decision.

[38] See Flight International, 10-16 July 1996, p12.

required performance to be achieved with any of a variety of navigation equipment."[39] The adoption of the RNP concept avoids the need for ICAO or Contracting States to select between 'competing' systems and thereby supports the development of more flexible route systems and area navigation environments.[40] ICAO is currently developing standards for RNP.

Accordingly, under RNP, in the same airspace, different operators can meet the prescribed navigation performance with different systems e.g. one might use Loran-C, another inertial navigation system (INS), another GNSS etc. In this respect RNP is similar in principle to, but more generally applicable than, Minimum Navigation Performance Specification which has been used for many years on North Atlantic routes. What navigation systems will meet a particular RNP is decided between the aircraft operator, State of Registry and the State providing the air traffic services (ATS) in the airspace, although ultimately the onus is on the operator to satisfy RNP requirements.[41]

Consequently, although all five GNSS options proposed by the FANS II Committee are capable of meeting RNP criteria for all phases of aviation operation up to and including Category I precision approach, GNSS is not the only system capable of meeting RNP. In this respect the FANS Committee specifically noted that "GNSS is one such

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[39] ICAO CASITAF/1, Information Paper No.1, 21/4/94, p11.

[40] "To support the implementation of a navigation concept affording maximum flexibility to users and air traffic services consistent with safety standards while, on the one hand, not placing a requirement on ICAO to adopt a single navigation system as a global standard and, on the other hand, ensuring that airspace users have a maximum freedom of choice when equipping their aircraft". ICAO Doc 9524, FANS/4 Report, p3.2-1, para. 3.2.1.1.

[41] "Various levels of navigation performance will be required within different airspaces and for different phases of flight, from en-route to CAT III precision approaches, and operators will be required to demonstrate that they can meet the necessary requirements. Thus the onus has shifted from the system providers having to prove that satellite navigation has a given specific accuracy to the operators having to demonstrate that whatever equipment is carried, the required navigation performance for a specific operation can be met." Supra 2, Report on Agenda Item 4, p4-11, para 4.3.2.1.

electronic aid."[42] In practice, aircraft engaged in international civil aviation will generally use an integrated navigation system of which GNSS could be one of a number of inputs.[43]

Therefore, under RNP States will specify such systems as meet their navigation requirements in much the same way as they have specified such systems as INS, Loran-C, etc in the recent past. In this respect, selecting GPS/GNSS to meet a specific RNP merely represents a continuation of existing institutional arrangements. Technically, the FANS Committee's CNS/ATM concept, as approved by the ICAO Council and endorsed by the 10th Air Navigation Conference, is asking States to commit themselves to RNP, not GNSS, as GNSS is only one means of satisfying RNP.

To summarise, under the FANS II Committee's evolutionary plan GPS and GLONASS, either separately or in conjunction, will provide the backbone of the ICAO GNSS concept until Option 5 eventuates. However, it is apparent that in reality it is GPS, which is the *de facto* GNSS: "ICAO chose to give the name GNSS (Global Navigation Satellite System) to the whole system of satellite navigation means. Today, in 1995, satellite navigation is, in practice, made up of the single American military system GPS."[44] ICAO for diplomatic reasons also refers to GLONASS in the context of GNSS but GLONASS is not a 'real' player in the satellite navigation market, at least at present, for geopolitical and technical reasons that will be discussed.

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[42] Supra 2, Report on Agenda Item 4, p4-15, para.4.3.9.2.

[43] "...the ability of aircraft to maintain their defined trajectory will be more than likely determined not by one single navigation system, for example VOR/DME, but by a combination of systems operating through some form of on board navigation management system." FANS II Working Group of the Whole (May 1993) - WP/82, Appendix A to the Report on Agenda Item 2, Attachment 2, para.1. Further, see note 21.

[44] Supra 28, para.1.

The fact GPS, a US military system, is the *de facto* GNSS (and will continue to be the core GNSS system for the foreseeable future) is the main reason certain States have institutional concerns. An understanding of why GPS has acquired this status and US policy in respect of GPS/GNSS is necessary in considering the development of the institutional debate re GNSS in ICAO fora.

Chapter III: Why the Global Positioning System is the *de facto* GNSS

GPS, like GLONASS, is a military satellite navigation system which from the outset was designed as a 'dual-use' system that could simultaneously meet military and civil applications. The basic operational and technical parameters of GPS have already been described. The US Air Force launched its first experimental GPS satellites, termed Block I satellites, on 22 February 1978. Initial operational capability of the GPS satellite constellation was achieved on 8 December 1993.

GPS is a demonstration of US technological prowess but also a statement of political will, for the system is expensive to procure and maintain. "Based on a fixed price, multi-year procurement contract totaling approximately $1.5 billion for 28 satellites, the unit cost of each [Block II/IIA] satellite is approximately $53.8 million (1995 dollars). Each Block II/IIA satellite is designed to operate for 7.5 years, but may operate beyond this life span based on the success of the Block I series."[45] "The follow on Block IIR replenishment satellite contract was competitively awarded in 1989...for a total of 20 satellites. The estimated unit cost of each Block IIR satellite is $30.1 million (1995 dollars)....first launch is scheduled for 1996."[46] The first launch of the next generation Block IIF GPS satellite is anticipated in 2001. The US Defense Budget for Fiscal 1997 contains $1.6 billion for 12 GPS satellites.[47] "According to the GPS Joint Program Office, current plans call for the Block IIF contract to include 6 short-term, and 45 long-term, "sustainment" satellites."[48]

Further, "The system requires between $400 million and $500 million a year to maintain and operate the constellation, including replacement satellites."[49] (In contrast

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[45] NAPA/NRC Report, supra 6, p203. All monetary figures given in this thesis will refer to US dollars.

[46] Ibid.

[47] AW&ST, March 11, 1996, p27.

[48] NAPA/NRC Report, supra 6, p203, Note 12.

[49] Ibid, p98.

the ICAO annual budget is some $50 million[50]). "The US has invested more than $5 billion to date in GPS and the program's total cost is expected to reach $19 billion by the year 2016."[51]

Accordingly, it is evident from the foregoing that since first launch in 1978 the US has systematically developed and funded its GPS system and, on currently announced plans, will continue to do so into the foreseeable future. Civil users of GPS have confidence that the system will continue to be funded and maintained because of the transparency and stability of the US political system. Further, "many foreign and commercial users acknowledge the stability and competence provided by the military's control of the GPS satellite system."[52]

Moreover, the GPS system has evolved into a mature technology, albeit one subject to continued development in areas such as differential GPS. However, the fact that GPS is a 'free good' (to be discussed in Chapter IX) is undoubtably the factor which has made it the international navigation and positioning system of choice, notwithstanding concerns among certain States about the control, management, and future availability of GPS.

The other point the foregoing starkly demonstrates is the significant start up costs (running into billions of dollars) and the annual maintenance and operational costs

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[50] The draft programme budget of ICAO for the triennium 1996-1998 was $156,302,000 see ICAO Doc. A31-WP/36, p4.

[51] NAPA/NRC Report, supra 6, p251. The NAPA/NRC Report also notes at p250: "An often quoted figure for the cost of GPS is about $10 billion. No particular basis has been presented for this number. An estimate of $11.5 billion has also been cited. This latter number was based on data developed by the Air Force in connection with the fiscal year 1995 budget and included costs for the development and procurement of military user equipment and for the completion and deployment of all planned block IIR satellites, from program inception in fiscal year 1974 through fiscal year 2008. For a variety of reasons.....these figures are now out of date." Other sources cited in this thesis will quote figures for GPS in the $10 -12 billion range.

[52] Ibid, p71.

(running into hundreds of millions of dollars) that a purely civil GNSS (ie the FANS II Committee's 'Option 5') would have to incur. Costs in this magnitude would have to be funded[53] notwithstanding the fact that civil GNSS satellites should be intrinsically cheaper to procure than GPS satellites as they will not have to incorporate expensive military features.[54] The international community (including civil aviation) has to date shown no enthusiasm for spending such sums to procure an international civil GNSS to complement or supersede GPS. This point will be developed in Chapter XIII.

An important characteristic of the GPS system is that the current accuracy level of the SPS (or 'civil mode' of GPS) of 100 meters in the horizontal plane is the result of a deliberate degradation by the US Department of Defense (DOD) "through an accuracy denial method known as Selective Availability (SA)[55] which was activated on March 25, 1990."[56] SA induced errors can be varied by the DOD or eliminated altogether.

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[53] 'One small sidelight: Some time before the [US] made its offering, there was consideration in FAA as to whether FAA should move forward with GPS or consider a purely civil satellite system. A study was done for FAA by Lincoln Laboratories...
The question was: how much less expensive would a purely civilian system like GPS be? The answer turned out to be about 85 percent of the cost of GPS. The European Space Agency did a similar study, by a Canadian consultant, with similar results.
The reason I dwell on this is that, of the perhaps $12 billion invested in GPS in the [US], (and equivalent in the Soviet Union I expect), we would have to find $8-9 billion to build a new one. I haven't seen many people lining up to spend that kind of money in Europe or the [US]." Testimony of Mr S Poritzky, senior vice president, Airports Council International, former Director, System Engineering Management, FAA, member of FANS Committee, Supra 7, p60.

[54] 'GPS satellite payload functionality is not fully needed; functions required are for civil use only, for example: no long-term memory support; no P-code or P-code encryption; no selective availability processing; no cross-link communication or ranging (autonomous navigation); no triple cross-strapped hardening; relaxation of frequency standard stability requirements; reliability and survivability commensurate with commercial satellites."McDonald K, 'Econosats: Toward an Affordable Global Navigation Satellite System?', GPS World September 1993, p44 at p50.

[55] 'SA is a purposeful degradation in GPS navigation and timing acuracy that controls access to the system's full capabilities. SA is accomplished in part by intentionally varying the precise time of the clocks on board the satellites, which introduces errors into the GPS signal. This component of SA is known as dither. A second component of SA, known as epsilon, can also add error to the signal by providing incorrect orbital positioning data. PPS [ie military] receivers with the appropriate encryption keys can eliminate the effects of SA."NAPA/NRC Report, supra 6, p209.

[56] Ibid.

"Recent measurements with SA turned to zero have ranged from 5 meters to 10 meters (95 percent probability)"[57] The DOD incorporated SA into the C/A mode because of the military implications of its inherent accuracy.[58]

Accordingly, GPS accuracy with SA is 100 metres, 95 per cent of the time. This is much better than most ground based radio navigation aids and achieves the accuracy required for enroute, terminal and non-precision approach flight phases. However, this accuracy is not sufficient for some applications e.g. precision approaches. The result has been the development by industry and commercial and State users worldwide of SPS of a proliferation of GPS augmentations, principally differential global positioning systems (D-GPS),[59] to meet the voracious civilian and commercial demand for greater accuracy. These augmentations remove the SA induced errors and indeed result in the

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[57] Ibid, pXXXV, Note 10

[58] "The realisation that a military adversary could use GPS technology against its creators led DOD to first separate military and civilian GPS signals and then intentionally to degrade the latter using SA when it proved more accurate than had been expected." Ibid, pXXVIII.

It is relevant to note that the military Precision Positioning Service (PPS) is only available to the US military, NATO members and other select users through the encryption of the signal. The PPS signal is accurate to 20 metres or less. Ibid, p67.

[59] DGPS works as follows: "A receiver is placed at a surveyed location (ie, a location whose position is known precisely). The GPS signals that arrive at that location contain errors that offset the position of the surveyed point by some distance. The errors in the GPS signal are determined by comparing the site's known position with its position according to GPS. Correction terms can then be calculated and transmitted to others. These correction errors allow a user's receiver to eliminate many of the errors in the GPS signal.....The accuracy of DGPS positioning varies depending on the user's range from the ground station, the timeliness of the corrections, the geometry of the satellites, and the user's equipment. Accuracies in the 1-5 meter range are typical." Lachow, I.,'The GPS Dilemna Balancing Military Risks and Economic Benefits' in International Security, Vol.20, No.1 (Summer 1995), p126 at p129.

Examples of worldwide D-GPS use: "The racal Skyfix system contains 40 wide-area D-GPS stations, 12 of which are within Europe." AW&ST, October 18, 1993, p63. Further, "Many countries are currently operating, prototyping, or planning maritime DGPS services similar to the US Coast Guard's.....Currently, Sweden, Finland, the Netherlands, Denmark, Iceland,and Germany have complete or nearly complete coastal coverage." NAPA/NRC Report, supra 6, p217. "Worldwide differential networks have already been established by several US and foreign companies. Two of the most widely used of these networks distribute their differential corrections for a fee over an international communications satellite system (Inmarsat) that is specifically designed for mobile users." NAPA/NRC Report, supra 6, p70.

SPS signal providing greater accuracy than the encrypted PPS signal. Ironically, agencies of the US Federal Government such as the FAA and the Coast Guard have been major developers of D-GPS systems (FAA sponsored D-GPS systems will be discussed subsequently). Industry analysts believe that the SPS signal with SA turned off or to zero would provide sufficient accuracy for many GPS applications that now use D-GPS systems e.g. GPS-based automobile navigation systems (which require accuracies in the 5 to 20 meter range) and Category I precision approaches.[60]

The NAPA/NRC report[61] found that SA no longer made sense in technical, military, geopolitical or economic terms and recommended that SA should be turned to zero immediately and deactivated entirely after three years. That report found that militarily denial of SPS to a potential enemy through jamming and 'anti-spoofing' techniques was more effective.

However, the US government has not adopted this recommendation. Policy Guideline 2 of a Presidential Decision Directive[62] announced on March 29 1996 (reproduced as Appendix 1) provides: "It is our intention to discontinue the use of GPS Selective Availability (SA) within a decade in a manner that allows adequate time and resources for our military forces to prepare fully for operations without SA." Further, that "Beginning in 2000, the President will make an annual determination on continued use of GPS Selective Availability."[63] Accordingly, prima facie the US has decided to retain SA for national security reasons. However, one may speculate that this decision was also based on other policy concerns. Both US Federal Government civil agencies and industry have invested heavily in differential GPS systems and the ten year

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[60] See remarks of Mr W. Unternaehrer, Honeywell's GPS program manager, cited in AW&ST, September 20, 1993 at p77.

[61] Supra 6.

[62] White House, Office of Science and Technology Policy, National Security Council, Media release March 29, 1996.

[63] Ibid, 'Reporting Requirements'.

moratorium on phasing out SA allows a period to recover investment in D-GPS systems. In any event in not phasing out SA immediately the USA has lost an opportunity to convey a political signal that although GPS will remain a military managed system the USA is sensitive to the needs of civil users worldwide.

In contrast to GPS: "Partly as a result of political, economic and military uncertainties in Russia....GLONASS has made slow progress in becoming fully operational, leading to doubts about its reliability. Completion of a constellation of 24 satellites has been hampered by the satellites' short lifespan (less than three years) and tendency to fail prematurely; to date, more than 60 satellites have been lofted into orbit in an effort to complete the constellation. Some technical characteristics of GLONASS have also caused difficulties in international use: its signals overlap those used by radioastronomers and mobile telephone communications networks; it uses the Soviet Geocentric Coordinate System rather than the World Geodetic System; and its Soviet-era timing standard uses a system of leap seconds that causes discontinuities and brought about a systems failure in 1993. Although recent launches have shown renewed commitment to the GLONASS program, at least eight satellites will have to be launched per year simply to maintain the system once it reaches the full complement of 24 satellites."[64]

However: "The full deployment of the [GLONASS] system was completed at the end of 1995"[65] and initial operational capability is imminent. This demonstrates that, like the USA, the Russian Federation has systematically developed and funded its global satellite navigation system. "The primary advantage of GLONASS over GPS is that it was not designed to support an accuracy degradation feature like Selective Availability; the accuracy of the civilian GLONASS signal is roughly equivalent to that of the GPS

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[64] NAPA/NRC Report, supra 6, p51. However, GLONASS's interference problems appear to have been resolved, see 'GLONASS Nears Full Operation', AW&ST, October 9, 1995, p52 at p54.

[65] ICAO Doc. C-WP/10397, 8/3/96, 'GLONASS - Global Navigation Satellite System', p5.

C/A-code without SA."[66] Further, Russia is proposing to make technical improvements to the system e.g. "work is being done to modernise the ground control system (GCS) and create a GLONASS-M satellite. This satellite will have a longer guaranteed lifespan (five years, instead of three as at present)"[67]

Notwithstanding these developments questions still remain about Russia's ability to finance and manage GLONASS on a long term basis. In this respect the severe cutbacks in other Russian space programs are noteworthy.[68] Potential users will not invest in GLONASS receivers and other related equipment until they have confidence the Russian Federation has both the political will and resources to support GLONASS.

Further, acceptability of GLONASS is also limited by a simple lack of receivers. Present civil users of GLONASS probably only number in the few thousands, with low production of GLONASS receivers hampering the system's market penetration.[69] A few Russian and foreign firms are developing joint GPS/GLONASS receivers for civil aviation and other purposes. Such joint receivers by utilising the two satellite constellations would give better accuracy, reliability and integrity, and should, lessen institutional concerns. However, it remains to be seen whether airlines and other users

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[66] Lachow, supra 59, p139.

[67] Supra 65, p5. Further, see 'GLONASS Nears Full Operation', AW&ST, October 9, 1995, p52.

[68] For example, Russia's ongoing "funding crisis that threatens to delay the launch of critical Russian components to the international space station" AW&ST, April 15, 1996, p23 and "Two Russian cosmonauts will be left in space for 40 extra days because the government doesn't have enough money to bring them back to Earth....Yuri Koptev of the Space Agency, said there isn't enough money to build the Soyuz booster rockets needed for bringing the cosmonauts home". The Gazette, Montreal, June 22, 1996: 'Cosmonauts stay up as rubles are low'.

[69] "....only a few hundred GLONASS civil receivers have been produced up to now. The shortage of such receivers has become a key issue hindering a wide application of GLONASS as a system." Gouzhva Y, Koudrysvtsev I, Korniyenko V, and Pushkina I, 'GLONASS Receivers: An Outline' GPS World, January 1994, p30. Further, "The main drawback is the user's segment, with very few receiver manufacturers. Most of those are in Russia, but many of the receivers were designed for specific purposes and are neither lightweight nor well suited for civil uses..." 'GLONASS Nears Full Operation', AW&ST, October 9, 1995, p52.

will be prepared to make the investment in GPS/GLONASS receivers which are inherently more expensive[70] than purely GPS receivers. The cost of the latter continues to fall through mass production[71] and technological improvements. Ultimately, it is that amorphous entity 'the market' that will determine whether GLONASS forms a significant element of GNSS, notwithstanding institutional concerns should prompt its increasing utilisation.

In the latter respect it appears the market has determined that GPS is the preferred GNSS, even in Russian airspace. Thus, new aligned airways from Europe to South East Asia passing through Russian Federation airspace have been negotiated and are in the process of being implemented. "Only aircraft fitted with the FANS-1 or FANS-A type equipment would be admitted to newly opened-up air routes."[72] The Russian Federation, applying the principle of sovereignty over territorial airspace and Articles 28 and 31 of the Chicago Convention (to be discussed in Chapter VII), could mandate that GLONASS, rather than GPS, be used to navigate these routes. However, GPS-based avionics installations are available and have been certified, not GLONASS, and Russia is eager to gain the lucrative overflight charges from the Western European and

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[70] "..at this point we cannot be sure that there will be a Glonass in the medium-to-long term. Even if there were, there would be a price to pay in the form of the increased cost of dual-capable receivers and higher susceptibility to interference." Lundberg, O. 'Civil GNSS: The Inmarsat Vision for the 21st Century', Journal of Navigation, Vol 48, No.2, May 1995, p166 at 170.

[71] "...SGS-Thomson Microelectronics in the UK, said it is designing a GPS product targeted at the huge automobile market. The goal is a four-chip core GPS receiver with component parts that would cost less than $50 in applications, with volumes over 100,000..." AW&ST, October 9, 1995, p50.

[72] ICAO Doc. A31-WP/126, 'General Review of Activities on the CNS/ATM Systems Implementation in the Russian Federation', p2, para.2.13. FANS-1 is the avionics package fitted to Being 747-400 aircraft, which includes GPS navigation equipment. FANS-A is a comparable avionics package fitted to Airbus A-340 and McDonnell Douglas MD-11 aircraft.
The same situation pertains to the Commonwealth of Independent States (CIS): "At present work is being carried out on establishment of straight transit international airways within the airspace of the CIS States and neighbour States (China, Mongolia etc). This work is being co-ordinated with European/North Atlantic and Asian/Pacific offices of ICAO. It is supposed to use GNSS and satellite fixed and mobile services facilities for provision of flights along straight routes. Aircraft for such operations must be equipped with airborne facilities of FANS-1 or FANS-A." ICAO Doc. A31-WP/150, 'Implementation of CNS/ATM Systems in CIS States', p2, para. 2.14.

Asian airlines involved .[73] A perhaps even more significantly institutional development is that a D-GPS system "will be installed at Moscow's Zhukovsky Airfield in August for use in a Russian programme to establish certification and operational procedures for local-area D-GPS."[74]

Accordingly, "so far, Russia's equivalent to the GPS, the Glonass, has not emerged as a major rival or even as a useful adjunct to the US system."[75] GLONASS will not replace GPS as the core system of GNSS, the question is whether it will evolve to be an effective complement to GPS. Consequently, for the geopolitical, technical and commercial reasons discussed, GPS is the global navigation and positioning system of choice, despite the institutional concerns of certain States and users ie it is the *de facto* GNSS.

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[73] "Russia sees FANS-1 ATC ground stations as a way to open its airspace and bring in overflight revenue without having to invest in expensive navigation aids. Nikolay Zubov, deputy chairman of the Russian Commission for Air Traffic Services and Navigation (Rosaeronavigatsiya), is a strong supporter of FANS-1equipped ATC facilities in the former Soviet Union." AW&ST, September 4, 1995, p28.

[74] Flight International, 28 February - 5 March 1996, p29.

[75] Flight International, 14-20 February 1996, p42.

Chapter IV: GNSS is a Global Utility

As discussed, the definition of a GNSS produced by the FANS II Committee is, quite understandably, tailored to reflect civil aviation requirements. However, "the technology that aviation would use is largely developed, in place, understood, and already in use for primarily non-aviation applications."[76] In the latter respect, when the FANS II Committee submitted its report to the Council in September 1993 GPS was already in widespread use (including its differential mode) by the maritime industry, trucking companies, surveyors, railroads and meteorologists, particularly in the US but also in other countries. [77]

The present GNSS is the FANS II Committee's 'Option 1' ie augmented GPS. The GPS-SPS mode is a passive system, available to any user with an appropriate receiver. Today, as a result of a combination of lower prices for basic GPS equipment (the simplest receivers now cost under US$200) and technological improvements bringing greater accuracy and reliability GPS is rapidly evolving into a low-cost, mass market system.

Thus: "The 1993 *Industrial Outlook Report* of the US Department of Commerce estimated that 350,000 civilians in the US used GPS in that year. More recently, the GPS Industry Council estimated that 485,000 US civilians will be using GPS in 1995. If the market expands as expected, the increasing multiplicity of consumer applications may eventually make such a count of GPS users meaningless, as GPS is integrated into mobile computers, communication devices, and the national information infrastructure."[78] Moreover, "The US government predicts that by the year 2005, the

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[76] Supra 7, Memorandum pVII.

[77] See remarks of the representative of the US (Mr Hinson, Administrator of the FAA) ICAO Doc 9645-C/1114, C-Min.143/1-22, para.6.

[78] NAPA/NRC Report, supra 6, p17. The national information infrastructure is a US consortium of technology companies that will develop high-speed telecommunication networks, capable of carrying voice, computer data, and video. For example, 'The increasing applications of GPS in small packages

number of civilian GPS users will be 84 times greater than the number of military users."[79] "The predicted number of users breaks down as follows: 38,000 DOD users, 180,000 civilian maritime users, 500,000 civil aviation users, and 2.5 million civilian land users (most of whom will employ GPS for vehicle tracking/navigation)."[80]

The figures in the preceding paragraph are for US users of GPS. I have not come across figures showing estimated total worldwide usage, although "the non-US GPS market is already somewhat larger than the US market; after 2000, the non-US market is projected to grow at a slightly higher rate as well."[81] Therefore, one can assume there are currently well over half a million non-US users of GPS (a very conservative assumption since "approximately 350,000 car navigation units"[82] utilising GPS were sold in Japan alone in 1994) and that there will be several million non-US users by the year 2000. Accordingly, GPS is well on the way to becoming a global utility, if it hasn't already acquired that status. A purely civil GNSS which inherited the existing GPS-SPS market would certainly have this status.

The NAPA/NRC report categorised worldwide GPS applications in 6 general classes[83], or user families: land transportation, aviation, recreation, maritime, surveying/mapping/scientific, and timing (the NAPA/NRC list of current or likely future GPS uses is reproduced as Appendix 2). "The largest user families in 1995...are

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are benefitting from electronics miniaturization. Rockwell International Corp's newest receiver, the NavCore MicroTracker, is a credit-card size five-channel device that weighs 2 oz." AW&ST, September 20, 1993, p85.

[79] Lachow, supra 59, p127, citing 1992 Federal Radionavigation Plan p 3-41.

[80] NAPA/NRC Report, supra 6, p217, note 3.

[81] Ibid, p39.

[82] Ibid, p22. Further, "[Japan GPS Council] vice-chairman Yoshimichi Inada reported that 1994 sales of GPS-based car-navigation systems in Japan are expected to reach more than 300,000." GPS World Feb. 1995, p20.

[83] Ibid, p21.

land transportation (approximately 32 percent of total GPS related sales), recreation (16 percent) and maritime (15 percent)."[84] Civil aviation and timing at 12 per cent represented the smallest user families.

Moreover, civil aviation as a proportionate user of GPS products is forecast to decline - a 1995 study by the US GPS Industry Council projected a worldwide market for GPS products of nearly $8.5 billion in 2000, led by car navigation systems ($3 billion) and consumer/cellular products ($2.25 billion), with aviation at $375 million being the smallest civil user category.[85]

Therefore, GPS is a ubiquitous technology with a myriad of applications. The figures cited above demonstrate the worldwide commercial acceptability of GPS. Civil aviation is (and will remain) a relatively minor sectoral user of GPS/GNSS both in numerical and economic terms ie civil aviation represents a niche market for satellite navigation systems. Consequently, while "aviation sales are expected to be significant, [they] are unlikely to drive commercial investments" [86] in future GPS/GNSS developments. This point will be picked up in Chapter XIII. "Thus, the value of...aviation GPS applications will depend more on how they serve public interests [e.g. enhancing safety] than the size of their sales alone."[87]

In the latter respect, in the ICAO context a number of States have stated that a GPS based GNSS will not be internationally acceptable until institutional concerns are resolved.

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[84] Ibid.

[85] Report summarised in GPS World, May 1995, p59.

[86] 'The Global Positioning System Assessing National Policies' prepared for the Executive Office of the President, Office of Science and Technology Policy by the RAND Critical Technologies Institute. Published 1995, Library of Congress Cataloging in Publication Data, "MR-614-OSTP", ISBN 0-8330-2349-7, p104 (hereinafter referred to as 'the Rand Report.')

[87] Ibid, p105.

Chapter V: US policy towards GNSS

Introductory Remarks:

GPS, perhaps more by accident than US intention (until recently), has become the *de facto* GNSS and this is the core reason for the institutional concerns of certain States. GPS is also a strategic military asset and because of this there has never been any question of the US ceding any degree of operational control of the system to the international community. The Presidential Decision Directive of March 29 1996 reiterates that the Department of Defense will continue to acquire, operate and maintain the basic GPS.

However, the US has been an enthusiastic supporter of the 'ICAO GNSS concept', indeed in many respects the prime mover. In 1984 it was the US which introduced the concept for what became GNSS to ICAO FANS.[88] The US also introduced the idea of an evolutionary path to a civil GNSS to FANS,[89] offered GPS as the US contribution and encouraged other States to contribute to the GNSS space segment.[90] At the 10th Air Navigation Conference in September 1991 then Admiral James Busey, Administrator of the FAA stated: "We view our offer of GPS as just the first step....Our goal is to help build an international system that will work well for everyone.....I want to emphasize, however, that we fully support the eventual replacement of our system by other systems - and we are certain that will happen."[91] (Emphasis added).

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[88] See supra 7.

[89] "A GNSS strategy was the major item considered by WG/1. Five possible medium- and long-term options for GNSS were presented by the United States." Supra 2, Report on Agenda Item 6, p6-4, para. 6.2.4.4.

[90] "....the United States has welcomed, and I know we did in the FANS time, others to provide satellites within that structure to broaden its universality. It would also spread the cost base." Testimony of Mr S. Poritzky, senior vice president, Airports Council International Noth America, former FAA representative on FANS Committee, supra 7, p68.

[91] Admiral Busey's remarks are reproduced in full as GPS Policy Reference 2, Appendix C to the Rand Report, Supra 86, pp275-279.

However, although the US continues to formally voice support for the ICAO GNSS concept,[92] the development of a civil GNSS appears incompatible with the current declared US policy of promoting the: "Implementation of the Global Positioning System as the world's standard in the air, on land, and over water."[93] This objective was reiterated in the Presidential Decision Directive of 29 March 1996.[94]

The US policy to make GPS (and its augmentations) the world standard of course reflects US national interests: "First, the globalisation of GPS markets provides an economic stimulus to firms in the growing US GPS industry, many of which...already rely on exports for a significant share of their revenues. Second, technological preeminence is an important pillar of national power. The acceptance of GPS as the world standard for position, velocity, and timing applications enhances the position of the US and allows it to lead in one important part of the process of technological and economic globalisation. Third, US national security is well served by the international acceptance of GPS. Most obviously, the ease and effectiveness of operations involving the US military and its allies or coalition partners benefit when all are using the same positioning technology. The international acceptance of GPS would also slow the development of alternative satellite radionavigation systems, the adverse use of which could be much more difficult for the US military to control or counter in wartime."[95]

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[92] "The FAA is actively supporting the activities of the ICAO and RTCA, INC. in the definition of the Global Navigation Satellite System (GNSS) and associated implementation planning guidelines. The GNSS is intended to be a worldwide position, velocity and time determination system.....GPS will be the primary satellite constellation used for navigation during early GNSS implementation." Supra 22, p4-5, para.4.2.1.

[93] Supra 22, p1-6, para.p.

[94] Appendix 1, see Policy Goal 2.

[95] NAPA/NRC Report, supra 6, p42.

Consequently, the maintenance of its hegemony in respect of satellite navigation would clearly serve the US's national interests. In this context it would appear illogical for the US to support the evolution of an international civil GNSS, which is independent of GPS. And in this respect the writer has come across one brief media report suggesting that COMSAT (the private governmental organization designated by the US as its Signatory to the Inmarsat Operating Agreement) in effect vetoed the placing of navigation payloads aboard Inmarsat's ICO satellites, thereby putting that organisation's plan to develop its independent International Satellite Navigation System (ISNS) in limbo.[96] This would seem to provide evidence of US antipathy toward a civil GNSS.

However, an alternate view is that the FANS II Committee merely postulated a possible evolutionary path to a civil GNSS, which no State is bound to support. Further, as noted the US encouraged other States to contribute to the GNSS space segment. However, with the notable exceptions of Japan with MT-SAT and Europe with EGNOS (the latter can legitimately be described as a minimalist contribution,[97] I think) no other State(s) has made a firm commitment to fund the GNSS space segment. In this regard, the report about Comsat cited in the previous paragraph also notes that the ICO proposal failed to come up for a vote in the Inmarsat Council and more detailed media reports pinpoint lack of customer support (ie commercial considerations) as the reason it not proceed. Inmarsat had made it clear on a number of occasions that it was not going to subsidise the market or incorporate navigation payloads in the ICO satellites on a speculative basis and perhaps the reported Comsat attitude needs to be seen in this context. The ICO proposal will be discussed fully in Chapter XIII.

Finally, the slow implementation globally of the ICAO CNS/ATM has seen a shift in US policy with a decision to focus on GPS developments, rather than await the

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[96] See AW&ST, April 22, 1996, p59.

[97] The entire EGNOS system has been budgeted at ECU 100 million ($130 million). See Flight International, 24-30 January 1996, p9.

uncertain horizon of a civil GNSS,[98] (a position also taken by numerous other States as will be discussed in Chapter XII). A policy strongly supported by US industry.[99]

In all these circumstances, and considering the fact that the US will bear the burden (financial and otherwise) of being the *de facto* GNSS provider for the foreseeable future, there is arguably nothing inherently sinister in the US trying to leverage the maximum national benefit it can out of GPS. All States seek to maximise the national benefits of their technology.

In the latter respect it is generally recognised that certain West European countries, realizing that satellite navigation constituted a threat to their electronic industries, which were orientated toward exploiting ground-based navaids, have endeavoured to

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[98] The following exchange between Congressman Valentine and Mr Pozesky, Associate Administrator for Systems Engineering and Development, FAA, is revealing:
'Mr Valentine. There - what's the difference between the GPS we talk about and the international Global Navigation Satellite System that you mentioned, and is there a problem that we develop GPS in this country and find that it doesn't fit with the international system.
Mr POZESKY. Well, let me address the difference first. The GNSS system right now, frankly, doesn't exist. It is a term, that is, a Global Navigation Satellite System, which is an umbrella term. It is intended to encompass separately developed systems by the various states and any international system....-so it is the ICAO term, the internationally used ICAO term that they are giving to satellite navigation.
The precise definition of that really is yet ahead of us. ICAO has yet to sit down and do the technical work to really define what a GNSS system will do.
But like it or not, it will probably take ICAO 7 to 10 years to finish that work because that is the way they operate.
We have made the policy decision that we cannot wait for ICAO to do that, to get on with GPS, as we are asking that whatever ICAO does, and the FAA will be a full participant - whatever ICAO does, to make it very clear that it will be fully compatible with GPS.
So our vision of GNSS will be compatible with GPS, will make use of GPS, and maybe other systems that other states put up...So it will be a kind of umbrella term covering the separate systems of our individual states." 'The Global Positioning System: What Can't It Do?', Hearing Before the Subcommittee on Technology, Environment and Aviation, 103d Cong., 2nd Session, March 24, 1994, ISBN 0-16-04425-9 at p54.

[99] For example, "since the [US] represents approximately 45 percent of the aviation traffic in the world, we should focus on the continental US, implement a system using GPS which is already in place, and gradually expand that system throughout the western hemisphere and eventually to Europe and the balance of the world if they so choose." Testimony of Mr R Ferguson, President and Chief Executive Officer, Continental Airlines Inc., Supra 7, p37.

slow down implementation of GPS/GNSS to enable their industries to 'catch up' with the US and compete for a share of the burgeoning GNSS technology market.[100] While it is, of course, entirely legitimate for States to advance their national interests one should perhaps view the expressed institutional concerns of certain States with a degree of cynicism. In fact one should always bear in mind that ICAO fora are essentially political in nature and that positions adopted by contracting States on GNSS (or indeed any other subject) will often serve a wider political agenda.

To return to US policy toward GNSS: to militate concerns over the fact that GPS is first and foremost a military system the Presidential Decision Directive injects a degree of civilian management by establishing a permanent interagency GPS Executive Board, jointly chaired by the Departments of Defense and Transportation, to manage GPS and US Government augmentations. This gives effect to a recommendation of a Defense/Transportation Joint Task Force that reported in December 1993 and in fact the two Departments reached an accord on joint management of GPS at that time.[101] To what extent this Executive Board will meet international institutional concerns is moot - governance and control of GPS remains a US monopoly and "Many foreign governments would prefer an international organisation to be responsible for GPS governance and policy making - even if ownership and operation of the GPS space segment remained in the hands of the US government."[102]

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[100] The writer's interpretation of remarks made by Dr. William Fromme, former director of the ICAO Air Navigation Bureau at a seminar at the Institute of Air and Space Law, McGill University, on 24 October 1995. Further, 'Many of our competing nations, world partners, particularly the Europeans, are focused on ground-based systems. If the US moves precipitously and with full vigour on a GPS system, it will leave their technology in the dust - star dust to be sure and they will have lost an important opportunity in the world market. They are, obviously - and I think for commercial purposes, going to be dragging their feet." Supra 7, remarks of Subcommittee Chairman Congressman Oberstar, p3.

[101] See AW&ST, January 3, 1994, 'Transportation, Defense Depts. Reach Accord on GPS Use'.

[102] NAPA/NRC Report, supra 6, p42.

Interestingly, the Presidential Decision Directive provides that the Executive Board is to consult with interested parties (including foreign governments) "involved in navigation and positioning system research, development, operation and use." The necessary implication being that consultation will include GPS but the Directive does not specifically mandate this.

US Civil Aviation Implementation of GNSS:

The FAA (which is an agency within the US Department of Transportation) has developed an aggressive program both to certify GPS as a navaid and to implement augmentation systems expeditiously. This is primarily because GPS is seen as delivering needed operational and cost-benefit gains.[103] The US plans to replace existing navigation systems with GPS wherever GPS performance is superior and cost-effective or can enable applications that are not currently feasible using other sensors. A secondary but important goal of the FAA program is to prove to foreign countries the utility of the technology and that institutional concerns over reliance on GPS are being addressed.

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[103] "The airlines expect that implementation of a qualified satellite-based navigation system will allow more-efficient routing, shorter flight times, fuel savings, and safer all-weather operations. The airline industry continues to be under severe financial and competitive pressures, and infrastructure improvements that promise major cost savings are of great interest. Similarly, the FAA's own budget is under great pressure at a time when it seeks to upgrade and modernize an increasingly outmoded air traffic control system. Implementation of a satellite-based navigation system could allow removal of older navigation aids, and the expectation that WAAS will be available by 1997 has allowed the cancellation of a multibillion-dollar microwave landing system (MLS) program." Rand Report, Supra 86, p131.

Cost savings to the US civil aviation industry from moving to a GPS-based air navigation system are estimated at billions of dollars annually. For example: "Because these systems are so economical, it will be within the financial reach of nearly 4400 domestic airports to implement precision approaches in adverse weather and visibility conditions. The satellite systems are easier to use, more accurate and less costly to maintain than our present ground-based system. The total savings estimated as a result of using satellite navigation is $2.6 billion - $6.7 billion in one time costs and $524 million annually, excluding ATC. Every day that we do not have the full benefit of satellite navigation costs the government, the industry and the passenger millions of dollars because they are forced to pay for an antiquated and costly ground based system." Statement of Mr R Ferguson, President and Chief Executive Officer, Continental Airlines Inc., supra 7, pp162-163.

Thus, in December 1992 the FAA issued Technical Standard Order C129, 'Airborne Supplemental Navigation Equipment Using GPS' (civil receivers built to TSO C-129 incorporate RAIM to ensure system integrity). On 9 June 1993 the FAA approved the supplemental use of GPS in the oceanic, domestic enroute, terminal and non-precision approaches to airports[104] (Transport Canada gave an identical authorization on 24 June 1993). By September 1993 there were estimated to be more than 25,000 GPS systems installed in general and corporate aircraft in the US.[105] The foregoing is a testament of faith in the technology since Initial Operational Capability for GPS was only declared on 8 December 1993, when the DOD determined that SPS could be sustained.

On 16 February 1994 the FAA certified several 8 channel GPS receivers as meeting its certification requirements for en route and nonprecision approaches anywhere in US airspace,[106] which meant that pilots could navigate solely with GPS.[107] The FAA abandoned the ICAO sanctioned transition to the Microwave Landing System (MLS) as a precision landing aid, in favour of GPS, in June 1994.[108] The FAA announced approval of GPS as a primary means of navigation for oceanic airspace in December 1994 (the US has responsibility for two oceanic areas: the western Atlantic and a portion of the northern Pacific). "The FAA's approach is to accomplish the implementation of GNSS services in achievable phases by approving a particular GPS operation as soon as that operation can be conducted safely."[109]

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[104] See ICAO FANS(II)/4-WP/58, 'Implementation of GNSS in US Airspace'. This opened more than 5,000 GPS approaches at 2,500 airports.

[105] Figure cited in AW&ST, September 20, 1993.

[106] GPS World, April 1994, p17. FAA Technical Standard Order C-129 requires receivers to incorporate Receiver Autonomous Integrity Monitoring (RAIM).

[107] "GPS still must be supplemented in the cockpit with the VHF omnidirectional range radio equipment for instrumented flight, but pilots can plot a course and follow it based entirely on GPS input." Ibid.

[108] See AW&ST, June 13, 1994, p13 "FAA Cancels MLS in Favour of GPS"

[109] 'GPS in Europe', Aerospace, June 1995, p36 at p 37, reporting comments from Mr N Solat, an FAA official.

As previously discussed GPS signals require augmentation to ensure the integrity, availability, and accuracy needed for certain air navigation requirements such as precision landings (this is the case even with selective availability turned to zero for the SPS signal or even in respect of the more accurate military PPS signal). To meet these requirements the FAA plans to augment GPS/SPS with both a Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS).[110] The WAAS differential system is designed to meet en route, terminal, nonprecision approach and landing, and precision Category I approach and landing requirements.[111] For more difficult Category II and II landings, which require greater accuracy than the basic WAAS can provide, the FAA plans to install LAAS differential systems at 150 airports.

The FAA awarded a contract for the development of the ground station element of the WAAS in August 1995. WAAS will consist of a fully integrated network of ground-based monitors and navigation payloads on Inmarsat-3 satellites in geo-stationary orbit broadcasting correction signals. The FAA expects to certify WAAS as a primary navigation aid. "The system will be useable for precision approaches beginning in 1998, and it is expected that by 2001 all Category I operations will be satisfied with WAAS."[112]

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[110] "The...Local Area Augmentation System (LAAS), involves the use of data from a GPS ground-based reference receiver in the vicinity of a GPS-equipped user that allows errors common to both the ground reference and airborne receivers to be removed from the user's range measurements. Wide area DGPS (WADGPS), sometimes referred to as part of the Wide Area Augmentation System (WAAS), enables users located hundreds of miles from servicing reference stations to profit from the observations of the GPS constellation by those satellites. Corrections based on these observations are then broadcast through Geostationary Earth Orbiting Satellites (GEOS) to all users within the GEOS footprint." ICAO Doc. A31-WP/119, 'Results of FAA DGPS CAT II/II Feasibility Research', para.1.2.

[111] "Where GPS today, for integrity, provides warnings of system faults within about 15 minutes, WAAS will provide integrity alerts in 6 seconds or less; availability data, now reliable to about 99 percent, will be enhanced to 99.99999 percent; accuracies, now limited to 100 meters horizontal, will be vastly improved to about 3 meters horizontal and 6 meters vertical." GPS World, May 1995, p16.

[112] ICAO Doc. A31-WP/91, 'ILS/MLS/GNSS Transition', para.4.1.

The aggressive nature of the FAA program is demonstrated by the fact that in April 1996 it reawarded the WAAS contract after expressing dissatisfaction with the progress made by the original prime contractor - as just noted the original contract was only awarded in August 1995. Obviously the FAA was not prepared to give the original prime contractor any leeway to deal with perceived technical difficulties. The FAA clearly intends to ensure that its schedule for implementing GPS technology will be kept.[113]

WAAS will sharply increase airline navigational accuracy over the approximately one-third of the globe centered on the US. GPS augmented by WAAS will, by 2001 (if things proceed as scheduled), be a stand-alone system providing sole-means navigation in the US (and in other countries which adopt the system). This will inevitably have significant implications for foreign airlines flying to and from the US (they will eventually have to be FANS equipped). It is also significant that Canada is keeping in step with US developments and is also transitioning to a satellite (ie GPS) based CNS system.[114] In these circumstances it is perhaps not surprising that Canada has not (at least as far as I can ascertain) supported the formulation of a formal legal framework for GNSS in any ICAO fora.

Canada and the USA together comprise the North American Region for ICAO statistical purposes. In 1994 this Region carried 17.6% of international scheduled

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[113] "Moving with unprecedented speed...the agency just terminated its contract with Wilcox Electric on Apr.26" [and awarded] "a rapid sole-source contract to Hughes Aircraft Co. to get the [WAAS] program back on track....George L Donohue, the FAA's associate administrator for research and acquistion, said ....that the change of contractors could cause some additional delay, but said it would be another two months at most. He said the FAA still hopes for an initial WAAS deployment in 1998." AW&ST, May 6, 1996, p34.

[114] Canada's embrace of GPS is outlined in ICAO Doc. A31-WP/122, 'Overview of Canadian CNS/ATM Planning and Implementation'. Briefly, Canada has approved GPS as a supplementary means of navigation in its airspace, as a primary means in oceanic and remote areas, is developing "stand alone" GPS non precision approaches to certain runways and has four Wide Area Reference Stations linked to the FAA WAAS testbed.

traffic and 43.4% of total world scheduled traffic in terms of passengers carried.[115] The ICAO CNS/ATM system is a global concept which must be implemented at a regional level. Accordingly, ICAO regions need to co-ordinate their CNS/ATM implementation plans to ensure global compatibility. However, it is clear that, having regard to the size and resources of the North American Region, as a practical matter implementation can proceed there regardless of what occurs in the rest of the world.

The other point is that through the FAA's aggressive programme the US is setting the pace and is clearly strongly influencing, if not, *de facto* setting the CNS/ATM implementation agenda. For example, WAAS is planned to be the first operational GPS overlay. Future satellite overlay systems will have to be compatible with WAAS if the goal of global interoperability under the ICAO Global Plan is to be achieved. In this regard as noted in Chapter II the other firm overlay programs (ie EGNOS and Japan's MT-SAT), have adopted the GNSS Integrity Channel (ie the WAAS signal format based on GPS's L1 frequency) and WAAS interface requirements to ensure full interoperability.

The FAA, consistent with US policy that GPS should be the world standard, has been engaged in an 'outreach program' for a number of years to promote the international use of GPS in aviation. In this regard the FAA has entered into technical cooperation agreements with the Civil Aviation Administrations (CAAs) of a number of States under which it provides equipment and technical support. One of the best known being the memorandum of cooperation signed with the CAA of Fiji in 1993 to carry out trials on the use of GPS, which has demonstrated the benefits of GNSS for developing countries. The most recent is with Mexico.[116]

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[115] ICAO Circular 258-AT/107, 'The World of Civil Aviation', p106.

[116] "The USA and Mexico have established technical pacts on satellite-based navigational systems and other navigational services. The two sides can now formally begin co-operative work on future navigation systems involving the global-positioning system (GPS)." Flight International, 21-27 August 1996, p6. This means almost the entire North American continent is now committed to GPS.

In respect of WAAS the FAA "is encouraging other nations to participate in the program at any level they feel comfortable with. Nations involved at the lowest level will simply utilise the GPS like WAAS signals without any contribution to the system in the form of ground based wide area reference stations. Participation at a higher level would involve the installation of wide-area reference stations and possibly wide area master stations within the sovereign territory of a nation. Even higher levels of involvement are possible if a nation is willing to provide a geostationary satellite for the space segment of the system. Several countries have expressed an interest in WAAS participation, including Canada, Australia, NZ, and Japan."[117] In this manner the FAA is promoting the GPS-based WAAS as the model for a seamless global system.[118]

Accordingly, the FAA is currently in the process of negotiating WAAS 'cooperation agreements' around the world. The fact that the US will not phase out selective availability for ten years certainly makes an investment in national and regional WAAS a more pressing issue for those States with users requiring greater accuracy than the SPS signal currently provides. The investment necessary to provide a wide-area reference station or even a wide area master station is relatively modest. The FAA strategy, if successful, will result in GPS becoming a GNSS that is useful to aircraft anywhere in the world. At the very least any degree of State participation promotes GPS expansion worldwide. Regional WAAS ground stations would provide a form of

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[117] NAPA/NRC Report, supra 6, p218. The FAA has also proposed a cooperative agreement with the States of the Gulf Cooperation Council with the objective of having a wide-area differential GPS system operational throughout the Persian gulf region by the year 2000 - see AW&ST, November 27, 1995, p40.

[118] "The United States already has discussed possible bilateral agreements with Australia, India, Japan, Italy, and others, relating to the provision by those countries of WAAS-like services compatible with those in the United States, to form a seamless worldwide system of augmented GPS services." Supra 111, p18.

Further, "Pena said that foreign governments are watching GPS, particularly WAAS, closely. The FAA said it is working with civil aviation officials in several nations to make WAAS the de facto worldwide standard." Report of press conference given by US Transportation Secretary Federico Pena in Global Positioning & Navigation News, August 10, 1995, Vol.5, No.16, p1.

ownership and participation in GPS outside the US, thereby diffusing institutional control, and through their integrity monitoring function could verify US assurances to provide a specific level of GPS service. Such regional augmentations to GPS could be a prelude to a global navigation network. However, ultimate control of the core GPS system would remain with the US throughout.

As noted in Chapter II, the required differential corrections for the US based WAAS system will be determined at FAA facilities and transmitted to Inmarsat-3 satellites via Comsat Earth stations in the US. It appears probable that the FAA will contract out the actual provision of these signals to private companies. Nonetheless, in terms of the Chicago Convention, institutionally the FAA will be the service provider in US airspace, ultimately responsible for the generation of these messages, including their integrity and other information.

The bilateral and regional 'cooperation agreements' the FAA is in the process of negotiating in respect of WAAS will almost certainly they would follow the pattern of Loran-C and Omega agreements (to be discussed in Chapter XII) ie they would deal with matters such as equipment supply and technical assistance, they would not impose institutional obligations such as 'responsibility and liability' for WAAS on the US through the FAA.[119] Such institutional obligations would fall on the nations hosting the regional WAAS ground stations from which differential corrections were being transmitted. Nations which choose to utilise the WAAS signals without any contribution to the system will be institutionally responsible and liable for that decision, as is the current position with nations which choose to utilise Loran-C, Omega or indeed the present unaugmented GPS signals. The latter point is discussed in Chapters VI and XII.

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[119] In this respect the following may be a 'straw in the wind': "The FAA is not contemplating an official relationship with the GCC. The Dubai symposium, one element of the FAA's "Partnership 21" outreach program in civil aeronautics, centered on GPS instruction and information exchanges, not a formal linkage between the FAA and the council." AW&ST, November 27, 1995, p41.

Chapter VI: US Policy toward ICAO

As noted the US constitutes over 40% of total world aviation traffic. In the context of CNS/ATM the US is the initial GNSS provider. It is a simple truism to state that ICAO's ongoing relevance depends to a significant extent on it retaining US support.

Among certain States (primarily first world, 'Western' States) confidence in international organizations is diminishing and support for them is dwindling. These States see organisations in the United Nations system[120] as being bureaucratic, inefficient and unresponsive to their needs and see financial discipline as the means to reform the multilateral system to ultimately benefit all countries in terms of greater efficiency and better program delivery. The USA is certainly in this category.[121] These States accordingly support policies of Zero Real Growth of budgets of such organisations or even Zero Nominal Growth applying to UN agencies, including ICAO.[122]

Accordingly, States which share the US philosophy are likely to oppose international organizations assuming expanded or new responsibilities that require them to provide increased funding. This is one factor that would militate against ICAO performing an operational or managerial role in the worldwide implementation of GNSS (as advocated

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[120] ICAO is, of course, a specialised agency of the United Nations under Articles 57 and 63 of the Charter of the United Nations.

[121] In this respect, section 162 of US Public Law 102-138 (Foreign Relations Authorization Act, Fiscal Years 1992 and 1993), 'United States Statutes at Large', Vol.105, Part1, permits the withholding of 20% of funds appropriated for assessed contributions to the UN or a specialised agency which has failed to implement consensus based decision making procedures on budgetary matters which assure that sufficient attention is paid to the views of the United States or other member States who are major financial contributors to such assessed budgets.

[122] "We call upon ICAO to rethink and refocus its priorities, reflecting carefully on those activities which count the most...The United States is calling for far greater restraint in the budgets of virtually all international organizations. Given the competing demands for very limited public resources, it is certain that we cannot contribute to multilateral agencies at the same levels as in the past. ICAO is a stellar important agency, but it cannot be exempt from these budget pressures..." Extract from Statement to 31st ICAO Assembly by D Hinson, Administrator, FAA, reported in ICAO Journal, November 1995, Vol.50, No.9, p42. Australia, Canada and the Russian Federation are examples of States that support Zero Real Growth of ICAO's budget.

by certain States with institutional concerns) - such an institutional role would require member States to collectively provide the organisation with significantly greater resources (financial, managerial and technical). This has been recognised by the ICAO Secretariat. States from the industrialised 'first' world would realistically have to provide most of these resources.[123]

In this regard the mooted legal basis for possible ICAO involvement in the operation, management or even ownership of GNSS is the co-financing principle of Chapter XV of the Chicago Convention. Article 73 is explicit - any expenditure under that Chapter on 'Airports and other Air Navigation Facilities' must be approved by the Assembly and the necessary capital funds assessed to *"the contracting States consenting thereto whose airlines use the facilities."*

In terms of the above mentioned criticisms of organisations in the United Nations system it is relevant to note that there has also been some industry criticism of ICAO's progress in implementing CNS/ATM.[124] Certainly, many international airlines and national CAAs are moving to adopt GPS-based GNSS systems rapidly (as will be detailed in Chapter XIII dealing with State practice), without waiting for ICAO SARPs to be finalised. I cannot say to what extent such criticisms are justified, although it should be borne in mind that CNS/ATM is an immensely complex system and implementation is ultimately the responsibility of ICAO's 183 member States, coordinating in their various regional fora (as is made clear in the FANS Global Plan).

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[123] Of ICAO's membership of 183 States, 110 pay the minimum contribution of 0.06 per cent. The US pays 25 per cent.

[124] For example, in respect of the 'FANS-1' package (discussed in Chapter XII): "The airlines, faced with their enormous losses caused in part by the massive inefficiencies and wastage due to the current ATC systems, could not afford to wait. ICAO had shown the way with the FANS concept which was essentially complete in 1986. Instead of waiting for the new ICAO ATN, which had promised perfection for the past 10 years and might take another 10 years before it becomes a worldwide interoperable system, the airline community decided to utilise their existing data link network." Mr A. Martin, former senior manager engineering, Boeing, cited in Aeronautical Satellite News, Number 47, October-November 1995, p20.

Further, ICAO's efficiency and relevance is directly related to the degree of support it receives from its member States (including prompt payment of contributions). To blame ICAO for slow implementation of CNS/ATM may, to some degree, be a case of 'shooting the messenger.'

Chapter VII: The Sovereignty Principle and the Chicago Convention

Sovereignty over the Space Segment of a GPS-based GNSS:

The universal implementation of the ICAO CNS/ATM concept will result in air navigation services in the great majority of countries being provided by one or more 'third party', service providers. In respect of the *de facto* GNSS, GPS, some "foreign nations are reluctant to cede responsibility for navigation safety in their sovereign airspace to the US Department of Defense unless they can obtain binding, formal commitments from the US government regarding GPS performance and liability provisions."[125]

These institutional issues are closely tied to the legal regime of the airspace. Article 1 of the Chicago Convention provides '*...that every State has complete and exclusive sovereignty over the airspace above its territory*'. National sovereignty over airspace is the cardinal principle of international air law. Article 1 addresses the legal status of airspace of '*every State*', ie not just that of Contracting States, and is therefore clearly declaratory of customary international law.

Article 28(a) of the Chicago Convention sets out the obligation of contracting States to provide air navigation services within their national jurisdiction: '*...each contracting State undertakes, so far as it may find practicable, to...provide in its territory,...radio services....and other air navigation facilities....*' '*Territory*' is defined in Article 2 as '*the land areas and territorial waters adjacent thereto under the sovereignty, suzerainty, protection or mandate of such State.*' Article 28 is subjective - it is entirely within a State's discretion to determine what is '*practicable*'. Accordingly, the Convention does not require any specific or minimum determined level of services or

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[125] Lachow, supra 59, p139. The author's note 54 reads: "Consider whether - without similar safeguards - the Federal Aviation Administration would allow the use of a foreign military satellite navigation system in US sovereign airspace." Both the NAPA/NRC and Rand Reports acknowledge the legitimacy of this institutional concern.

facilities to be provided. Article 28 is also an application of the sovereignty principle - no State has the obligation to provide air navigation services beyond its own territory.

Article 30(a) deals with the regulation of radio and telecommunications facilities. In summary, it requires an aircraft to obtain a license for the installation and operation of radio transmitting apparatus from its State of Registry (or under the terms of Art 83*bis*, the State of the operator) and to use that apparatus in conformity with the regulations of the State flown over. Article 30(a) is also an application of the sovereignty principle - every State[126] has the right to determine what radio transmitting apparatus shall be operated in its territorial airspace and how e.g. whether an aircraft can broadcast its position (ascertained by GNSS) for Automatic Dependent Surveillance.

The combined effect of these provisions, in respect of GNSS, is that a State has the right to prohibit the use of GNSS in its airspace as a means of navigation. Conversely, a State could theoretically decree that GNSS is to be the only means of navigation in its airspace.[127] Therefore, as an exercise of sovereignty States can embrace or reject GPS/GNSS.

Obviously, with GPS and GLONASS respectively, the USA and Russian Federation are providing a means of air navigation beyond their own territory, ie in foreign sovereign airspace and over the high seas, which they are under no obligation to do

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[126] Article 30(a) refers throughout to '*contracting State*', however, in my opinion, it is merely declaratory of customary law - every State has the sovereign right to determine what navigation systems can be used in its national territory, a convention is not necessary to confer this right. In this regard it is of interest that the US Public Law 101-380 (Oil Pollution Act 1990), US Statutes at Large, Vol.104, Part 1, p484) mandates the use of GPS on foreign and domestic ships carrying oil or hazardous cargo in US navigable waters.

[127] "Responsibility for the regulation of the safety of aircraft and ground and airborne navigation equipment falls to individual States, and there is no reason why this should change in respect to the GNSS. It will be for each country to decide how it should regulate the provision and use of a GNSS." Asbury M.J., 'Some Institutional Factors and Aspects Relating to a Civil Global Navigation Satellite System', The Journal of Navigation, Vol.47, No.2, May 1994, p133 at p139.

under the Chicago Convention,[128] the corollary being they are not internationally responsible to persons who choose to utilise that means of navigation. Indeed, it appears that at international law the only positive obligation cast upon the USA and Russia is that the radio signals emitted by their GNSS systems must not cause harmful interference with other users of the radio frequency spectrum and to facilitate this that there be international coordination and notification under the provisions of Articles 33 and 35 of the International Telecommunication Union (ITU) Convention as elaborated in Articles 8, 11, 13 and 14 of the ITU Radio Regulations.[129] The GPS system complies with these requirements but it has already been noted that GLONASS has interference problems to resolve.

CNS/ATM services are usually provided by ATS authorities normally owned and operated (and hence effectively controlled) by States themselves. However, consistent with the sovereignty principle and Article 28(a) States are free to determine how '*air navigation facilities*' will be provided in their national territory. In this respect a State could delegate to another State, or an international body, or a private agency (either nationally or foreign owned) the control of air operations within its sovereign territory,[130] and, in fact, this has occurred frequently. But, pursuant to the sovereignty principle and the Chicago Convention, the delegating State will retain legal responsibility at international law for any failure of air traffic facilities in or over its airspace, any damages or compensation arising to be assessed under the applicable

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[128] "Any function or obligation of a State to be involved in the provision, operation or management of air navigation services beyond its territory can be based only on a specific commitment of that State, entered into through the Regional Air Navigation Plans or under an international agreement." ICAO Doc. LC/28-WP/3-1, p5, para.1.1. Neither the US nor Russian Federation has entered into any such specific committment.

[129] The International Telecommunication Convention of Nairobi, 1982, Geneva. Opened for signature 6 November 1982; entered into force 1 January 1984. The Radio Regulations are an annexure to the Convention.

[130] "Nothing legally prevents the States from delegating their functions to a specific entity, public or private, within their jurisdictional limits. Nothing legally prevents several States from entering into arrangements or agreements under which one of the States or an entity created by the States or designated by them would provide certain aeronautical facilities and services to the collectivity of States concerned." Milde M., 'Legal Aspects of Future Air Navigation Systems', 1987 AASL, Vol XII, p87 at p95.

liability regime, which remains national law (because, as discussed in Chapter XIII attempts to formulate a uniform legal framework governing Air Traffic Control liability have come to nought). This will be the position of States who choose to rely upon GPS.

In this context, the concept of RNP, whereby the prescribed navigation performance required for a given area of airspace could be achieved by a variety of systems is consistent with the sovereignty principle and the Chicago Convention. As noted in Chapter II the FANS Committee formulated a 'menu' of options (GNSS being merely one such option) from which States could choose those systems which best suited their RNP needs.

Consequently, with GPS/GNSS there are competing sovereignty interests ie certain user States want the US to give up some degree of sovereignty over the GPS space segment (ie share governance and control), before they are prepared to rely upon the system, thereby giving up some degree of sovereignty over navigation in their territorial airspace. However, US policy is that GPS will remain solely a US managed and controlled system. There have been some changes in the US offers of GPS to ICAO to meet institutional concerns but, as will be discussed in Chapter VIII, these offers have the status of non binding policy statements. Consequently, those potential user States with institutional concerns are faced with a choice between upholding the principle of territorial sovereignty and pragmatism (taking the benefits of the system without institutional guarantees from the GNSS signal provider).[131] GNSS, by doing away with the need for a network of ground-based navaids, is mooted to provide the greatest benefits to developing countries, many of whom lack or have only a rudimentary

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[131] "...many countries, such as those in the European Community, have domestic laws that require navigation aids (eg, those used for safety-of-life applications) to be under sovereign control...[since]....the use of GPS promises large benefits in terms of safety, reliability, and lower costs. This poses a dilemna [for such] countries....On the one hand, they want the benefits of GPS; on the other, they are reluctant to allow use of a system that may impose liabilities on them without their having ownership or control of that system." Rand Report, supra 86, p157.

navigation infrastructure.[132] Ongoing developments (to be discussed in Chapter XII) provide empirical evidence that pragmatism is prevailing.

Other Sovereignty Issues raised by GNSS:

Quite apart from which State(s) or entities own the space segment, implementation of CNS systems also raises other issues of sovereignty over territorial airspace.

1.The Concept of 'Seamless Airspace'

In order to coordinate the provision of ATS on an international basis, the world is divided into a number of ICAO air navigation regions, with air navigation facilities and procedures for a region listed in a corresponding Air Navigation Plan. Each region consists of a number of Flight Information Regions (FIRs), which are closely aligned with national airspace boundaries. International air traffic is channeled along specified air routes and each air route is part of a network of air routes within a FIR.[133] "Air navigation's safety, regularity and efficiency rely on air traffic services ...are based at present on the organization of [FIRs]."[134]

However, "the present CNS systems have been implemented on a country by country basis, in that each country implements internationally standardised systems, but to a scope and intensity to suit that country's needs."[135] As the FANS I Committee observed this can (and frequently does) result in interface problems at FIR boundaries and differing levels of ATS being provided within and between regions. In this regard

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[132] For an example of the benefits (both in terms of economics and enhanced safety) that GNSS can bring to a developing country, see ICAO Doc. A31/-WP/110, 'Information on Fiji's Implementation of the GPS Automatic Dependent Surveillance (ADS) System'.

[133] Under Article 68 of the Chicago Convention a State may designate the routes which any international air service must follow over its territory.

[134] Kotaite, A. 'Sovereignty under great pressure to accommodate the growing need for global cooperation', ICAO Journal, Dec. 1995, Vol 50, No.10, p20 at p21.

[135] ICAO Doc. A31-WP/96, 'Implementation of FANS CNS/ATM in the Asia/Pacific Region', para.1.2.

the implementation of CNS/ATM needs to be coordinated, 'particularly between adjacent countries and aircraft operators which fly through the countries' airspace. If there is no co-ordination, there will be different time scales and discontinuities at the airspace [ie FIR] boundaries which would negate many of the benefits which the new system offers."[136] The objective is "a single continuum of airspace where boundaries are transparent to the users."[137]

This need for coordination in the implementation of CNS/ATM at FIR boundaries is why the focus has now shifted to the regional level where the national ATS bodies come together. For example, "the Asia Pacific Air Navigation Planning and Implementation Regional Group [comprising 16 States and 2 international organisations] has prepared a Regional Plan for the FANS CNS/ATM and is now proceeding with a detailed implementation plan which is based on the major traffic flows in the Region."[138]

The working through of implementation planning has resulted in a recognition that "the current organization of FIRs may, in the future, only be useful in the lower airspace, especially for low level and regional traffic."[139] Long distance international traffic, operating in the upper airspace and navigating by GNSS, would then obtain the benefits of 'seamless airspace' from one FIR to another. But this would require States to relinquish control over navigation in their upper airspace to another State or entity performing this role. In this regard EUROCONTROL, which through its ATC center at Maastricht, controls the upper airspace of the Benelux countries and Northwest Germany, may be an institutional model.[140] Further, "Fiji provides air traffic services

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[136] Ibid, para.3.1.

[137] Supra 2, Executive Summary, p3, para. 3.3.1.

[138] Supra 135, Summary, p1.

[139] Kotaite, supra 134, pp21-22.

for the Kingdom of Tonga above flight level 245, while Tonga's own services control domestic traffic and the state's six airports."[141]

2. The Ground Monitor Segment of GNSS

Related to the reorganisation of FIRs and navigational control over upper airspace is the question of State control over ground monitor stations (the definition of GNSS in Chapter I outlines satellites form only one element of GNSS, the others being aircraft receivers and ground monitor stations). These also give rise to sovereignty issues since "a very limited number of ground earth stations can function in each region, thus requiring several sovereign States to rely upon a station located in another State within their region for the essential transmission services such stations perform."[142] Accordingly, if States in a particular region are to achieve the full benefits of the new CNS/ATM systems (including GNSS) they may need to agree to cede a degree of sovereignty in respect of the ground infrastructure elements.

The above demonstrates that: "The FANS CNS/ATM is a shared resource which requires multilateral co-ordination in a partnership approach to ensure the most cost effective implementation."[143] Such co-ordination, to be successful, requires States to 'pool' sovereignty. Or to put it more elegantly: "Functional jurisdiction has to be adopted to meet common needs and to derive common benefits....wherein *de jure* equality will be maintained paralleled to functional inequality."[144]

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[140] In October 1995 'Eurocontrol completed most of its matrix of European states signing up to the Brussels based central flow management unit (CFMU) - effectively handing over the management of flight-slots from nation states to a supranational body". Jane's Airport Review, Jan/Feb 1996, p28.

[141] Jane's Airport Review, May 1996, pp25-26

[142] Kotaite, supra 134, p22.

[143] Supra 135, Summary p1.

[144] Matte, NM, Aerospace Law: Telecommunications Satellites, (Montreal, 1982) p196. The author discusses the myths of absolute sovereignty, equality of States and the need for the adoption of 'functional sovereignty'.

Consequently, even if sovereignty over the space segment were shared "the full implementation of an integrated global satellite-based air navigation system is [still] bound to infringe on States' sovereignty."[145] The number of public pronouncements made by the ICAO Secretariat in this respect demonstrate that the organization has undertaken an educative role to impress upon its member States that the traditional notion of complete and exclusive sovereignty over territorial airspace provided for in Article 1 of the Chicago Convention requires rethinking if the full benefits of CNS/ATM implementation are to be acquired.[146]

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[145] Kotaite, supra 134, p21.

[146] For example, "Although the CNS/ATM system will be a dramatic step away from the strict application of territorial sovereignty over airspace, it will be a perfectly logical one for the air transport community to take." Kotaite, A. 'ICAO Ushers in a Revolution in Global Navigation Technology', 1994, AASL, Vol.XIX-I, p337 at p338.

Chapter VIII: Review of Legal and Institutional Debate within ICAO re GNSS

In this Chapter I will set out chronologically what I consider to be the significant institutional developments in ICAO in respect of GNSS to endeavour to show how the thinking of various participants has evolved. The foregoing Chapters have, I hope, provided relevant 'background illumination' to these developments.

Initial Developments

During its 124th Session, on 29 June 1988, the ICAO Council included in the general Work Programme of the Legal Committee, the subject "Institutional and legal aspects of the Future Air Navigation Systems".

The terms of reference of the FANS Phase II Committee (established on 6 July 1989) included the requirement to "identify and make recommendations for acceptable institutional arrangements, including funding, ownership and management issues for the global future air navigation system."[147]

When reviewing the General Work Programme of the Legal Committee on 16 November 1990, the Council "....understood that....consideration would be given to the possibility of the institutional aspects of FANS taking full account of the experience gained by ICAO in the field of joint financing, including the possible ownership of the satellite systems by ICAO..."[148] This 'experience' is principally a reference to the Denmark and Iceland (DEN-ICE) Agreements for the provision of air navigation facilities over the North Atlantic. These international facilities are operated by the two countries involved under ICAO Assembly Resolution A1-65 pursuant to the co-financing principle of Chapter XV of the Chicago Convention.[149] The facilities, which

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[147] Supra 2, Executive Summary, p4, para.4.1.

[148] ICAO Doc. C-DEC 131/6, 16 November 1990. Cited in LC/28-WP/3-1, para.1.3.6.

[149] The DEN/ICE system is based on the provision and operation of the services by the two States. "The Secretary General of ICAO generally supervises the operation of the "services" and may at any time arrange for an inspection of the "services", including any equipment used in connection therewith; this inspection may, *inter alia*, guarantee compliance with the applicable standards. The Council of ICAO is

are relatively modest in scope,[150] are provided pursuant to Agreements to which ICAO, the two provider States and the twenty-three user States are parties.[151]

Consequently, at that stage the Council appeared to harbour high ambitions for the institutional role to be played by ICAO in respect of GNSS. A role that would see ICAO "remain the management machinery in the field of FANS"[152] and possibly extending to ownership of the space segment ie ICAO being the actual 'service provider'. If one takes this statement of the Council at face value then it must have considered that ICAO had the financial, operational and technical expertise to manage an enterprise of such magnitude[153] (or could rapidly acquire such expertise) and that, notwithstanding its specialised character, ICAO was an appropriate body to both operate and manage GNSS (a global utility), where quantitatively civil aviation is a very minor user.

The other point is that Chapter XV of the Chicago Convention does not appear to provide a very strong legal basis for ICAO to operate, manage or have ownership of GNSS. ICAO has no specific authority under the Chicago Convention to operate navigation systems ie the Convention contains no explicit provisions on air navigation

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the governing body of the joint financing system and acts through its Joint Support Committee which is served by a special section of the ICAO Secretariat. Although the day to day management of the scheme is the responsibility of the Governments of Denmark and Iceland, the entire scheme is under close international supervision."Milde, supra 130, p97.

[150] "Meteorological services, together with air traffic control, communication servies and one radio navigation beacon, comprise the jointly financed air navigation facilities maintained in Greenland and Iceland." 'Continued MET Services Are Provided by Danish/Icelandic Agreements', ICAO Journal, April 1991, p18.

[151] See 'Chapter IV Joint Financing', Annual Report of the Council 1995, ICAO Doc.9667, p32. The Report details the 1996 assessments, which come to under $2.5 million.

[152] ICAO Doc. LC/28-WP/3-1, 'The Institutional and Legal Aspects of the Future Air Navigation Systems', Report to the Legal Committee of ICAO, by Guildimamm,W., para.13.6.

[153] As previously discussed (see note 53), the satellite constellation for a purely civil GNSS would cost billions of dollars to procure and hundreds of millions of dollars annually to maintain.

facilities created and operated internationally. From a legal and institutional perspective possible ICAO operation, management or ownership of GNSS should be constitutionally certain and, as far as possible, legally unassailable. I believe this certainty could only be achieved by an amendment to the Convention. The practical difficulties of amending the Chicago Convention in terms of ratification will be discussed subsequently in this Chapter. Notwithstanding, if there was a consensus among States that ICAO should adopt such a role then an 'expansive' interpretation of the Convention could facilitate this.

A final point is that in respect of the DEN-ICE Agreements ICAO functions are essentially administrative in nature, not operational or managerial, since the technical work is performed by the two provider States.

10th Air Navigation Conference

As previously discussed the 10th Air Navigation Conference held in September 1991 endorsed the global CNS/ATM concept. Agenda Item 4 of the Conference dealt with the "Consideration of institutional aspects of the future air navigation systems." The Conference "emphasized the important role for ICAO in future institutional arrangements and the indisputable role for the organization under Article 44 of the Chicago Convention [which sets out 'the aims and objectives of the Organization']; the FANS concept would be fully within the mandate of ICAO as the only constitutional regulatory body to adopt Standards and Recommended Practices which were relevant for the future systems."[154]

The Conference adopted three Recommendations dealing with institutional arrangements for FANS, Recommendation 4/4 being: "That ICAO, as a matter of urgency, develop the institutional arrangements (including integrity aspects) as a basis

[154] ICAO Doc. C-DEC 131/6, para 1.1.

for the continued availability of GNSS for civil aviation."[155] Recommendation 4/5 stated: "That ICAO, as a matter of urgency, establish a mechanism to:

a) co-ordinate and monitor the implementation of the FANS concept on a global basis, and

b) provide assistance to States as required with regard to such technical, financial, managerial and legal institutional and co-operative aspects this may involve."[156]

28th Session of the Legal Committee

The 28th Session of the Legal Committee was held in May 1992. The Legal Committee considered the four illustrative institutional scenarios developed by the FANS Committee,[157] the Recommendations of the 10th Air Navigation Conference and the report of the Rapporteur, Dr Werner Guildimann of Switzerland. "The Legal Committee concluded that there was no obstacle to the implementation and achievement of the CNS/ATM systems concept and there was nothing inherent in the CNS/ATM concept which could be considered inconsistent with the Chicago Convention. The Committee also approved the guidelines developed by the third meeting of the FANS (Phase II) Committee for acceptable institutional arrangements relative to the implementation of aeronautical mobile satellite services (AMSS) and global navigation satellite systems (GNSS) for civil aviation."[158]

"The Committee was of the opinion that it would be useful to distinguish between AMSS and GNSS from institutional and legal points of view. Mechanisms for the development of the arrangements for AMSS were already being developed to make it

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[155] Cited at para.1.2.4, FANS (II)/4-WP/9.

[156] Ibid.

[157] These ranged "from one where virtually all elements of the system are under the control of aeronautical administrations, to one in which virtually all elements of the system are under the control of satellite and communication service providers". Supra 152, para.1.3.4. They are reproduced as Appendix C to that document.

[158] ICAO Doc. LC/29-WP/3, para.2.1.

an internationally standardized system for aeronautical communications and some AMSS were already operational for aeronautical safety communications. With regard to GNSS, the Committee decided to include in its General Work Programme with priority 5 the subject: *"Desirability of a legal framework with regard to global navigation satellite systems (GNSS)".*[159] AMSS was removed from the agenda as satisfactory institutional arrangements were already in place.[160] The fact that INMARSAT was a major AMSS provider was important in this regard.[161]

'On 17 June 1992, during its 136th session, the ICAO Council amended this subject to read: *"Consideration, with regard to global navigation satellite systems (GNSS) of the establishment of a legal framework"*, and gave it the highest priority in the work programme of the Legal Committee.'[162]

Clarification of Legal Committee's Task

The 29th Session of the ICAO Assembly was held for two weeks, September/October 1992. The Assembly endorsed the FANS concept as recommended by the 10th Air

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[159] Ibid, para.2.2.

[160] The second meeting of the FANS II Committee (FANS(II)/2) had been informed 'that experience with the numerous AMSS developments currently underway had not revealed institutional issues that might preclude world-wide implementation of the FANS system. A number of members shared with the committee their State's experience in contracting communication services (including satellite services) for air traffic control. Questions of liability were integral to these contracts and no particular problem had arisen. The committee was also informed of occasions where States had been involved in intergovernmental arrangements for the provision and sharing of air traffic services. In summary, the initial legal analysis had identified no fundamental legal obstacles to the implementation of any of the scenarios. In particular, it was noted that contractual and intergovernmental arrangements could be made which would fully satisfy State obligations and responsibilities imposed by the Chicago Convention." See ICAO Doc. C-WP/9323, 28/5/91, para.2.4.2.

[161] Inmarsat has been coordinating the introduction of AMSS with ICAO since 1983, including compliance with draft ICAO SARPs. See 'Specialist providers offer cost-effective approach to obtaining ATS satellite communications" by Featherstone DH, Manager, ATS Services development, INMARSAT, ICAO Journal June 1993, p21.

[162] Supra 158, para.2.3.

Navigation Conference and passed resolutions for the implementation of the ICAO CNS/ATM systems.

In respect of the work programme of the Legal Committee a number of delegations from developed countries argued there was no pressing need for the establishment of a legal framework for GNSS and that in terms of use of resources this item should not be the highest priority for the Legal Committee. However, after an indicative vote (50-25) "the Legal Commission of the 29th Assembly approved the priority assigned by the Council but concluded that the task assigned to the Legal Committee was not well defined and needed to be clarified."[163]

The indicative vote is clearly significant - it obviously evidences a lack of consensus and that a significant minority of contracting States thought the topic not even worth spending much, if any, time or resources on. It also suggests a developed/developing country divide on this topic. Further, as the minority were principally developed countries they almost certainly represented, proportionally, a majority in terms of the totality of civil aviation and, accordingly under international law, States "whose interests are specially affected."[164] Consequently, the auspices for future cooperative progress on this topic were not good.

In the circumstances it is perhaps not surprising that the Assembly provided no basic principles, no real guidance to the Council on the objectives to be established for item one of the work programme of the Legal Committee,.

During its 137th (November 1992) and 138th sessions (March 1993), the ICAO Council followed up on the matter and "noted that the main institutional element in the global introduction of GNSS was related to the provision of assurances to all users of

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[163] Supra 158, para.3.1.

[164] Supra 11.

the reliable quality of information and of assurances to sovereign States that the service will be continuous. Civil aviation authorities must be certain that navigation services in their sovereign airspace are being provided in accordance with ICAO [SARPs]. The Council noted that these assurances would have to be provided by all system providers for the basic services that comprise GNSS, and for the augmentations to enhance system integrity and availability including those needed to meet future civil aviation requirements for precision and airport surface operations."[165]

"The Council further noted, *inter alia*, that the Legal Committee should address the following issues:

- The definition of internationally acceptable institutional arrangements that are deemed necessary for the provision of a long-term GNSS system which is designed to meet civil aviation needs, taking into consideration the Guidelines for acceptable institutional arrangements relative to the implementation of GNSS as approved by the 28th Session of the Legal Committee. The arrangements should include provisions relating to ownership, operation and control of GNSS components, systems funding, costs and equitable cost-recovery and liabilities.
- The possible role of ICAO in the long-term provision of GNSS and the need for co-ordination with other potential users of GNSS.
- The content of the arrangements to be entered into between ICAO and the present GNSS-provider States as a possible basis for the development of a legal framework for the provision of long-term GNSS.
- The obligations of the GNSS system providers to fully comply with the relevant ICAO [SARPs]."[166]

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[165] Supra 158, para.4.1.

[166] Supra 158, para.4.2.

I have set this out fully as it is the most detailed statement of what the Council, which is the critical decision making body in ICAO, intended the Legal Committee to achieve.

It is clear the Council still envisaged ICAO potentially playing a significant institutional role in the implementation of GNSS both in the interim and the long term. In this respect, certain States were continuing to promote the idea that ICAO could financially manage the GNSS space segment using the DEN-ICE joint financing agreements as a model and were also in support of an IATA proposal that an agency under the umbrella of ICAO was necessary to manage the implementation of CNS/ATM systems. The reference to 'the need for co-ordination with other potential users of GNSS' tacitly recognises the obvious ie that a GNSS system dedicated to civil aviation was not a practical proposition.

In my view the next significant development was an informal meeting of Representatives on the Council in late March 1993 to discuss a report prepared by the Secretariat on the current status and future developments regarding the CNS/ATM systems. That report and the Minutes of the meeting are not publicly available. However, I understand the thrust of the report as presented by the Secretary General and supported by the President was that ICAO simply did not have the capability in terms of resources to take on the operational and management role in respect of CNS/ATM that some States wished. It appears the Secretary General and the President were attempting to inject a dose of realism into the institutional debate. The President has subsequently made public remarks to the same effect on a number of occasions.[167] It is relevant to note in this context that IMO has also concluded it lacks the resources

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[167] For example, "Some voices are calling for an international body to take over the system, but this is really a matter for the (174) member states to sort out among themselves. If ICAO should be involved, the member states would have to give the organisation the proper means to participate." Interview with Dr Assad Kotaite, President of the ICAO Council, reported in Jane's Airport Review, April 1993, p17.

to operate 'its' world-wide radionavigation system, of which GNSS is a key component.[168]

The proposed ICAO CNS/ATM Agency

During the 139th Session of the Council in May 1993 the Secretary General presented C-WP/9776, 'Establishment of ICAO [CNS/ATM] Mechanism'. This paper was the Secretariat's response to the 10th Air Navigation Conference's Recommendation 4/5 and envisaged "a multidisciplinary Secretariat project team, an advisory group and an ICAO CNS/ATM agency."[169] The last was the most significant element from an institutional perspective and "would involve establishing a separately financed agency under the control of ICAO to assist States in the implementation and operation of CNS/ATM systems in line with ICAO practices, procedures and principles. This approach is being proposed because of the growing interest among States to see ICAO play a major role in assisting States in CNS/ATM provision and management which requires substantial resources well beyond the current and regular programme budget of ICAO. This solution is based on ICAO's successful experience with administering the [DEN-ICE Agreements]..."[170]

The agency's financing was to be derived from user charges and possibly commissions on equipment purchases and service contracts negotiated[171] ie a self financing, 'user pays' mechanism. The "agency would **not** be intended to participate in any CNS/ATM

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[168] "It is not considered to be feasible for IMO to fund a world-wide radionavigation system. Existing and planned systems being provided and operated by Governments or organizations have therefore been studied to ascertain the conditions under which such systems might be recognized or accepted by IMO." IMO Doc MSC 64/22/Add.1, Annex 12, p2, para.1.4. As discussed IMO's consideration of satellite navigation technology parallels ICAO's. IMO's has been studying a world-wide radionavigation system since 1983.

[169] ICAO Doc.C-WP/9776, p3, para.2.1.1

[170] Ibid, p5, para.2.4.1.

[171] Ibid, p8, para.2.4.3.2.

regulatory activities which fall within the domain of ICAO"[172] ie it would have no regulatory role (as a Council created body the proposed agency would obviously lack constitutional power to deal with regulatory matters outside of ICAO's domain).

The working paper envisaged the proposed agency would have quite broad functions, including "7. Facilitate the provision of GNSS global integrity monitoring services [and] 8. Participate in the development of arrangements for future GNSS services (role to be determined)."[173]

IATA had been advocating the creation of such an agency for the best part of a year prior to the Secretary General's working paper. *Prima facie* it represents an attempt to ensure an operation and management role for ICAO in the implementation of CNS/ATM and in so doing addresses to some extent the institutional concerns raised by certain States, particularly in respect of GNSS. It seeks to deal with the lack of resources issue identified by the Secretariat at the informal Council meeting in March 1993 through user charges and this financing mechanism was undoubtably the most sensitive element of the proposal. The fact that the proposed agency would have no regulatory role is presumably responsive to the views of a number of major States that there was no need for a legal framework to regulate GNSS.

The constitutional basis for the proposed agency was given as Chapter XV of the Chicago Convention as amplified by ICAO Assembly Resolution A1-65,[174] ie the basis of the DEN-ICE Agreements. As previously noted this does not appear to form a sound legal basis for an agency with such broad proposed functions. In the latter respect the Secretary subsequently stated: "ICAO agency functions would be global in character and much broader in scope, magnitude and complexity. They would

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[172] Ibid, p5, para.2.4.1.2.

[173] Ibid, p7.

[174] Ibid, p9, para.2.4.5.

primarily call for technical and financial expertise from ICAO (rather than the administrative expertise called for with regard to the Joint Support Agreements)..."[175]

The FANS II Committee's initial response to this proposed agency was somewhat sceptical.[176]

On one level this proposed ICAO CNS/ATM agency could be viewed as merely a logical response to the urgings of IATA and those States with institutional concerns. On another level I am aware that some States saw this proposal as an attempt at bureaucratic empire building by the organisation in an area where ICAO had no real expertise or express mandate.

In July 1993 Dr Kenneth Rattray QC, Solicitor General of Jamaica was appointed by the Chairman of the Legal Committee as rapporteur.

FANS II Committee's Institutional Recommendations

The FANS II Committee submitted its final report to the Council in September 1993. As noted in Chapter III the Committee formulated an evolutionary path to an independent civil GNSS and concluded that any of the five options proposed 'would provide acceptable GNSS service provided the respective institutional issues were resolved'. This proviso was designed to accommodate "institutional concerns [of some States] in regard to the provision of GNSS. These relate principally, to ownership, control and operation of GNSS and their impact on provision of the infrastructure and service, the financial arrangements and safety regulation."[177]

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[175] ICAO Doc. Information Paper for the Air Transport Committee related to C-WP/9776, 10/6/93, p2, response to question 2.

[176] See FANS(II)/4-WP/30, 18/8/93, 'Some Thoughts on the Creation of an ICAO CNS/ATM Agency.'

[177] Supra 2, Report on Agenda Item 6, p6-10, para. 6.4.3.2

The FANS II Committee agreed that the international acceptability of GNSS by States depended on the distribution of the elements "ownership", "control" and "operation" among the interested parties. However, the Committee concluded "that ownership is not the most important element of institutional arrangements since property rights can be shared or distributed. The most important element is control. By means of control, the State ATS authority can influence operations and management, quality level, continuity, costs and procurement. The interests of an individual State ATS authority will be served by all institutional arrangements which provide **an acceptable level** of control to the State ATS authority."[178]

The Committee gave a comprehensive definition of 'control'[179] and considered a civil GNSS as being "a system over which civil users exercise an acceptable level of control on those aspects that relate to the responsibilities of civil aviation"[180] and that "agreements, contracts or regulations, as appropriate, could meet this need and thus any one of the GNSS options can be made institutionally acceptable."[181] In this context the Committee appeared to be referring to legally binding arrangements ('contracts or regulations' by their very nature are intended to be legally enforceable, 'agreements' are perhaps more problematic but if not legally binding how would the required level of control otherwise be made certain?).

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[178] Supra 2, Report on Agenda Item 6, p6-7, para. 6.3.3.5

[179] "**Control** provides the competence to exert control over policy and to define the framework for operations. Exerting control means, eg to influence standard setting, and to define procedures and financing arrangements. It also means influencing continuity, availability and quality. Control will therefore provide the State ATS authority with the influence and/or jurisdiction to derive at the level of safety, liability arrangements, funding and cost-recovery mechanisms, management structure and procurement policy as required by the State ATS authority." Supra 2, Report on Agenda Item 6, p6-7, para. 6.3.3.4.

[180] Supra 2, Report on Agenda Item 6, p6-9, para. 6.4.2.2.

[181] Supra 2, Executive Summary, p5, para.4.4.

The Committee noted that many States did not find ATS authorities control over GPS and GLONASS (or Inmarsat) institutionally acceptable.[182] A not surprising response in respect of GPS and GLONASS, since no control actually exists - the signal providers are clearly institutionally separate from State ATS authorities.[183] State concerns raised in respect of Inmarsat seem a little puzzling as Inmarsat would presumably provide GNSS services on the same institutional basis it provides AMSS services, (including safety communications) where institutional arrangements had been judged acceptable.

The key institutional issue is therefore what constitutes an acceptable level of control to the State ATS authority? This is ultimately a matter for each State to satisfy itself as to and will reflect its national interests and political perceptions. Some States may be happy to access GNSS signals without any institutional arrangements in place, others may be satisfied with a bilateral technical cooperation agreement between an agency of a GNSS provider State and their ATS authorities, and yet others may insist that only an formal legal agreement (e.g. a bilateral or multilateral international treaty) giving institutional guarantees will suffice.

The FANS II Committee did not accept the legitimacy of the DEN-ICE co-financing agreement as a model establishing ICAO's ability to financially manage a civil GNSS. "The operation of the joint finance activity in the North Atlantic region was cited in the early work of FANS as an example of an ICAO task akin to the operation of an

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[182] "Having looked at the present level of control in specific single State options (GPS and GLONASS and the international organization Inmarsat) the meeting concluded that many States viewed that control by the State ATS authorities is not yet at an acceptable level. Specific issues to be addressed by means of agreements and regulations are long- and short-term continuity, liability, management and procurement policies (GPS and GLONASS); and cost and cost recovery, management and accountability (Inmarsat)." Supra 2, Report on Agenda Item 6, p6-8, para 6.3.3.7.1

[183] This absence of control is detailed in FANS(II)/4-WP/9. The latter provides at p13, para.4.5.2,: "Because of the current lack of arrangements which provide guarantees and assurances, GPS and GLONASS cannot be placed in the framework of acceptable options. But by means of bilateral or international agreements of the State ATS authority with the owner of the GNSS system, all issues could be solved in an acceptable manner. Whether this will happen depends on the willingness of the GNSS provider."

aeronautical mobile-satellite service, albeit much smaller than the satellite task. For a number of reasons, an ICAO role of this nature was not considered by the FANS as a feasible possibility."[184]

In the latter respect the FANS II Committee thought no new international body was required - there being a growing number of satellite service providers available to aviation administrations, and it would not be cost effective to create a new agency. Further, if ICAO assumed an operational role its undisputed and successful position as the international technical legislator re SARPs could be undermined. It is clear that the FANS II Committee saw INMARSAT as the most appropriate candidate to provide GNSS services.

It is relevant to note that these conclusions of the FANS II Committee as to ICAO's possible management role were disputed by certain contracting States (and it appears by the ICAO Secretariat). Thus, in his report to the 28th Session of the Legal Committee (the Secretariat normally has a heavy input to such reports) the Rapporteur commenced: "There is a basic difference of opinion - perhaps coupled with some misunderstandings - with regard to the role of ICAO" and then discussed fulsomely the merits of the DEN-ICE co-financing agreement as an institutional model, without actually endorsing it. The Rapporteur concluded: "The political decisions of ICAO will have to be taken in due time by the Council; on that basis corresponding legal instruments could subsequently be elaborated."[185]

The Rapporteur was making the point that any decision on an ICAO role in the operation or management of CNS/ATM implementation was a political matter. Obviously, necessary prerequisites for ICAO to assume an operational/management role would be a substantial degree of political consensus among contracting States and

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[184] FANS II/1, WP/82, p3-10, para. 3.6.1.

[185] Supra 157, para.1.3.6.

support for such a role from the major civil aviation States. Such political consensus and support were obviously wanting.

Statement of ICAO Policy on CNS/ATM

On 9 March 1994, during its 141st Session, the Council approved a Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation (reproduced as 'Appendix 3') and requested the Legal Committee to incorporate, as appropriate, the elements of the Policy in its proposals regarding a legal framework. In summary, these elements are: universal accessibility without discrimination, sovereignty, authority and responsibility of Contracting States, technical and coordinating role of ICAO, rationalisation, integration, harmonisation, cooperation and competition in implementation, evolutionary progression, continuity and quality of service and reasonable cost allocation to users. These institutional elements were considered by the FANS II Committee and the Statement reflects the recommendations and language of that Committee.

The Policy Statement is, of course, not legally binding and represents a consensus reached by the Council, as a collective. As it seeks to cover all CNS/ATM systems the Statement is of necessity constructed in general terms. Although one cannot read too much into such a short document of such generality, it is significant that Precept 3 on the 'Responsibility and Role of ICAO' and Precept 4 'Technical Co-operation' do not include any reference to possible ICAO ownership, operation or financial management in respect of CNS/ATM implementation but rather focuses on matters such as the formulation of SARPs, technical assistance and coordination. As such it reflects the political reality that there was lack of support from major States for the mooted ICAO CNS/ATM agency.

29th Session of the Legal Committee

The 29th Session of the Legal Committee was held from 4 to 15 July 1994 and attended by over 60 States (ie just over a third of ICAO's membership at that time). The

meeting considered the recommendations of the FANS II Committee and the report of the Rapporteur (Dr Kenneth Rattray, QC).

The Rapporteur concluded: "In order to be responsive to these concerns it is proposed that the legal framework should be established by an international convention or agreement sponsored by ICAO regulating the provision of aeronautical navigation, communication and surveillance by requiring that GNSS should be provided in accordance with the convention. The convention would require a GNSS provider to obtain a certification from the [ICAO] and as conditions for certification would have to satisfy ICAO in respect of the matters contained in the guidelines recommended by the Legal Committee [at its 28th Session]."[186]

The Rapporteur further proposed "transitional provisions which would recognise the existence of GPS and GLONASS as a component part of the evolutionary approach to the definitive [GNSS]. It would be possible to make a start with the acceptance of GPS and GLONASS as a supplementary means but within a framework in which certification would be required by ICAO with appropriate guarantees".[187] The mechanism proposed was a Memorandum of Understanding (MOU) between ICAO and the USA and Russian Federation (the MOU is reproduced as Appendix 4). Consequently, the Rapporteur was in essence proposing that ICAO would become the regulator of the definitive GNSS and GPS/GLONASS (certification being merely a form of public law regulation).

Before discussing the Legal Committee's deliberations I would make the obvious point that the Rapporteur was in favour of legal regulation of GNSS and legal regulation now. In this respect his report clearly came down on the side of those States with

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[186] ICAO Doc LC/29-WP/3-, 'Report of the Rapporteur on the consideration, with regard to Global Navigation Satellite Systems (GNSS), of the establishment of a legal framework', by Rattray, K., para.9.

[187] Ibid, para.16.

institutional concerns and in this sense was clearly a political document. It does not appear to sit well with the Council's Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation of 9 March 1994, indeed it seems out of step with the flavour of the Council's deliberations. Further, the report does not, as the Council required, address 'the need for co-ordination with other potential users of GNSS'. The fact that the Rapporteur proposed an international convention or agreement adopted under ICAO auspices as a legal framework is perhaps inevitable having regard to his mandate. However, with respect, as will be discussed in Chapter XI it appears unrealistic to think that ICAO can regulate selective aspects of a global technology such as GNSS. If international regulation of GNSS is necessary this must address the needs of all users.

My interpretation of what occurred during the Legal Committee's deliberations is gleaned from reading the working papers and the Report on Agenda Item 3[188] and by discussing what occurred with the delegates of various States who attended.

Having regard to the proposals contained in the Rapporteur's report it is perhaps not surprising those States with institutional concerns attending the Legal Committee initially had their sights fixed on a convention as an end point.[189] However, also not surprisingly, discussions became very bogged down when the USA, as the *de facto* GNSS provider, made it clear it would not be a party to either a convention or the MOU. The US criticised the draft MOU proposed by the Rapporteur as placing obligations essentially on one party (ie the GNSS provider) and in particular made reference to the 'onerous' liability clause. The Russian Federation also made comments to the effect that the latter provision was wholly hypothetical. Accordingly, both the initial GNSS providers (who in terms of international law are clearly States

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[188] ICAO Doc.9630-LC/189, Report of Legal Committee, 29th Session, Montreal 4-15 July 1994.

[189] For example, see ICAO Doc. LC/29-WP/3-7 presented by Argentina and Brazil.

"whose interests are specially affected"[190]) rejected the draft MOU. I understand that Russia neither expressly agreed to or rejected the idea of a convention as a legal framework.

In the course of the meeting the impracticality of producing such an instrument and bringing it into force within a reasonable time-frame was pointed out by some delegations.[191] This point was increasingly appreciated as the meeting proceeded. Consequently, in the end a convention effectively became just one of a number of possible options for the future.[192]

The Committee in its second week did manage to produce the following documents: (1) A model "agreement" for the ICAO Council to use as a basis in negotiations with GNSS signal providers. However, it contains similar obligations (e.g. liability) to those criticised by the USA and the Russian Federation in the draft MOU, such that clearly no provider would agree to it. This "agreement" was seen by some delegations as a partial, short-term response of doubtful practical use;

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[190] Supra 11.

[191] The practical difficulties a convention would face are similar to those re an amendment to the Chicago Convention. In this respect Article 94(a) of the Convention requires amendments to be ratified by no less than two-thirds of the total number of contracting States. With current ICAO membership at 183, any amendment adopted would require at least 122 ratifications for entry into force, a number attained by only a small percentage of instruments ever concluded, in both the aviation and non-aviation fields. Moreover, amendments do not take effect *erga omnes*. It is significant that at the recent 31st ICAO Assembly the Secretariat prepared A31-WP/26 (Ratification of ICAO Air Law Instruments) which raised various solutions to the accepted slow progress in the ratification of international air law instruments, including the provisional application of treaties and amendments to the Chicago Convention.

Further, "The Representative of the United Kingdom observed that a fair number of the air law conventions listed...had not been ratified; the Organization should learn from this that new conventions were not necessarily the best way forward when it came to dealing with new problems. [He] referred specifically to the field of CNS/ATM, in respect of which a great deal of time and effort had been spent in the 29th Session of the Legal Committee on the prospect of a new convention, with little attention paid to the current situation." ICAO Doc 9645-C/1114, C-Min.143/1-22, p66, para 39.

[192] "The Chairman stated that the Committee did not favour the drafting of an international legal instrument at this stage, but that the Rapporteur's report could be used as a basis in the future development of any legal framework." Supra 188, p3-10, para 3:39:2.

(2) A checklist of items for model contracts between GNSS signal providers and users; this was very similar to the work done by the 28th Legal Committee (Annex 2 of its report) in developing a communications checklist for AMSS services. The check list was seen as part of the long-term response to GNSS.

(3) The elements (11) of a long-term legal framework were painstakingly extracted, adapted and very slightly modified from paragraph 6 of the report of the Rapporteur.

In addition, the Committee agreed to recommend the establishment of a panel of legal and technical experts to further the work on long-term GNSS and by a grudging process of consensus agreed its terms of reference.

Accordingly, I believe the Legal Committee made no real progress on the substantive issue of what form a legal framework for GNSS should take. In fact there was no explicit recognition that a 'legal framework' was necessary. In particular there was no endorsement of a convention which as the meeting progressed was seen as impractical. The Committee was in fact paralysed by the conflicting State interests expressed and the evidence for this is its recommendation to set up a panel of experts - a classic political response if an issue is 'too hard', set up another body to look into it. In the circumstances the documents produced by the Committee are of questionable utility - the checklist may be of some value for contractual relationships with service providers.

Apart from the practical difficulties in bringing a convention into force within a relevant time frame, the position adopted by the USA effectively makes a multilateral convention a dead letter. As the most important air transportation power any global multilateral 'aeropolitical' convention must have US participation and continued support to be an effective instrument.[193] A number of States made this point during the

[193] See note 10.

Legal Committee's deliberations. This *realpolitik* has been reflected in the history of the adoption of 'aeropolitical' conventions of both a public and private international law character since World War II. For example, because the 1975 Montreal Protocols 3 and 4 to the Warsaw Convention 1929 have not been adopted by the USA they remain in limbo, although technically they could have been ratified and brought into effect by the rest of the world.

Further, a treaty, of course, only binds those States which consent to be bound by it,[194] unless that treaty is accepted as being declaratory of customary international law. In today's world it is probably correct to state that no treaty which is not supported by the US will be treated as declaratory of customary international law. This is certainly the case where the treaty deals with matters (such as GNSS) where the USA is clearly a State "whose interests are specially affected."[195]

US Renewal of Offer of GPS-SPS

The US renewed and updated its offer of GPS-SPS to ICAO by letter dated 14 October 1994 from the Administrator of the FAA to the President of ICAO (reproduced as 'Appendix 5'). That letter, not surprisingly, did not mention any institutional role for ICAO in respect of the control and operation of GPS. At the Council meeting at which that letter was discussed the Director of the Legal Bureau advised that an exchange of letters between the US and ICAO would constitute a binding international agreement.[196] With respect I have some difficulty in accepting this conclusion, the letter from the FAA Administrator Mr Hinson is a statement of US policy at that date, its terms

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[194] Article 34 of the Vienna Convention on the Law of Treaties, 23 May 1969, 1144 UNTS 331.

[195] Supra 11.

[196] "As regards the question of whether the proposed exchange of letters was as legally binding for a GNSS signal provider as a memorandum of understanding or other agreement, D/LEB indicated that once the Organization decided to accept the offer, this would have the effect of binding the Government of the United States to fulfil all of the obligations outlined in the letter." Supra. 191, C-Min 143/12, p120, para.41.

clearly indicate no intention on the part of the US to create legal relations.[197] I would respectfully agree that: "This exchange of letters would likely be characterized as a non-binding international agreement."[198] It certainly does not constitute a binding guarantee under international law concerning the availability of GPS.

In the latter respect the Rand Report noted: "As distinct from US statements, there is no overarching international agreement or treaty on GPS...the United States has not entered into any commitment to provide GPS services to particular parties or to agreed upon specifications."[199]

Further, it is also relevant to note the response to a letter dated 2 December 1994 from US Coast Guard Commandant R. E. Kramek to the Secretary-General of IMO (in exactly the same material terms as the Hinson letter to ICAO), offering GPS-SPS as "a candidate component of the future Global Navigation Satellite System (GNSS) as envisioned by IMO, as well as ICAO." IMO, like ICAO is also a specialised UN agency, with legal capacity. The IMO Sub-Committee on Safety of Navigation has recommended that GPS-SPS be recognised as a component of IMO's World-Wide Radionavigation System and stated: "It was noted that the letter from the USCG requires the Secretary-General to reply accepting the offer of GPS-SPS. This reply together with the letter from the USCG dated 2 December 1994 will conceive *a* mutual understanding between IMO and the USCG. There will be no formal agreement or

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[197] The letter concludes: "I would be grateful if you could confirm that International Civil Aviation Organization is satisfied with the foregoing, which I submit in lieu of an agreement. In that event this letter and your reply will comprise mutual understandings regarding the Global Positioning System between the Government of the United States and the International Civil Aviation Organization." (Emphasis added).

[198] Epstein J.M. 'Global Positioning System (GPS) - Defining the Legal Issues of Its Expanding Civil Use', Journal of Air Law and Commerce, 61(1995) p243 at p276. The author analyses whether this letter (and other US statements of assurance) represents a unilateral policy statement or a binding international agreement at pp274-277. Amongst points the author makes is that (at p275) "if intended to be legally binding, proper United States procedures for entering executive agreements would have to be followed", which was clearly not the case here.

[199] Rand Report, supra 86, p43.

memorandum of understanding."[200] (Emphasis added). In my opinion the exchange of letters between ICAO and the FAA has the same status ie a non-binding, 'mutual understanding'. The IMO attitude obviously undermines, probably fatally, any argument that the exchange of letters between the FAA and ICAO constitutes an 'international agreement.'

The President of the Council stated that the US offer was compatible with the Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation[201] and ICAO formally accepted the US offer by letter dated 27 October 1994 from the President of the Council. A reading of the Presidential Decision Directive of March 29 1996 seems to confirm that the US would regard this exchange of letters as non binding.[202]

How does ICAO's acceptance of the US offer sit with the FANS II Committee's definition of acceptable institutional arrangements? As noted, the Committee considered any one of its proposed GNSS options (ie including augmented GPS) would be institutionally acceptable, provided State ATS authorities had 'an acceptable level of

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[200] IMO Doc. NAV 41/23, p13, para. 6.13.

[201] See supra 191, p123, paras.53-55.

[202] The Directive (Appendix 1) sets down the roles and responsibilities of those Federal Government Agencies involved with GPS policy making and provides that: "The Department of State will:
(1) In cooperation with appropriate departments and agencies, consult with foreign governments and other international organizations to assess the feasibility of developing bilateral or multilateral guidelines on the provision and use of GPS services.....
(3) Coordinate the interagency review of international agreements with foreign governments and international organizations concerning international use of GPS and related augmentation systems."
In my opinion there must be a degree of uncertainty in the international community until the US clarifies what these points actually mean. On a literal interpretation they seem to have a degree of internal contradiction. For example, Point 1 with its reference to 'bilateral and multilateral guidelines' implies there are no legally binding agreements governing 'the provision and use of GPS services' ('guidelines' are normally understood to be non-binding statements of policy). This is consistent with the Epstein analysis (supra 198). However, does point 3 mean that the US views the exchange of letters between the FAA and ICAO as an 'international agreement' 'concerning international use of GPS'? If so, this 'agreement' is apparently going to be subject to an 'interagency review' ie a unilateral policy review by the US.

control.' As will be discussed in Chapter XII certain State ATS authorities will have a degree of control over GPS augmentations but they will have no actual control over the core GPS system. Under the terms of the offer the US, as the provider of GPS, will remain institutionally separate from State ATS authorities. As also noted the FANS II Committee considered 'agreements, contracts or regulations' could meet the need for 'an acceptable level of control'. In that context the FANS II Committee appeared to be referring to legally binding arrangements. The comments of the Director of the Legal Bureau that an exchange of letters between the US and ICAO would constitute a binding international agreement was perhaps an attempt to ensure 'institutional consistency' between the FANS II Committee's findings and the decision to accept the US offer.

However, whether the renewed US offer is institutionally acceptable and confers 'an acceptable level of control' is ultimately a matter for each State to satisfy itself as to, having regard to its national interests and political perceptions. In this respect many States are on record as stating the exchange of letters between the US and ICAO has met outstanding institutional concerns.[203]

The 1995 Special Communications Operations Division Meeting

This meeting was held in Montreal from 27 March to 7 April 1995 and attended by 79 Contracting States and 15 international organisations. Special Com/Ops meetings are held every 3-5 years. They are forums concerned with technical policy issues rather than legal or institutional issues. Nevertheless the decisions of this meeting clearly had significant institutional implications in respect of State acceptability of GPS/GNSS.

[203] For example: "Issues related to the continued access to and reliability of the GNSS have been overcome with recent agreements being reached between the United States and ICAO regarding guarantee of service availability." ICAO Doc. A31-WP/97, 'Australia's Implementation Plans for CNS/ATM as at July 1995', p8, para.2.11.2.

The principal focus of the meeting was to identify and recommend future precision approach and landing transition scenarios. In this respect Annex 10 to the Chicago Convention contained a transition plan from Instrument Landing System (ILS) to Microwave Landing System (MLS), with MLS required to be installed on international runways by 1 January 1998. This would have resulted in standardisation in precision approach and landing navaids and avionics throughout the world. However, at this meeting the US formally confirmed it would not proceed with MLS (a decision announced in June 1994) as it considered that D-GPS could more cost effectively meet its precision approach and landing requirements. The US decision to abandon MLS (after having supported the transition plan) was naturally of concern to those States which had already heavily invested in MLS systems and gave rise to questions whether the US commitment to GPS would prove as fleeting. In part to militate such concerns the head of the US delegation read a letter from President Clinton to the meeting reiterating the US's commitment to provide GPS signals to the international civil aviation community free of charge.

The deliberations of the meeting resulted in the adoption of a new strategy for precision approach and landing.[204] Essentially a compromise was reached to accommodate the diversity of regional operational demands and to provide sufficient flexibility in selecting systems and technologies: States which wanted to retain ILS could do so, those which supported MLS could introduce it in place of ILS and those which wanted to use D-GPS were given time to bring their technology up to ICAO standards. This is consistent with the 'menu' of options approach produced by the FANS II Committee in respect of CNS/ATM.

As the FAA accurately, if perhaps immodestly, put it "the US succeeded in achieving all its goals with regard to ILS/MLS/GPS transition"[205] at the Com/Ops Meeting. The

[204] The deliberations and results of the Com/Ops Meeting are summarised in ICAO Doc. A31-WP/48.

[205] Satnav News, Volume 3, No.2, August 1995, p7. Satnav News is a FAA publication.

transition plan to MLS was abandoned and GNSS (ie in effect D-GPS) was endorsed as a candidate precision approach and landing system, albeit subject to the development of ICAO SARPs 'as appropriate'. The results of the meeting clearly reflect the US's influence as the premier aviation power but, more importantly, the fact that most States at the meeting were very interested in the status of D-GPS development, how it could be implemented in their own environments and what level of benefits they would derive.[206] In the latter sense the Com/Ops Meeting recognised that choice of landing navaids "will be based on a simple premise - economics."[207]

31st Assembly

The ICAO Council discussed the necessity for a panel of legal and technical experts as recommended by the 29th Session of the Legal Committee and the timing of its establishment at its 144th Session (27 February 1995). The Council decided to await the views of 31st Assembly. The Council tacitly acknowledged the paralysis in the Legal Committee by noting that without further guidance from the Assembly the Legal Committee would not be able to do the work expected of it in connection with item 1 of its General Work Programme.

The ICAO Assembly's 31st Session was held in Montreal for a 2 week period, September/October 1995. During that period the Legal Commission, which was attended by representatives from 93 Contracting States, held 3 meetings (which the writer attended) at which Item 1 of the work programme, 'consideration with regard to GNSS of a legal framework', received the most attention. In many respects this was a

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[206] In this respect, "Airports are interested because local-area DGPS promises at least Cat I capability for considerably less cost than that of today's ILS. Whereas an ILS serves only one runway end, one DGPS ground station for one-third of the cost, can provide precision-approach capability at every runway within a 40-60 km (20-30 nm) radius." Flight International, 28 February - 5 March 1996, p28.

[207] 'Three Systems, One Standard?' Avionics Magazine, September 1995, p26. This article concludes at p28: "In retrospect, the ICAO COM/OPS meetimg came up with what is probably the wisest compromise that the circumstances allowed, and recognized that economics, and only economics, is the driving force behind civil aviation today."

rejoining of the debate in the 29th Session of the Legal Committee, with States reiterating their respective positions for and against a legal framework.

A number of States (principally from Latin American and West European) endorsed the need for a legal framework (a convention continued to be mentioned) to regulate service providers and in this respect emphasised that this should be progressed by the establishment of a panel of legal and technical experts by the Council immediately. Another group of States noted that the Technical Commission panel on GNSS would report in 1996 and provide a mature technical definition of GNSS and argued that the timing of the establishment of a legal/technical panel (which was a matter for the Council) should await that report to avoid duplication. Some States expressly made the point that any work done in drafting a convention or a 'model agreement' that would not be ratified by the US would be a pointless exercise. To paraphrase one West European 'State of chief importance in air transport': "the end product of any such work could immediately be filed in the waste paper bin."

These divergent views were faithfully recorded in the Legal Commission's report.[208] Resolution 16/1 adopted by the Plenary of the Assembly did 'request' the Council to convene a panel of legal and technical experts.

Consequently, the 31st Assembly in effect returned this matter to the Council for decision with, in my respectful opinion, little, if any, guidance on how to progress the question of 'a legal framework'. It is evident that this issue has been passed between various organs of ICAO (ie the Council, the Legal Committee and the Legal Commission) in a vain attempt to reach consensus, which has not been forthcoming because the various national State interests involved are fundamentally irreconcilable such that no political compromise is possible.

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[208] ICAO Doc. A31-WP/193.

Latest Developments

The Council, on 6 December 1995, decided to convene a panel of legal and technical experts. The panel's terms of reference are to basically "consider the different types and forms of a long-term legal framework for GNSS, citing strengths and weaknesses of various alternatives, and will also explore the possible need for a convention."[209] The panel is scheduled to meet in November this year. Presumably the intention is that the panel should produce a report for consideration at the 30th Session of the Legal Committee (scheduled for the first half of 1997). Given that the 29th Legal Committee recognised the impracticality of a convention as a legal framework one might expect the panel not to expend too much time on this aspect and instead formulate alternatives, focusing on those elements of a long-term legal framework identified in the report of the Rapporteur (Dr Rattray), which GNSS providers are prepared to accept.

On 5 February 1996 the Russian Federation renewed its offer to ICAO for civil aviation users to have free access to GLONASS for a period of at least 15 years (see Appendix 6). I understand that the terms of that offer were discussed at a Council meeting on 13 March 1996 during which the Representative of the Russian Federation made it clear that his country would not be liable to users. More detailed analysis awaits publication of the Council Minutes.

For completeness it should be mentioned that the ICAO Council established a GNSS Panel in 1994 to continue to develop the FANS Committees' findings, including legal and institutional matters. The outcome should be a set of recommendations for GNSS. "The GNSSP is developing draft SARPs for GNSS and is expected to have mature material to recommend for incorporation in Annex 10 by the GNSSP/3 Meeting tentatively planned for 1997."[210] As noted, during the 31st Assembly deliberations on

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[209] ICAO Journal, January/February 1996, Vol 51, No1, p 24.

[210] Supra 19, para.2.1.2.

GNSS a number of States argued that the establishment of any panel of legal and technical experts should await the GNSS Panel's recommendations to avoid any duplication of work.

ICAO is also in the process of organising a global CNS/ATM implementation conference to be held in 1998. The conference "will examine all of the economic, institutional, legal, managerial and funding questions related to transition to the new technologies."[211] Obviously, legal and institutional issues in respect of GNSS will still be unresolved by then and will certainly feature prominently on the conference's agenda.

Consequently, there is a great deal of activity (both ongoing and planned) in various ICAO fora to see if consensus can be reached on legal and institutional issues re GNSS. Whether all this activity will be productive remains to be seen.

[211] ICAO Journal, June 1996, p25.

Chapter IX: Institutional Concerns in respect of a GPS-based GNSS - Charging and Availability/Non-discriminatory Access

In this Chapter I will examine two institutional concerns (imposition of direct charges and availability/non-discriminatory access) that have been raised in respect of GPS to see whether such concerns have substance.

1. Charging

As previously noted, in September 1991, at the 10th Air Navigation Conference the US offered to provide GPS to civil users free of charge[212] for the next ten years, while the Russian Federation offered to provide GLONASS to civil users free of charge for a period of fifteen years. At the 29th ICAO Assembly the US modified its offer to meet States' concerns on respect of duration of service and notice of termination or changes to service by providing that, "subject to the availability of funds", it would give at least 6 years' advance notice before terminating GPS operations or eliminating GPS-SPS.[213]

The US renewed and updated its offer in a letter dated 14 October 1994 from FAA Administrator David Hinson to ICAO (see Appendix 5) to make the SPS/GPS "available for the foreseeable future, on a continuous, worldwide basis and free of direct user fees." As noted in Chapter VIII, the US made a similar offer to the IMO in December 1994. On March 16, 1995, in a message to ICAO, President Clinton reaffirmed the US commitment to provide the GPS signals free of charge to the civil aviation community and to other peaceful users worldwide.

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[212] In fact, President Reagan made the first pledge that GPS would be available for international civilian use free in 1983 after the destruction of Korean Airlines flight 007 by the then Soviet Union, in the hope of preventing a similar disaster.

[213] See ICAO Doc. A29-WP/89, 'Clarification and Expansion of the Offer of the Use of the US Global Positioning System (GPS)', in particular para.2.3.2.

As noted, on 5 February 1996 the Minister of Transport of the Russian Federation wrote to the President of the ICAO Council confirming "the provision of a standard-accuracy GLONASS channel to the world aviation community for a period of at least 15 years with no direct charges collected from users." (see 'Appendix 6')

According to the NAPA/NRC report the USA had invested more than $5 billion in GPS development to March 1995. Presumably the Russian Federation has expended comparable funds in developing GLONASS. *Prima facie* these offers by the US and the Russian Federation appear magnanimous.

However, notwithstanding the foregoing a major institutional concern for certain State users of GPS/GNSS is what happens after the period of free access. This concern is linked to a fear that if terrestrial navigation systems are abandoned in favour of GPS it will give the US enormous bargaining power upon the expiry of the period of free use. Comments such as: "Let's get them [ie the international community] hooked first, and then we will tax them,"[214] do not engender confidence in US intentions. Further, members of the branch of the US Government with 'the power of the public purse' (ie the Congress) have consistently raised the issue of how to charge 'foreign' users,[215] and will undoubtably do so in the future.

However, the fact of the matter is that these 'free' offers by the US and the Russian Federation are simply making a virtue out of a necessity - for administrative and technical reasons, neither has the ability to collect charges from international civil users. Moreover, both have a vested interest in promoting the international acceptability of their systems for geopolitical and economic reasons (openly admitted in the case of the USA) and are using 'free' access to facilitate this. To some extent both

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[214] Supra 7, p20. Comment of Congressman Oberstar, Chairman of the Subcommittee.

[215] The Department of Defense submitted reports on possible GPS user charges to Congress in March 1982 and in May 1984 and again in 1985 - see NAPA/NRC report, supra 6, p99. Whether the US should charge users was one of the issues Congress instructed the NAPA and NRC to report on.

are naturally utilising 'free' access to deflect institutional concerns e.g. the international community cannot legitimately expect them to be liable for systems they provide *gratis*. Such institutional concerns can be characterised as "looking a gift horse in the mouth."[216]

In fact providing the civil SPS signal worldwide requires no, or little, additional funding by the US. The up-front investment to develop GPS for its primary military purposes has already been made and funding will continue for that purpose, irrespective of civil uses (a similar situation presumably pertains to GLONASS). In economic terms the marginal cost of serving additional users is zero. The NAPA/NRC report characterises GPS as a 'public good'.[217]

Moreover, technical considerations make the recovery of user charges both impractical and undesirable: "Two major design elements of the GPS system greatly influence the ability to identify users and assign costs to users or beneficiaries. First the system is "passive", that is, the signal is available to anyone who has a receiver. Second, the use of the signal by one individual does not interfere with its use by any other individual."[218] (GLONASS, like GPS, also operates in a passive mode.[219]) Because the system is passive and the GPS-SPS signal is unencrypted "it is impossible to calculate the amount of an "equitable" user charge, given current and likely available data; it is not even technically possible to determine who uses the GPS signal or how much they use it. It would be possible to tax individual users or impose user charges in

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[216] Editorial, GPS World, March 1993, p10.

[217] "A public good has two major characteristics: first once the public good has been paid for and is available, an additional user imposes no cost on the system and does not diminish its availability to others; second, it is impossible or very expensive to prevent anyone from using it. In addition, a public good usually benefits a large segment of the citizenry." NAPA/NRC Report, supra 6, pXXXII, Note 5.

[218] Ibid, p101.

[219] See GLONASS system description, supra 2, Appendix H to the report on Agenda Item 4, p4H-3, para.3.1.

the US in some fashion, but it would not be possible to tax users overseas in the same fashion or on the same basis, if at all."[220]

The NAPA/NRC Report noted that encryption of the SPS signal might make it possible to determine who is using the system and, through controls on the decryption process, to charge for access to it, but: "This encryption process has been widely criticised as potentially dangerous to public safety. The administrative and logistical problems of implementing such a massive encryption system could be prohibitive."[221] "The largest encryption system now in operation serves no more than several hundred thousand users; this system could involve tens of millions."[222] The panel also noted that encrypting the SPS "would clearly contravene the US commitment to provide the world with an SPS free of direct user charges for the indefinite future."[223]

Because GPS is a passive system the US cannot control, let alone charge, foreign users. This is demonstrated by the fact that major States which are not military allies of the US are incorporating GPS-SPS receivers into their weapons systems e.g. China and India[224] plan to install GPS into their next generation of fighter aircraft.

Consequently, for administrative and logistical reasons it is effectively impossible for the US to charge international users of GPS fees.[225] Moreover, the USA has a vested

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[220] NAPA/NRC Report, supra 6, p9. Similarly, the Rand Report, supra 86, noted at p153: "GPS signals.....flow one way from the satellite to the passive receiver. In order to impose a user fee, there must be a way of denying the signal to enforce payment.....Enforcing a fee collection for SPS today would be impossible without costly changes (both technical and political) to the GPS architecture."

[221] NAPA/NRC Report, supra 6, p101. WAAS will also be unencrypted, presumably in part because the same 'administrative and logistical problems' apply :"The augmented [WAAS] signals will not be encrypted; they will be broadcast at 1575.42 Mhz, same frequency as the GPS L1 carrier, direct to the head ends of onboard GPS receivers in an elegantly simple configuration." GPS World, May 1995, p18.

[222] Ibid, p101, Note 13.

[223] Ibid, p102.

[224] India's next generation Light Combat Aircraft "will also have DGPS and a datalink for better aiming accuracy." Interavia, December 1995, p35.

interest in allowing 'free access' as this encourages greater use of GPS and "the more people use GPS, the greater the economic benefits to the US economy."[226]

Accordingly, having regard to the above it is submitted that there is in fact nothing altruistic about the US and Russian offers of respectively GPS and GLONASS 'free of charge.' Conversely, there are no real grounds for institutional concerns about the US imposing a charging regime for GPS/GNSS after the period of 'free access' - the majority (if not all) contracting States should be aware that the US cannot do this for the practical reasons outlined.

In any event even if the US did hit upon a practical mechanism for charging for the GPS-SPS signal, this in itself would raise institutional issues for the US:
1. Paying for a service (ie 'consideration') prima facie indicates the existence of a contractual relationship and everything that flows from this. If the US were to charge for access to the GPS-SPS signal this would open up all the international institutional issues (e.g. liability, guarantees of availability, signal integrity etc) that the US at present can effectively ignore (at present GPS-SPS is clearly 'offered' on a *volenti non*

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[225] "it probably would have proven expensive or impossible to collect direct user fees for a system that (a) was not asked for, (b) could displace national radionavigation systems, (c) was subject to US national control, and (d) was already available without encryption to US users. Short of creating some kind of signal "shadow" over a country (which would overlap neighboring areas), or changing the signal so that new receivers would have some kind of metering system, the [US] did not have much leverage to induce payment." Rand Report, supra 86, pp180-181.

[226] Lachow, supra 59, p138. For example: "While the United States is offering this technology free and others are using it free, this technology is, like so much other technology that we offer through the FAA and through their certification process as the flying wedge. This opens the way for US commercial sales in many other technologies, and by continuing to be the world leader through this type of offering, we are opening the door for a whole range of other commercial opportunities for American technologies." Supra 7, pp19-20, comments of Congressman Oberstar.

Further, "Today US manufacturers have about 75 percent of worldwide market share in GPS equipment." GPS World, May 1995, p10. According to US Commerce Secretary Ronald Brown by 2000 the GPS industry will employ as many as 100,000 Americans (remarks reported in GPS World, Jan 1994, p16).

fit injuria basis). In my opinion it is not in the national interests of the US to open such a Pandora's box and the US recognises this.[227]

2. Article 15 of the Chicago Convention stipulates uniform conditions must be applied to the use of airports and air navigation facilities available for public use by national and foreign aircraft, with the imposition of user charges being subject to the requirement of equal treatment of national and foreign aircraft engaged in similar international operations. Principles on such uniform charging are set forth in the *Statements by the Council to Contracting States on Charges for Airports and Air Navigation Services* (ICAO Doc. 9082).

Consequently, if it were possible to introduce a charging regime non-US airlines (and their contracting States) would obviously argue GPS-SPS was an 'air navigation facility' and they must be subject to uniform charges ie the same as US airlines.[228] Charging regimes for augmentations to GPS-SPS (often described as 'value added' services) would also, applying Article 15, have to accord equal treatment to national and foreign aircraft. In any event cost recovery for WAAS, EGNOS and MT-SAT, which will also be passive systems broadcasting unencrypted signals, would have to be through an indirect mechanism such as route charges.

Consequently, if any possible charging regime for GPS/GNSS will be subject to Article 15 of the Chicago Convention where is the institutional concern (apart from 'how much?').

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[227] "...it would be unwise to require direct foreign payments for GPS because that creates a contractual relationship that would lead to an unnecessary degree of foreign influence over GPS." Rand Report, supra
86, p210.

[228] "The basis for ICAO's position on route facility cost recovery and charges is set out in Article 15 of the Convention on International Civil Aviation. It is a fundamental principle that cost recovery mechanisms developed for the recovery of civil GNSS costs must be opertaed within this framework. ICAO Doc FANS(II)/4-WP/41p5, para 2.2.

2. Availability/Non-discriminatory access

Certain States see institutional guarantees as to GPS/GNSS continual availability/non-discriminatory access as a necessary prerequisite[229] to adopting the new technology. There is concern that in the future ground-based navigation systems could be eliminated, leaving States dependent on a stand alone satellite system (ie GPS) which they neither own nor operate. In this respect there is also a fear that the global aviation community will commit to GPS only to have it turned off at some point for US national security reasons. In a wider political context reliance on GPS/GNSS without institutional guarantees as to continual availability/non-discriminatory access is seen as giving the US enormous bargaining power.

"This form of institutional dependence is clearly unacceptable to many States, which would be forced to maintain an infrastructure of conventional radio aids as a safeguard against the possibility that the provider State revokes the GNSS at any time, at its discretion. Thus, the successful implementation of a global GNSS for aviation necessitates an institutional structure which allays the legitimate fears of ICAO member states. Moreover, ICAO should take steps to obtain the necessary guarantees of access to the GNSS system without restriction as to time or place so that it may continue the timely transition to the future CNS system."[230]

This requirement for institutional guarantees was noted in the FANS II/4 report.[231] However, as discussed in Chapter VIII the US offer(s) in respect of GPS contain no

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[229] For example, 'The main institutional aspect associated with the introduction of GNSS as a sole means of navigation is the need for long term availability of GNSS elements meeting the ICAO specifications. Guarantees regarding this aspect, before acceptance of the GNSS by the aviation community as sole means of navigation is essential."ICAO Doc. LC/29-WP/3-6, 21/6/94, 'The Definition of an Evolutionary Institutional Path' (presented by the Kingdom of the Netherlands), para 2.2.

[230] Hong S-K & Shin H-K, 'The Need to Improve the Role of ICAO in Relation to the Legal and Other Aspects of ICAO CNS/ATM System Implementation for the 21st Century', 1994 AASL, Vol.XIX-II, p399 at 416.

[231] Supra 2, see Report on Agenda Item 6, p6-10, para.6.4.3.1.

legally binding institutional guarantees. Those States with institutional concerns should therefore perhaps maintain their existing 'infrastructure of conventional radio aids as a safeguard' (as a number of States are doing in respect of 'abandoned' US Loran-C systems). To do so will ensure institutional 'peace of mind' and *prima facie* involves these States in no great hardship. States' institutional responsibility in respect of providing navigation aids is clearly set out in the Chicago Convention. States which maintain their existing navaids are merely perpetuating the *status quo* in this respect (ie it should involve them in no greater expenditure of resources) and they can still take the benefit of accessing the free GPS-SPS signal, including augmentations such as WAAS.

In any event this institutional concern too seems misplaced. The writer's lay interpretation of the technical literature is that it appears the US Department of Defense (DOD) could not deny the GPS-SPS signal to a particular area or user without degrading other users. Any withdrawal or degradation of the signal would almost certainly result in a torrent of international criticism that the US could not ignore[232] and would be inimical to US geopolitical interests. However, it is domestic US political pressures that make it inconceivable that the DOD would withdraw or degrade the GPS-SPS signal, except perhaps in the most dire national emergency (when 'paper' guarantees may have little efficacy anyway).

As discussed, at present there are some half million US users of GPS (roughly half of all users worldwide) who have invested hundreds of millions of dollars in the technology. By 2005 there will be well over 3 million US users and their investment will be in the billions of dollars. GPS is increasingly an integral part of the US economy and, more significantly, is increasingly relied upon by US citizens worldwide

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[232] "GPS is still relatively unknown to the general public, and users number only a few hundreds of thousands. As GPS becomes a key part of vehicular navigation systems and mobile communications, among other uses, millions will come to know and depend on it. Turning off the SPS signal, degrading it further, or even interrupting service briefly would cause a widespread outcry that the federal government could not ignore." NAPA/NRC Report, supra 6, p88.

to provide safety information. Consequently, "the political will to deny or degrade the civilian signal in response to military imperatives is eroding rapidly. The increasing integration of GPS technologies into the commercial and civil sectors ensures that such denial or degradation would have a powerful negative impact on public safety and the economy and would impede the delivery of an increasing array of public and private services."[233]

Accordingly, if the GPS-SPS was shut down or degraded the nation that would feel the most adverse impact would almost certainly be the US. A fact recognised by US policy makers.[234] The US Department of Defense also recognises the constraints it is under in this respect and is looking to develop techniques to selectively jam GPS augmentations,[235] a recommendation made in the NAPA/NRC report, rather than deny the GPS-SPS signal entirely.

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[233] NAPA/NRC Report, supra 6, p60. Further: 'The needs and interests of GPS users are a significant input to the formulation of GPS policy because they drive the technology and markets for GPS and, to put it bluntly, each US user of GPS is a potential voter." Rand Report, Supra 86, p95. And "...if commercial and private users do not keep or install local, alternate navigation systems as back-up to the safety-of-life uses of the GPS, then turning off the 'civilian signal" will be a politically difficult option to exercise. Clearly, military users will need other means of countering potential hostile users of GPS than simply turning the system off." Rand Report, Supra 86, p187.

[234] Congressman Inhofe: "...It is my understanding that there wouldn't be a way, even if it were desirable, to force a shutdown in certain areas or to certain others who may want to use it.
Is that correct?
MR BRODERICK [FAA] The best answer I can give to that is that anything is conceivable with modern technology, but you can't selectively shut it down for individual users.
US international airlines are going to be counting on this system all over the world just like local, domestic airlines will. The best insurance that people have against something like that being done is that United or Delta or American or TWA would be equally as adversely affected as the local airlines. So it is not something that is a practical matter to worry about." Supra 7, p20.

[235] "The US Defense Dept. was upset earlier this year over the FAA's plans to establish [WAAS] to increase GPS accuracy. The concern was that the broadcast, since intended for civil use, would not be encrypted and therefore could be vulnerable to misuse. After several rounds of meetings, the Defense and Transportation Depts. produced a classified agreement that Defense will not 'interpose itself further in the WAAS process, pending the outcome of tests of techniques that would allow Defense Dept. to selectively jam the WAAS signal in military theaters or other regions of security concerns.'" AW&ST, October 9, 1995, pp56-57.

These constraints are also well understood in the international community[236] and are a factor in explaining why international usage of, and investment in, GPS technologies is increasing exponentially.

A final practical point militating against the US withdrawing GPS-SPS is that the DOD GPS community currently relies on the SPS signal to acquire the military PPS signal.[237]

Therefore, in summary, for the reasons discussed above two of the institutional concerns voiced by certain States about relying upon a GPS-based GNSS ie charging and universal availability, are really chimeras. I believe the realities of the situation are well understood by the international community.

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[236] For example, IATA believes that: "..after a GNSS service has been offered and its civil, non-aviation use has become widespread, the likelihood of its untimely withdrawal will become extremely remote". ICAO Doc. C-WP/9482, 13/2/92, Appendix B-9.

[237] See NAPA/NRC Report, supra 6, p61.

Chapter X: Institutional Concerns in respect of a GPS-based GNSS - Liability

Introductory Remarks

Here I merely wish to make some observations of a general nature. For the sake of completeness I would begin by noting that there is no international law regime specifically governing the liability aspects of satellite navigation systems. There has been some academic debate as to whether the Convention on Liability for Damage Caused by Space Objects[238] (hereinafter 'the Liability Convention') applies to transmissions from satellites. However, the consensus is that: ".... "*damage*" covered under this Convention is limited to physical damage only. It is important to note that damage caused by transmission failure or unclear or incorrect links by telecommunication satellites is covered neither by the 1972 Liability Convention, nor by any other international treaty."[239] By analogy transmission failure by navigation satellites that indirectly results in damage would not come within the ambit of the Liability Convention. This conclusion is supported by other commentators.[240]

As discussed, at the 29th Session of the Legal Committee the Rapporteur proposed "transitional provisions", ie a Memorandum of Understanding (MOU) between ICAO and the USA and Russian Federation, to deal with GPS and GLONASS. The MOU contained a 'Responsibility and Liability for Service' clause (see clause 5 of Appendix 4), which received a substantial measure of State support.[241]

As an exercise of national sovereignty the US could, of course, accept such a unilateral obligation in respect of GPS. But as a practical matter this will not occur, as the US

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[238] 961 UNTS 187. Opened for signature 29 March 1972, entered into force 9 October 1973.

[239] Jakhu R 'International Regulation of Satellite Telecommunications', Space Law Applications, Course Materials, Institute of Air and Space law, McGill University 1995, p75 at p79.

[240] See Epstein, supra 198 at p269 and Spradling, K Major USAF, 'GPS and the Law', in GPS World, November/December 1990, p48 at p50.

[241] "Twenty-one delegations...were primarily of the opinion that it was necessary to obtain these guarantees regarding responsibility and liability from the provider of GNSS signals and that this paragraph constituted a fundamental element in the draft agreement." Supra 188, para 3:38.7.3.

made clear during the Legal Committee deliberations (as did the Russian Federation in respect of GLONASS).

As discussed in Chapter VIII it is apparent from the terms of the US letters to ICAO and IMO and other US official pronouncements, that the US has offered GPS to the international community on a *volenti non fit injuria* basis and this has been tacitly recognised by other Contracting States.[242] Any State bringing an international law claim for compensation against the US in respect of GPS could not rebut the defences of assumption of risk[243] and estoppel[244] in my opinion.

However, the US has made it clear that it regards itself as liable for GPS on the same basis as other States providing navaids: "As regards the question of liability....the Representative of the United States indicated that it is his Government's position that the Global Positioning System as provided by the United States is under the same liability provisions as all navigation aids provided by all Member states and therefore needs no different interpretation."[245]

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[242] "The Representative of Saudi Arabia understood that GPS would not be a primary system, but would, rather, be a complementary system which would be used on a voluntary basis by anyone wishing to use it." Supra 191, p114, para.17 (ICAO Council discussion of US offer of GPS).

[243] "Tribunals accept defences of assumption of risk of the particular harm and contributory negligence.....The defences also apply, of course, where conduct of organs of the claimant state amounts to assumption of risk or contributory negligence." Brownlie, I.,'Principles of Public International Law,' Fourth Edition, 1990, pp465-466. Quite apart from the US's unqualified rejection of any institutional 'responsibility and liability' to foreign users of GPS there is also the point previously discussed that under the Chicago Convention it is for contracting States to certify navigation aids and ensure such aids meet their safety requirements. In this respect the act of certification itself arguably constitutes assumption of risk.

[244] "...the essential of estoppel to be: (1) a statement of fact which is clear and ambiguous; (2) this statement must be voluntary, unconditional, and authorized; and (3) there must be reliance in good faith upon the statement either to the detriment of the party so relying on the statement or to the advantage of the party making the statement. A considerable weight of authority supports the view that estoppel is a general principle of international law, resting on principles of good faith and consistency..." Ibid, p641. The US letters to ICAO and IMO are clearly statements that meet these criteria in my view. The statement of the Representative of Saudi Arabia cited at 242 may also meet these criteria.

[245] Supra 191, C-Min 143/7, pp63-64, para 25.

Air Traffic Services (ATS) functions include the operation of radionavigation aids (VOR, DME, NDB, Loran etc). As previously discussed States are internationally responsible under the Chicago Convention for navaids in their territory.[246] However, ATS liability is governed by national law, with liability being tortious or contractual, fault based or strict or complete immunity from liability. In the latter respect ATS are still overwhelmingly provided by governmental authorities, which raises traditional issues of sovereign immunity. Consequently, under the principle of sovereignty over territorial airspace and applying Articles 28 and 30 of the Chicago Convention a State can require a foreign carrier in its airspace to use its navigation aids but plead sovereign immunity in respect of any claim for alleged negligent operation of such aids.

The US has waived sovereign immunity in circumstances prescribed in its domestic legislation (such as *The Federal Tort Claims Act*). Consequently, the US may be liable for any negligent operation of the GPS constellation which results in damage in terms of such legislation. And in this respect it is relevant to note that the declaration of Initial Operational Capability of the GPS satellite constellation by the Department of Defense on 8 December 1993 triggered provisions in the US Federal Radionavigation Plan[247] that ensure predictable access to GPS for civilians, including the availability of SPS to levels of signal quality providing 100-meter horizontal accuracy at least 95 per cent of the time and notification to the FAA and the Coast Guard 48 hours before any planned satellite outages. However, a discussion of US domestic liability provisions is beyond the scope of this paper and has already been treated fulsomely by other writers.[248]

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[246] "States provide air navigation facilities in accordance with Art 28. If an accident was caused by a defect or mistake in the ground control, the State providing the service - or the agency providing the service on behalf of the state - would be responsible." Supra 191, C-Min 143/12, p120, para.40.

[247] GPS policies are published as regulations in the US Federal Radionavigation Plan, supra 22.

[248] For example, see Epstein, supra 198 at p269 and Spradling, supra 240 at p50.

The points I wish to discuss here are whether the proposed liability clause in the MOU was in fact equitable, or consistent with how contracting States, as providers of navaids in their own territorial airspace, have treated their own ATS liability.

Equity

Equity[249] is a general principle of customary international law, which the International Court of Justice applies pursuant to Article 38(1)(c) of its Statute in appropriate circumstances.[250]

As discussed in Chapter VII with GPS and GLONASS respectively the USA and Russian Federation are providing a means of air navigation beyond their own territory, which they are under no obligation to do under the Chicago Convention, the corollary being they are not internationally responsible to persons who choose to utilise that means of air navigation. Moreover, as discussed in Chapter VIII, GPS is a passive direct broadcast system - the US has no idea who is using (or misusing) the system. Further, GPS is the *de facto* GNSS and is evolving into a global utility/international public good. If the US were liable to all civil GPS users (it would clearly be inequitable and illogical for liability only to attach to civil aviation users) this would see the fulfillment of US Supreme Court Justice Cardozo's famous dictum: "liability in an indeterminate amount for an indeterminate time to an indeterminate class."[251]

There is also the obvious point that acceptance of liability could see US taxpayers (who have already paid some $5 billion to establish and maintain GPS) under a potentially open-ended obligation to pay damages to citizens of all user States (none of whom

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[249] "Equity' is used here in the sense of considerations of fairness, reasonableness, and policy often necessary for the sensible application of the more settled rules of law." Supra 243, p26.

[250] See for example, the *North Sea Continental Shelf Cases*, ICJ Reports (1969), 3 at 46-52 and the *Fisheries Jurisdiction Case (United Kingdom v Iceland)*, ICJ Reports (1974), 3 at 30-5.

[251] *Ultramares Corp. v Touche*, 255 N.Y. 170, 174 N.E. 441 (1931).

presently materially contribute to the GPS system), a significant number of whom have per capita income similar to that of the US.

Moreover, as discussed, the utilisation of GPS worldwide is growing exponentially. Many States are sanctioning (either expressly or implicitly) the use in their sovereign territory of GPS by their citizens in a myriad of land, maritime, aviation and other applications ie they are prepared to take the benefits of the system. This includes many States which have expressed institutional concerns in ICAO fora.

There is the argument that the US in offering GPS to the world is inducing reliance on the system and therefore is under a general duty to take all reasonable steps to ensure the system is kept in good working order and that timely warnings of degradation of the system be provided. I believe the US is under a political and moral obligation in this respect but *ipso facto* this does not result in a general legal duty of care arising to international users. One mechanism by which the US discharges this obligation is through the GPS Information Center (CGSIC) operated by the USCG as part of the US Civil GPS Service (CGS).[252]

Consequently, having regard to the above to argue that it is equitable for the US to accept international 'responsibility and liability' for 'its' system is not tenable, in my opinion.[253] The position appears even more untenable when one considers how the issue of ATS liability has been treated in the Legal Committee.

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[252] "The CGSIC was established to identify civil GPS technical information needs in support of the CGS programme. Membership in the committee is intended to represent the widest possible coverage of the civil community. Objectives include identifying needs of States other than the United States, for GPS information and the communication methods for them to obtain it. This represents a means by which international co-operation in sharing information on GPS has been accomplished." Supra 2, Appendix B to the Report on Agenda Item 6, p6B-2, para 1.5.

[253] I am cognisant of already having made the point that in terms of geopolitical influence, economic benefits and maintaining a technological advantage the US gains substantial benefits from GPS becoming the world standard, however, I do not think this detracts significantly from the point that to expect the US to accept worldwide liability for GPS (and strict or absolute liability has been mooted by some commentators) is simply unreasonable, inequitable and unrealistic.

Air Traffic Services (ATS) liability

Liability for GNSS signal providers is inextricably bound up with the wider issue of ATS liability generally. As noted ATS liability is governed by national law and some States have not waived sovereign immunity in respect thereof. Logically, if providers of GNSS signals are to be subject to liability (whether fault based, strict or absolute) worldwide then State providers of other navigation services (whose potential liability exposure will always be several orders of magnitude less) should also be subject to the same liability regime, especially since GNSS operations may involve questions of joint liability arising.[254] This will ensure certainty, uniformity and universality of law.

Thus: "In the context of the introduction of the CNS/ATM concept it appears to be short-sighted to reduce liability questions to system operators' and service providers' liability. Instead the liability issue should be addressed on a broader basis and also take into account the future relationship among pilot in command, aircraft operator and air traffic control."[255] However, it is just these broader issues in respect of ATS liability that contracting States have demonstrated they are unable or unwilling to address in the forum of the ICAO Legal Committee.

The issue of subjecting ATC to a common liability regime was formally put on the work programme of the ICAO Legal Committee in 1979 (however, this issue had been considered by various States and within ICAO for many years prior to this). It is not necessary for my purposes to detail the tortuous progress (or rather lack thereof) of this

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[254] "The Representative of the United States wished to point out also that the United States was not the only potentially liable party in the event of a problem. In most of the world the United States would be providing only the satellite signals; presumably a regional body or a sovereign State would be providing the rest of the satellite navigation services. In the event of an accident, there might be joint liability." Supra 191, p117, para.28.

[255] Kaiser, S., 'Infrastructure, Airspace and Automation Air Navigation Issues for the 21st Century', 1995 AASL, Vol.XX-I, p 447 at p453.

issue in the Legal Committee.[256] Suffice to say there was no consensus to draft a convention on ATC liability as basically a significant number of States did not want to cede any sovereignty over their territorial airspace or lose their sovereign immunity in respect of ATC liability ie the status quo served most States national interests. The result: "it had been decided unanimously, not only by the Legal Committee but also by the Legal Commission of the Assembly, that there was no need for a convention."[257] In effect no convention on ATC liability was adopted for the same reason (lack of consensus) no formal legal framework is likely to be adopted for GNSS.

The Rapporteur in respect of ATC liability, Professor H. Perruchi, proposed as an alternative to a Convention, a model law to be incorporated in the domestic legislation of each State. However, States have shown little interest in developing this proposal. At the 29th Session of the Legal Committee Professor Perruchi's report was re-edited as a working paper.[258] It "was the view of the Committee that the Rapporteur's report needed some further updating to cover the elements arising out of the CNS/ATM concept."[259] This seems rather an understatement. In my opinion it is rather illogical to put forward liability as an issue that requires a formal legal framework to regulate GNSS (only one electronic aid that may satisfy RNP criteria according to the FANS II Committee) while concluding that no such formal legal framework (in the form of a convention) is necessary for wider liability issues dealing with ATC and ATS.

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[256] For background see, Lagarrigue, I., "ATC Lability and the Perspectives of the Global GNSS" is an international convention viable?) (August 1994), Institute of Air and Space Law. Thesis. McGill University.

[257] ICAO Doc 9645-C/1114, p120, para.40.

[258] ICAO Doc LC/29-WP/7-3.

[259] ICAO Doc.9630-LC/189, Report on Agenda Item 7, para.7.11.

In summary, having regard to the foregoing, clause 5 of the MOU considered by the 29th Session of the Legal Committee was clearly inequitable from both a legal and institutional perspective, and as a result was a 'soft' target for the US to criticise.

However, as touched upon in Chapter I think the liability of GNSS signal providers is not a major practical issue. If there came a point when there was political will to establish a civil GNSS then liability would merely be another 'legal' issue that would be worked through as a matter of course, probably resolved by a combination of mandatory insurance and cross-waiver of liability provisions between signal providers and State users.

As previously noted that it the FAA and EGNOS will be institutionally responsible, as the service providers,[260] for their respective overlay systems broadcast in 'their' airspace through the Inmarsat-3 satellites. The US government, through the FAA, will be liable for WAAS in accordance with US domestic law in exactly the same way it is liable for the operation of other government sanctioned navaids. Liability for operation of the EGNOS system will presumably be dealt with through some agreement among the participating European States.

Further, those State civil aeronautical authorities which have certified GPS as a navaid in their airspace or certified GPS based avionics for installation in their carriers aircraft (such as the FANS-1 package) as meeting RNP requirements[261] are already responsible at international law for those decisions, for which liability may also arise in accordance

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[260] See note 29.

[261] See supra 2, Appendix A to the Report on Agenda Item 8, p8A-31, Guideline III-5. The commentary to the Guideline provides: "This guideline relates to the responsibility of States to certify avionics, on the basis of conformance to required navigation performance (RNP) criteria, which include, *inter alia*, integrity, fault warning, reliability, continuity of service and accuracy for different phases of flight". Under the Chicago Convention States have the regulatory responsibility for certifying avionics in their carriers' aircraft, this commentary to Guideline III-5 is emphasising the matters that States must satisfy themselves in respect to in certifying GNSS avionics.

with their national law. The same legal position as pertains to Omega and Loran-C, other radionavigation aids where the majority of certifying States lack any degree of institutional control. Those CAAs in States where immunity has been waived, and are not 'self insured' through their governments, should have already taken steps to ensure their existing insurance arrangements cover any possible liability exposure through certifying GPS systems.

Chapter XI: Is ICAO the appropriate body to formulate a legal framework for, or operate or manage GNSS?

Those contracting States which have institutional concerns in respect of a GPS based GNSS would like to see ICAO regulate such a system and also be involved in the operation or management of a civil GNSS (if such a system eventuates). As discussed in Chapter 7, ICAO did for a time see itself as serving in a governance capacity in respect of GNSS, as did the IMO. It is, I think, apparent that the Secretariats of both organizations have accepted practical realities and are no longer advocating such a role. However, the issue of a regulatory, operational or management role for ICAO is still being advocated by certain contracting States.

Is it appropriate for ICAO to formulate a legal framework for GNSS? Constitutionally, the ambit of ICAO's jurisdiction is limited to matters concerning civil aviation. As discussed, GNSS is a global utility and logically a formal, multilateral framework should address the legal concerns of all users. If there was political agreement among States that a legal framework in the form of a multilateral convention was necessary to regulate a civil GNSS then logically this would involve the calling of a Diplomatic Conference and the drafting of a convention which would address the needs and institutional concerns of all users worldwide. Alternatively, perhaps the United Nations Committee for the Peaceful Uses of Outer Space has the expertise and broad mandate to draft such a legal framework. In any such scenario ICAO would obviously have a prominent advocacy and advisory role in respect of the interests of civil aviation. ICAO has no mandate to develop a legal framework 'institutionally acceptable to all users,' although it could be given such a mandate by the international community.

At present ICAO's position is that of a specialised body dealing with the needs of a transport mode which is a minor sectoral user of GNSS services. It is not therefore appropriate for ICAO, through its Legal Committee or other fora, to attempt to define the legal and institutional parameters to regulate a global, intermodal technology such

as GNSS. GNSS is not a 'discrete' technology confined to a single body of users with homogeneous requirements, such as the aeronautical community and ILS or MLS. GNSS simply cannot be legally regulated on a sectoral basis.[262] The setting of technical standards is a different matter.[263]

Is ICAO an appropriate body to operate or manage GNSS? Leaving to one side the point that ICAO has no specific authority under the Chicago Convention to operate or manage navigation systems of an international character, again this comes back to the fact that GNSS is a global utility and therefore should be institutionally acceptable to all users,[264] as should its operator or manager. If an international, civil GNSS did evolve then an internationally-constituted body responsive across the full spectrum of user requirements would be necessary to manage and operate the system.

"The traditional major users of radionavigation aids - aviators and mariners - are represented internationally on radionavigation matters through the [ICAO], [IMO] and International Association of Lighthouse Authorities (IALA)."[265] "All these bodies and groups are concerned only with specific problems within their own spheres of interest and there is little or no formal liaison between them. None is suitable as a GNSS operational or regulatory body, since each represents only its own, sometimes very small, specialist user class. Moreover, none has power to actually operate navigation

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[262] "There is no international organization that can address all GPS-related issues at a government-to-government level. Multilateral organizations such as ICAO...can address certain categories of GPS applications, but not broader [issues]...associated with the technology." Rand Report, Supra 86, p209.

[263] Under Article 37(a) of the Chicago Convention, ICAO can adopt SARPs dealing with communication systems and air navigation aids (including satellites which act as air navigation aids) and pursuant to this article ICAO adopted Annex 10 dealing with aeronautical telecommunications and is drafting SARPs for GNSS.

[264] "Within Eurocontrol as well as in the European Civil Aviation Conference (ECAC) States, there is broad agreement that the ultimate objective is to have available a Global Navigation Satellite System (GNSS) which independently meets the requirements of all users on land, at sea and in the air. Only if and when such requirements were met would a GNSS be regarded as institutionally acceptable to all users ..." ICAO Doc.A31-WP/121, 'European Activities related to Satellite Navigation', para. 1.4.

[265] Blanchard W., and Broughton D.W., 'Institutional Requirements for a Global Navigation Satellite System', The Journal of Navigation, Vol.48, No.2, May 1995, p249.

systems, although some have become accepted as regulatory bodies. This is not to say that authority could not be given to one or more, but in the necessary process of extending its interests outside its own user group it would become divorced from them. This might well be found to be unacceptable."[266]

I have come across nothing in my research for this thesis to indicate ICAO would be an acceptable operator or manager of a civil GNSS to larger sectoral users such as the maritime industry, or even that ICAO has seriously sought such a role. In the latter respect ICAO has taken only half-hearted steps to coordinate the requirements of civil aviation GNSS users with those of other user groups. For example, liaison between ICAO and IMO has largely been confined to the infrequent sending of observers to the other's fora discussing GNSS. Rather amazingly, in my opinion, there is no ICAO/IMO joint working group on GNSS and there was no liaison between the two agencies in respect of GNSS in 1995, according to the Annual Report of the Council.[267]

Therefore, ICAO seems an inappropriate choice to operate or manage a civil GNSS. However, "Agencies that could provide a model for GNSS include the newly-formed NW Europe Loran-C Operating Authority (comprising six European States' representatives), COSPAS/SARSAT, INTELSAT, EUTELSAT, EUMETSAT and Inmarsat. Some of them have in their Charters authority to operate radionavigation

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[266] Ibid, p253.

[267] Supra 151, see Chapter IX -Relations with Other International Organizations, p87.

In this respect the NAPA/NRC Report, upra 6, notes at p240: "At the 40th session of the IMO Subcommittee on Safety of Navigation in July 1994, representatives of the IMO and ICAO discussed the establishment of a joint planning group to address the development of a post-GPS/GLONASS, internationally controlled, civilian worldwide navigation system....The IMO Secretariat accepted that participation in each others' technical sessions would be mutually beneficial but suggested that the group should also address institutional issues, such as administartive, legal and financial matters. The opinion of ICAO was that participation in a joint planning group was premature and should be delayed until several ICAO bodies considering different aspects of the GNSS had progressed in their work." This seems to evidence a distinct lack of enthusiasm for coordination on ICAO's part. No joint planning group has been established since.

systems and Inmarsat in particular is already highly involved in GNSS-1 activity by virtue of its navigation payloads."[268]

It is beyond the scope of this paper to discuss the respective constitutional and institutional arrangements under which these international bodies operate and hence their respective merits as an institutional model to operate a civil GNSS. Further, discussing the respective merits of these bodies is somewhat superfluous given the functional premise of this paper that a civil GNSS will not eventuate unless and until the US supports such a system. However, it is evident that the FANS II Committee considered Inmarsat to be the obvious candidate to operate a civil GNSS'[269] and in this respect to establish a new agency would be a lengthy process and therefore impractical in the timeframe available.[270]

There is perhaps a larger question as to whether a universal, ubiquitous, passive technology such as GPS/GNSS can be legally regulated as a practical matter. GPS, like the Internet, may be considered an element of the emerging global information infrastructure ie the much touted 'information superhighway'. "Information technologies such as GPS represent a serious challenge to government control."[271] Passing laws to regulate such information technologies in a domestic context (or presupposing necessary political agreement, the formulation of a legal framework in an international context) is relatively simple. Ensuring compliance with such legal

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[268] Supra 265, p253.

[269] Some of the characteristics of Inmarsat that make it attractive as a potential GNSS operator are that it is an international treaty organisation with membership open to all States (Art.32(1) Inmarsat Convention), which guarantees non-discriminatory access to its space segment; its Convention (Art.3) already covers the provision of satellite navigation services; it, unlike ICAO, is an operational organisation with experience of navigation systems and well-established methods of financing and cost recovery; and it has agreements with ICAO and IATA to cooperate on ways to implement a civil GNSS. In short, Inmarsat appears to offer the most realistic and effective way forward.

[270] "The history of existing UN agencies shows that it is upwards of 10 years before all the necessary international consultations have taken place and they become fully operational." Supra 265, p254.

[271] Rand Report, Supra 86, p197.

regimes (ie enforcement) is another matter. For example, it is well known that numerous private pilots around the world (and even some commercial pilots) have been using hand held GPS receivers (ie receivers not certified for air navigation purposes) for navigation.[272] The GPS/GNSS genie has been out of the bottle for some time, it may be difficult to force the genie back in and then cork the bottle ie impose an effective, as opposed to a nominal, regulatory regime.

A final point is that those States with institutional concerns, which continue to advocate that ICAO should regulate or operate or manage the GNSS, are probably well aware of the inappropriateness and impracticality of such ICAO involvement. But of those international organizations who may be considered stakeholders in GNSS ICAO is by far the most representative (e.g. ICAO currently has 183 State members, IMO 152 and Inmarsat 79) and therefore arguably the least dominated by 'first' world States. In this respect there appears to have been a much more robust and dynamic institutional debate within ICAO than IMO. Accordingly, States with broad institutional concerns re GNSS (ie not confined to air navigation matters) may have concluded that ICAO 'is the only game in town' in terms of maintaining political pressure on the initial GNSS provider to ensure their concerns continue to be addressed. Further, there is undoubtably an unawareness by all parties that if a legal framework did emerge in the ICAO context then the political pressures to extend this framework to all GNSS users would almost certainly be irresistible. In these terms the ongoing institutional debate within ICAO is a logical means of advancing the acknowledged legitimate interests of States with political or institutional concerns re GPS.

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[272] "While many pilots, particularly in general aviation, use GPS receivers to navigate, this use is unofficial and performed with equipment that does not meet FAA standards for functionality and reliability." Supra 7, Memorandum, pXI.

Chapter XII: Does State practice demonstrate a need for a 'legal framework' to regulate GNSS?

Introductory Remarks:

The principal argument made for a formal legal framework ('ideally' a multilateral convention according to certain States) is that only this will provide the requisite institutional guarantees and that accordingly, the CNS/ATM concept will not be internationally acceptable unless these guarantees are provided. In that event the full global benefits of CNS/ATM with 'seamless airspace' from one Flight Information Region to another will not be achieved and commercial airliners would have to carry a multitude of separate navigation systems to meet the requirements of individual States. (The latter argument would appear to be undermined somewhat by the decisions of the 1995 Special Communications Operations Division Meeting in respect of the ILS/MLS/D-GPS transition. Moreover, industry is already trialing multi-mode receivers that will accept radionavigation signals from all 3 systems).

Another argument is that only a formal legal framework will confer uniformity of law and therefore certainty, encouraging States to implement both GNSS and the global FANS CNS/ATM concept. However, although no one would disagree that uniformity of international air law is a worthwhile ideal the fact of the matter is that this is not occurring at present, both in respect of existing air law instruments[273] and, more ominously, in respect of ICAO SARPs.[274] Moreover, as discussed in Chapter X, a convention to unify ATC liability (an issue obviously directly linked to GNSS) has been on the agenda of the ICAO Legal Committee for decades without result.

However, as discussed, both of the initial GNSS providers have rejected mooted legal frameworks that seek to impose liability or elicit institutional guarantees from them. A

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[273] See ICAO Doc. A31-WP/26 (Ratification of ICAO Air Law Instruments), prepared by the ICAO Secretariat.

[274] See Milde M., 'Enforcement of Aviation Safety Standards', Zeitschrift fur Luftrecht und Weltraumrecht (German Journal of Air and Space Law), 1996 Vol.1, pp3-17.

multilateral convention as a practicality is a dead letter, as was tacitly acknowledged by the 29th Session of the Legal Committee.

The institutional debate within ICAO fora is essentially deadlocked. However, as a practical matter is there a significant lacuna in regulation which needs to be filled by a formal, multilateral legal framework? What is past and present State practice in respect of radionavigation systems that are used internationally?

Past State Practice - Loran-C and Omega

The USA has sought to allay concerns and blunt arguments that a legal framework is needed by arguing that navigation signals from satellites are not revolutionary from a legal and institutional viewpoint - that institutionally they are indistinguishable from present worldwide ground based long range navigational aids which are owned by one or perhaps a few States and operated without a legal framework. In other words that past and ongoing State practice has not required a formal multilateral legal framework to regulate international radionavigation aids. In this respect reference is made particularly to the Loran-C and Omega systems (until the advent of GPS long range navigation was provided by Loran, Omega, self-contained navigation systems such as INS or by dead reckoning). Both are radionavigation systems which were initially developed to provide US military users with greater navigation coverage and accuracy but over time have evolved into systems predominantly used by both domestic and international civil users. However, do these systems in fact operate without a 'legal framework'?

Loran-C

Loran is a Low Frequency (LF) 100kHz hyperbolic radionavigation system developed during World War II. The name is derived from the words **long range navigation**. The system is based upon measurement of the difference in time of arrival of pulses of radio frequency energy radiated by a chain of synchronised transmitters which are separated by hundreds of miles. Three stations are required (master and two

secondaries) to obtain a position fix in the normal mode of operation. The US Department of Defense (DOD) commenced operating the most advanced version of Loran (Loran-C) in 1964. Loran-C has triad reliability exceeding 99.7 percent, with high integrity (the system has signal integrity built in and will alert users if the signal becomes unavailable) and 'repeatable accuracy' of between 18 and 20 meters that can be enhanced by a technique called differential Loran-C.[275] Accordingly, *prima facie* Loran-C and GPS share a number of characteristics.

The US domestic system consists of 29 transmitting stations comprising 12 Loran-C chains operated by the USCG. Included in this count is the Russian-American chain and the East Newfoundland chain which are subject to bilateral operating agreements with Russia and Canada respectively. The USCG also operated Loran-C stations in the Far East, Northern Europe, and in the Mediterranean under international agreements covering Loran-C availability, until 31 December 1994 when the DOD requirement for overseas Loran-C was terminated (because of the introduction of GPS) and certain of these stations was turned over to other nations. Countries in these geographic areas have entered into multilateral agreements to continue operating Loran-C (such as the NW Europe Loran-C Operating Authority, comprising six European States) - one motivation being that Loran-C provides a means of navigation independent from GPS.

Accordingly, in respect of Loran-C the US clearly entered into international agreements of a bilateral and multilateral nature. However, these were (and are) purely "operational and logistical support agreements ...[which included] sections relating to costs, cost sharing and division of responsibilities."[276] They did not (and do not) deal

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[275] For technical specifications see supra 22, pp A-4 to A-9.

[276] Statement of Mr J. Beukers, Beukers Technologies, Supra 7, p104. Mr Beukers statement (pp102-112) contains a valuable compendium of US laws, agreements, administrative procedures, policies etc in respect of radionavigation aids.

with the institutional matters the ICAO Council asked the FANS II Committee to report on.[277]

It is also relevant to note that Russia operates a chain of Loran-C equivalent stations called Chayka and other nations which have their own loran chains are France, the People's Republic of China, Saudi Arabia and India.

Accordingly, there are a number of purely national loran chains in operation and some chains being operated subject to bilateral arrangements. Loran has been used extensively by the international civil marine and aviation communities for decades and this use is continuing. It is designated by the FAA as a supplemental system in the US National Airspace System and has also been certified by a significant number of contracting States for use by their national carriers in international airspace and also for use in their territorial airspace.

Omega

Omega is a Very Low Frequency (VLF) 10.2 - 13.6kHz hyperbolic radionavigation system. The system is comprised of eight continuous wave transmitting stations situated throughout the world (Norway, Liberia, North Dakota, Hawaii, La Reunion Island, Argentina, Australia and Japan). Worldwide position coverage was attained when the station in Australia became operational in August 1982. Three of the eight stations are funded by the US, the others by the host nations.

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[277] For example, all international agreements the USA entered into in respect of the operation of Loran-C stations that I have researched contain in the nature of a standard term excluding US liability. In this respect the USA/Canadian agreement of March 29 1979 (Agreement relating to the construction, operation, and maintenance of a Loran-C station in British Columbia; exchange of notes Ottawa July 26 and December 20, 1978; entered into force March 29, 1979. 30 UST 2840) provides:
"16. Liability
The US Coast Guard [the US designated cooperating agent] shall not be liable for any claims arising out of the use of the equipment provided to the Canadian Coast Guard. Responsibility for these claims is with the Canadian Coast Guard."

"Bilateral agreements between the US and the partner nations govern partner-nation operation, and the varying amounts of technical and logistic support. The USCG has operational control of the system; the International Omega Technical Commission (IOTC), which is composed of one representative from the operating agency of each country involved with the Omega system, is the forum for consultation regarding operational maintenance of Omega."[278]

Originally the Omega system was developed "to meet a DOD need for worldwide general en route navigation but has now evolved into a system used primarily by the civil community."[279] "Because of its worldwide coverage, international civil use of Omega includes trans-oceanic shipping and aircraft navigation. A number of air carriers and general aviation aircraft operators have received approval to use Omega as an update for their self-contained systems or as a primary means of navigation on oceanic routes. It is also approved by the FAA for use as a supplement for domestic high altitude en route airspace navigation."[280] "Many civil transport operators have...adopted Omega rather than INS, because of the much lower cost of fitting and maintaining Omega."[281]

Accordingly, there is a framework of bilateral agreements between the US and the five nations that host Omega transmitting stations. However, these agreements, like the Loran-C agreements entered into by the US, deal with technical matters. In their terms they do not purport to regulate the global operation of the system.[282] Overall control of

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[278] Supra 22, p3-13.

[279] Supra 22, pA-10.

[280] Supra 22, p3-13. In respect of the international civil aviation use of Omega: "To navigate the African continent, you must rely on traditional ground stations (VOR, NDB, DME, etc) and the Omega long-range system (Africa has two ground stations in Liberia and La Reunion Islands)." El Hadi A B, avionics engineer Air Algerie, 'A Challenge for Africa', Avionics Magazine, October 1995, p66.

[281] Stratton A., 'Towards a Global Navigation System', The Journal of Navigation, Vol.47, No.2 May 1994, 191 at p198.

the system remains with the US throughout (effected by a master timing signal broadcast from the US). Similarly the IOTC is simply a technical forum.

As with Loran-C, Omega has also been certified by a significant number of contracting States for use in their territorial airspace and has also been certified by a significant number of national aeronautical authorities as a primary means of navigation on oceanic routes such as the North Atlantic. Moreover, "although not a part of any current US effort, a differential Omega System has been developed and there are now differential stations in operation along the coast of Europe, in the Mediterranean, and in South East Asia."[283]

Loran-C and Omega are mentioned in ICAO Doc.9613 (Manual on Required Navigation Performance) as radionavigation aids that may be used for RNP (GPS is also mentioned in the Manual in this respect) and there is a specification in Annex 10, 'Aeronautical Telecommunications' for Loran-C (there is no ICAO sanctioned specification for Omega). Previously, Loran-C and Omega were mentioned in ICAO Doc.9573 (Manual of Area Navigation Operations) as radionavigation aids that may be used for area navigation.

Consequently, Omega and the US Loran-C chains are both US military derived international radionavigation systems which have achieved widespread use and acceptability in the international civil aviation community, notwithstanding institutionally overall operational and management control remained throughout with the US and notwithstanding these systems are not subject to ICAO SARPs. However, obviously the States that host(ed) US Loran-C chains and Omega transmitting stations

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[282] See, for example, the Memorandum of Understanding concerning the operation and maintenance of OMEGA Station Le Reunion (USA/France), signed at Washington June 24, 1981; Entered into force June 24, 1981. 33 UST 2109, Clause 3a: "....[Etat Major de la Marine] will be fully responsible for operation of Omega Station La Reunion." and clause 10c: "Nothing in this [MOU] shall be considered as authorising judicial or administrative action against the US Government in France or La Reunion".

[283] Supra 22, Appendix A, ppA-11 to A-12.

by that very fact have a degree of institutional control over that part of the overall system. It is an obvious point but one perhaps worth making that the other national Loran-C chains identified are used by international civil aviation and are not subject to ICAO SARPs or 'certification.'

The US, as the provider of these radionavigation systems is clearly institutionally separate, and not responsible to, foreign civil users of the system (including State ATS authorities). Officials in ICAO and IATA that the writer has consulted are unaware of any instance where the US has degraded the accuracy of Loran-C or Omega signals or sought to deny the use of these systems to civil users (similarly in respect of other national loran chains).

Those nations which operate 'international' Loran-C chains and the Omega system have never provided institutional guarantees on such matters as continued availability, reliability, accuracy, liability etc, which are sought by some States in respect of GNSS (although the Loran-C and Omega agreements by their very existence are often said to be guarantees of availability). In this respect the six nations which operate Omega transmitters agreed at an IOTC meeting in April this year to terminate the system on 30 September 1997. An advisory statement to this effect has been sent to ICAO, IMO, IALA and the World Meteorological Organisation. This decision is an exercise of sovereignty these States are obviously entitled to make (similarly the US with its decision to withdraw from its overseas Loran-C chains) and is not inconsistent with any provision of the Chicago Convention. However, those international airlines which rely on Omega for navigation over oceanic areas or areas devoid of navaids (such as parts of Africa) will now have to make other arrangements to satisfy RNP criteria.

There are of course technical differences between Loran-C and Omega and GPS - the former are terrestrial based radionavigation systems which provide a two-dimensional fix while GPS is a space based radionavigation system which provides a three-dimensional fix. Consequently, GPS offers superior performance in terms of accuracy,

coverage, reliability etc and hence is a much more useful technology. But all three are basically radio transmitters - the GPS satellites just happen to be space based. In principle all three systems appear to raise exactly the same institutional issues re governance and control, liability etc. The writer has come across no ICAO working paper or other reference source refuting the US claim that from a legal and institutional perspective GPS is no different from Omega and Loran-C. At the 29th Legal Committee some "delegations observed that institutionally, the GNSS system was in fact different from other navigation systems"[284] but the record of the meeting does not show that these differences were articulated. The US analogy does appear to have substance.

Therefore State practice in respect of Omega and Loran-C suggests that radionavigation systems which have an international character can be operated successfully without the necessity for a formal multilateral legal framework. Or in other words State practice demonstrates that such radionavigation systems do not necessarily require regulation by international law. Of course, State practice in respect of Omega and Loran-C does not constitute a legally binding precedent in respect of how States should respond to GPS/GNSS. However, those States which, for decades, have approved and certified Loran-C and Omega both for use in their territorial airspace and also by their carriers in international airspace but now raise institutional concerns about GPS may arguably leave themselves open to criticism for inconsistent State practice.

As previously discussed the 28th Session of the Legal Committee adopted the conclusion of the Rapporteur that there was nothing inherent in the CNS/ATM concept which could be considered inconsistent with the Chicago Convention. It is difficult to envisage the Rapporteur coming to a different conclusion in respect of GNSS - to do so would logically have raised questions as to whether the widespread approval and

[284] ICAO Doc.9630-LC/189, p3-11, para 3:39:3 h.

certification of Omega and Loran-C by contracting States was consistent with the Convention.

Present State Practice - GPS/GNSS

CNS/ATM implementation in the Asia/Pacific Region using GPS.

The ICAO Region with the most advanced implementation plan for CNS/ATM after the North American Region is the Asia/Pacific Region. "FANS has been eagerly embraced by civil aviation bodies and airlines in the Asia/Pacific Region,"[285] who are now implementing the CNS/ATM concept with GPS as the GNSS component.

Examples abound: The CAA of Fiji has utilised GPS for air navigation since 1992 and in April 1994 Fiji became the first country in the world to implement GPS as the primary navaid for en route and terminal operations in its domestic airspace environment.[286] In Singapore an advanced automated air traffic control system - the long-range radar and display system known as LORADS II - entered service in 1995. LORADS II incorporates aeronautical satellite technology such as ADS where aircraft location is determined by GPS. In December 1995 GPS was approved as a primary-means IFR navigation aid for some phases of flight in Australia.[287] The Philippine Department later this year will begin installing differential GPS landing systems at three airports.[288]

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[285] Supra 135, p3, para.4.1. This paper details the regional coordination efforts of the 16 States in the Asia Pacific Air Navigation Planning and Implementation Group re FANS CNS/ATM. I have come across no ICAO working paper or other reference source documenting institutional concerns in respect of GNSS by any State in the Asia/Pacific Region or voicing support for a legal framework to regulate GNSS.

[286] Further, "The operational trials that Fiji has carried out so far on Phase II of our programme has further confirmed that GPS is extremely reliable, accurate and will become a stand alone navigational system in the future [GNSS]. Phase II, to commence in 1996, will involve the use of GPS for precision approach to CAT I." See 'Statement of Fiji' to 31st ICAO Assembly, A31-WP/166. Fiji is often cited as a developing country that has adopted GPS/GNSS with no apparent institutional problems.

[287] Flight Safety Australia, Summer 1995-6, p9.

[288] AW&ST, 12 February 1996, p43.

However, the development in the Asia/Pacific Region which has generated the most industry attention is the simultaneous certification in June 1995 by Australia and the USA, following extensive engineering trials, of the use of the 'FANS 1' package on trans-Pacific routes by Boeing 747-400 aircraft.

"Aircraft equipped with FANS 1 avionics are able to navigate with great accuracy using [GPS] navigation satellite signals, and then relay their current position, speed, heading, projected trajectory and selected other information extracted from the aircraft Flight Management System, to ground-based air traffic control computer systems, through either satellite or VHF radio data link networks."[289] "To date, over 150 B747-400 aircraft from a dozen airlines operating in the Asia/Pacific Rim have made commitments to upgrade their aircraft with FANS-1 avionics."[290] The Airbus A340 and McDonnell Douglas MD-11 are in the process of being certified with a modified FANS-1 package (called FANS-A on these aircraft).

There are of course practical reasons why States in the Asia/Pacific Region have embraced GNSS. The region is comprised of vast oceanic and land areas which are devoid of high quality CNS and ATM services and States are looking to FANS to provide these.[291] In particular, satellites can provide very accurate navigation in these areas with no need to build costly navigation infrastructure on the ground.[292]

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[289] Aviation Bulletin (Air Services Australia publication) March 1996, Volume 5, No.2, p1.

[290] ICAO Doc. A31-WP/88, 'FANS-1 Implementation in the South Pacific', para7.1. The FANS-1 avionics package includes "such capabilities as the Global Positioning System (GPS), Required Time of Arrival (RTA), Airline Operational Communications (AOC) Datalink, Controller/Pilot Datalink Communications (CPDLC) and Automatic Dependent Surveillance (ADS)." Ibid, para.3.2.

[291] For example, "Airways Corporation of New Zealand's Oceanic Control System was the first satellite based aviation navigation system to be introduced globally. The Canadian made equipment looks over the country's 34 million square kilometre flight information region which extends from the South Pole to the equator." Australian Aviation, September 1995, p51.

Further, "Recent GPS demonstrations in Xian, China, dramatized the availability of satellite navigation technology and its advantages for a country with limited infrastructure but a growing demand for aviation services." AW&ST, April 15, 1996, p36.

This is not to say that some States in the Asia/Pacific Region may not harbour some institutional concerns about relying upon GPS and no doubt if a convention or other legal instrument were negotiated whereby the present GNSS provider States agreed to cede some measure of control or agreed to meet other institutional concerns (e.g. liability) Asia/Pacific States would not expeditiously sign up to such an instrument (it would obviously be in their national interests to do so). However, given that this is not going to occur the States in the Asia/Pacific Region have decided that it is in their respective national interests to accept the US GPS offer at its face value and take the practical benefits of the GPS technologies by implementing the ICAO CNS/ATM concept as rapidly as possible, rather than dwelling on the geopolitics or potential pitfalls of relying upon a US system over which they exercise little or no institutional control. It is of interest that one of these States is France,[293] a State which has expressed institutional concerns in the past.

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[292] "The application of GNSS and datalinks to and from the aircraft will allow the air traffic navigation and management ground structure to eliminate many current navaids, such as VOR, DME, ADF, ILS and potentially MLS...The opportunity exists to develop entire air traffic and management systems at relatively low cost in those parts of the world that are currently without services." Statement of Mr D Mineck, Collins Commercial Avionics, Rockwell International on behalf of the General Aviation Manufacturers Association, Supra 7, p196.

In this respect a Booz ,Allen & Hamilton analysis projected China could save up to $4.4 billion in infrastructral costs over 20 years by adopting a satellite based CNS/ATM system. AW&ST, April 15, 1996, p36.

[293] "The Tahiti Flight Information Region (FIR), which is entrusted to France, includes close to 200 inhabited islands and islets." See "France is devoting considerable resources to the development of ATC capabilities."by O. Carel, Director-General of Civil Aviation (France), ICAO Journal, June 1993, p25. France is a member of the Informal South Pacific Air Traffic Service Coordinating Group which, utilising GPS, coordinated the introduction of flexible tracks and distance-based separation standards in the Pacific area. The Visualisation des Vols Oceaniques system will be operational in Tahiti by early 1997 and will form a major component of the South Pacific Fans environment. See Jane's Airport Review, May 1996, p25. France has raised institutional concerns about reliance on GPS in the past - see ICAO Doc. A31-WP/113 (Evolution of GNSS institutions in Europe and in the world).

As the fastest growing ICAO region in terms of traffic[294] State practice in the Asia/Pacific Region is obviously extremely relevant to the international acceptability of GPS/GNSS. The adoption of GPS/GNSS technologies by various States in the Asia/Pacific Region is, of course, an exercise of sovereignty entirely consistent with the provisions of the Chicago Convention. Under the Chicago Convention States which have certified GPS/GNSS for use in their territorial airspace or for use by their carriers in international airspace are institutionally responsible for that decision - as was the position with Loran-C and Omega.

The concept of Required Navigation Performance formulated by the FANS II Committee was discussed in Chapter III. States in the Asia/Pacific Region are in fact in the process of certifying GPS (through the FANS-1 package) as meeting their RNP requirements for certain routes. The key criteria for RNP is the maintenance of separation standards. Significantly, the Asia/Pacific Regional Plan has been amended to allow aircraft fitted with FANS 1 to operate with reduced separation standards (one of the benefits of CNS by GNSS). The amendments are awaiting approval by the ICAO Council.[295]

The development of the FANS-1 package represents a model of intra-regional cooperation for CNS/ATM implementation. However, it also illustrates the need for Air Traffic Service providers to establish a suitable operating environment for implementation to occur: "Only after the CAAs of Australia, Fiji, NZ, and Tahiti, along with the FAA, committed to providing benefits for aircraft equipped with FANS-1/A could the airlines justify the investment."[296] The benefits are the granting of

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[294] "ICAO forecasts that the airlines of the Asia/Pacific Region would achieve an average annual growth rate of 8.7 per cent in international scheduled traffic to the end of the century compared with the global growth rate of 6 per cent....In fact, by the year 2010, total international scheduled traffic to/from the Asia/Pacific Region will represent 51.1 per cent of the world total, compared with approximately 25 per cent realized in 1993." Supra 2, Appendix A to the report on Agenda Item 8, p8A-6, para.1.3.1.3.

[295] See ICAO Doc.C-DEC 147/12, 12/3/96.

[296] Supra 290, para.1.1.

preferred routes to FANS-1 aircraft[297] which in turn translates into economic benefits in fuel savings and improved fleet management for airlines.[298]

The Asia/Pacific Region has proved that the business case for adopting GPS technology in respect of long distance routes is overwhelming. So much so that European-Asian routes dedicated to FANS-1 equipped aircraft will be established over India[299] later this year and also over Russia.[300] The economies and operational advantages are such that airlines which service Europe/Asia routes are being compelled to adopt the technology. For example, British Airways is investing some $4 million to install the FANS-1 package on its 36 strong Boeing 747-400 fleet,[301] which will result in saving of some 2 hours on the London-Hong Kong route and give British Airways an estimated additional $50 million a year in revenue.[302]

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[297] In this regard the FANS II Committee in its Global Coordinated Plan for Transistion to the ICAO CNS/ATM Systems provided that States and/or regions should consider segregating traffic according to navigation capability, and granting preferred routes to aircraft with more accurate navigation capability. See FANS(II)/4-WP/82. The Global Plan is Appendix A to the report on Agenda Item 8, supra 2.

[298] United Airlines "equipped its Boeing 747-400 fleet with the FANS-1, and demonstrated potential near-term savings of around $750,000 [per aircraft per annum] in the recent series of Pacific region FANS-1 tests." Flight International, 4-10 October 1995, p17.

[299] "Navigation-planners expect that, by September, India's CNS/ATM capability and a new FANS-1-dedicated route will be relieving the current chronic air traffic congestion over Calcutta. The area marks the intersection of several major Asia-Europe routes which suffer from night-time traffic peaks in an environment of historically poor HF-communications and radar coverage. If all Boeing 747-400 aircraft on the route were equipped with FANS-1 avionics, the new initiative would more than halve traffic overflying Calcutta, and flight-level blockages between 747-400s would be virtually eliminated by reduced in-trail separation requirements on what will, initially at least, be a single type route." 'Indian FANS-commitment to bring big benefits over Calcutta...', AirNavigation International Vol.2, No7, 10 April 1996, p2.

[300] See notes 72 and 73.

[301] Reported in Jane's Airport Review, April 1996, p19.

[302] Figures given by Dr. William Fromme, former director of the ICAO Air Navigation Bureau at a seminar at the Institute of Air and Space Law, McGill University, on 24 October 1995.

Thus, India and the Russian Federation (both "States of chief importance in air transport" within ICAO) will shortly join a number of Asian/Pacific countries which have CNS/ATM systems in place, utilising a GNSS (ie GPS) for which there is no formal legal framework and no ICAO SARPs (the avionics and datalinks comprising the FANS-1 package are, of course, certified to technical standards approved by individual State aeronautical authorities).

Other State Practice utilising GPS for CNS/ATM implementation.

Although the Asia/Pacific and North America are the ICAO Regions with the most advanced CNS/ATM implementation plans relying on GPS, aeronautical navigation by GPS has been underway to a greater or lesser extent in all ICAO Regions for a number of years. For example, the Algerian flag-carrier, Air Algerie, began installing GPS in its Boeing B727-200A aircraft in 1991.[303] "A340s have been in service with satellite navigation in a supplementary role, used mainly as an en route aid, since spring 1994. Today, more than 15 airlines make use of this on A320s, A321s, A330s and A340s."[304] "Eastern Europe with its lack of precision approaches and navigation aids in general, provides fertile ground for innovative approach solutions. European carriers serving the area are already routinely using GPS as a back-up aid for en route navigation, and would like to see more extensive approach aids".[305] "Led by the Philippines, at least half a dozen countries in the Far East are actively pursuing local-area D-GPS, plus at least three in the Middle East and Africa, and four in Latin America."[306] And so on, and so on. In fact, the adoption of GPS/GNSS technology in

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[303] El Hadi A B, avionics engineer Air Algerie, 'A Challenge for Africa', Avionics Magazine, October 1995, p66.

[304] Aeronautical Satellite News, No.49, February-March 1996, p15. One of these airlines is Lufthansa, the German flag carrier, which is of interest since Germany is a State that has strongly voiced institutional concerns in the ICAO Council and other ICAO fora.

[305] Air Navigation International, Vol.2,No.6, 27 March 1996, p6, 'Honeywell/Pelorus launches major European DGPS-approach demo...'

[306] Flight International, 28 February-5 March 1996, p30.

civil aviation is increasing exponentially,[307] even among States which have professed institutional concerns.

A distinction is often drawn, contrasting the undoubted worldwide commercial acceptability of GPS and official acceptability, which "depends on international decisions to use GPS in safety applications, especially civil application."[308] In this regard 'official acceptability' is increasing rapidly, notwithstanding voiced institutional concerns. It is perhaps superfluous to state that airlines which have fitted or have ordered GPS based navigation aids for their aircraft will have done so with the approval of their national aeronautical authorities (these airlines would not have committed the significant investment in installing GPS compatible avionics if this was not the case). And *ipso facto* these national aeronautical authorities must be prepared to certify[309] the installation of such GPS based avionics packages. For example, Italy, which has strongly voiced institutional concerns and has supported a formal legal framework for GNSS, has recently approved Alitalia fitting GPS navigation units to its 90 MD-82 airliners.[310]

Further, 14 nations have now approved GPS as a supplemental means of navigation for en route operations: Argentina, Australia, Brazil, Canada, Chile, Fiji, Germany, Iceland, Italy, New Zealand, Peru, South Africa, United States, and Uruguay. Six countries have approvals pending: Bolivia, Costa Rica, France, Mexico, Panama, and Spain.[311] Many of these countries have voiced institutional concerns in ICAO fora

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[307] "Commercial and general aviation aircraft equipage for the [GNSS[is estimated to be at a level of 4 000 by the mid-1990s, 80 000 by the year 2000, and 200 000 by 2010." ICAO Doc CASITAF/1, Information Paper No.1, 21/4/94, p20.

[308] Rand Report, Supra 86, p203.

[309] As noted in Chapter VII under Art. 30 of the Chicago Convention the State of Registry of an airliner are responsible for certifying its radio equipment fit. A responsibility that can be delegated to the State of Operation when Article 83*bis* comes into force.

[310] "Douglas Upgrading Alitalia's MD-82 Cockpit Systems", AW&ST, June 3 1996, p41.

about relying on GPS. I appreciate the distinction in safety terms between approval for supplemental as opposed to sole means of navigation. Nevertheless, approval of GPS as a supplemental means of navigation can only be interpreted as official acceptance of the technology. And, as noted in Chapter II, Phase II of the FANS II Committee's GNSS implementation strategy: 'the transition to a sole-means system' is already underway.

It is the material benefits to be gained from GPS/GNSS that is governing States' acceptance (no doubt grudgingly in some cases) of the technology. National aeronautical authorities are certifying GPS-based avionics installations in response to pressures from their airlines who, in an increasingly competitive world market with dynamics such as 'globalisation', 'privitisation', 'open-skies' etc in play, need to access the economic benefits of satellite navigation as soon as possible.[312] This economic reality has been recognised by ICAO.[313] In the face of these pressures States, acting through their CAAs, are to a greater or lesser extent subsuming their institutional concerns (whether 'real' or mere political rhetoric) over GPS/GNSS. Moreover, in a number of ICAO regions CAAs themselves as ATS providers are under increasing

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[311] See Satnav News, Volume 4, Number 2, p4.

[312] "...the operating benefits are being offered to those who equip their fleets and adopt new procedures. Those who do not participate should be warned that their choice not to participate could result in their financial demise." United's flight-management-systems procedures manager Tom Graff discussing his airline's FANS-1 program, cited in Flight International 4-10 October 1995, p17.

[313] "As the airline industry stands to reap major savings from the CNS/ATM systems which will indirectly also benefit States, there is much pressure to proceed as rapidly as possible with the implementation process. Moreover, the faster implementation proceeds, the faster the benefits will accrue." Supra 175, p3, response to question 3.

Further: "With this global outlook, economies of scale, and other factors, have come global ambitions; thereby ensuring the globalisation of the [airline] industry. It is common knowledge that we are experiencing a transition to an increasingly competitive industry, a change which has all kinds of implications for suppliers, financiers, airline planners, and regulators.....I mention all these trends because I think there is a link between the globalisation in the commercial, organisational and operating environments with what will take place on the air traffic management side in the 1990s and the first decade of the 21st century. With the globalisation of this sector must come the globalisation of technology to serve it." Kotaite, supra 146 at p338.

pressure to be more efficient and cost effective ('privitisation' is also occurring here with Canada and New Zealand in the vanguard) and this is also driving the adoption of GPS-based technologies.

In Chapter VII conflicting sovereign interests were discussed and it was noted that States with institutional concerns had a stark choice between principle (upholding State sovereignty over territorial airspace) and pragmatism (taking the benefits of GPS/GNSS without institutional guarantees). The foregoing provides empirical evidence that pragmatic economics are prevailing - the potential cost savings for aircraft operational and air traffic control systems are such that they are mandating adoption of the technology by the aviation community.

The most dramatic example of the increasing official acceptability of GPS is perhaps the United Kingdom (UK), the second largest civil aviation nation. Until relatively recently the UK, although conducting extensive trials with GPS, refused to countenance the use of the system before ICAO SARPs were in place and institutional concerns resolved.[314] Now, in a major reversal of policy, it is reported that "the UK is set to become the first nation in Europe to approve the use of [GPS] as a primary navigation system on North Atlantic (NAT) routes."[315] The UK is also lobbying strongly for one of the two EGNOS master control centers to be located on its territory.[316] The UK has clearly made the policy decision that it is in its national interests to adopt a GPS-based GNSS and obtain the significant material benefits of the technology, notwithstanding institutional concerns.

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[314] For example, "It is inconceivable that a GNSS could be accepted as a sole means of navigation system unless and until States have assurances regarding the level and continuity of GNSS services and the safety of those services. New safety regulatory arrangements will be necessary for a GNSS, as up to now ATS authorities have largely installed and self-regulated their navigation aids on the basis of ICAO SARPS - they have not had to regulate third-party providers." Supra 127 at p138. Mr Asbury was a member of the FANS II Committee and his views are reflected in the FANS II Report - see FANS(II)/4-WP/35, Appendix A, para5.1.

[315] Flight International, 26 June - 2 July 1996, p8.

[316] See Flight International, 17-23 July 1996, p23.

Consequently, pragmatic economics and practical realities are determining GPS/GNSS acceptability and implementation in the civil aviation context (as indeed they are in other applications). In this regard the basically circuitous and unproductive debates on a legal framework in ICAO fora look increasingly irrelevant, measured against what is happening in the 'real' world. However, as indicated in Chapter XI these ongoing debates almost certainly serve a valuable political purpose for certain States.

Wider State practice re GPS

In considering the international institutional acceptability of GPS/GNSS in the civil aviation context one must logically have regard to the whole of State practice in respect of GPS. As previously discussed GNSS is a global utility with a myriad of applications of which civil aviation is a minor sectoral user. Also as previously discussed, land transportation is the greatest sectoral user of GPS[317] and will be into the foreseeable future, in particular in intelligent transportation systems (vehicular navigation). Consequently, the number of citizens in any given State who will be relying to some extent on GPS/GNSS in respect of land transportation will almost certainly be significantly greater (probably by several factors) than the number relying on GPS/GNSS in respect of civil aviation. Similarly, the national investment (both private and governmental) in GPS based land navigation systems in any given State will almost certainly be significantly greater than the comparable investment in civil aviation systems by that State's ATS authority and airlines. And yet the proliferation of GPS-based land applications grows unabated with no institutional concerns raised in this context (as far as I can ascertain) about relying upon a satellite system owned, operated and managed by a foreign sovereign.

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[317] "Car-navigation systems represented the leading category of GPS receiver sales, about 64 percent of the 1993 dollar volume of $240 million." GPS World, Feb 1995.

For example, if one looks at Western Europe, where major States such as Germany, France, Italy and the UK have voiced institutional concerns about relying upon GPS in the aviation context one finds that the European Commission's "15 member states have issued a full endorsement of GNSS [ie GPS] for multimodal navigation uses in Europe."[318] States there have active programs to develop GPS based transportation infrastructure applications. For example, all motor vehicle manufacturers in Western Europe are offering intelligent transportation systems, which incorporate GPS receivers, into their latest models. In the UK GPS is being used to provide location information for bus fleets, London cabs and railway signaling systems.[319] Further, certain Western European countries (e.g. Norway, Sweden, Germany) have installed national differential GPS to provide navigation in their entire territorial waters. And so on, and so on. In summary, "GPS is not an under-used resource in Europe....GPS technologies ..are rapidly diffusing through Europe's economies and infrastructures, and European businesses have emerged as influential actors in the provision of D-GPS. Growth in the use of GPS in Europe is expected to continue unabated."[320]

I appreciate that, for safety reasons, civil aviation requires GNSS to meet much higher technical standards than other applications in terms of reliability, integrity, accuracy etc. But in some of the European land applications mentioned above and certainly in respect of the maritime applications GPS is being relied upon to provide safety information. Moreover, the point is that all applications raise (and all users of GPS face) the same legal and institutional issues in terms of governance and control of navigation facilities in one's sovereign territory,[321] availability, non-discriminatory access, liability etc. I also appreciate that institutional concerns about GPS/GNSS have

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[318] Supra 34, p3. Report of statement given by Mr Luk Tytgat of the European Commission to a meeting of the US Coast Guard's Civil GPS Service Interface Committee.

[319] The Sunday Times (London), 9 June 1996, p5.

[320] NAPA/NRC Report, supra 6, p46.

[321] Article 30(a) of the Chicago Convention is irrelevant in this regard - see note 126.

previously been raised in IMO, but the debate there appears to have been effectively concluded with the recent adoption of GPS-SPS as a component of IMO's World-Wide Radionavigation System. My understanding is that the formulation of a legal framework for GNSS in the maritime context is not on IMO's agenda (and maritime transportation is a greater sectoral user of satellite navigation than civil aviation).

Accordingly, I believe that States which are adopting a *laissez-faire* attitude to GPS by utilising it for non-aviation purposes and reaping national benefits thereby but at the same time raising institutional concerns in respect of GPS in ICAO fora can legitimately be criticised for inconsistent State practice.

Consequently, past and present State practice would appear to suggest that a formal legal framework is not a practical necessity for GPS/GNSS. However, perhaps such a framework remains a political necessity for certain States.

Chapter XIII: Will an international civil GNSS be developed by 2010?

In Chapter III ,the FANS II Committee's evolutionary plan towards an international civil GNSS was discussed and the fact that current developments will see the Committee's 'Option 3: GPS/GLONASS plus overlay' in place by 2000 through the firm WAAS, EGNOS and MT-SAT programs. However, the deployment of these overlay systems will still be far short of a civil GNSS (the Committee's Option 5).

Before considering whether an international civil GNSS will evolve by 2010 (the end of the FANS II Committee's 'long term') a small but important point is that the Committee recognised that it may be inequitable to expect the US and Russia to contribute financially to Options 4 and 5 because of their existing contributions in respect of GPS and GLONASS.[322] This touches upon what I believe is the fundamental institutional issue preventing the development of a civil GNSS - who should/who will fund such a system?[323] If it is accepted that it is inequitable for the US or Russia to financially contribute to a civil GNSS then obviously the development of such a system is dependent upon funding from other Contracting States. And such funding must be 'up-front' because of the long lead times in building and procuring a satellite constellation.

There are a number of geopolitical and practical considerations militating against other contracting States or users funding an independent civil GNSS:

1. Technically a civil GNSS will not be a 'new' system, designed from a 'clean sheet of paper,' but will essentially provide an improved GPS-SPS signal in terms of accuracy, reliability etc. This is because for practical and economic reasons a civil

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[322] "...with regard to Options 4 and 5....It is noted...that, since GPS and GLONASS satellites are operational and form part of the GNSS, any financial participation from those States may not be equitable." Supra 2, Appendix to the Report on Agenda Item 6, p 6A-4.

[323] "...one might argue that the only really necessary and sufficient condition for [an independent civil GNSS] is a source of funds - whether from public or private sources. Not surprisingly, funding is a central institutional issue." Rand Report, supra 86, p165.

GNSS would have to be "backward compatible" with GPS ie it must operate compatibly with pre-existing equipment. Thus, the signal parameters for a civil GNSS will remain similar to those used for GPS-SPS to serve the existing installed base of GPS users, who, by the time a civil GNSS is operational, will certainly number in the tens of millions and will have invested tens of billions of dollars on GPS equipment and services that will need to be amortised. This compatibility requirement is recognised by all parties, as the FANS II Committee did in the context of civil aviation users.[324]

Moreover, despite the aviation community desiring a system "which can meet all the technical requirements without augmentation and corrections"[325] at present it appears a civil GNSS will still require augmentation for the most demanding safety applications e.g. precision approach.[326]

Consequently, a civil GNSS will not offer a markedly superior product over GPS, especially bearing in mind that the US has technical improvements to GPS in hand,[327] and that the US may terminate Selective Availability after 2000 or even offer the more accurate PPS signal. The improved capabilities that a civil GNSS would presumably offer over GPS appear marginal as against the billions of dollars it would cost to

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[324] "In producing the performance criteria for a future GNSS, the sub-group had to take note of the development work and the operational capabilities of both GPS and GLONASS. The major investment by users in equipment suitable for both these systems by the time a future GNSS is introduced has also to be recognized. There would therefore need to be, where practicable, significant compatibility between the existing and new systems." Supra 2, Report on Agenda Item 4, p4-16, para 4.3.9.4.

[325] Supra 2, Report on Agenda Item 4, p4-27, para.4.7.5.2.

[326] "...no matter which option is selected some augmentation is required." Supra 2, Report on Agenda Item 6, p6-11, para. 6.4.4.1.

[327] See Chapter VII 'Performance Improvements to the Existing GPS Configuration' and Chapter VIII 'Technical Enhancements for Future Consideration' of the NAPA/NRC Report, supra 6.

More specifically the US is considering incorporating a second civil frequency (L5) in the future generation of GPS satellites (Block IIF) to be launched between 2001 and 2015. The L5 frequency will offer improved accuracy as well as availability for some civil applications over the existing L1 (ie SPS) frequency - see supra 311, p 3.

procure such a system and the hundreds of millions of dollars in annual maintenance costs.[328]

2. It is acknowledged that a civil GNSS will be a commercial system ie self-funding.[329] It is further acknowledged that commercially such a system could not succeed in competition with the user free GPS and/or GLONASS.[330] Consequently, there is no commercial case for a civil GNSS unless it takes over the existing GPS-SPS market, which means in turn the US at some agreed transition point terminates SPS (users will logically not use and pay for a civil GNSS, if the free GPS-SPS signal is still available). In turn this presupposes US political support for a civil GNSS. Current US policy as regards GPS/GNSS, discussed in Chapter V, suggests such support is problematic.

However, even presupposing US political support for a civil GNSS was forthcoming this would not necessarily translate into US financial support for such a system. The FANS II Committee's point that it may not be equitable to expect US (or Russian) financial support has already been noted. In terms of US domestic arrangements it is unlikely the Congress would agree to contribute to the capital or operating costs of a civil GNSS which essentially duplicates the functions of the solely US funded GPS. Moreover, US satellite navigation users (including airlines) will certainly strenuously object at having to pay for access to a civil GNSS when the GPS system which their taxes have helped fund (and will continue to do so) satisfies their needs. US political support for a civil GNSS (including terminating the GPS-SPS signal) may therefore

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[328] See note 53.

[329] "The question of costs [for GNSS systems other than GPS and GLONASS] was considered to be the final arbiter - if there was no demand, there would be no implementation, since any future system would probably be developed along strictly commercial lines." FANS II Working Group of the Whole (May 1993) - WP/82, para.2.5.1.4.

[330] "It is dificult to imagine purely commercial development of such satellite radio navigation. The fact that GPS and GLONASS will certainly be free of charge for a long time makes any commercial competition quite risky." Supra 28, para.2.7.

require free access to such a system for US domestic and international users. Would other contracting States countenance such an arrangement whereby they paid the capital and operating costs of a civil GNSS without US (or Russian) financial support? To state such a premise is simply to demonstrate its political implausibility.

3. The FANS CNS/ATM Starter Kit, picking up detailed work done by the FANS II Committee, contains extensive material on the need for, and how to conduct, cost-benefit studies to enable States and ICAO Regions to assess if implementation of satellite based CNS systems is justified from an economic perspective. It is important to bear in mind that ATS authorities and airlines will only adopt (and pay for) CNS capabilities (including GNSS) where it is cost-effective to do so (a situation pertaining to all commercial GNSS users). Only those contracting States which will achieve significant benefits from a civil GNSS system (and who have serious institutional concerns about GPS) are likely to financially support such a system.

Therefore, the technical and commercial rationale for a civil GNSS appears to be wanting. The political/institutional rationale perhaps remains. The bottom line is whether the strength of institutional concerns held by certain States are such that they are prepared to fund such a system. Ongoing developments (or rather the lack thereof) suggest this is not the case.

Thus, INMARSAT had developed a detailed plan toward a civil GNSS.[331] "But Inmarsat's ambitious scheme to develop its International Satellite Navigation System (ISNS) suffered a setback with the Inmarsat Council's decision [in early April 1996] not to fund a further augmentation of the system with navigation payloads on board the satellites to be orbited by its personal-phone spin-off, ICO Global Communications."[332]

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[331] Lundberg, supra 70, p166.

[332] 'Inmarsat Council decision clouds international navigation plans', Supra 299, p4. ICO Global Communications is a private limited company registered under English national law. It was formerly known as the Inmarsat-P Affiliate. This private affiliate was approved by the Inmarsat Assembly as some

This augmentation was one of Inmarsat's three evolutionary steps to an independent ISNS (ie a civil GNSS).[333] The writer understands that the Inmarsat Council's decision is a result of an inability to raise the necessary financing for the navigation payloads (the figure of $500 million being mentioned in Inmarsat briefings to ICAO and IATA).

Accordingly, Inmarsat officials were unable to convince its signatories or the user community that the benefits of continued development of its international civil GNSS system were sufficient to justify the necessary substantial up front investment.

European organisations and governments have also formulated a strategy for a civil GNSS that broadly parallels the Inmarsat strategy: "Under Eurocontrol's *aegis*, a Satellite [CNS] (SATCNS) Committee was instigated [in 1992], together with a specialist sub-group dealing with satnav, and a GNSS office was established....Eurocontrol has adopted a GNSS strategy under which an entirely civil GNSS, 'GNSS-2', is seen as the ultimate goal - the currently-proposed GPS augmentation being considered an interim measure only. Eurocontrol uses the acronyms 'GNSS-1' and 'GNSS-2' to describe two different stages of GNSS development. GNSS-1 is an intermediate stage wherein GPS (and possibly GLONASS) is monitored by independent monitors located in, and under the control of, countries outside the USA."[334]

Signatories did not want to contribute capital to the $3 billion cost of the ICO system in proportion to their investment shares as required by Arts. 5(1) and 5(2) of the INMARSAT Convention and Art. XIX of the INMARSAT Operating Agreement. The establishment of the Inmarsat-P Affiliate is decribed in detail by Auckenthaler A., 'Recent Developments at Inmarsat', 1995 AASL, Vol XX-II, p53 at pp56-60. ICO is an acronym for Intermediate Circular Orbit since the satellites are planned to orbit at an altitude of 10-15,000km ie between low earth orbit and the geostationary orbit.

[333] "The civil GNSS constellation envisaged by Inmarsat combines the navigation payloads aboard the four Inmarsat-3 geostationary satellites with auxiliary payloads on 15 intermediate circular orbit (ICO) communications satellites and another 15 dedicated navigation lightsats." 'GPS in Europe', Aerospace, June 1995, p36 at p 38.

[334] Supra 265 at 251.

'GNSS-1' is being implemented through the EGNOS program. However, European plans for a civil 'GNSS-2' have never got beyond the conceptual stage, there is no European commitment to fund such a system.[335] "GNSS-2 is presently a vision for the future, with an architecture yet to be defined."[336]

Consequently, the FANS II Committee's 'Option 5: civil GNSS satellites', Europe's 'GNSS-2' and Inmarsat's ISNS are all conceptually the same theoretical beast ie an independent, international civil GNSS.

The Inmarsat Council's decision not to place navigation payloads on its ICO satellites has two broad implications, in my view:

1. The FANS (II) Committee's proposed evolutionary path to a civil international GNSS is now effectively suspended. Inmarsat's ISNS was the only system being actively promoted. There is now no internationally controlled GNSS subsystem in development (as opposed to planned) beyond the navigation payloads in the Inmarsat-3 satellites. Even if the question of financing could be resolved, a window of opportunity has been lost given the long lead times in satellite development and production and in populating a constellation.[337] In this respect the ICO satellites (which

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[335] "In a series of separate decisions, France decided not to build a French GPS, ESA decided not to build an ESA GPS , and the French space agency (CNES) decided not to build its own GPS augmentation system...." Rand Report, Supra 86, p38.

The latest proposal I have come across is a suggestion by Mr Wolf Liedhegener, Director of Air Navigation Services in the German Ministry of Transport that Europe should launch 8 multi-modal satellites from 2005 that would provide navigation coverage over Europe and Africa. This is essentially the FANS II Committee's 'Option 4' ie GPS/GLONASS plus Civil GNSS satellites, as such it represents a regional solution, not a 'GNSS-2'. See 'La Succession du GPS/Navstar se prepare' in Air & Cosmos Aviation International No. 1556, 8 Mars 1996, p29. The article makes it clear that funding such a system is the major impediment.

[336] Supra 34, p3.

[337] "Considering the lead time for a civil GNSS implementation, work should begin now on the civil successor system." FANS II Working Group of the Whole (May 1993) - WP/82, para.3.4. In this regard it took the US over 15 years to complete the GPS constellation.

have a ten year life span) are now being built without a navigation payload, the first to be launched in 1998 with the full constellation scheduled to be operational in 2000.[338] Consequently, unless another entity (ie international organisation, group of States etc) relatively quickly picks up where Inmarsat has left off, then as a purely practical matter there will not be a civil GNSS by 2010.

2. Those States which profess institutional concerns about reliance on GPS were apparently unable or not prepared to fund the augmentation payload on the ICO satellites as a safeguard or hedge against changes in US policy re GPS.[339] The strength of their institutional concerns can perhaps be questioned, particularly as: "the Inmarsat navigation services will operate subject to an international legal framework consisting mainly of the Inmarsat Convention and Operating Agreement, the ITU Convention and the 1989 Agreement of Cooperation between ICAO and Inmarsat. These instruments ensure that the Inmarsat services will be available on a universal, non-discriminatory basis, subject to governmental regulation, priced on an equitable, cost-recovery basis, and conform to ICAO's SARPs."[340] *Prima facie* Inmarsat's plan fully conformed with the Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation

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[338] AW&ST, November 13, 1995, p68.

[339] "'....we don't have a customer for [the navigation payload]....But it doesn't mean that the opportunity is totally lost in future. They can always come on the later satellites as a business arrangement." There is currently, however, no firm source of funds for further work on the navigation payload." Supra 299, pp6-7, quoting ICO Global Communications executive vice president, Mr J Singh,.

In respect of the Inmarsat-P proposal the editor of AW&ST noted as far back as August 2, 1993, p70: "Those who question the international civil use of GPS...now need to cut the debate and get down to specific proposals. During the next six months these critics should obtain financial commitments from major civil aviation agencies that are willing to underwrite the cost of an internationally owned and operated GNSS.
This is an opportunity to obtain GNSS services at a bargain price because the navsat service need bear only a portion of the total spacecraft cost....
The success GPS critics have in obtaining financial commitments from aviation agencies will provide a quantative measure of how serious the international community is about moving forward."

[340] Supra 188, para.3:18.1.

and would largely (if not totally) meet the concerns of those States worried about reliance on GPS.[341]

In the latter respect: "..if GPS were taken away, this mix of civil satellites could support a two-dimensional but still very useful navigation service....the existence of such a safety net would go some way towards calming fears over the sudden withdrawal or degradation of GPS"[342] ie the ICO satellites, although an interim step toward ISNS, would have provided a stand-alone navigation capability. In this regard it is also relevant to note that civil aviation is the sectoral user with the most demanding satellite navigation requirements necessitating augmentations.

Why was the international GNSS user community (especially civil aviation which has articulated the greatest institutional concerns) not prepared to financially support Inmarsat's ICO proposal? Undoubtably this represent a pragmatic business decision by potential users (including civil aviation) - there is no commercial rationale in investing in such a system when GPS-SPS is available free and, with current augmentations, essentially provides the required capability. The factors (globalisation, privatisation, 'open skies' bilateral agreements etc) mandating adoption of GPS/GNSS by airlines and CAAs were discussed in Chapter XII. International aviation is increasingly competitive and operated along fully commercial lines. Consequently, many governments and airlines are unlikely to be responsive to proposals that do not take account of commercial realities. In this respect for civil aviation the ICO project did not meet ordinary investment criteria.

The failure of the ICO proposal demonstrates that no private or mixed private/public funded civil GNSS system will evolve unless there is a guaranteed market.

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[341] In this regard some States had cost and cost recovery, management and accountability concerns re Inmarsat - see note 182.

[342] Lundberg, supra 70 at p171.

One can theorise a scenario whereby institutional concerns reach such a pitch that the international community agrees to fund a civil GNSS. For example, if the US for reasons of national advantage degraded or restricted the availability of GPS-SPS to the rest of the world this would clearly precipitate an international crisis (and would of course be contrary to US undertakings) and could trigger the necessary critical mass of mutual interests among other States to procure an independent civil GNSS. It would be a matter of political will. In this respect the development of the Ariane space system by Western Europe (France being the prime mover), following US restrictions on access to its launch systems for European satellites is perhaps illustrative.[343] However, for the reasons discussed in Chapter VIII it is difficult to imagine circumstances where the US would feel constrained to degrade or withdraw the GPS/SPS signal. At present this is not a possibility that appears to constrain the market (including international airlines and national governments).

In summary, for the above reasons I believe an international civil GNSS will not emerge by the FANS II Committee's 'long term' ie 2010. As recognised by that Committee (and by Inmarsat in respect of its ISNS and Europe in respect of its 'GNSS-2') any such system must proceed on a commercial basis. But there simply is no commercial rationale as long as the US is prepared to fund the free GPS-SPS signal. This is the view that users have taken (including the international civil aviation community) judging from their failure to commit financing to support navigation payloads on Inmarsat's ICO satellite constellation, and the 'paper' status of Europe's 'GNSS-2' proposal. Institutional concerns by certain States about reliance on GPS-SPS are not such that they are prepared to commit the substantial funding necessary to build a civil GNSS ie in effect subsidise the satellite navigation market.

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[343] NASA launched two Franco/German 'Symphonie' satellites in the mid 1970s after securing written guarantees that they would be "experimental", and not operational/commercial. This spurred the development of Ariane - see Matte, supra 144 at p162.

Chapter XIV: Conclusions

For technical, geopolitical and commercial reasons the US GPS system has evolved as the *de facto* worldwide global navigation satellite system, in the generic sense of that term, for almost all civil applications. GPS presently has millions of users worldwide and this use is growing exponentially in all sectoral applications, including civil aviation, facilitated by the fact that GPS is a free 'public good'. This evolution has occurred without an international legal framework and with no evident institutional problems arising.

There will not be a satellite constellation devoted to the CNS needs of civil aviation for the reasons discussed in Chapters II and XII. But GPS (in its augmented form) will satisfy the technical and operational requirements of a GNSS for all users, including civil aviation (as acknowledged by the FANS II Committee). In this respect GPS/GNSS are global utilities of which civil aviation will always be a minor sectoral user, albeit the one with the most demanding safety requirements in terms of accuracy, reliability etc.

Certain States have legitimate political and/or institutional concerns about relying on GPS, a system that is a strategic military asset for its State owner and operator (with all that implies), and would like to see a dedicated civil system. These institutional concerns have been most prominently raised in ICAO fora and in this context: "Concerns expressed by several States about reliance on systems of other States for a national airspace system design will continue until an acceptable civil GNSS service is realized."[344] An 'acceptable civil GNSS service', according to the FANS II Committee is one where State ATS exercise an 'acceptable level of control'.

However, it is because GPS is a strategic military asset that the US will not cede any degree of operational control of the system to the international community. State ATS

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[344] FANS II Report 6B-4, para.1.11.2.

exercise no actual control over GPS - the US as the signal provider is clearly institutionally separate from them. In this respect the US offers of GPS to ICAO (and IMO) are unilateral, non binding policy undertakings with no legal significance *per se* ie they do not provide institutional guarantees. Whether the US assurances re GPS are institutionally acceptable to an individual State depends upon its political perception of its national interests.

The institutional concerns of certain States are heightened by declared US policy to promote increasing worldwide use (and hence dependency) on GPS and to ensure that GPS remains the backbone of any civil GNSS, to safeguard US geopolitical and economic interests. The US does not support the evolution of an international civil GNSS, independent of GPS. These competing sovereignty interests (ie US monopoly control over GPS versus contracting States desire for an 'acceptable level of control' over a significant radionavigation aid available in their airspace) are not likely to be resolved in the foreseeable future.

As discussed in Chapter XIII the depth of these institutional concerns is not such that the international community is prepared to devote the resources for a civil GNSS system. Funding (or rather the lack thereof) is the major institutional issue stymieing the development of a civil GNSS. No States (except Japan with MT-SAT and Europe with the modest EGNOS overlay system) are materially contributing toward the space segment of a civil GNSS. Market forces will not finance a civil GNSS that essentially duplicates the existing GPS-SPS signal and which could not compete commercially with GPS-SPS. This is demonstrated by the failure of the Inmarsat proposal to attract commercial support for navigation payloads on its ICO satellites. As long as the US is prepared to maintain the GPS system there is no practical or commercial rationale for a civil GNSS.

Under the concept of Required Navigation Performance developed by the FANS II Committee and adopted by ICAO, GPS/GNSS is simply one option a State can choose

to meet its RNP requirements. State sovereignty in the choice of navaids to meet RNP is undiminished, however, at a practical level the safety and economic benefits of GPS/GNSS are compelling States to adopt the technology. In this respect, as documented in Chapter XII, State practice indicates that pragmatism (ie taking the material benefits of the technology) is prevailing over institutional concerns (and a rigid adherence to concepts such as sovereignty over territorial airspace) with an increasing number of States officially sanctioning the use of GPS-based navigation systems in domestic applications. As discussed in Chapter VII implementation of the CNS/ATM systems globally will require a pooling of sovereignty, quite apart from who controls the space segment of GNSS.

The most significant institutional concerns in respect of a GPS based GNSS are availability/non-discriminatory access, liability and the possible imposition of direct charging regimes after the period of 'free' access. These concerns appear to have been exaggerated. In terms of continued availability it should first be acknowledged that because GPS is a strategic military asset continued funding of the system by the US for the foreseeable future appears assured. In this respect the military character of GPS is actually reassuring to a number of States and international civil users. Further, as the GPS-GPS signal is a global utility of which US citizens are and will be the greatest users worldwide (including safety applications) it is inconceivable that the US would degrade or withdraw the system, except perhaps in an extreme case of national emergency. And in such circumstances 'paper' guarantees of availability are likely to have little efficacy anyway. This institutional concern is not constraining the international GPS market (including national governments).

The implementation of the CNS/ATM concept will result in changes in the relationships between pilots, aircraft operators and ATC with the introduction of concepts such as 'free flight'. Liability of GNSS signal providers should logically be dealt with in this broader context. The GPS and GLONASS signals are clearly offered to all international users on a *volenti non fit injuria* basis and the responsibility is on

such users to make their own arrangements. It is simply inequitable to expect the existing GNSS signal provider States to assume liability worldwide, particularly when a number of States claim sovereign immunity in respect of their ATC and ATS responsibilities. However, where contractual arrangements exist between GNSS signal providers and users then liability will be covered off as a normal term of the contract (as is the case with AMSS). Mandatory insurance arrangements will form an institutional 'safety net.'

Because GPS is a passive system, available to all, it is simply administratively impractical for the US to apply a charging regime to international users. In any event from civil aviation's perspective any theoretical charging regime would presumably have to comply with Article 15 of the Chicago Convention.

In terms of the 'ICAO GNSS concept' the FANS II Committee's evolutionary model was discussed in Chapter II. It is in the context of this theoretical model that GPS was described as a 'subsystem.' The present GNSS is effectively GPS (ie 'Option 1'), which is now operational as a CNS system to some extent or other by certain airlines and ATS providers in all ICAO Regions. The most successful international civil aviation usage to date has been on trans Pacific routes utilising the 'FANS 1' package.

GPS and GLONASS will not be subject to ICAO SARPs. The technical parameters of the firm satellite-based augmentations to GPS and GLONASS (ie EGNOS, WAAS and MT-SAT) have largely been defined - all three will use compatible signal formats to ensure interoperability. Almost certainly they will be 'backward compatible' with the SARPs on overlay systems which are scheduled to be completed in 1998. In my research I have come across no ICAO documentation indicating that the European Union or Japan are prepared to operate EGNOS and MT-SAT respectively in accordance with a formal, multilateral legal framework.

ICAO's organisational role in the ongoing evolution of GNSS will be limited to the matters contained in the precept on the 'Responsibility and Role of ICAO' in the March 1994 Council approved Statement of ICAO Policy on CNS/ATM (ie the formulation of SARPs, technical assistance and coordination) for two main reasons. First and foremost there is no consensus among member States for ICAO to play a greater role in respect of operational or management of GNSS (indeed as discussed in Chapter XI ICAO is ill-suited to perform such a role). A related reason is that ICAO could only perform such a role if it received the necessary resources from its member States and it is apparent these will not be forthcoming. These constraints have been privately and publicly articulated by the ICAO Secretariat. The proposed ICAO CNS/ATM Agency funded by user charges did not receive State support.

In an attempt to allay institutional concerns the US has argued that legally and institutionally GPS is in principle no different from other radionavigation systems which have been derived from US military systems (e.g. Loran-C and Omega), and which have been provided on a free and uninterrupted basis to civil users for decades, with no formal multilateral legal framework in place and the signal providers being institutionally separate from the ATS users. The analogy does have substance.

The US (through the FAA) is currently seeking to negotiate a series of bilateral or regional 'cooperation' agreements to develop WAAS as the worldwide augmentation system to GPS, which would result in the installation of ground reference stations in certain States. Institutionally, this policy appears to be following the path of the Omega and Loran-C systems where the US reached 'technical cooperation' agreements with nations hosting the infrastructure of the systems, but retained overall control. If the US policy comes to fruition one could expect to see a patchwork of similar WAAS agreements evolve, which consistent with the Omega and Loran-C precedents, would not provide institutional guarantees on such issues as availability, reliability, liability etc. This would be a 'legal framework' of a sort but certainly not that envisaged by the Council of ICAO when it first gave this topic to the Legal Committee. As discussed,

the addition of other overlay systems would diffuse institutional control of GNSS, but the US would still retain sole institutional control of the core GPS.

If the Legal Committee of ICAO was a pure legal forum then logically, the topic "Consideration, with regard to Global Navigation Satellite Systems (GNSS), of the establishment of a legal framework" should be removed from its agenda. In the preliminary remarks in Chapter I it was noted that legality follows social agreement. There is no political consensus that a legal framework for GNSS is necessary and until there is such a consensus no real progress in formulating a legal framework will occur. Law cannot be made in the absence of agreement. Until a consensus is reached one can expect to see what has become a ritualistic debate on this topic in the Legal Committee continue, with the existing entrenched State positions merely being restated. It is difficult to envisage the panel of legal and technical experts established by the Council progressing this topic. Again, if there is no political agreement what can one realistically expect the panel to accomplish? However, the establishment of the panel at least provides the semblance of movement on this topic.

Alternatively, as also noted in the preliminary remarks, 'law follows technology', GPS has now been in use as an approved navigation system by a number of contracting States for the past two to three years with no overarching legal framework in place, no ICAO SARPs and no perceived institutional problems. In this respect GPS is following the path of its predecessor radionavigation systems, Loran-C and Omega. It may therefore be appropriate for discussion on this topic to be suspended and revisited by the Legal Committee in say 2001 when ICAO SARPs in respect of RNP, augmentations to GPS, a civil GNSS system etc have been finalised, the shape of future GNSS systems to follow the GPS overlay systems should be clearer and any institutional problems in respect of GPS and its augmentations (and a consensus on how to deal with them) will have had more time to emerge.

However, the fact of the matter is that the Legal Committee is a political rather than a legal forum and this topic is a political, rather than a legal, issue. For these reasons this topic will remain on the Committee's agenda and will almost certainly retain its priority. Although the institutional debates in ICAO fora are *prima facie* unproductive (no multilateral legal framework will emerge) they are a mechanism whereby States can publicise their institutional concerns and thereby maintain political pressure on the initial GNSS provider to continue to address these concerns. In this sense the ongoing institutional debate within ICAO serves a valuable political purpose for these States.

The fact that at the 31st ICAO Assembly certain contracting States still advocated a formal legal framework in the form of a multilateral convention, notwithstanding the 29th Legal Committee recognised the impracticality of a convention **as a legal solution**, perhaps needs to be seen in this light.

A final point is that the reality of more and more contracting States adopting CNS systems with GPS as the GNSS component (ie official acceptability) should see the intensity of the institutional debate lessen (presupposing no adverse development otherwise crystallises institutional concerns). However, given the nature of the State interests involved this essentially political topic will continue to be aired in ICAO fora for the foreseeable future.

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Appendix 1

The White House, Office of Science and Technology Policy; National Security Council

Fact Sheet: US Global Positioning System Policy

Details Presidential Decision Directive of 29 March 1996

THE WHITE HOUSE

Office of Science and Technology Policy
National Security Council

FOR IMMEDIATE RELEASE
March 29, 1996

Contact: (202) 456-6020

FACT SHEET

U.S. GLOBAL POSITIONING SYSTEM POLICY

The President has approved a comprehensive national policy on the future management and use of the U.S. Global Positioning System (GPS) and related U.S. Government augmentations.

Background

The Global Positioning System (GPS) was designed as a dual-use system with the primary purpose of enhancing the effectiveness of U.S. and allied military forces. GPS provides a substantial military advantage and is now being integrated into virtually every facet of our military operations. GPS is also rapidly becoming an integral component of the emerging Global Information Infrastructure, with applications ranging from mapping and surveying to international air traffic management and global change research. The growing demand from military, civil, commercial, and scientific users has generated a U.S. commercial GPS equipment and service industry that leads the world. Augmentations to enhance basic GPS services could further expand these civil and commercial markets.

The basic GPS is defined as the constellation of satellites, the navigation payloads which produce the GPS signals, ground stations, data links, and associated command and control facilities which are operated and maintained by the Department of Defense; the Standard Positioning Service (SPS) as the civil and commercial service provided by the basic GPS; and augmentations as those systems based on the GPS that provide real-time accuracy greater than the SPS.

This policy presents a strategic vision for the future management and use of GPS, addressing a broad range of military, civil, commercial, and scientific interests, both national and international.

Policy Goals

In the management and use of GPS, we seek to support and enhance our economic competitiveness and productivity while protecting U.S. national security and foreign policy interests.

Our goals are to:

(1) Strengthen and maintain our national security.

(2) Encourage acceptance and integration of GPS into peaceful civil, commercial and scientific applications worldwide.

(3) Encourage private sector investment in and use of U.S. GPS technologies and services.

(4) Promote safety and efficiency in transportation and other fields.

(5) Promote international cooperation in using GPS for peaceful purposes.

(6) Advance U.S. scientific and technical capabilities.

Policy Guidelines

We will operate and manage GPS in accordance with the following guidelines:

(1) We will continue to provide the GPS Standard Positioning Service for peaceful civil, commercial and scientific use on a continuous, worldwide basis, free of direct user fees.

(2) It is our intention to discontinue the use of GPS Selective Availability (SA) within a decade in a manner that allows adequate time and resources for our military forces to prepare fully for operations without SA. To support such a decision, affected departments and agencies will submit recommendations in accordance with the reporting requirements outlined in this policy.

(3) The GPS and U.S. Government augmentations will remain responsive to the National Command Authorities.

(4) We will cooperate with other governments and international organizations to ensure an appropriate balance between the requirements of international civil, commercial and scientific users and international security interests.

(5) We will advocate the acceptance of GPS and U.S. Government augmentations as standards for international use.

(6) To the fullest extent feasible, we will purchase commercially available GPS products and services that meet U.S. Government requirements and will not conduct activities that preclude or deter commercial GPS activities, except for national security or public safety reasons.

(7) A permanent interagency GPS Executive Board, jointly chaired by the Departments of Defense and Transportation, will manage the GPS and U.S. Government augmentations. Other departments and agencies will participate as appropriate. The GPS Executive Board will consult with U.S. Government agencies, U.S. industries and foreign governments involved in navigation and positioning system research, development, operation, and use.

This policy will be implemented within the overall resource and policy guidance provided by the President.

Agency Roles and Responsibilities

The Department of Defense will:

(1) Continue to acquire, operate, and maintain the basic GPS.

(2) Maintain a Standard Positioning Service (as defined in the Federal Radionavigation Plan and the GPS Standard Positioning Service Signal Specification) that will be available on a continuous, worldwide basis.

(3) Maintain a Precise Positioning Service for use by the U.S. military and other authorized users.

(4) Cooperate with the Director of Central Intelligence, the Department of State and other appropriate departments and agencies to assess the national security implications of the use of GPS, its augmentations, and alternative satellite-based positioning and navigation systems.

(5) Develop measures to prevent the hostile use of GPS and its augmentations to ensure that the United States retains a military advantage without unduly disrupting or degrading civilian uses.

The Department of Transportation will:

(1) Serve as the lead agency within the U.S. Government for all Federal civil GPS matters.

(2) Develop and implement U.S. Government augmentations to the basic GPS for transportation applications.

(3) In cooperation with the Departments of Commerce, Defense and State, take the lead in promoting commercial applications of GPS technologies and the acceptance of GPS and U.S. Government augmentations as standards in domestic and international transportation systems.

(4) In cooperation with other departments and agencies, coordinate U.S. Government-provided GPS civil augmentation systems to minimize cost and duplication of effort.

The Department of State will:

(1) In cooperation with appropriate departments and agencies, consult with foreign governments and other international organizations to assess the feasibility of developing bilateral or multilateral guidelines on the provision and use of GPS services.

(2) Coordinate the interagency review of instructions to U.S. delegations to bilateral consultations and multilateral conferences related to the planning, operation, management, and use of GPS and related augmentation systems.

(3) Coordinate the interagency review of international agreements with foreign governments and international organizations concerning international use of GPS and related augmentation systems.

Reporting Requirements

Beginning in 2000, the President will make an annual determination on continued use of GPS Selective Availability. To support this determination, the Secretary of Defense, in cooperation with the Secretary of Transportation, the Director of Central Intelligence, and heads of other appropriate departments and agencies, shall provide an assessment and recommendation on continued SA use. This recommendation shall be provided to the President through the Assistant to the President for National Security Affairs and the Assistant to the President for Science and Technology.

# # #

Appendix 2

'Civil Uses of GPS: Current or Likely Future GPS Uses Replacing Less Accurate or More Costly Methods'

'The Global Positioning System, Charting the Future', by a Panel of the National Academy of Public Administration and by a Committee of the National Research Council for the Congress of the United States and the Department of Defense. MAY 1995, p7.

Civil Uses of GPS

Current or Likely Future GPS Uses Replacing Less Accurate or More Costly Methods

Aviation
- Oceanic and en route navigation.
- Non-precision and precision all-weather approaches.
- Direct routing of aircraft for fuel savings.
- Improved aircraft separation standards for more efficient air traffic management.
- Airport surface traffic management.
- Monitor wing deflections in flight.
- Wind shear detection.
- Precise airfield and landing aid locations.
- Seamless (global) air space management.
- Less expensive avionics equipment.
- Monitoring aircraft locations in flight.

Maritime and Waterways
- Navigation on the high seas.
- Search and rescue.
- All-weather harbor approach navigation.
- Vessel traffic services.
- Dredging of harbors and waterways.
- Positioning of buoys and maritime nav-aids.
- Navigation for recreational vessels.
- Location of commercial fishing traps and gear.
- Offshore drilling research.
- Monitoring deflections in dams as a result of hydrostatic and thermal stress changes.
- Ice breaking and monitoring ice bergs and flows.
- Observing tides and currents.
- Harbor facility management.
- Location of containers in marine terminals.

Highway and Construction
- Intelligent Vehicle-Highway System operation.
- Highway facility inventory and maintenance.
- Accident-location studies.
- Highway construction.
- Navigation for motor vehicle drivers.
- Truck fleet on-the-road management.
- Monitoring status of bridges.
- Robotics for construction and mining.

Public Transportation
- Bus fleet on-the-road management.
- Passenger and operator security monitoring.

Railroad
- Railroad fleet monitoring.
- Train control and collision avoidance.
- Facility inventory control and management.

Communications
- Precise timing for interlacing messages.

Emergency Response
- Ambulance, police, and fire department dispatch.
- Road service locating disabled vehicles.

Surveying
- Electronic bench marker providing absolute reference of latitude, longitude, and altitude.
- High-precision surveys in minutes by anyone.
- Hydrographic surveying.
- Efficient and accurate photo surveys.
- Measuring areas without triangulation.
- Oil and mineral prospecting.
- National Spacial Data Infrastructure.

Weather, Scientific, and Space
- Use as weather balloon position radiosonde.
- Measurement of sea level from satellites.
- Navigating and controlling space vehicles.
- Placing satellites into orbit.
- Monitoring earthquakes and tectonic plates.
- Measuring ground subsidence (sinking).
- Measuring atmospheric humidity from ground.
- Precise global mapping of ionosphere.

Environmental Protection
- Hazardous waste site investigation.
- Ground mapping of ecosystems.
- Oil spill tracking and cleanup.
- Precise location of stored hazardous materials.

Recreation
- Hiking and mountain climbing.
- Measuring at sports events.
- Setting lines on sports fields.

Law Enforcement and Legal Services
- Tracking and recovering stolen vehicles.
- Tracking narcotics and contraband movements.
- Maintaining security of high government officials and dignitaries while traveling.
- Border surveillance.
- Measuring and recording property boundaries.
- Tort claim evidence in aviation and maritime accidents.

Agriculture and Forestry
- Forest area and timber estimates.
- Identifying species' habitats.
- Fire perimeters.
- Water resources.
- Locating property boundaries.
- Plowing, planting, and fertilizing without operators (robotics).

Appendix 3

Statement of ICAO Policy on CNS/ATM Systems Implementation and operation 9 March 1994. Reproduced in ICAO Doc.LC/29-WP/3-2.

WORKING PAPER

INTERNATIONAL CIVIL AVIATION ORGANIZATION

LC/29-WP/3-2
28/3/94

LEGAL COMMITTEE - 29TH SESSION

(Montreal, 4 - 15 July 1994)

Agenda Item 3: Consideration, with regard to global navigation satellite systems (GNSS), of the establishment of a legal framework

STATEMENT OF ICAO POLICY ON CNS/ATM SYSTEMS IMPLEMENTATION AND OPERATION

Approved by the ICAO Council on 9 March 1994

In continuing to fulfil its mandate under Article 44 of the *Convention on International Civil Aviation* by, *inter alia*, developing the principles and techniques of international air navigation and fostering the planning and development of international air transport so as to ensure the safe and orderly growth of international civil aviation throughout the world, the International Civil Aviation Organization (ICAO), recognizing the limitations of the present terrestrial-based system, developed the ICAO communications, navigation and surveillance/air traffic management (CNS/ATM) systems concept, utilizing satellite technology. ICAO considers an early introduction of the new systems to be in the interest of healthy growth of international civil aviation.

The implementation and operation of the new CNS/ATM systems shall adhere to the following precepts:

1. UNIVERSAL ACCESSIBILITY

The principle of universal accessibility without discrimination shall govern the provision of all air navigation services provided by way of the CNS/ATM systems.

2. SOVEREIGNTY, AUTHORITY AND RESPONSIBILITY OF CONTRACTING STATES

Implementation and operation of CNS/ATM systems which States have undertaken to provide in accordance with Article 28 of the Convention shall neither infringe nor impose restrictions upon States' sovereignty, authority or responsibility in the control of air navigation and the promulgation and enforcement of safety regulations. States' authority shall be preserved in the co-ordination and control of communications and in the augmentation, as necessary, of satellite navigation services.

3. RESPONSIBILITY AND ROLE OF ICAO

In accordance with Article 37 of the Convention, ICAO shall continue to discharge the responsibility for the adoption and amendment of Standards, Recommended Practices and Procedures governing the CNS/ATM systems. In order to secure the highest practicable degree of uniformity in all matters concerned with the safety, regularity and efficiency of air navigation, ICAO shall co-ordinate and

(3 pages)

monitor the implementation of the CNS/ATM systems on a global basis, in accordance with ICAO's regional air navigation plans and global co-ordinated CNS/ATM systems plan. In addition, ICAO shall facilitate the provision of assistance to States with regard to the technical, financial, managerial, legal and co-operative aspects of implementation. ICAO's role in the co-ordination and use of frequency spectrum in respect of communications and navigation in support of international civil aviation shall continue to be recognized.

4. TECHNICAL CO-OPERATION

In the interest of globally co-ordinated, harmonious implementation and early realization of benefits to States, users and providers, ICAO recognizes the need for technical co-operation in the implementation and efficient operation of CNS/ATM systems. Towards this end, ICAO shall play its central role in co-ordinating technical co-operation arrangements for CNS/ATM systems implementation. ICAO also invites States in a position to do so to provide assistance with respect to technical, financial, managerial, legal and co-operative aspects of implementation.

5. INSTITUTIONAL ARRANGEMENTS AND IMPLEMENTATION

The CNS/ATM systems shall, as far as practicable, make optimum use of existing organizational structure, modified if necessary, and shall be operated in accordance with existing institutional arrangements and legal regulations. In the implementation of CNS/ATM systems, advantage shall be taken, where appropriate, of rationalization, integration and harmonization of systems. Implementation should be sufficiently flexible to accommodate existing and future services in an evolutionary manner. It is recognized that a globally co-ordinated implementation, with full involvement of States, users and service providers through, *inter alia*, regional air navigation planning and implementation groups, is the key to the realization of full benefits from the CNS/ATM systems. The associated institutional arrangements shall not inhibit competition among service providers complying with relevant ICAO Standards, Recommended Practices and Procedures.

6. GLOBAL NAVIGATION SATELLITE SYSTEM

The global navigation satellite system (GNSS) should be implemented as an evolutionary progression from existing global navigation satellite systems, including the United States' global positioning system (GPS) and the Russian Federation's global orbiting navigation satellite system (GLONASS), towards an integrated GNSS over which Contracting States exercise a sufficient level of control on aspects related to its use by civil aviation. ICAO shall continue to explore, in consultation with Contracting States, airspace users and service providers, the feasibility of achieving a civil, internationally controlled GNSS.

7. AIRSPACE ORGANIZATION AND UTILIZATION

The airspace shall be organized so as to provide for efficiency of service. CNS/ATM systems shall be implemented so as to overcome the limitations of the current systems and to cater for evolving global air traffic demand and user requirements for efficiency and economy while maintaining or improving the existing levels of safety. While no changes to the current flight information region organization are required for implementation of the CNS/ATM systems, States may achieve further efficiency and economy through consolidation of facilities and services.

8. CONTINUITY AND QUALITY OF SERVICE

Continuous availability of service from the CNS/ATM systems, including effective arrangements to minimize the operational impact of unavoidable system malfunctions or failure and achieve expeditious service recovery, shall be assured. Quality of system service shall comply with ICAO Standards of system integrity and be accorded the required priority, security and protection from interference.

9. COST RECOVERY

In order to achieve a reasonable cost allocation between all users, any recovery of costs incurred in the provision of CNS/ATM services shall be in accordance with Article 15 of the Convention and shall be based on the principles set forth in the *Statements by the Council to Contracting States on Charges for Airports and Air Navigation Services* (Doc 9082), including the principle that it shall neither inhibit nor discourage the use of the satellite-based safety services.

- END -

Appendix 4

Proposed Draft Agreement between [ICAO] and [name of GNSS signal provider] regarding the provision of signals for GNSS service. ICAO Doc.LC/29-WP/3-9.

WORKING PAPER

INTERNATIONAL CIVIL AVIATION ORGANIZATION

LC/29-WP/3-9
6/7/94

LEGAL COMMITTEE - 29TH SESSION

(Montreal, 4 - 15 July 1994)

Agenda Item 3: Consideration, with regard to global navigation satellite systems (GNSS), of the establishment of a legal framework

Draft Agreement between the International Civil Aviation Organization (ICAO) and [name of GNSS signal provider] regarding the provision of signals for GNSS services

(Presented by the Secretariat)

Whereas Article 44 of the Chicago Convention mandates ICAO to develop the principles and techniques of international air navigation and to foster the planning and development of international air transport, and

Whereas the ICAO Council established in 1983 the Special Committee on Future Air Navigation Systems (FANS) to make recommendations for the future development of air navigation for international civil aviation, and

Whereas the concept of the ICAO communications, navigation and surveillance/air traffic management (CNS/ATM) systems provides that global navigation satellite system(s) (GNSS) will provide world-wide coverage and will be used for aircraft navigation, and

Whereas the ICAO CNS/ATM concept was formally endorsed by States and international organizations at the Tenth Air Navigation Conference and was approved by the Council and endorsed by the 29th Session of the Assembly as the ICAO CNS/ATM systems, and

Whereas the availability of GNSS signals constitutes an essential component for the provision of GNSS services, and

Whereas it is necessary to establish the conditions and framework within which GNSS signals would be made available to all States

Now therefore ICAO and [name of GNSS signal provider] hereby agree as follows:

UNIVERSAL ACCESSIBILITY

1. [Name of GNSS signal provider] undertakes and agrees to make GNSS signals of reliable quality for global positioning of aircraft available on a continuous world-wide basis to all users of civil aviation, including all States and air lines on a non-discriminatory basis.

(2 pages)

DURATION AND FREE OF CHARGE

2. [Name of GNSS signal provider] agrees to offer GNSS signals to all users of civil aviation including all States and air lines [free of charge] for a period of not less than [ ] years from the date of this Agreement and thereafter for not less than [ ] years from the giving of notice to ICAO of its intention to terminate this Agreement.

COMPLIANCE WITH SARPS

3. [Name of GNSS signal provider] agrees that the [operations] [provision] of GNSS signals shall be in compliance with the international Standards and Recommended Practices and Procedures established by ICAO.

RESPONSIBILITY AND LIABILITY FOR SERVICE

4. [Name of GNSS signal provider] shall be responsible and liable to take all necessary measures to maintain the integrity and reliability of the GNSS signal and its continuous and uninterrupted availability in order to meet the needs of air navigation.

PROVISION OF INFORMATION AND MONITORING BY ICAO

5. [Name of GNSS signal provider] shall provide to the Council of ICAO such information as it may reasonably require regarding the [operation] [provision] of the GNSS signals in order to carry out its responsibilities under the Chicago Convention.

PRESERVATION OF SOVEREIGNTY

6. Nothing in this Agreement shall derogate from the rights of States to control the operations of aircraft and enforce safety regulations within its sovereign airspace.

ENTRY INTO FORCE

7. This Agreement shall enter into force on signature

DONE at ..... this ..... day of ..... 19...

for the
International Civil Aviation Organization
(ICAO)

for the
GNSS signal provider

- END -

Appendix 5

US Offer of GPS to ICAO dated 14 October 1994.

U.S. Department of Transportation
Federal Aviation Administration

Office of the Administrator

600 Independence Ave., S.W.
Washington, D.C. 20591

OCT 14 1994

Dr. Assad Kotaite
President of the Council
International Civil Aviation Organization
1000 Sherbrooke Street West
Montreal, Quebec, Canada H3A 2R2

Dear Dr. Kotaite:

This letter supersedes my letter of April 14, 1994.

I would like to commend, on behalf of the United States, the Committees on Future Air Navigation Systems (FANS) of the International Civil Aviation Organization (ICAO) for pioneering progress in the development of global statellite navigation for civil aviation. I note in this regard that the ICAO Council, on December 11, 1991, requested the Secretary General of ICAO to initiate an agreement between ICAO and Global Navigation Satellite System (GNSS) provider states concerning the duration and quality of the future GNSS.

I would like to take this opportunity to reiterate my Government's offer of the Standard Positioning Service (SPS) of the United States Global Positioning System (GPS) for use by the international community. As the United States made clear at the ICAO Tenth Air Navigation Conference and the 29th ICAO Assembly, the United States intends, subject to the availability of funds as required by United States law, to make GPS-SPS available for the foreseeable future, on a continuous, worldwide basis and free of direct user fees. This offer satisfies ICAO requirements for minimum duration of service (10 years) and freedom from direct charges. This service, which will be available as provided in the United States Government's technical sections of the Federal Radio Navigation Plan on a nondiscriminatory basis to all users of civil aviation, will provide horizontal accuracies of 100 meters (95 percent probability) and 300 meters (99.99 percent probability). The United States shall take all necessary measures to maintain the integrity and reliability of the service and expects that it will be able to provide at least 6 years notice prior to termination of GPS operations or elimination of the GPS-SPS.

The GPS/SPS is a candidate component of the future GNSS as envisioned by FANS. The United States believes that making the GPS available to the international community will enable states to develop a more complete understanding of this valuable technology as a component of the GNSS. The availability of GPS-SPS, of course, is not intended in any

way to limit the rights of any state to control the operations of aircraft and enforce safety regulations within its sovereign airspace.

In the coming years, the international community must decide how to implement an international civil global navigation system based on satellite technology. The United States pledges its full cooperation in that endeavor and in working with ICAO to establish appropriate standards and recommended practices (SARP) in accordance with Article 37 of the Convention on International Civil Aviation (Chicago Convention). Consistent with this goal, the United States expects that SARP's developed by ICAO will be compatible with GPS operations and vice versa and that states will be free to augment GPS-SPS in accordance with appropriate SARP's. The United States will also undertake a continuing exchange of information with ICAO regarding the operation of the GPS to assist the ICAO Council in carrying out its responsibilities under the Chicago Convention.

I would be grateful if you could confirm that International Civil Aviation Organization is satisfied with the foregoing, which I submit in lieu of an agreement In that event this letter and your reply will comprise mutual understandings regarding the Global Positioning System between the Government of the United States of America and the International Civil Aviation Organization

Sincerely,

David R. Hinson
Administrator

Appendix 6

Russian Federation Offer of GPS to ICAO dated 20 February 1996.

INTERNATIONAL CIVIL AVIATION ORGANIZATION
ORGANISATION DE L'AVIATION CIVILE INTERNATIONALE
ORGANIZACIÓN DE AVIACIÓN CIVIL INTERNACIONAL
МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ГРАЖДАНСКОЙ АВИАЦИИ
منظمة الطيران المدني الدولي

INTERNATIONAL AVIATION SQUARE, 1000 SHERBROOKE STREET WEST, MONTREAL, QUEBEC, CANADA H3A 2R2
FACSIMILE TEL.: (514) 288-4772 CABLES: ICAO MONTREAL TELEX: 05-24513 SITA YULCAYA

OFFICE TEL.:

PRES AK/495

20 February 1996

To: Representatives on the Council

From: President of the Council

Subject: **Offer of the Global Navigation Satellite System (GLONASS) from the Government of the Russian Federation**

On 13 February 1996, the Representative of the Russian Federation on the Council of ICAO transmitted to me a letter dated 5 February 1996 from the Minister of Transport of the Russian Federation containing a proposal from the Government of the Russian Federation for providing world civil aviation with a standard-accuracy position-finding channel through the Russian global navigation satellite system (GLONASS).

I have attached for your information a copy of the above-mentioned letter, the content of which will be considered by the Council during its current 147th Session.

Assad Kotaite

PRES
G:\MEMOS\REPSCIL\GLONASS

ATTACHMENT

5 February 1996

Dear Dr. Kotaite,

The introduction of satellite technology into world civil aviation operations is a new stage in the practical implementation of the future CNS/ATM concept developed by the International Civil Aviation Organization. On behalf of the Russian Federation, I would like to congratulate ICAO on its great achievements in planning for the future air navigation system and express my hopes for its successful implementation.

One of the most important parts of the future navigation system is the global navigation satellite system (GNSS). At the Tenth ICAO Air Navigation Conference in 1991, the Government of the USSR offered the world aviation community free use of the global navigation satellite system GLONASS. It was guaranteed that the system would continue to operate for at least 15 years from the time of full deployment in 1995.

The Russian Federation has now completed deployment of the space constellation and the ground control system for GLONASS, and the GLONASS system is operating, providing the required position determination information to aircraft.

I would like to take this opportunity to confirm, on behalf of the Government of the Russian Federation, the proposal made at the Tenth Air Navigation Conference concerning the provision of a standard-accuracy GLONASS channel to the world aviation community for a period of at least 15 years with no direct charges collected from users. This channel will be accessible to all civil aviation users and will provide position information with an accuracy of 60 metres in the horizontal plane (with a probability of 0.997) and 75 metres in the vertical plane (with a probability of 0.997). No method of degrading accuracy is to be used.

Subject to the allocation of resources, as required under the legislation of the Russian Federation, all necessary measures will be taken to ensure the reliability and integrity of the GLONASS channel in question.

In order to make GLONASS available to world civil aviation, the Russian Federation is prepared to cooperate in every way with ICAO in preparing the required GNSS Standards and Recommended Practices (SARPS) in accordance with the provisions of Article 37 of the Chicago Convention, and also to keep ICAO informed of the operational status of the GLONASS system.

The Russian Federation hopes that the SARPS developed by ICAO will be compatible with GLONASS system characteristics, and vice versa. Different states will then be able to introduce the augmentations to GLONASS that they require, in accordance with the ICAO SARPS.

The provision of the GLONASS system to the world aviation community is not intended in any way to limit the right of any state to control aircraft operations and monitor compliance with flight safety regulations in its airspace.

Since ICAO is to act as the international coordinating body for the global implementation of the future air navigation system, we are prepared to conclude an agreement with ICAO under which the GLONASS system can be used by the world aviation community as an element of the GNSS with the above-mentioned performance characteristics.

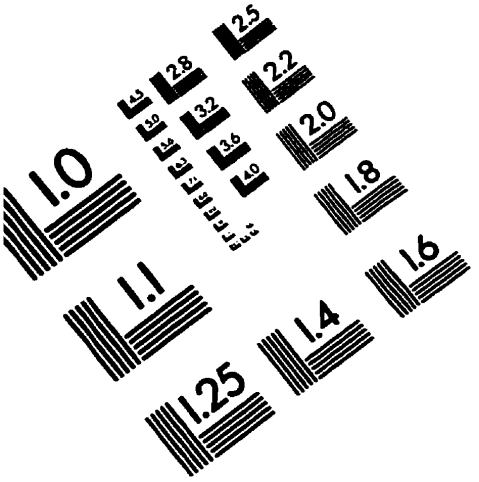
I would be grateful if you would confirm that the International Civil Aviation Organization is satisfied with these positions. If that is the case, this letter and your reply will represent a mutual agreement between the Government of the Russian Federation and the International Civil Aviation Organization concerning the GLONASS satellite navigation system.

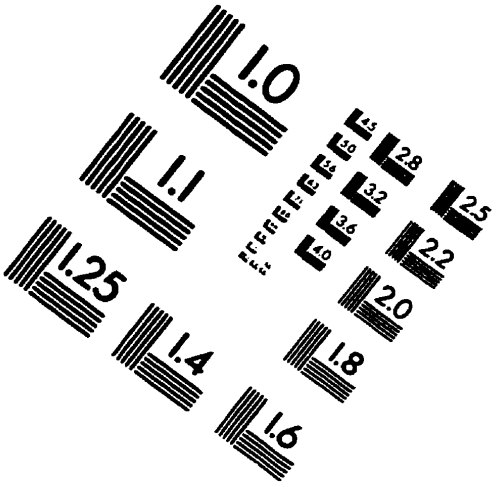
Yours respectfully,

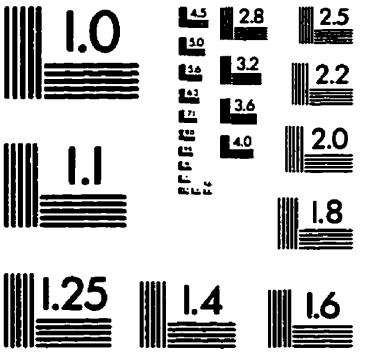
N. P. Tsakh
Minister of Transport

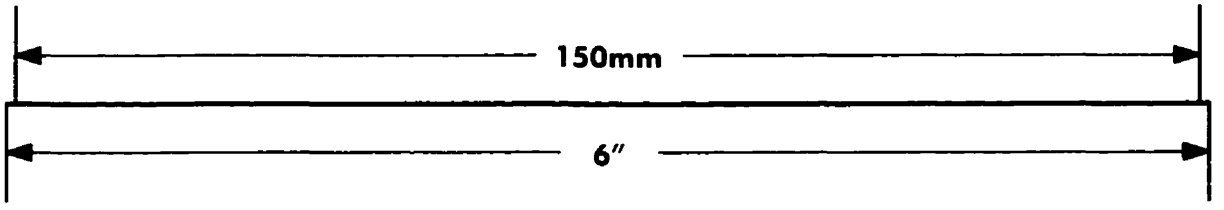
Dr. Assad Kotaite
President of the Council of the
International Civil Aviation Organization

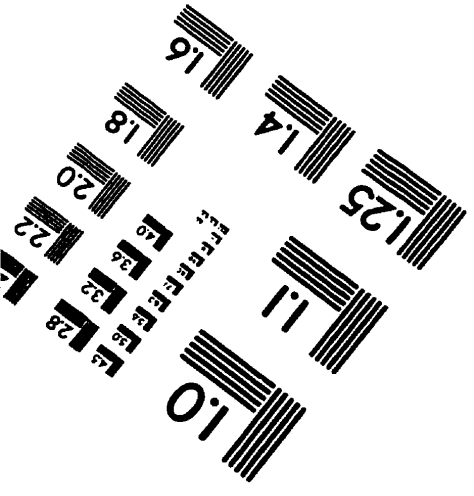
IMAGE EVALUATION TEST TARGET (QA-3)

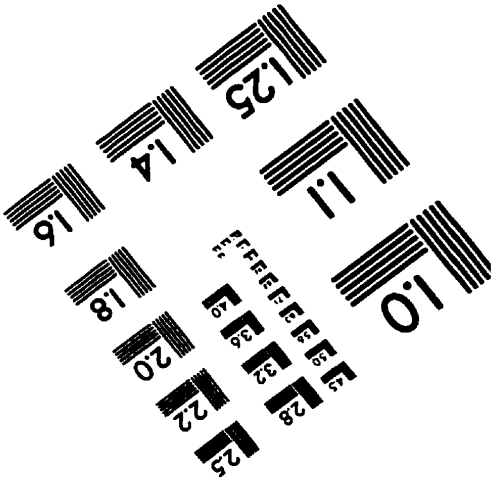












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