GENERAL LEGAL ISSUES CONCERNING GNSS AND THE IMPACT ON DEVELOPING COUNTRIES

Battama Kantasuk

Institute of Air and Space Law

Faculty of Graduate Studies and Research

McGill University, Montreal

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DEDICATION

To My Beloved Parents

Mr. & Mrs. Kantasuk

ABSTRACT

Global Navigation Satellite Systems (GNSS) are a key component of the ICAO Communication Navigation Surveillance – Air Traffic Management (CNS/ATM) system. The fact that GPS and GLONASS, currently the only systems that partially meet the requirements for ICAO's GNSS, are military systems owned, operated and controlled by the US and the Russian Federation raises several institutional and legal issues for civil aviation.

This thesis will present the institutional and legal issues of the GNSS which have been recently discussed in the framework of ICAO. The certification issue to ensure the safety of civil aviation will be considered. The possibility of the legal system for the existing GNSS will correspondingly be examined.

The thesis will also discuss the impact on developing countries in respect of utilizing the existing GNSS as a sole-means navigation system in considering whether a guarantee of quality and continuity of the services in long term is needed, and if so which alternative it is likely to take. Finally, the CNS/ATM trials and implementation plan of Thailand will be presented in order to illustrate the inclination with which the developing countries are going through.

Résumé

Les systèmes de navigation globale par satellites (GNSS) sont un élément clé du système de surveillance de communication et de navigation et du système de gestion du traffic aérien (CNS/ATM). Le fait que les systèmes GPS et GLONASS, présentement sont les seuls systèmes qui satisfont partiellement les exigences du système GNSS du ICAO, sont de propriété militaire, opérés et controlés par les us et la féderation russe et soulèvent plusieurs questions institutionnelle et légales pour aviation civile.

Cette thèse présentera les questions institutionnelles et juridiques de GNSS qui ont été récemment discutées dans le cadre du ICAO. La question de la certification pour garantir la sécurité de l'aviation civile sera abordée. Il sera aussi la question de la possibilité d'instituer un système légal concernant le système GNSS existant.

La thèse abordera aussi l'impact que peut avoir sur les pays en voie de développement, l'utilisation du système GNSS comme unique système de navigation en s'interrogeant sur la nécessité de garanties en ce qui concerne la qualité et et la continuité des services et dans ce cas quelle voie dera choisie. En dernier lieu, les essaies et plans de mise en oeuvre des systèmes CNS/ATM en THAÏLANDE sera présentés de façon à illustrer les pays en voie de développement.

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ABBREVIATION

AAC	Aeronautical Administrative Communication
ADS	Automatic Dependent Surveillance
AEROTHAI	Aeronautical Radio of Thailand
AMSS	Aeronautical Mobile Satellite Services
AOC	Aeronautical Operational Control
AOR	Area of Responsibility
APANPIRG	Asia/Pacific Air Navigation Planning and Implementation Regional Group
APC	Aeronautical Public Correspondence
ATC	Air Traffic Control
ATM	Air Traffic Management
ATN	Aeronautical Telecommunication Network
ATS	Air Traffic Service
B.E.	Buddhist Era
CAT	Communication Authority of Thailand
CNS	Communication, Navigation and Surveillance
DME	Distance Measuring Equipment
DOD	Department of Defense
EGNOS	European Geostationary Navigation Overlay System
FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems
FIR	Flight Information Region
FMS	Flight Management System
GES	Ground Earth Station
GIC	GNSS Integrity Channel
GLONASS	The Russian Global Orbiting Navigation Satellite System
GNSS	Global Navigation Satellite System
GPS	Global Positioning System
HF	High Frequency

ICAO	International Civil Aviation Organization
IFR	International Frequency Registration
ILS	Instrument Landing Systems
INS/IRS	Inertial Navigation System / Inertial Reference System
ISO/OSI	International Standardization Organization / Open System Interconnection
ITU	International Telecommunication Union
LEO MSS	Low Earth Orbit Mobile Satellite System
LORAN	Long-Range Radio Aids to Navigation
LTEP	The Panel of Legal and Technical Experts on the Establishment of a Legal Framework with regard to GNSS
MLS	Microwave Landing System
NDB	Non-Directional Beacon
PPS	Precision Positioning Service (GPS military mode)
RNP	Required Navigation Performance
SA	Selective Availability
SARPs	Standards and Recommended Practices
SPS	Standard Positioning Service (GPS civil mode)
SSR	Secondary Surveillance Radar
THAI	Thai Airways International
UHF	Ultra High Frequency
UIR	Upper Flight Information Region
UNDP	United Nation Development Programme
VHF	Very High Frequency
VOR	VHF Omnidirectional Range
WARC	World Administrative Radio Conferences

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INTRODUCTION

Due to the tremendous growth of air traffic worldwide, both in the number of passengers and the volume of cargo, the existing air traffic systems will not be able to meet the demands of increasing air communication. During the past few years, several studies have been conducted in an attempt to find a way to satisfy the communication, navigation, and surveillance demands, which allow an aircraft to arrive at its destination safely and efficiently. The purpose of most of the studies has been to search for a system that can cope with future air traffic growth. Such a system must cover the full use of the automation that exists both on the ground and in the air and include the real-time information.

In order to keep pace with future Communications, Navigation, and Surveillance/Air Traffic Management (CNS/ATM) systems, the ICAO Council, in 1983, established a Special Committee on Future Air Navigation Systems (FANS I). The inception of this Committee took place according to the realization of the potential use of satellites to solve aeronautical mobile communication problems, particularly over oceans and meagerly-populated land masses, and for surveillance of air traffic where conventional land-based radar surveillance is not feasible. Hence, at that time the FANS Committee was in charge of studying technical, operational, institutional, and economic questions, such as cost/benefit effects relating to potential air navigation systems, identifying and assessing new concepts and new technologies, and making recommendations for co-operative efforts of air navigation on a global scale.

The capability and flexibility of many new navigation systems have been recognized by this Committee, including satellite navigation systems. The FANS I Committee introduced and developed the satellite-based concept while a second Committee (FANS II) was later established in order to consider the issues of implementation. The overall goal is to improve air traffic management so as to increase the utilization of the airspace, as well as to improve safety in order to meet the air traffic demands anticipated up to the year 2010.

Satellites will be used for both data and voice communications. This thesis will focus only on the system being operational for the benefit of navigation, known as the Global Navigation Satellite System (GNSS). GNSS creates a technical uniformity in the air-ground communication system which has proven to be insufficient and inefficient. The two GNSS, which have been operational since 1995, are the US Global Positioning System (GPS) and the Russian Federation Global Orbiting Navigational Satellite System (GLONASS). They provide complete navigation coverage worldwide, without the need for ground facilities.

Both of these systems have been made available to civil aviation free of charge by their governments. Because these systems were originally developed for military purposes by the owner States, several institutional and legal questions have been raised.

The first chapter of this thesis provides an overview of the nature of GNSS and describes how these systems work. The second discusses the general legal principles concerning GNSS, including universal accessibility, sovereignty of States, responsibility and the role of ICAO, technical co-operation, institutional arrangements and implementation, continuity and quality of service, and cost recovery. The third and the fourth chapters examine the liability of air traffic services providers and the certification of GNSS, respectively. The possibility of a legal system for the existing GNSS is discussed in chapter five. This chapter also considers the compatibility of the GNSS concept with the Chicago Convention, which has been at the forefront of the international regulation of civil aviation for more than half a century. Finally, the sixth and seventh chapters examine the impact that the utilization of GNSS has had on developing countries and alternatives to assure the quality and continuity of the service in the long-term before relying completely on GNSS and phasing out the old navigation systems. In particular, the last chapter will present the CNS/ATM trials and implementation in Thailand, which will be used to illustrate the direction in which developing countries are heading.

CHAPTER 1

"WHAT IS GNSS?"

I. Introductory Remarks

In the early 1980s, it became clear to the aviation community that the current air navigation systems and their ability to cope with international air traffic growth were not efficient enough to keep up with the existing civil aviation demands. ICAO, whose major task has been to set the basic international standards in the area of civil aviation, thus realized that major improvements were necessary.

> 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 propagation 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.[1]

Most of the present limitations are restricted to radio propagation over line-of-sight, as mentioned above in a). Although the existing systems provide services that offer a high degree of reliability and accuracy, they are still confronted by limitations of service area coverage. The range and contact below the visible horizon is restricted because of the earth's round

[1] ICAO, *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)*, ICAO Doc. 9623 (1993), Report on Agenda Item 8, app. A at 8A-5, para. 1.2.1 [hereinafter FANS (II)/4].

shape and the fact that radio waves in the Very High Frequency (VHF) and Ultra High Frequency (UHF) ranges travel in straight lines.[2] Hence the curvature of the earth, the propagation limitations of the radio signals, and other geographical features are problematic for long distance flights. Moreover, the voice communications used for aviation, as discussed above in c), are usually carried out on HF,[3] and are thus subject to interference and noise. Additionally, such voice communications do not allow for high traffic demands, due to the possibility of ambiguities and misunderstandings between those on the ground and those in the air, which is very common at the moment.

These shortcomings are the most relevant factors affecting aviation safety today. Safety during all phases of flight requires not only the technical performance of the aircraft and its crew, but also reliable infrastructures, including: adequate communications between aircraft (air-to-air) and the ground facilities for Air Traffic Control (air-to-ground and *vice versa*); a trustworthy means of navigation and surveillance to safeguard precise and economic navigation by the optimal routes; and the maintenance of a safe separation of aircraft in the airspace.[4] It is obviously true that some of

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[2] See M.A. Ghonaim, *The Legal and Institutional Aspects of Communication, Navigation, Surveillance and Air Traffic Management Systems for Civil Aviation* (D.C.L. Thesis, Montreal: Institute of Air and Space Law, McGill University, 1995) at 28.

[3] See *ibid.*

[4] See M. Milde, "Solutions in Search of a Problem?" – Legal Problems of the GNSS (Manuscript, 1997) [unpublished].

the most serious aeronautical accidents of recent times took place due to human error. As M. Milde stated: "[a]viation in the 1980s [was] based on advanced high technology that appear[ed] to reduce the importance of the human element, human judgement and human error."[5] As a matter of fact, most of these accidents could have been avoided if a more precise and reliable means to support air navigation had been available at the time and place of the accident.[6] Therefore, a new technology, which is able to indicate the actual position of each aircraft in real time and ensure a sufficient separation of the two aircraft whose flight paths could possibly converge, is necessary to deal with the ever-increasing rates of the air traffic growth.

II. Course and Development of GNSS

ICAO's objectives are to develop the principles and techniques of international air navigation and to foster the planning and development of international air transport so as to, *inter alia*, ensure the safe and orderly growth of international civil aviation throughout the world and promote generally the development of all aspects of international civil aeronautics.[7] In 1983, ICAO set up the Future Air Navigation Systems

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[5] M. Milde, "Legal Aspects of Future Air Navigation Systems" (1987) XII Ann. Air & Sp. L. 87 [hereinafter "Legal Aspects"].

[6] See Milde, *supra* note 4 at 2.

[7] See *Convention on International Civil Aviation*, 7 December 1944, ICAO Doc.7300/6, 15 U.N.T.S. 295, art. 44 [hereinafter *Chicago Convention*].

(FANS) Committee to lay the framework for "the development of air navigation for international civil aviation over a period of twenty-five years".[8] Four years later the FANS Committee, which came to be known as GANS I, concluded:

> The exploitation of 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.[9]

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).[10]

The "Special Committee for the Monitoring and Coordinating of Development and Transition Planning for the Future Air Navigation System", also known as the FANS II Committee, was established by the ICAO Council in July 1989 to advise on the implementation of the new CNS/ATM concept.

III. Definition of GNSS

A key element in the introduction of the new CNS/ATM concept is the Global Navigation Satellite System (GNSS), which is defined as

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[8] FANS (II)/4, WP/9, *supra* note 1 at 2, para. 1.2.1.

[9] *Ibid.*

> a worldwide position, velocity, and time determination system that includes one or more satellite constellations, receivers, and system integrity monitoring, augmented as necessary to support the required navigation performance for the actual phase of operation.[11]

GNSS is both a satellite-based positioning system and a time transfer system that provides worldwide services for location and time to anyone possessing a GNSS receiver. It consists of one or more satellite constellations, aircraft receivers, ground monitoring stations, and systems integrity monitoring.

This system will eventually overcome the limitations and shortcomings of current CNS/ATM systems.[12] It 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. Hence, there is no doubt that GNSS will evolve to become the sole means of

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[10] See *ibid.*

[11] RTCA Inc., *Global Navigation Satellite System Transition Implementation Plan*, Final Report, Doc. No. RTCA/TF (1 September 1992).

[12] The disadvantages of other navigation systems at present are:
Landmark: Only work in local area. Subject to movement or destruction by environmental factors.
Dead Reckoning: Very complicated. Accuracy depends on measurement tools which are usually relatively crude. Errors accumulate quickly.
Celestial: Complicated. Only works at night in good weather. Limited precision.
OMEGA: Based on relatively few radio direction beacons. Accuracy limited and subject to radio interference.
LORAN: Limited coverage (mostly coastal). Accuracy variable, affected by geographic situation. Easy to jam or disturb.
SatNav: Based on low-frequency doppler measurements so it is sensitive to small movements at receiver. Few satellites, so updates are infrequent.

navigation, and will eventually replace the current long-range and short-range navigation systems.

In 1991, two satellite navigation systems, which were originally designed and launched for military purposes, were offered for use by the international civil aviation community free of charge. These systems are:

1. the Global Positioning System (GPS), developed by the US; and
2. the Global Orbiting Satellite Navigation System (GLONASS), developed by the Russian Federation.

GPS and GLONASS have been offered for a period of ten and fifteen years, respectively. However, if these States intend to terminate their offers, they will advise all users six years in advance of such termination.

GPS was opened to civil use and to the world of international civil aviation in 1983, immediately following the Korean Airlines' Flight 007 disaster. The US offer was reiterated to the FANS Committee, reformulated and formalized at the 10th Air Navigation Conference held in September 1991, and further clarified and expanded at the 29th Assembly of ICAO. GLONASS was also made available at the same Air Navigation Conference.[13] The Conference emphasized the important role for ICAO in future institutional arrangements as outlined in Article 44 of the Chicago Convention. Three recommendations dealing with institutional

[13] See ICAO, *Report of the 10th Air Navigation Conference*, ICAO Doc. 9583 (1991); ICAO, *Report of the 29th Session of the ICAO Assembly*, ICAO Doc. 9595 (1992).

arrangements for FANS were adopted at this Conference. Recommendation 4/4 requested: "that ICAO, as a matter of urgency, develop the institutional arrangements (including integrity aspects) as a basis for the continued availability of GNSS for civil aviation."[14] Recommendation 4/5 asked 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 that may involve.[15]

Following the offers of the US and the Russian Federation, the International Maritime Satellite Organization (Inmarsat) volunteered to augment and monitor the primary navigation signals provided by GPS and/or GLONASS with its Inmarsat–III system,[16] as will be discussed later in this chapter. The US formalized its proposal to provide GPS to the international civil aviation community in an exchange of letters between the Administrator of the Federal Aviation Administration (FAA) and the President of ICAO.[17]

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[14] See FANS (II)/4, WP/9, *supra* note 1 at para. 1.2.4.

[15] *Ibid.*

[16] See B.D.K. Henaku, "The International Liability of the GNSS Space Segment Provider" (1996) XXI:I Ann. Air & Sp. L. 144 at 145.

[17] See Letter of D. Hinson, the Administrator of the FAA, to A. Kotaite, the President of ICAO Council (13 December 1994), State Letter LE 4/49.1-94/89.

At present, GPS and GLONASS are the only systems available that partially meet the requirements for ICAO's GNSS.[18] Simultaneously, some countries or groups of countries are discussing the possibility of developing their own systems, which would be purely civilian GNSS, but no specific plans have been formulated so far.[19]

IV. GNSS Options

In its Report of the Fourth Meeting, the FANS II Committee concluded that

> 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.[20]

Therefore, the Committee has highlighted five possible system combinations, each of which meet the requirements for GNSS and could provide long-term GNSS services. The five possible system combinations are:

1) GPS or GLONASS, plus integrity monitoring and augmentation;
2) GPS and GLONASS;
3) GPS/GLONASS plus an overlay which would embrace ranging, differential and integrity applications;
4) GPS/GLONASS plus civil GNSS satellites; and,

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[18] See RTCA Inc., *supra* note 11.

[19] See Milde, *supra* note 4 at 10.

[20] FANS (II)/4, Report on Agenda Item 4, *supra* note 1 at 4-13, para. 4.3.4.8.

5) Civil GNSS satellites.[21]

These five options are all able to provide GNSS services in accordance with the Required Navigation Performance (RNP) criteria for all phases of aviation operations. Inmarsat's plan to add satellites, which would supplement the existing GPS system in order to improve the signal availability, is within the scope of the third option. The current 24 GPS satellites, when augmented by Inmarsat-III services and local differential corrections, may be sufficient to support precision approaches for all aircraft to touchdown.[22] Moreover, GLONASS could augment the GPS coverage, but its long-term support is uncertain.[23] Nevertheless, not all elements of GNSS need to be in place before operations can begin to demonstrate benefits.[24] Full benefits will not be realized, however, until GNSS is authorized as a sole-means[25] navigation system, and ground-based navigation aids are no longer supported.[26]

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[21] Report on Agenda Item 4, Executive Summary, *Ibid.* at 4-5, para. 4.3.

[22] See B.D. Nordwall, "Inmarsat Offers Plan for Civil GPS" [7 November 1994] Av. Wk & Sp. Tech. 41.

[23] See *ibid.*

[24] See M.J. Asbury, "Some Institutional Factors and Aspects Relating to a Civil Global Navigation Satellite System" (1994) 47 J. Navigation 133 at 134.

[25] GNSS as the sole means of navigation is navigation of the aircraft for a particular phase of operation where the horizontal component of the aircraft position determination is provided exclusively by the GNSS.

[26] See Asbury, *supra* note 24 at 135.

V. Benefits of GNSS

The arrival of GNSS will significantly improve the safety of air navigation. Simultaneously, it is also expected to enhance the economy and regularity of flights by permitting the rationalization of air routes, while reducing both the distance needed to separate aircraft from one another and the congestion at airports. The benefits of GNSS, mentioned at the Fourth Meeting of the FANS Committee,[27] are as follow:

1) GNSS will provide a high integrity, high accuracy, and worldwide navigation service suitable, as the sole means of navigation, for en-route, terminal and landing operations.

2) The implementation of the system will enable aircraft to navigate in all airspace environments worldwide, using satellite-based navigation avionics. Thus, existing ground-based navigation aids will find a diminished utility and may eventually be withdrawn, offering significant savings to provider States.

3) 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. In addition, GNSS will enhance airport capacity by providing the basis for a precision surface movement guidance and control system.

4) Moreover, "[i]n 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 GNSS will be capable of providing such positional information."[28]

In conclusion, GNSS will make it easier to meet the planned departure and arrival times of each flight. Moreover, it will improve the acquisition of information relating to weather conditions, traffic, and the availability of flight information while refining navigation and landing capabilities by supporting advanced approach and departure procedures. Also, the proposed system will make available non-precision approach capabilities to a large number of airports which would not otherwise be accessible in low visibility conditions. As a result, these benefits will reduce flight-operating costs and will, therefore, be economically beneficial. For the service providers, this system will permit a more efficient use of airspace by reducing aircraft separation and providing greater route flexibility.

VI. How GNSS Works

GNSS is an electronic type of radio navigation and positioning system based on the range measurement from a satellite signal which is timed by an "atomic clock".[29] The signal's arrival time is measured by high

[27] See FANS (II)/4, Report on Agenda Item 8, app. A, *supra* note 1 at 8A-10.

[28] See FANS (II)/4, Report on Agenda Item 4, app. I, *supra* note 1 at AI-1, para. 1.5.

[29] Atomic clocks use the oscillations of a particular atom as their "metronome". This form of timing is the most stable and accurate reference man has ever developed.

precision GNSS receivers, which calculate the differences in the signals from three or more satellites. The receiver is able to determine the distance from those signals and, hence, its position in three dimensions and real time. Since GNSS is currently based on the availability of both GPS and GLONASS, this thesis will examine how these systems work. In addition, several rudimentary systems, such as Inmarsat-III, EGNOS, MT-SAT, and Twin-Star will be discussed.[30]

A. Global Positioning System

GPS is a continuous, global satellite navigation system under active development by the US. The system consists of three segments, including a space segment of 24 orbiting satellites, a control segment that includes a master control centre on the US mainland and access to overseas command stations, and a user segment, consisting of GPS receivers and associated equipment.[31] It has the capability to provide the geodetic position and velocity in three dimensions, with a highly accurate time. The satellites execute 12-hour circular orbits, all inclined at 55 degrees to the Equator. The total number of satellites for the operational configuration is twenty-one plus three working spares on six orbital planes.[32]

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[30] See S.A. Kaiser, "Infrastructure, Airspace and Automation Air Navigation Issues for the 21st Century" (1995) XX Ann. Air & Sp. L. 447 at 451.

[31] See W.V. Kries, "Some Comments on the U.S. Global Positioning System Policy" (1996) 45 ZLW 406 at 408.

[32] ICAO, *Special Committee on Future Air Navigation Systems (Fourth Meeting)*, ICAO Doc. 9524 (1997) at 3.2B-5, para. 2.2.1 [hereinafter FANS/4].

GPS provides both a standard positioning service (SPS) and a precise positioning service (PPS). The SPS is provided to any user, does not require any cryptographic means and is made freely available to civil, commercial and other users internationally. It has been degraded intentionally by the US Department of Defense (DOD), for purposes of their national security, through an accuracy denial method known as Selective Availability (SA).[33] The level of accuracy for the SPS is set at 100 meters horizontally and 157 meters vertically at 95 per cent probability. The PPS is a military position/navigation service that provides accuracies higher than those of SPS through the use of cryptography.[34]

Technically speaking, GPS works on the basis of triangulation from satellites. To triangulate, a GPS receiver measures distance by calculating the length of time the radio signal takes to reach a position on earth or an aircraft in flight. It is necessary to assume that both the satellite and the receiver are generating the same pseudo-random[35] codes at exactly the same time. Accordingly, the distance will be known by multiplying that travel time by the speed of light.[36]

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[33] SA is a purposeful degradation in GPS navigation and timing accuracy 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.

[34] See *ibid.*

[35] Pseudo-random is the apparent range from the satellite, which is measured with receiver clock error.

B. Global Orbiting Satellite Navigation System (GLONASS)

GLONASS was developed by the USSR military and has been continued by the Russian Federation. Like GPS, it also consists of 24 satellites (including 3 spares), which execute 11 hour and 15 minute orbits at an altitude of 19,100 kilometres. It provides similar and compatible data and a level of accuracy similar to that of GPS, and operates in C/A mode.[37] Compared to millions of GPS receivers, very few GLONASS receivers are available to users. One reason for this could be the political and economic uncertainty of Russia.

C. Inmarsat

Inmarsat began, in 1979, as the International Maritime Satellite Organization. Initially, the objective of this organization was to provide a space segment for improving maritime communications, but Inmarsat's competence was later expanded to include aeronautical communications.[38] It is an inter-governmental organization; seventy-nine States are now Parties to its convention.[39]

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[36] On the Internet, see http://trimble.com/gps/

[37] See FANS (II)/4, *supra* note 1, para. 2.3.1.

[38] See A. Auckenthaler, "Recent Developments at Inmarsat" (1995) XX:II Ann. Air & Sp. L. 53.

[39] See *Convention on the International Maritime Satellite Organization* (INMARSAT), 3 September 1976, 1143 U.N.T.S. 105.

As mentioned earlier, the primary signals from the current GPS and GLONASS alone cannot meet all aviation requirements. Hence, Inmarsat has offered to provide augmentation and integrity monitoring signals through Inmarsat-III geostationary orbiting satellites.[40] O. Lundberg, the Director-General of Inmarsat has stated that since this generation of satellites will carry navigation transponders, they can perform several functions:

1) Relay ground-derived GPS and GLONASS integrity information to users. This function is already known as the GNSS Integrity Channel (GIC).
2) Provide additional ranging signals to increase GPS availability worldwide and help users to do their own integrity monitoring.
3) Increase positioning accuracy from the unaugmented level of 100 metres to as little as 20 metres by relaying wide-area ionospheric calibration and differential correction to GPS and GLONASS signals.[41]

Inmarsat-III will be the first satellites capable of both providing navigation signals and relaying timely, independently monitored integrity information. They will also be the first internationally civil-owned contribution to any GNSS that may emerge over the next few years.[42]

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[40] See Henaku, *supra* note 16 at 148.

[41] See O. Lundberg, "The Inmarsat Vision for the 21st Century" (1995) 48:2 J. Navigation 166 at 168.

D. Other systems

The trend of GNSS, which is currently dominated by only GPS and GLONASS, might be changed in the near future because some countries or groups of countries are developing their own navigation satellite systems.

The US wants GPS to become the core of the future GNSS.[43] However, other nations and international organizations consider a combination of GPS and GLONASS to be the first step, which would then be followed by a transitional period. GNSS would still be based on GPS/GLONASS, but civil users would set up and operate other networks to correct the signals from both systems. Finally, it might be possible to develop a system which exclusively uses civil satellites.[44] Some of the systems that have been developed by countries or groups of countries, which include EGNOS, MT-SAT and Twin-Star, will now be presented.

1. EGNOS, as the European Geostationary Navigation Overlay System has become known, has been contributed by Europe, and will augment the GPS and/or GLONASS systems. This contribution will generate supplementary information, which will be broadcasted to users via geostationary

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[42] See *ibid.*

[43] See P. Hartl & M. Wlaka, "The European Contribution to a Global Civil Navigation Satellite System" (1996) 12:3 Sp. Policy 167 at 168.

[44] See *ibid.*

satellites equipped with specific navigational transponders.[45] Europe will certainly benefit from this project in that it will gain influence due to its role in GNSS. However, the biggest shortcoming of EGNOS is that it is completely dependent on GPS and/or GLONASS and will be useless without either of them.[46] Hence, EGNOS can only be regarded as an intermediate step towards a civil navigation satellite system.

2. MT-SAT is a satellite system established by Japan for the provision of aeronautical communications and supplemental air navigation services throughout the Asia-Pacific region. This system is a multi-functional transport satellite and will provide overlay functions for both Aeronautical Mobile Satellite Services (AMSS) and Global Navigation Satellite Systems (GNSS). The decision to launch and operate the satellites for air traffic services (ATS) purposes was based on the outcome of the ICAO 10th Air Navigation Conference in 1991, which endorsed the use of a satellite-based system.[47] The MT-SAT is strongly supported by the FANS II Committee because it will enable ATS provider States to exercise their power to the maximum extent for the sake of aircraft safety.[48] The MT-SAT is one way to enable the application of Automatic

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[45] See *ibid.* at 171.

[46] See *ibid.*

[47] See K. Okada, "Japan Launches Major Programme to Provide Satellite-based Aeronautical Services" (1993) 48:8 ICAO J. 24.

[48] See *ibid.*

Dependent Surveillance (ADS)[49] in the Asia-Pacific region, leading to the possibility of increasing air traffic capacity while maintaining the existing level of air traffic safety. In addition, the entire international civil aviation community will reap large benefits from it. However, K.Okada, a Japanese scholar, also noted that "[t]he success of the MT-SAT system depends largely on co-operation and co-ordination with adjacent States and the international civil aviation community."[50]

3. **Twin-Star** is a position-location satellite system developed by China. Its purpose is to provide military and civilian users with a rudimentary capability for space-based Asian navigation separate from other satellite systems.[51] It will consist of two spacecraft, positioned about 40 degrees apart in geosynchronous orbit over the Equator, south of China.[52] The satellites are tentatively scheduled to be launched in 1998.

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[49] The objective of ADS is to decrease ATC separation to the minimum distance possible and to raise air traffic route capacity.

[50] See Okada, *supra* note 47 at 24.

[51] "Chinese 'GPS' Project Set" [17 October 1994] Av. Wk & Sp. Tech. 25.

[52] See *ibid.*

CHAPTER 2

GENERAL LEGAL PRINCIPLES

During the 141st Session of the Council on 9 March 1994, the Council approved a Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation.[53]

The Policy Statement only represents the consensus reached by the Council; it is not a legally binding instrument. It is constructed in very general terms since it seeks to cover all CNS/ATM systems, which use relatively new technologies. However, all of the principles in this statement deserve attention since they have some relevance to GNSS and could be useful for the formulation of a legal instrument regarding GNSS in the future. There is nothing specific in either the technical or the legal aspects because very little experience has been gained from these systems so far.

The Legal Committee was asked to incorporate, as appropriate, the elements of the Policy Statement into its proposals regarding a legal framework. These elements can be summarized as follows: universal accessibility without discrimination; sovereignty, authority and responsibility of Contracting States; technical and co-ordinating role of

ICAO; rationalization, integration, harmonization, co-operation and competition in implementation; evolutionary progression, continuity and quality of service; and reasonable cost allocation to users. These elements will be discussed below.

I. Universal Accessibility

Since GNSS will serve the international civil aviation community as a whole, universal access to it by all States and their airlines without discrimination is a necessary requirement if GNSS is to become a truly universal means of air navigation. States have discussed the issue of accessibility since the beginning of their deliberations over this new concept,[54] and special attention has been given to it by the FANS II Committee. Through a series of meetings, the Committee has formulated a set of guidelines on acceptable institutional arrangements, including the issue of "universal accessibility".[55] It is stated therein that "this guideline is one of the fundamental principles underlying the philosophy of ICAO as the specialized agency of the United Nations of civil aviation".[56]

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[53] See ICAO, *Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation*, LC/28-WP/3-2 (28 March 1994), reproduced in (1994) XIX:II Ann. Air & Sp. L. 715. [hereinafter *Policy Statement*].

[54] See S.-K. Hong & H.-K. Shin, "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) XIX:II Ann. Air & Sp. L. 399 at 404.

[55] FANS (II)/4, *supra* note 1 at 8-1.

[56] *Ibid.*

In addition, Article 15 of Chicago Convention stipulates that 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.[57]

It is important that satellite navigation, one of the space application activities which requires global coverage, works on the basis of universal accessibility without any discriminatory distribution of access to the services. Article 1 of the Outer Space Treaty of 1967 stipulates that the use of outer space shall be carried out for the benefit, and in the interests of all countries.[58] With regard to satellite communications, international organizations have been established to promote and facilitate satellite communication services to all States. For example, INTELSAT and INMARSAT are two such organizations which function on the basis of non-discriminatory rights of access granted to all their member States. This gives effect to Article 1(1) of the Outer Space Treaty. Undoubtedly, guaranteeing universal accessibility is one of the fundamental elements that must be taken into consideration for any institutional arrangement. In conclusion, GNSS must be accessible to all States without discrimination.

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[57] See Hong & Shin, *supra* note 54 at 405.

At the moment, both the US and the Russian Federation's governments have made a commitment to maintain their systems, namely GPS and GLONASS, "on a continuous world-wide basis" and "on a non-discriminatory basis" to all users of civil aviation.[59] Both commitments were made in the form of an "exchange of letters" between the governments of both countries and ICAO.[60] However, these exchanges of letters are only an informal agreement between ICAO and both countries since the ICAO Council and the Organization itself have no legal authority to enter into a formal agreement concerning GNSS.

II. Sovereignty of States

The principle of a State's sovereignty over the airspace above its territory, which means "the land areas and territorial waters adjacent thereto under the sovereignty",[61] is confirmed in Article 1 of Chicago Convention. This Article states: "[t]he contracting States recognize that every State has complete and exclusive sovereignty over the airspace above its territory."[62] The legal status of the airspace of States as addressed in

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[58] See *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including Moon and Other Celestial Bodies*, 27 January 1967, 610 U.N.T.S. 205, 18 U.S.T. 2410, T.I.A.S. No. 6347, 6 I.L.M. 386, art. 1 [hereinafter *Outer Space Treaty*] (entered into force on 10 October 1967).

[59] See Letter of D. Hinson, the Administrator of the FAA, to A.Kotaite, the President of ICAO Council (14 October 1994) – Attachment1 to State Letter LE 4/49.1-94/89 (undated) and the letter from the Russian Federation's Minister of Transport to President of ICAO Council dated (4 June 1996) – see Attachment A to State Letter LE 4/49.1-96/80 dated (20 September 1996) [hereinafter "Exchanging of Letters"].

[60] See *ibid.*

[61] See *Chicago Convention*, *supra* note 7, art. 2.

Article 1 is applied not only to the Contracting States, but to "every State". Hence, each State can enjoy the right to restrict international flights by various means, including the establishment of prohibited zones and the temporary restriction of flights. The application of the rules and regulations regarding flights and the movement of aircraft in every State is governed by the territorial principle. Each State has the right to designate the routes to be followed within its territory by international air services. The enforcement of this is not only a right, but an obligation imposed upon the territorial authority.[63]

In addition, Article 28 of Chicago Convention states that "each Contracting State has undertaken, so far as it may find practicable, to provide in its territory radio services, meteorological services and other air navigation facilities to facilitate international air navigation ..."[64] This means that even within the sovereign territory, States are only obliged to provide air navigation systems on the level they "may find practicable".

Technically speaking, it is appropriate to say that the function of GNSS in no way infringes upon the sovereignty and authority of States in the control of air navigation over their sovereign airspace since GNSS satellites operate by generating signals that enable the precise positioning

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[62] *Chicago Convention, supra* note 7, art. 1.

[63] See Hong & Shin, *supra* note 54 at 406.

[64] *Chicago Convention, supra* note 7, art. 28.

and navigation of aircraft. States still retain full authority for the provision of Air Traffic Services within their territorial jurisdiction.

As mentioned in Chapter 1, the scope of GNSS, which benefits from satellite-based systems, is of a global nature. They make it possible to provide a very accurate geographic latitude and longitude, universal time, and geocentric altitude to a flight no matter what the aircraft's position. Hence, these GNSS systems actually require one global standard, and must rely on international co-operation from every State. However, States will always reserve jurisdiction above their airspace. As M. Milde writes:

> States do not have any pre-existing legal obligation to provide air navigation facilities or services beyond their sovereign territory. Express consent of states, possibly in the form of international arrangements, will be required for their participation and assumption of duties with respect to the operation of the new air navigation system.[65]

At the same time, ICAO Assembly Resolutions continue to request that States ignore the limitations of national boundaries in ATC services planning.[66] To respond to such requests, it is necessary that ICAO develop new concepts to deal with GNSS. However, States' sovereignty and authority must be preserved in the co-ordination and control of

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[65] "Legal Aspects", *supra* note 5 at 98.

[66] See Ghonaim, *supra* note 2 at 305.

communications and in the augmentations, as necessary, of satellite navigation services.[67]

III. Responsibility and Role of ICAO

For over fifty years ICAO has been a regulatory organization in the aviation field. ICAO standards are non-binding international soft laws. However, this should not be considered as a shortcoming of ICAO's role in aviation since public international law, which is binding treaty law, usually comes into force reluctantly due to slow ratification by the required number of States.[68] The Chicago Convention demonstrates perfectly that many amendments do not enter into force for many years because the sufficient number of ratifications have not been met.[69] In conclusion, ICAO has become such a successful organization in the field of air navigation regulation only because of the non-binding nature of its standards. ICAO would never be able to keep up with the many new technologies entering the aviation field yearly if standard-making needed unanimous Council approval or even a two-thirds Assembly majority,[70] or formal ratification by States.

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[67] See *ibid.*

[68] See Kaiser, *supra* note 30 at 454.

[69] See *ibid.*

[70] See *ibid.*

The Statement of ICAO Policy on CNS/ATM Systems Implementation and Operation asserts that:

> In accordance with Article 37 of the Convention, ICAO shall continue to discharge the responsibility for the adoption and amendment of Standards and 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 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...*[and]* 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.[71]

There is nothing new in this statement. It only reiterates that the mandatory function of the ICAO Council is to adopt Standards and Recommended Practices (SARPs),[72] in accordance with Article 37, on all matters relevant to the safety, regularity and efficiency of air navigation. However, it seems impossible to expect the Council to be in the position to formulate any standards for the existing GNSS since both GPS and GLONASS are technologies developed by States and in use by other States that were developed independently, before the ICAO FANS programme began in 1983. Moreover, the standards designed by the creators are being accepted in practical use on a worldwide scale and if ICAO is to

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[71] *Policy Statement, supra* note 53 at 715.

[72] See *Chicago Convention, supra* note 7, art. 54(1).

develop SARPs, the Governments of both countries expect them to be compatible with their express wishes.[73]

Furthermore, the US GPS system policy proclaimed by President Clinton on 29 March 1996 states, in its policy guideline (5): "We will advocate the acceptance of GPS and the US Government augmentation standards for international use".[74] This guideline apparently shows that the US government, and probably also the Russian Federation, have not relied on ICAO's co-ordinating role with regard to the allocation of the frequency spectrum used by GPS and GLONASS. These States intend to proclaim their own standards as the international regulation. Moreover, thus far there is no constitutional legal basis giving ICAO any specific authority.

Practically, it seems that the practices of the GNSS operational system will be under the control of the signal providers rather than ICAO. Developing an international civil aviation GNSS might be the only way for ICAO to have full authority of the law-making process.

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[73] The US Government states that "the United States expects that the SARPs developed by ICAO will be compatible with GPS operations", see letter of 14 October 1994 referred to in *supra* note56. Simultaneously, the Russian Federation "hopes that the SARPs developed by ICAO will be compatible with GLONASS system characteristics." See letter of 4 June 1996 referred to in *supra* note59.

[74] See 'U.S. Global Positioning System Policy', The White House, (29 March 1996) http://www.spacenews.com/gps96.txt.

IV. Technical Co-operation

The Statement of the ICAO Council of 9 March 1994 on CNS/ATM Systems Implementation and Operation, which states that "ICAO shall play its central role in co-ordinating technical co-operation arrangements for CNS/ATM systems implementations", indicates clearly that ICAO should be the leader in the implementation of the new systems, including GNSS. 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."[75]

The term "technical co-operation" has been used for some time in the same context as "technical assistance" for these new technologies due to a great need by the less developed countries for ICAO's co-ordinated assistance in CNS/ATM planning, cost-benefit analysis, systems specification, and training.[76] As to the complexity of the new technology, the less developed countries would never be in a position to share in the benefits offered by GNSS without such "technical assistance" or "technical co-operation".

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[75] *Policy Statement*, *supra* note 53 at 715.

[76] See Ghonaim, *supra* note 2 at 342.

ICAO has been providing technical assistance to its member States in implementing its SARPs and Regional Air Navigation Plan since 1951.[77] This assistance has been funded by the United Nations Development Programme (UNDP), the World Bank, other regional development banks, and the member States. However, ICAO still needs extra budgetary resources to enable the Technical Co-operation Program to perform any additional functions necessary, as new technologies emerge. In addition to technical assistance by ICAO, many States already have training facilities that could be used to assist other States with the new systems. ICAO's central role is essential in co-ordinating and ensuring that the training provided is standardized globally. Nevertheless, ICAO's co-ordinating role for such technical co-operation is not automatically assured; it must be earned by the political support of States and the industry.

V. Institutional Arrangements and Implementation

A number of countries have established organizations for the improved operation of satellite telecommunication systems because of the technical advantages and the economic benefits that could be gained from such systems. In addition to such substantial benefits, telecommunication satellites also have significant political implications, due to the attempt by the US to have its regulations adopted internationally. The European

Union and other States, not wishing to be completely controlled by the US, have begun planning their own systems. As M. Ghonaim has stated: "[I]t is not surprising that the prior political split of the world into blocs was reflected in the division of global telecommunication satellite organizations".[78]

Studying the appropriate institutional framework for the implementation of the new CNS/ATM systems has been one of the principle tasks of ICAO's FANS Committee.[79] Currently, ICAO's strategy is "to make optimum use of existing organizational structure [so that] the systems shall be operated in accordance with existing institutional arrangements and legal regulations".[80] New institutional arrangements and legal regulations should not be established if the existing ones are still satisfactory. In fact, it might be possible to make adjustments to the existing organizational structure. Such adjustments might be warranted since different institutional and legal arrangements are required for different types of systems and technologies. However, the institutional arrangements would not inhibit competition among service providers as long as they are complying with the relevant ICAO SARPs.[81]

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[77] See *ibid.*

[78] *Ibid* at 35.

[79] See "Legal Aspects", *supra* note 5 at 89.

[80] *Policy Statement*, *supra* note 53 at 715.

[81] See *ibid.*

GPS and GLONASS are the only two GNSS currently available and accepted by the international community. So far, no institutional arrangements for GNSS have been defined, even though more and more civilian users have come to rely on these new systems. One of the most important reasons for this lack of arrangements is that both systems were developed for the military purposes of the US and the Russian Federation, and they are not primarily intended for civil aviation use. Thus, the military still has the leading role in setting the policy for both systems.[82]

The need to have institutional arrangements for these systems is based on an inspiration to develop a new civil GNSS, which would be independent from the monopoly or oligopoly of the current providers and from the fundamentally military roots of GPS and GLONASS. However, this would be difficult since GPS already has a wide spectrum of users in fields other than aviation. Furthermore, the total cost of the development and launching of GPS is estimated at US $10 billion,[83] in addition to the more than US $500 million a year required to maintain the whole system.[84] Many States are not ready to invest such a large amount of money to develop an international system when they already have a system which can be used free of charge. Furthermore, developing a parallel system

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[82] See Kries, *supra* note 31 at 408.

[83] D. Latham, "GPS Does Not Need a Bureaucratic Fix" [14/20 June 1993] Commercial Aviation News 18 at 20.

[84] L. Burgess & N. Mounro, "Officials Seek Wider GPS Access" [26 April/2 May 1993] Space News 8.

solely for international civil aviation might be considered wasteful and technically redundant.

In conclusion, there has been no consensus on the need to adopt a legally binding instrument for the GNSS framework and no indication of the States' willingness to negotiate a specific international arrangement in the form of a legal instrument.

VI. Continuity and Quality of Service

Since GNSS will become the sole means of navigation in the near future, it is of the utmost importance to assure the reliable quality of information and the continuity of this service to all users. Practically, very few details have been gained thus far about the continuity and quality of this service and, hence, there is no legal instrument to cope with this issue. The exchange of letters has been the only assurance to the States of the continuity and quality of GPS and GLONASS.[85]

A. Continuity

One apparent legal loophole affecting the continuity of this service is found in Chicago Convention, which has currently 185 parties[86] and

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[85] See "Exchanging of Letters", *supra* note 59.

represents a legal framework for international civil aviation.[87] Article 89 of this Convention states that

> In case of war, the provisions of this Convention shall not affect the freedom of action of any of the contracting States affected, whether as belligerents or as neutrals. The same principle shall apply in the case of any contracting States which declares a state of national emergency and notifies the fact to the Council.

According to this Article, it is obvious that full "freedom of action" is reserved for States in the case of war or declared national emergency.

Applied to GPS and GLONASS, this is a practical problem since national security will be of paramount importance to both the US and the Russian federal government. The role of the military is a major concern for all users because it is feared that national security may be used as an excuse to give a low priority to commercial aviation in situations foreseen in Article 89 of the Chicago Convention. However, the Panel of Experts on the Establishment of a Legal Framework with Regard to GNSS believe that "despite Article 89 of the Chicago Convention, continuity of service should be maintained even in war or emergency situation"[88] and that

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[86] See list in attachment to ICAO State Letter LE 3/2-97/5 (17 January 1997).

[87] See Milde, *supra* note 4 at 4.

[88] ICAO, *Report of the Meeting of the Working Group on GNSS Principles*, ICAO Doc. LTEP/1 (Montreal, 10-12 March 1997) at 3-2, para. 3:8-3:12 [hereinafter LTEP/1].

"international law [does] not allow States to put civil aviation into danger because of military reasons".[89]

The other point that should be remembered is that the US offer of GPS service was specifically made "subject to availability of funds".[90] What will happen if GPS finally becomes the sole means of navigation and the US declares that it has insufficient funds to continue this system? The best approach would be to set up a GNSS system which would be used only for international civil aviation, independent from monopoly or oligopoly influence. However, this is unlikely in the real world since it costs US $10 billion just to set up a system like GPS plus an additional US $500 million a year, which is ten times ICAO's annual budget, to maintain the whole system.[91] Not only is it virtually impossible to find a State or an organization to be responsible for the cost of the system, but it is also considered to be a waste of precious resources to invest such a large amount of money on civil air navigation.

B. Quality

The basic requirements of the quality of the GNSS service are to assure the integrity of the service; and to protect it from interference and

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[89] *Ibid.*

[90] "Exchanging of Letters", *supra* note 59.

[91] See Latham, *supra* note 83 at 20.

malfunctions. As mentioned in Chapter I,[92] neither GPS nor GLONASS in themselves can meet all the needs of civil GNSS and, therefore, must be augmented with other sub-systems to remedy their shortcomings. These sub-systems could be provided by other entities, such as Inmarsat, by a country, or by a group of countries. These subsystems, nevertheless, must rely on GPS and/or GLONASS and will be useless without them.

In conclusion, if GNSS is ever to become the sole means of navigation, which means that the current systems will be discarded, the first principle that should be guaranteed is the continuity and quality of the services. The best alternative in theory is to develop a purely civilian GNSS under international control, but practical considerations lead to other conclusions in view of the large amount of money required to develop a new system.

VII. Cost Recovery

Regarding cost recovery, the ICAO Council's statement has declared that:

> In order to achieve a reasonable cost allocation between all users, any recovery of the cost 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 Service (Doc.9082), including the principle that it shall

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[92] See Chapter I-IV, above.

> neither inhibit nor discourage the use of the satellite-based safety services.[93]

Article 15 of Chicago Convention describes the non-discrimination principle regarding charges for all air navigation facilities, which are provided for public use in the territory of a particular State. It is not automatically applicable for the existing GNSS, which are services provided on a global basis.[94] This issue is not considered to be problematic at the present time because both GPS and GLONASS are being offered to all users free of charge for a period of 10 and 15 years, respectively. However, the augmentations, which bring the accuracy of the signal up to the standard required for civil GNSS, will not be offered to the users for free. These costs might be determined according to the number of users, the size of the territory of each State or the benefits derived by each State (which would, of course, vary greatly according to the level of development of the State). Accordingly, the costs of such augmentation services among different users[95] will surely require lengthy discussions in the future.

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[93] *Policy Statement*, *supra* note 53 at 721.

[94] See Milde, *supra* note 4 at 11.

[95] Aviation is only one of several users and being considered as a small minority group.

CHAPTER 3

LIABILITY ISSUE

I. System of Liability

The typical malfunctions of the current GNSS are the degrading of precision of the system and the partial or total disruption of services. It has already been mentioned in the first chapter that the GPS and GLONASS systems are owned by the military of the US and the Russian Federation, who may decide to degrade and/or disrupt the system for the purposes of their own national security. At the moment, the signal provided by GPS has been deliberately degraded by the US Department of Defence through an accuracy denial method known as "Selective Availability" (SA) to be accurate only to 100 metres.[96]

Technically speaking, the degrading and disruption of navigation services could lead to damages, resulting in signal delays or, in the worst situation, aviation disasters caused by an abnormality of the system.[97] Even if the systems are offered globally free of charge, a lower standard of liability should not be adopted simply because there is a lack of user charges. This means that the signal provider should not be exempt from any liabilities

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[96] See http://www.faa.gov.

[97] See S.A. Kaiser, *Legal Implications of Satellite Based Communication* (LL.M. Thesis, Montreal: Institute of Air and Space Law, McGill University, 1990) at 139.

caused by a malfunction of the system only because its navigation signal is provided for free.

A. Fault Liability

The fault-based system revolves around the practical difficulties of proving negligence, which is left to the victim who has already suffered from the damage. As new technologies continue to develop, it becomes increasingly difficult for either the government or the victim to show the exact cause of the accident, and it may even be impossible to prove whether the aircraft was destroyed in flight due to a GNSS fault. Even when it is possible to determine the cause, the complexities of aircraft technology and modern security equipment, as well as the confidential nature of much of the evidence,[98] result in great expense. Moreover, delays certainly occur when litigating the issue. In his thesis, S. Kaiser suggested that a fault liability system is perhaps a move backward and gives too much protection to the provider of the service, that is a State, an international organization or even a private entity.[99]

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[98] See I. Lagarrigue, *ATC Liability and the Perspective of the Global GNSS (Is an International Convention Viable?)* (LL.M. Thesis, Montreal: Institute of Air and Space Law, McGill University, 1994) at 72.

[99] See Kaiser, *supra* note 97 at 241.

B. Strict Liability

One may pose the question whether strict liability should be applied to satellite navigation systems in the same way as has been introduced to Air Traffic Services (ATS) satellite communications.[100] It is believed that a strict liability regime would alleviate the problems caused by a fault liability regime since a strict liability regime would shorten the litigation period and reduce the costs of proof. Moreover, no victim would be left without compensation as long as he or she did not contribute to his or her own injury since an award under the strict liability regime is automatically based only on the causal link between the "accident" and the "injury". For all the above-mentioned reasons, a strict liability regime would be appropriate for GNSS if one is needed. Unfortunately, it would not be easy to achieve an international consensus on the definition of "accident" attributed to the GNSS signal providers. GNSS providers would, therefore, have valid objections regarding this strict liability regime if they were to be placed in the position of "global insurers" for services provided by them free of charge and to an unlimited number of "users".

The service providers and even SITA (Societé Internationale de Telecommunication Aerienne), who might become a service provider in the near future, do not agree with such a strict liability regime. They are in favour of a fault liability system since they claim that failures or malfunctions of navigational satellites to provide the service will not occur. In other words, because the system is accurate and precise, the users already have enough guarantees while using it. Hence, the provider should not have to rely on a strict liability regime, in which fault needs not be proven.

The liability issues are complex, especially where the best system needs to be chosen for a very new technology for which everyone still has little experience. Compared to Air Traffic Services liability, which is still governed by national law, it is theoretically too complicated to specify a liability regime for GNSS since it is only a type of navigation service. If the providers of GNSS signals are to be subject to a liability regime, either fault liability or strict liability, then the providers of the other navigation services should also be subject to the same liability regime.[101] Many questions still need to be answered in order to choose the most appropriate liability system to satisfy every party of this service, namely

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[100] The Air Traffic Services Communication satellites are communication aeronautical satellite, directly responsible for aviation safety. The information needs to be as reliable as possible since the user as well as his passengers cannot take counter-measures to avoid the danger of interruption or malfunction of ATS communication, but must rely blindly on the service. See Kaiser, *supra* note 97 at 108. It seems unfair to leave the burden of proof with the user and/or the passengers, who have suffered damage.

[101] See H. Addison, ***Consideration with Regard to Global Navigation Satellite Systems (G.N.S.S.) of the Establishment of a Legal Framework*** (LL.M. Thesis, Montreal: Institute of Air and Space Law, McGill University, 1996) at 100.

the regime which can protect the interests of the victim as well as the service providers.

C. Limitation of Liability

The question of whether liability should be based on fault or strictly imposed is not the only issue which needs to be answered. Another equally important question is whether liability should be limited or unlimited.[102] Limited liability seems to be a good choice for GNSS providers because they will know in advance the exact amount to be awarded.[103] However, several obstacles are apparent with respect to this liability regime: no one can tell the total number of aircraft using the services or even the number of people in each aircraft. This regime also benefits the consumer, since he will know in advance the sum he or she may be awarded in the case of an accident and can, therefore, decide for himself if he wants to incur the extra expense of private insurance.

On the other hand, one might be in favour of unlimited liability according to the better protection of the interests of the victim. Certainly, the signal provider will never like unlimited liability, especially since they have already paid a large amount of money to develop the system and have offered the service free of charge, as is the case for the US. However,

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[102] See Largarrigue, *supra* note 98 at 76.

this is not a direct legal problem: It is actually a problem of a political and economic nature since the value of human life in each country is not based on the same standard. More work and discussions at the international level need to be completed before a consensus for this regime can be reached.

II. The Obstacles to Having an International Convention on GNSS Liability (Compared to ATC Liability)

Liability of Air Traffic Control (ATC) is a complicated long-term issue. This has been proven by the sustained efforts to draft and bring into force an International Convention on ATC Liability. Even after several years of deliberations within ICAO, the international community is still discussing different concerns related to this subject without result. Two distinct obstacles are discussed hereunder.

The first obstacle, one of the fundamental principles of International law, has been the cause of several problems for international communication and navigation. Article 1 of the Chicago Convention stipulates that "every State has complete and exclusive sovereignty over the air space above its territory".[104] If States ratify an ATC liability convention, they will automatically infringe upon part of their sovereignty. This provision is generally considered by States before ratifying any international

[103] The maximum ceiling is already established for the limited liability.

convention, but has been emphasized much more for international ATC liability since ATC is State-owned and operated in most countries. Thus, States have not ratified an ATC liability convention because they do not want to lose their control and immunity over ATC liability. Accordingly, the sovereignty principle has raised the question of how far States are willing to allow limitations on this sovereign competence to control ATC liability operations to and from their territory.[105]

Moreover, ATC laws also vary greatly from one country to another. There is no guarantee of uniformity even in countries which share the same legal regime. They may have enacted different laws or they may apply the same law differently. A consensus on the sovereignty principle and its limitations is thus necessary on the multilateral level. However, the sovereignty principle has a very important impact on the progress of discussions. Even though some States have already planned to relax their sovereign control with regard to the agreed principles and procedures, the majority of States are still hesitant to take the final steps necessary. In conclusion, the sovereignty principle has been considered to be an enormous barrier to the drafting of an international convention on ATC liability.[106]

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[104] See *Chicago Convention, supra* note 7, art. 1.

[105] See Lagarrigue, *supra* note 98 at 41.

At the economic level, an unequal opportunity of air transport in each State causes varying national perspectives concerning how international ATC liability should be developed. This second obstacle is actually not a legal issue, but rather an economic or political problem which has an important impact on the international legal regime. At present, the world is too heterogeneous to legislate on a matter such as ATC liability. A multilateral agreement on liability would need to take into account the economic status and the complexity of aviation interests of all States since a regulatory system based on the interests of a few States could never fulfil the obligations of a multilateral agreement.

These two obstacles, as mentioned above, testify as to the enormity of the task of drafting an international convention on ATC liability. Since satellite technology has become the basis of the air navigation system of the future, it might be possible to draft an international convention in the field of CNS/ATM liability, especially the liability of GNSS providers. Past efforts, which have demonstrated the long-lasting and futile process of drafting an ATC liability convention, could help the GNSS working group to develop other possible instruments.

Nevertheless, a convention should be drafted only if and when a conflict arises. Since traditional sovereign immunity protects governments at all

[106] See J.D. Gunther, *ICAO and the Multilateral Regulation of International Air Transport* (LL.M. Thesis, Montreal: Institute of Air and Space Law, McGill University, 1986) at 9.

levels from legal action, including actions based on tort principles, a sovereign government cannot be sued by one of its subjects unless it consents to the suit.[107] Practically speaking, international cases involving foreign parties, which have been caused by the Air Traffic Control or GNSS and have an "international claimant", are rare.

However, the importance of international air traffic and its continual dependence on ATC services should not be avoided since it is probable that any cases resulting from accidents will be pursued by the foreign parties involved. Although at this point in time few cases have been brought forward, one case which deals with ATC liability is that of *Eastern Airlines, Inc.* v. *Union Trust Co.*,[108] which involves an American carrier and a Bolivian military aircraft. On 27 May 1994, a Northwest aircraft 747-200 nearly collided with a Cathay Pacific 747-400 over the Pacific Ocean, after an air traffic controller put the two aircraft on a collision course, according to the Japanese authorities. Fortunately, they did not collide due to the traffic alert and avoidance system (TCAS).[109] The US government was held liable for the negligence of its ATC agency for damages of $1 million, but damages were not awarded. This incident is a good illustration of the possibility of accidents caused by ATC negligence. It also raises the question of which liability regime should

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[107] See Lagarrigue, *supra* note 98 at 9.

[108] See *Eastern Airlines, Inc.* v. *Union Trust Co.*, 221 F.2d 62 (D.C. 1955).

[109] See Lagarrigue, *supra* note 98 at 9.

have been applied if an accident had occurred. However, to have an international convention on ATC liability, there should be a real need, not only a "hypothetical" situation. This means that conflicts must actually occur where no existing legal regime is applicable. According to current practical considerations, civil aviation can be regulated without an international convention on ATC liability. In the case where such a convention is to be adopted, there should be a consensus by all States since it would be worthless if only some States were parties to it.

III. Could the Space Liability Convention of 1972 be Applied to a Failure of GNSS?

So far, there is no international law regime that specifically governs the liability aspects of a satellite navigation system. There has been some academic debate as to whether or not the Space Liability Convention of 1972[110] is applicable to a failure of the service provided by one of those satellites which affects air transport.[111] The 1972 Liability Convention elaborates on the liability provisions of the Outer Space Treaty. Articles II and III provide:

> A launching State shall be absolutely liable to pay compensation for damage caused by its space object on the surface of the earth or to aircraft in flight.

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[110] See *Convention on International Liability for Damage Caused by Space Objects* 29 March 1972, 961 U.N.T.S. 187, 24 U.S.T. 2389, T.I.A.S. No. 7762 [hereinafter *Liability Convention*] (entered into force on 1 September 1972).

[111] See K.K. Spradling, "The International Liability Ramifications of the U.S. NAVSTAR Global Positioning System" (1990) 33 Colloquium 90 at 93.

> In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible.[112]

The regime of liability under this Convention depends on where the space object inflicts the damage. If the damage occurs on the ground or to an aircraft in flight, the launching State will be held liable. If the damage occurs in outer space or to another spacecraft in flight, liability exists if the launching State is negligent based on principles of fault. The above-cited provisions clearly create a regime of liability based on the site of the damage, but the Convention itself has never been specific on the type of damages recoverable. The real question concerning the application of the Liability Convention of 1972 as it relates to GNSS is whether or not the provisions of this Convention also apply to the damages where the physical impact of a space object is not directly responsible.

Nevertheless, there is an international consensus that "damage" caused under this Convention is limited to physical damage only because

> The term 'damage' in the Liability Convention means loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations.[113]

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[112] *Liability Convention*, *supra* note 110, arts. II & III.

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.[114]

According to the definitions provided in Article I of the Liability Convention, the US could be considered as "a launching State" and the GPS satellite constellation as "space objects" with respect to GPS-provided services.[115] Therefore, if, when launching a space object such as a replacement satellite in the constellation, the rocket goes in the wrong direction and crashes, causing property damage, the provisions of the Convention should hold the launching State liable. Correspondingly, if the rocket negligently strays from its projected flight path and collides with an orbiting communications satellite, the Convention could also hold the launching State liable.[116] These are direct damages as mentioned in the definition of damage included in Article I of the Convention.

On the other hand, the Convention is unlikely to apply in cases where the damage arises, not directly because of the physical impact of a space

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[113] R. Jakhu, "International Regulation of Satellite Telecommunications", Space Law Applications, Course Materials (Montreal: Institute of Air and Space Law, McGill University, 1995) 75 at 79.

[114] See *ibid.*

[115] *Liability Convention*, *supra* note 110, art. I(d) defines "space object" to include "component parts of a space object as well as its launch vehicle and parts thereof."

object, but indirectly because a space object, such as a GPS satellite, may have transmitted an erroneous or improper navigation signal causing an aircraft accident.[117]

At the national level, the subject of indirect damages has been raised in the context of electronic interference from an orbiting satellite in Congressional documents prepared for ratification hearings before the US Senate. The Senate indicated that liability for space activities did not include recovery for non-physical damages, and that the US position before the United Nations, stated as early as 1971, was that indirect damages were not covered by the Liability Convention.[118] Moreover, the terms of the letter of ICAO[119] and other US official pronouncements apparently show that the US has offered GPS to the international community on a *volenti non fit injuria basis;*[120] this intention has been tacitly recognized by other Contracting States.[121] We could say that neither the language of the Convention, the negotiations leading to its

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[116] See J.A. Rockwell, *Liability of the United States Arising out of the Civilian Use of the Global Positioning System* (LL.M. Thesis, Montreal: Institute of Air and Space Law, McGill University, 1996) at 116.

[117] See *ibid.*

[118] See Spradling, *supra* note 111 at 98.

[119] See Letter quoted in *supra* note 59.

[120] These Latin words mean that the volunteer suffers no wrong; no legal wrong is done to the person who consents. In tort law, it refers to the fact that one cannot usually claim damages when one consented to the action that caused the damages.

[121] See Addison, *supra* note 101 at 96.

passage, nor State practice would support a claim for damages sustained in the context of an alleged negligently-provided GPS signal.

In addition, there are other aspects of the Space Liability Convention concerning the damages issue that may limit its useful application. For example, the condition that claims made under this Convention must be filed by the individual's State through diplomatic channels. In this case, even if a claimant can convince his government to pursue a claim on his behalf under the Convention's claim procedure, there is no guarantee that he will ever be compensated. Furthermore, if the State is not bound by the Commission's recommendations, a claimant could conceivably wait for many years to have his claim processed.[122]

In conclusion, damages caused by GNSS failure or any failure and/or malfunction caused by navigation and communication satellites are considered "non-physical damages". Hence, they should not be taken into account by the 1972 Liability Convention. One possibility is to amend the Liability Convention to explicitly enforce the aforementioned damages.

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[122] See Spradling, *supra* note 111 at 98.

IV. Potential Dangers for the Existing GNSS Operations

The present structure of GNSS for aeronautical use relies on GPS and GLONASS and, as mentioned in Chapter 1, the accuracy, integrity, and availability of these systems all need to be enhanced in order to be suitable for aeronautical use. It is already apparent that some of the augmented programmes, such as EGNOS, could be easily interfered with, resulting in signal failure. For example, it is claimed that the functioning of the EGNOS system is currently being endangered by various activities related to mobile satellite services.[123]

The most recent threat to the EGNOS/GNSS system is the perspective of harmful interference, especially with regard to GLONASS, stemming from planned mobile phone services.[124] During the past decade, Low Earth Orbit Mobile Satellite Services (LEO MSS) have been introduced through several large joint ventures.[125] They are primarily designed to deliver hand-held and vehicular telephone services worldwide. The 1992 ITU World Administrative Radio Conference (WARC) allocated several portions of the frequency spectrum to LEO satellites, some of which are

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[123] See H.Hauzen, "Aviation, Telecommunications, and Frequencies: Will LEO Satellite Services Obstruct Planned GNSS?" (1997) XXII:3 Air & Sp. L. 114 at 117.

[124] See *ibid.*

[125] The first MSS project presented was Iridium, led by Motorola, whose frequency band is not expected to interfere with GNSS operations. Another resembling project which frequency band is closer to GLONASS is Globalstar, which is planned by a joint venture of several leading aerospace manufacturers and telecommunications companies. See Rockwell, *supra* note 116 at 116.

close to frequencies allocated to satellite navigation services.[126] Unfortunately, these allocations are binding and not easily reversible.

Because the frequency bands assigned to the MSS projects are adjacent to GLONASS frequencies, there is a considerable risk of harmful interference stemming from MSS earth stations, unless the allowed emission levels of those stations are set very low.[127] The only possible way to remedy this situation is to have very strict standards applicable to MSS earth stations with respect to emissions outside their assigned frequency bands.

However, the aforementioned problem proves that the existing GNSS is not as reliable as we have been led to believe, as an accident might stem from the cause mentioned above. The passengers or users who suffer from damages arising from such services should be compensated in a just and equitable manner.[128] Therefore, the liability problem should be solved before GNSS becomes the sole means of navigation. In other words, "the duty of care of each provider in the GNSS system should be fully

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[126] See *ibid.*

[127] See *ibid* at 119.

[128] ICAO, *Report of the Meeting of the Working Group on GNSS Framework Provisions*, LTEP/2-WP/3 (Montreal, 6-10 October 1997) at 2-2, para. 2:10 [hereinafter LTEP/2].

acknowledged, and should not be weakened by a transfer of liability to other parties."[129]

V. Liability Regime on the Existing Systems

As mentioned earlier in this Chapter, there has been no international law regime adopted to specifically govern the liability aspects of satellite navigation, although liability is considered to be one of the central issues of legal theory and practice. Questions concerning liability have been raised repeatedly within the FANS Committee at the 10th Air Navigation Conference, the ICAO Legal Committee, etc. This issue was also put on the agenda of the Meeting of Panel of Legal Technical Experts on the Establishment of a Legal Framework with Regard to GNSS (LTEP) held in Montreal from 6 to 10 October 1997.

Some spokesmen, especially the current service providers, have expressed the opinion that providers should not be liable in any case since the high quality of the systems should be enough of a guarantee for all users. On the other hand, not everyone agrees since it has already been shown that interference by outside influences, such as the signals with respect to mobile phones for worldwide service,[130] could easily affect the system.[131]

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[129] *Ibid.*

[130] See Chapter 3-IV, above at 42.

[131] See *ibid.*

To ensure the highest degree of safety for the international civil aviation community, the US and the Russian Federation, as the current service providers, should definitely be responsible for any damage caused by the failure of the system or interference, even though such damage is extremely unlikely. However, "interference" should not include any impact or interference from "outside" elements taking place which are not the providers' fault and are beyond their control. Nevertheless, this will probably never happen since any States bringing an international law claim for compensation against the US in respect of GPS could never rebut defences of assumption of risk and estoppel.[132] In addition, GPS is provided as a public utility free of charge and the US will not know who is using or misusing the system. The US is in no way obligated to provide the signal as offered in the unilateral statement[133] (this is also the case for the Russian Federation in respect of GLONASS).

In addition, GNSS is only a navigational aid and, thus, should not be treated differently in any respect from the other existing navigational aids.[134] The US has clarified its position concerning the liability issue of GPS on the same basis as other navigation aids:

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[132] See Addison, *supra* note 101 at 96.

[133] See Letter quoted in *supra* note 59.

[134] Some of the existing navigational aids are VOR/DME, LORAN-C, OMEGA, INS, etc.

> As regards the question of Liability ... the Representative of the United States indicated that it is his Government's position that the GPS 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.[135]

It is also clearly recorded that both the providers of GPS and GLONASS have rejected the idea of any reference to "responsibility and liability" in a legal instrument.[136]

During its first meeting of the Panel, the LTEP agreed that it was premature to attempt to devise a legal framework for GNSS in general, or to develop a specific regime governing liability in particular.[137] G.R. Baccelli, the Italian representative at this meeting, expressed the view that the issue of liability had not yet been fully explored and that further studies would be necessary.[138] He also stated that if there were to be any possible solutions regarding the legal framework of GNSS, they should be flexible in order to accommodate the technical developments of the system.

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[135] Doc.9645 – c/1114, C-Min.143/7, at 63-64, para. 25.

[136] ICAO, *Legal Committee 29th Session*, ICAO Doc. 9630-LC/189 (1994) at 3-7, para. 3:38:7.2 [hereinafter *29th Session*].

[137] See LTEP/2, WP/3, *supra* note 128 at 2-1, para. 2:7.

[138] See *ibid.*, para. 2:6.

CHAPTER 4

CERTIFICATION OF GNSS

I. Introductory Remarks

Certification is an adjudicatory process whereby a government makes a determination of eligibility based upon a factual presentation by the applicant.[139] Each year the government issues a large number of certificates which authorize private persons to manufacture products, such as aircraft, automobiles, drugs, etc., and to perform a host of other activities, such as operating banks and hospitals. "GNSS, like other air navigation facilities, requires certification by the relevant authorities to ensure that it complies with navigation performance criteria related to civil aviation safety."[140] In other words, certification exists as another instrument to assure the safety of all consumers, or at least to ensure that compensation will be paid to the consumers should an accident occur.

However, the current air navigation systems, which are owned by one State or a group of States, have been operating radio-navigation aids internationally without a formal multilateral legal framework. The Loran-C[141] and Omega[142] systems are good examples in this respect. Both of

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[139] See M.A. Dombroff, "Certification and Inspection: An Overview of Government Liability" (1981-82) 47 J. Air L. & Com. 229 at 231.

[140] J. Huang, "Development of the Long-term Legal Framework for the Global Navigation Satellite System" (1997) XXII:I Ann. Air & Sp. L. 585 at 593.

them are radio-navigation systems which were initially developed for US military purposes but have, over time, evolved into systems predominantly used by both domestic and international civil users. Accordingly, Loran-C and Omega, and GPS, which is *de facto* GNSS, share a number of characteristics.

The US, as the owner State, has entered into international agreements of a bilateral and multilateral nature with several States according to the operating of Loran-C chains and the wave transmitting stations of Omega worldwide. However, these are operational agreements relating to costs, cost sharing, and the division of responsibility. They do not deal with any legal or institutional matters.

In other words, Loran-C and Omega have never been subject to any formal agreements concerning the certification process. The question has been raised whether the GNSS should be organized in the same manner.

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[141] Loran-C (Long Range Navigation) works by measuring 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.

[142] Omega is a Very Low Frequency (VLF) 10.2-13.6 kHz hyperbolic radio-navigation system, comprising of eight continuous wave transmitting stations situated throughout the world (Norway, Liberia, North Dagota, Hawaii, La Reunion Island, Argentina, Australia and Japan).

II. Consideration with Regard to Article 33 of the Chicago Convention

Article 33 of the Chicago Convention deals with the certification of airworthiness of the aircraft issued by the government of each State. The question, whether Article 33 of the Chicago Convention could be applicable to the certification of GNSS, was raised during the Second Meeting of the LTEP.[143]

ICAO's provisions on aviation safety and more particularly on the certification and inspection process can be found in Annex 8 of the Chicago Convention. It establishes the international standards with respect to the "Airworthiness of Aircraft". Section 2.2 of Part Two of this Annex provides:

> A Contracting State shall not issue or render valid a Certificate of Airworthiness for which it intends to claim recognition pursuant to Article 33 of the Convention on International Civil Aviation, unless the aircraft complies with a comprehensive and detailed national airworthiness code established for that class of aircraft by the State of Registry or by any other Contracting State. This national code shall be such that compliance with it will ensure compliance with:
> a) the Standards of Part II; and
> b) where applicable, with the Standards of Part III or Part IV of this Annex.
> Where the design features of a particular aircraft render any of the Standards in Part III or Part IV inapplicable or inadequate, variations therefrom that are considered by the State of Registry to five at least an equivalent level of safety may be made.[144]

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[143] See LTEP/2, WP/4, *supra* note 128 at 1 & 2-1, para. 1:2.

It is well established that the Chicago Convention does not affect the legislative sovereignty of each Contracting Party. However, each Contracting Party must consider the provisions of this Convention for the adoption of the legal framework for its civil aviation in order to assure that international civil aviation is developed in a safe and orderly manner. In other words, international air transport should be established on the basis of equality of opportunity and operated in an organized and cost-effective way.

In addition, since Article 33 of the Chicago Convention places the burden on the State of Registry to recognize and render valid an airworthiness certificate issued by another Contracting State,[145] this provision also helps to facilitate the import and export of aircraft, the exchange of aircraft for lease, charter or interchange, and the operations of aircraft in international air navigation. However, the airworthiness certificate, as mentioned above, must be equal to or above the minimum standards which are established periodically by ICAO pursuant to the Convention.[146] For all the aforementioned reasons, it may be concluded that Article 33 of the Chicago Convention makes the government of each State responsible for the certification of aircraft, thereby ensuring the airworthiness of commercial aircraft.

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[144] *Chicago Convention*, *supra* note 7, ann.8, "Airworthiness of Aircraft".

[145] See *Chicago Convention*, *supra* note 7, art. 33.

GNSS is a new technology, which will be used to improve the standards of navigation. Moreover, GNSS should rely on more than one system to make the signal accurate and reliable.[147] For example, the GPS signal has to be augmented by Inmarsat-III to meet the RNP requirements. Certification for GNSS thus requires more complex details than aircraft to ensure the highest level of aviation safety possible. The Secretariat took the view that "Article 33 only [applies] to certificates of airworthiness and certificates of competency and licenses, while certification of GNSS may involve a much larger scope than the terms of Article 33".[148] As for the authorization of the use of GNSS, it might be possible to hold those granting the authorization to be somewhat responsible for liability.[149]

In conclusion, Article 33 of the Chicago Convention stipulates that the government of each State is obliged to comply with the minimum standards established periodically by ICAO in respect of certificates of airworthiness and certificates of competency and licenses. It is "not" a legal basis for any processes of certification of GNSS under international law. Nevertheless, one expert suggested at the Second Meeting of the

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[146] "The Convention on International Civil Aviation, 'Annex 1 to 18... the first 46 years'" (1991) ICAO Bulletin 1 at 14.

[147] See Chapter 1-IV, above.

[148] LTEP 2, WP/4, *supra* note 143 at 1 & 2-1, para. 1:2.

[149] See *ibid.*

LTEP that "the underlying rationale of Article 33 may by analogy be considered as a point of departure in the certification of GNSS".[150]

III. Certification of the Existing GNSS

According to the Introductory Remarks in this chapter, certification is an instrument used by the government to standardize specific kinds of products and services in order to ensure public safety. Air navigation systems are a kind of service relating directly to public safety that have never been certified; this is also the case for GNSS at present. The Rapporteur of the Legal Committee recommended the following conditions of certification:

> 1) the GNSS provider would accept an obligation to make available the services on a universally acceptable basis without discrimination;
> 2) services would be available on a continuous basis;
> 3) the services must ensure satisfactory navigation performance criteria including integrity, fault-warning, reliability, continuity and accuracy for the different phases of flight, in accordance with ICAO standards;
> 4) the rights and responsibilities of States to control operation of aircraft and enforce safety operations within their sovereignty airspace must be recognized and must not be compromised as to the GNSS air borne and associated ground augmentation facilities which would be required to satisfy a particular level of operational service.[151]

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[150] LTEP/2-WP/4, *supra* note 143 at 1 & 2-1.

[151] ICAO, *Report of the Rapporteur on the Consideration, With Regard to Global Satellite Systems (GNSS), of the Establishment of a Legal Framework*, LC/29-WP/3-1 (3 March 1994).

Moreover, the certification issue has been dealt with by the LTEP at their meetings on several occasions. However, no consensus has yet been reached.

At the beginning of 1997, the LTEP's Working Group II requested that the Secretariat prepare a draft questionnaire[152] containing certain questions in order to clarify some legal issues related to the work of the Working Group. "Certification" is the first issue mentioned in the Questionnaire.[153] The first page of the Questionnaire indicates that details obtained will be used for further studies by the Working Group. Hence, they do not represent a commitment of any kind by the expert of the State nominating him/her. Although no consensus has been reached, the details from this Questionnaire might help to predict the future of the certification issue. There are five major areas, which are examined below.

A. The Elements of GNSS to be Certified at the National Level

Issuing certifications has been the duty of governments for a long time. The elements which need to be certified, as mentioned in the Questionnaire, are avionics, ground facilities, satellite components,

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[152] This Questionnaire was an informal survey. The draft questionnaire was discussed and revised during the informal meeting held on 20 June 1997 and was distributed on 27 June 1997. See ICAO, *Report of the Meeting of the Working Group on GNSS Framework Provisions*, LTEP-WG/II(2)–WP/2 (14 August 1997), app. C.

[153] This Questionnaire included several issues which are certification, liability, administration, financing, and cost recovery as well as future operating structure of GNSS. See *ibid.*

signal-in-space, the whole system, and the human interface. The majority of the replies received indicate that avionics, ground facilities, and human interface should be certified at the national level.[154] However, in the opinion of some experts, there are additional elements not mentioned above which should also be certified. These include augmentation systems, IFR (International Frequency Registration) operations, operational approval, flight manuals, etc. Contracting States might have differing opinions about which elements should be certified, but all of them revolve around aviation safety.

In addition, the majority of States also agree that ICAO's SARPs should cover the certification of all of the elements mentioned above. It is important that all governments abide by the SARPs in order to keep the systems standardized, especially since GNSS might become the sole means of navigation in the near future. The only shortcoming of the SARPs is that they are not legally binding. Hence, they will never work without the co-operation of the governments of all the States.

B. Information about the Failure Modes

Being well-informed is of the utmost importance when States need to deal with a new technology such as GNSS. They cannot make clear decisions without knowing the advantages and disadvantages of such technologies.

From this Questionnaire, an overwhelming majority does not believe that their States have the necessary information if called upon to certify the signal-in-space furnished by the existing providers.[155] They also indicate that they need to know the failure modes of each component of GNSS for the purpose of certification. Moreover, this information is not only important as concerns the certification issue, but is also necessary for the purposes of authorization of the use of GNSS signals.

Hence, it is generally believed that additional information needs to be obtained through both multilateral arrangements, such as through ICAO, and through bilateral arrangements by the providers of the signal-in-space. Moreover, the information should also be available elsewhere, such as on the Internet, so that it is readily available to all who require it.

C. Definition of "Certification" and the Need to Distinguish "Certification" of GNSS from "Authorization" for the Use of GNSS

Defining "certification" is a technical matter that needs to be accomplished at the international level so that each State can develop its legal framework according to the same standards. Accordingly, this particular issue must confirm worldwide to the given criteria.

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[154] See *ibid.*, para. 2.1.1.

[155] See *ibid.*, para. 2.1.2.

At the same time, distinguishing "certification" of GNSS from "authorization" of the use of GNSS is considered to be a policy matter. Any decisions dealing with this policy matter should be left to the States themselves and should be based on their own national policy considerations. In addition, other factors, such as financial considerations, may influence the decision to authorize the use of GNSS. Therefore, it could be concluded that the Working Group may wish to provide definitions for these areas as well as such related concepts as "approval" and "validation", and may delimit the areas of responsibility among the various parties.

D. Exchange of Information

The survey apparently shows that access to information is a crucial step in the process of certification. States which do not certify but authorize the use of GNSS also need certain information to satisfy themselves concerning the reliability of the system. Therefore, it is considered necessary to enable a user State to obtain detailed design and historical data from the owners and operators of the various GNSS components approved for use in its airspace for the purposes of, *inter alia*, accident investigation.[156] Regarding this issue, the predominant view seems to support an ICAO forum for information. In this respect, one observer has proposed the following functions of the forum:

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i. to liaise State ATS providers and regulatory authorities with GNSS signal-in-space providing authorities;
ii. to establish the risks (failure modes) that a GNSS signal-in-space can pose to the safety of air traffic services nationally, and to refer them to the SARPs development panel (GNSSP) for resolution;
iii. to establish what user States require from signal-in-space providers in order to be confident that performance and risks associated to the signal-in-space are adequately managed over the lifecycle of the system;
iv. to facilitate audit of GNSS signal-in-space providers by user States as required to maintain confidence in the reliability of the system.[157]

Nevertheless, the specific features of this forum and the category of information provided to this forum must still be agreed upon.

E. Compatibility with the Existing Certification Systems for the Current Air Navigation

Some experts indicate that the only reasonable way to approach the question of certification is to examine how the safety of systems for air navigation is certified today, and to determine the details of GNSS that would require modifications. In this respect, Loran-C and Omega, which are the air navigation systems currently used throughout the world, have never been subject to any "certification" process and there have never been any ICAO SARPs relating to them. Certification is, therefore, a new legal issue for air navigation.

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[156] See *ibid.*, para. 2.1.4.

[157] *Ibid.*

Thus, the conclusion that must be drawn from the Questionnaire is that avionics, facilities, and human interface should be certified at the national level. Moreover, the responsibility for certification of satellite components and of the system as a whole should devolve on the provider States or on international organizations, such as ICAO. In fact, States are not necessarily users themselves but they, rather, may authorize the use of the signal by others, particularly by aircraft operators. States, therefore, need adequate knowledge concerning the signals and the failure modes of system components in order to define safety regulations. Accordingly, the GNSS SARPs should contain adequate information concerning performance and failure modes of the signal-in-space and other components to enable a State to reasonably determine the impact of safety on its air traffic services.

CHAPTER 5

POSSIBILITY OF THE LEGAL SYSTEM FOR THE EXISTING GNSS

I. Current Applicable Law

Satellites are the most significant element of the GNSS and, thus, outer space will become very important to civil aviation in the future. This technical development will not only affect avionics but will also influence the structure and content of the legal regulation. Various fields of law will be considered when trying to find an appropriate approach to handle the legal problems arising as a consequence of the implementation of GNSS. GNSS challenges the current framework of air law, space law, and telecommunications law. As co-operative space ventures among the States have been increasing, the international legal community has had to co-ordinate more legislative attempts to cope with this new environment in order to prevent legal conflicts among States. Moreover, the commercial utilization of outer space with respect to civil aviation is expected to grow rapidly. Hence, improvements to the current international air law, space law, and telecommunications law are also essential in order to guarantee that such activities are conducted in a just and orderly manner. Apparently, a specific legal regime must be established to govern GNSS. However, the existing legal instruments must be examined before developing a new legal regime.

A. International Air Law

The objective of the legal regime is to ensure the safe and efficient development of modern international civil aviation. For the purposes of regulation, both economic and technical aspects are important.[158] However, the Chicago Convention, as the major treaty, regulates many technical areas of international civil aviation, but deals only marginally with the economic aspects.

The technical areas of aviation consist of the provision of facilities and services to establish meteorological conditions, the establishment of radio contact, the determination of aircraft position, and certification of aircraft and flight personnel.[159] The scope of the Chicago Convention itself covers general regulatory guidelines and rules dealing with aviation. For example, Article 6 of the Convention stipulates that air transport services can be operated into, across and within the territory of a State only with its consent and that facilities provided by the State can be utilized by aircraft registered by other States only with the consent of the State concerned. In addition, Article 28 recognizes that air navigation facilities and systems need to be provided. Accordingly, the responsibility to make provision for the required facilities and services at airports and at other places as may be needed has been placed on each State. Other standards

[158] See B.D.K. Henaku, "The ICAO CNS/ATM System: New King, New Law?" (1994) XIX:3 Air & Sp. L. 146 at 148 [hereinafter "New King, New Law"].

and procedures dealing with air navigation facilities and services have been adopted by ICAO and are contained in the Annexes to this Convention.

However, the Chicago Convention does not address the very important liability issue. Many questions have been raised with respect to damage caused by a space object to an aircraft in flight and consequently to passengers on-board that aircraft, as well as to victims on the surface of the Earth.[160] The matter of liability is addressed in the Warsaw Convention,[161] which seeks to ensure that victims who have suffered from such damage are compensated. However, it is important to note that the Warsaw Convention applies only to the field of private air transport law, based on the contract of carriage (ticket). The Liability Convention would seem paramount, but it refers only to public law responsibility of States for "physical impact" damage. It has nothing to do with damages caused by any interference or failure of GNSS.

In addition, the Chicago Convention is intended to establish the highest practicable degree of uniformity of regulations in order to ensure safe, regular, and efficient air navigation. Unfortunately, the new technology

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[159] See *ibid.*

[160] See B.D.K. Henaku, "The International Liability of the GNSS Space Segment Provider" (1996) XXI:1 Ann. Air & Sp. L. 143 at 154 [hereinafter "International Liability"].

used for navigation systems has brought aviation beyond the scope of the conventions. According to the use of space technology, particularly satellites, and discussions concerning the liability issue, it is clear that civil aviation requires changes to the current international air law that will remove any restrictions impeding the introduction of modern technology. For example, a clear GNSS liability regime for the signal providers should be established before GNSS is introduced into practice. Others argue that the introduction of GNSS into practical application does not have to be deployed pending the adoption of a legal framework.[162]

B. Space Law

The exploration and use of outer space has been regulated since the first launching of satellites in 1957. All the regulations[163] have the same basic features – they represent treaty law in the form of multilateral instruments ratified by a relatively small number of States. They recognize that outer space is the "province of mankind" and is free to be explored and used by

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[161] See *Convention for the Unification of Certain Rules Relating to International Carriage by Air*, 12 October 1929, 137 L.N.T.S. 11, 49 Stat. 3000, TS No. 876, ICAO Doc. 7838 [hereinafter *Warsaw Convention*].

[162] See, e.g., Milde, *supra* note 4 at 7.

[163] Space law consists of *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies*, 27 January 1967, 610 U.N.T.S. 205, 18 U.S.T. 2410, T.I.A.S. No. 6347, 6 I.L.M. 386 [hereinafter *Outer Space Treaty*]; *Agreement on the Rescue of Astronauts, the Return of Objects Launched Into Outer Space*, 22 April 1968, 672 U.N.T.S. 119, 19 U.S.T. 7570, T.I.A.S. No. 6599, 7 I.L.M. 151 [hereinafter *Rescue Agreement*]; *Convention on the International Liability for Damage Caused by Space Objects*, 29 March 1972, 961 U.N.T.S. 187, 24 U.S.T. 2389, T.I.A.S. No. 7762 [hereinafter *Liability Convention*] (entered into force 1 September 1972); *Convention on Registration of Objects Launched Into Outer Space*, 14 January 1975, 1023 U.N.T.S. 15, 28 U.S.T. 695, T.I.A.S. No. 8480, 14 I.L.M. 43 [hereinafter *Registration Convention*] (entered into force 15 September

all States. According to Articles II and III of the Outer Space Treaty, the freedom to explore and to use outer space is, however, conditional on the operation being in accordance with international law and that realm not being subjected to national appropriation by a claim of sovereignty.[164] Although the exercise of sovereign appropriating powers in outer space is prohibited, equality, as a fundamental attribute of each State, is still recognized as stated in Article I of the Outer Space Treaty. This equality is, however, exercised on the basis that the prohibition of discrimination must be assumed as a necessary condition to the freedom of exploration and usage.[165] In addition, States always remain responsible and liable for any space activity carried out by either their governments or by their private enterprises.

All these general principles are contained in the Outer Space Treaty, which is the principal agreement governing all the activities taking place in outer space. It is, however, admitted that not all space activities are, as yet, the subject of detailed legal principles,[166] particularly since modern technology is evolving daily. The modern technology issue that has often been discussed is the international responsibility and liability arising from

1976); *Agreement Governing the Activities of States on the Moon and other Celestial bodies*, 5 December 1979, 1363 U.N.T.S. 3, 18 I.L.M. 1434 [hereinafter *Moon Agreement*] (entered into force 11 July 1984).

[164] See "New King, New Law", *supra* note 158 at 146.

[165] See *ibid*.

[166] See *ibid*.

the operation of satellites. Until now, it has been regulated by the Outer Space Treaty of 1967 and the Liability Convention of 1972.

In fact, the Liability Convention elaborates upon the principle contained in Article VII of the Outer Space Treaty. The Outer Space Treaty, which has crystallized into customary international law, is only binding on signatory States. Therefore, the principle stated in the Outer Space Treaty could be applicable to any damage that falls outside the scope of the Liability Convention.[167] However, apparently this means nothing since the Outer Space Treaty is very general and fairly vague in this regard. Accordingly, allowing modern technology to rely solely on the existing space law regime or any customary law rule will be fraught with difficulties. In conclusion, new technologies, such as satellite-based navigation, need to be governed by an appropriate legal regime. The characteristics of such new technologies, however, must be considered very carefully before determining a specific legal regime.

C. Telecommunications Law

Satellite communication is one of the activities that involves the use of outer space. This kind of communication exploits the benefits of outer space by using the orbit and the radio frequency spectrum. It has been considered as a way to extend the scope and capability of terrestrial communication. It works by transmitting and receiving information from one position to another on earth via a satellite. Since access to an orbital position and the related radio frequency depends on the co-operation of every State, satellite communication is regulated by the International Telecommunication Convention and the Radio Regulations of the International Telecommunication Union (ITU).[168] These legal instruments represent the institutionalization of the rules and rights concerning the co-operative use regime for both the orbit and the radio frequency spectrum.[169]

The orbit and the radio frequency spectrum are allocated to different services (such as aeronautics, space research, broadcasting) in the three ITU regions[170] through negotiation and co-operation by all States. Each national assignment or actual utilization of the radio frequency spectrum must be notified to the International Frequency Registration Board (IFRB). However, the spectrum and orbit should be used in such a manner as to guard against any harmful interference to its users, while allowing equitable access to subsequent users. It is important to note that ITU regulation is applicable only to members of the organization, but the legal

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[167] See "International Liability", *supra* note 160 at 143.

[168] See "New King, New Law", *supra* note 158 at 148.

[169] See Ghonaim, *supra* note 2 at 165.

[170] The three regions are Region 1- Africa, Europe, the Middle East, Mongolia and the former USSR; Region 2- The Americas, the Caribbean and Greenland; Region 3- Asia, and the Pacific Basin other than Hawaii.

regime created by the ITU has a wide scope according to the essential character of those resources managed by the organization.

The possibility for harmful interference to satellite navigation and communication has increased since the electromagnetic spectrum has become increasingly utilized. As emphasised by the ICAO FANS II Committee,[171] it is necessary to guarantee the capability of securing navigation signals and supporting communication signals from harmful interference. Therefore, even non-aviation users must comply with the critical conditions imposed by the safety requirements of the civil aviation community. However, the international telecommunication policy should keep up with the advances in technology and the evolution of the telecommunications market[172] in order to prevent the possibility of interference and to ensure the safety of air navigation.

II. Compatibility with the Chicago Convention

The Chicago Convention is the result of a consensus reached by 52 States during the final year of World War II. This ninety-six article Convention came into force on 4 April 1947 and has been the backbone of the international regulation of civil aviation for more than half a century. At

[171] See FANS (II)/4, *supra* note 1, WP/82 at 4-17.

[172] See Ghonaim, *supra* note 2 at 183.

present, 185 States[173] worldwide have already become parties to this Convention. Each Contracting Party must consider the provisions of this Convention before adopting a legal framework for civil aviation in order to assure that the development of international aviation will be done in a safe and orderly fashion. This remarkable legal instrument has a "dual personality", namely it is a comprehensive codification of public international air law and a constitutional instrument of an international intergovernmental organization of universal character.[174] Any amendment to this Convention is considered to be significant since the technology and the economic situation of aviation is changing constantly. However, this legal instrument is not easy to amend.

Article 94 of this Convention specifically deals with the amendment of the Convention. It states that:

> (a) Any proposed to this Convention must be approved by a two-thirds vote of the Assembly and shall then come into force in respect of States which have ratified such amendment when ratified by the number of contracting States specified by the Assembly. The number so specified shall not be less than two-thirds of the total number of contracting States.
> (b) If in its opinion the amendment is of such a nature as to justify this course, the Assembly in its resolution recommending adoption may provide that any State which has not ratified within a specified period after the amendment has come into force shall thereupon cease to

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[173] See list in attachment to ICAO State Letter LE 3/2-97/5 dated 17 January 1997.

[174] See M. Milde, "The Chicago Convention – Are Major Amendments Necessary or Desirable 50 years later?" (1994) XIX:I Ann. Air & Sp. L. 401 at 403 [hereinafter "Chicago Convention"].

> be a member of the Organization and a party to the Convention.[175]

Consequently, any amendment to this Convention would enter into force only after ratification by no less than 124 Contracting States. However, the amendment still does not enter into force for all States once it is ratified by the prescribed constitutional majority. This is because the amendment does not have an *erga omnes* effect; it comes into force only for the States that have ratified such amendment. Theoretically, this method of amendment fully respects the sovereignty of States, which cannot be bound by an amendment unless they specifically ratify it. However, this process could be extremely slow and harmful: If certain amendments are in force for some States and not for others, the unity and homogeneity of the organization itself is jeopardized and the practical result is the disunification of law and the fragmentation of the organization into groups of States governed by different rules.[176] A good illustration from ICAO's experience already exists: The ICAO Assemblies have adopted thirteen amendments to the Chicago Convention since 1947, but only eight of them have come into force and none of them is in force for all of ICAO's Contracting States. This amendment process, which requires a two-thirds majority, could lead to absurd results according to the increasing number of Contracting States. The problem

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[175] *Chicago Convention*, *supra* note 7, art. 94.

[176] See "Chicago Convention", *supra* note 174 at 409.

arises whether it should be two-thirds of the current membership or not. In conclusion, amending the Chicago Convention is a time-consuming and difficult process. Hence, it is of utmost importance that GNSS should be compatible with the existing legal framework of the Convention.

In addition, according to Article 28 of the Chicago Convention, States have the duty to provide the air navigation facilities and services "in their territory" and "as far as practicable". They are not obliged to provide air navigation facilities and services beyond their territory under the Chicago Convention. At the time the Chicago Convention was drafted, no one even considered a system with complete global coverage, such as GNSS; the Convention remains silent about it. No State is compelled to provide a global type of service and no State is obliged to make use of such technology if it is available from whatever source as an aid to air navigation and air traffic control within the sovereign airspace.[177] ICAO's Legal Committee concluded that "there was no legal obstacle to the implementation and achievement of the CNS/ATM systems concept and that there was nothing inherent in the CNS/ATM systems concept which was inconsistent with the Chicago Convention".[178]

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[177] See Milde, *supra* note 4 at 4.

[178] See *29th Session*, *supra* note 136 at 3-1, para. 3:1.

III. Need for a New Convention on GNSS

A formal legal framework is needed to cope with GNSS based on the fact that the whole CNS/ATM concept will not be internationally acceptable unless one is provided.[179] In this case, the full global benefits of GNSS as the sole means of navigation will never be achieved. For example, commercial airlines would have to carry a multitude of separation and other avionics systems, from one Flight Information Region to another, to meet the requirements of individual States. Therefore, a formal legal framework seems to be the only way to convince all States to implement GNSS.

However, one might argue that a formal legal framework for GNSS is unnecessary when comparing it to the existing navigation systems, such as Loran-C and Omega. Both Loran-C and Omega are radio-navigation systems which were initially developed to provide US military users with greater navigation coverage and accuracy. Only later did they come to be used by both domestic and international civil users.

Loran-C is derived from the words "long range navigation". This system was developed during World War II. It works by measuring the difference in arrival times of pulses of radio frequency energy radiated by a chain of synchronized transmitters which are separated by hundreds of miles. So

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[179] See Addison, *supra* note 101 at 109.

far, the US has entered into international agreements of a bilateral and multilateral nature with several countries. It is important to mention that all the agreements in respect of Loran-C are totally "operational and logistical support agreements ... [consisting of] sections relating to costs, cost sharing, and division of responsibilities."[180] They only regulate technical matters; no essential legal issues are mentioned there.

The second system is Omega, which consists of eight continuous wave transmitting stations situated throughout the world. They are located in Norway, Liberia, North Dakota, Hawaii, La Reunion Island, Argentina, Australia, and Japan. Three of the eight stations are subsidized by the US, the rest by the host nations. Initially the Omega system was developed "to meet a Department of Defense (DOD) need for worldwide general en route navigation but has now evolved into a system used primarily by the civil community."[181] The US has entered into bilateral agreements with five of the nations hosting Omega transmitting stations. As is the case with Loran-C, these agreements deal only with technical matters.

Accordingly, both Omega and Loran-C are US military systems that have achieved widespread use and acceptability in the international civil

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[180] Statement of Mr. J. Beukers, Beaukers Technologies, "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 (28 July 1993) at 104.

aviation community. Technically speaking, the only difference between Loran-C and Omega and GPS is that the former are terrestrial-based radio-navigation systems that provide the position of the object in two dimensions while GPS is a space-based radio-navigation system that provides the position of the object in three dimensions. Despite this difference, all three are basically radio transmitters. Hence, they should all be treated in the same manner.

State practice in respect of Omega and Loran-C has proven that radio-navigation systems, which have an international character, can be operated successfully without the necessity for a formal multilateral legal framework.[182] In other words, they do not require regulation under international law. Additionally, it is difficult to adopt a legal framework for the existing GNSS while there are still a great number of varying political and economic influences among all nations. Therefore, it seems to be premature that ICAO has already prepared a Draft Agreement[183] between ICAO and the signal providers regarding the provision of signals for GNSS services since GNSS is still a novel element in the navigational area. Practically, it needs to gain much more experience before having a formal legal framework to cope with all the activities or any conflicts that

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[181] US plans for its infrastructure of radio-navigation systems is set out in the 1994 Federal Radio-navigation Plan, Published by Department of Defense and Department of Transportation, DOT-VNTSC-RSPA-95-1/DOD-4650.5 at A-10.

[182] See Addison, *supra* note 101 at 116.

[183] See *29th Session, supra* note 136 at 3-8, para. 3:38:10.

might take place from its performance. Moreover, ICAO as such has no constitutional competence to enter into an agreement with the signal providers.

CHAPTER 6

THE GNSS AND DEVELOPING COUNTRIES

I. Introductory Remarks

Article I of the Outer Space Treaty provides that outer space, including the Moon and other celestial bodies, shall be explored and used "for the benefit and in the interests of all countries, irrespective of their degree of economic and scientific development". This provision apparently implies the recognition of the special interests and needs of the developing countries in the exploration and utilization of outer space. It also demonstrates that developing countries have been playing an important role in the formulation and development of space law from the very beginning. Accordingly, this principle not only secures legal protection for developing countries but also safeguards their interests in the exploitation and utilization of outer space.[184]

However, the Outer Space Treaty has only established a "proper balance" of interests for the developing and the developed countries. It does not require an equal share of every advantage, profit or benefit accruing from the space activity of one State with others.[185] However, it does establish that all States have an equal right to explore and use outer space and that

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[184] See R.S. Jakhu, Developing Countries and the Fundamental Principles of International Space Law, S.S.H.R.C.C. Project on Space Activities and Emerging International Law, No. 13 (Montreal: Institute of Air & Space Law, 1981) at 11.

[185] See *ibid.*

such right must be exercised in a non-prejudicial way. Hence, developed countries are under a legal obligation not to hinder the exploitation and utilization of outer space by developing countries. Moreover, co-operation between developed and developing countries should be enhanced in order to narrow the gap, which is rapidly widening, between them.

Developing countries are generally unable to take advantage of international co-operative ventures due to a lack of financial resources. Hence, a program, such as a transfer of technology, should be actively developed so as to alleviate the dependence of developing countries on the developed world.

II. The Impact of GNSS on Developing Countries

The existing GNSS will be used by both developed and developing countries to overcome the limitations and shortcomings of the other navigation systems,[186] such as the limitations of voice communications and the propagation limitations of current line-of-sight terrestrial means. These new navigation systems, as introduced to the international civil aviation community, involve advanced satellite technology, which has been identified as the only technology capable of alleviating all the current shortcomings on a worldwide basis.

GNSS is able to provide worldwide coverage and could be used for aircraft navigation and for non-precision type approaches and, with the appropriate enhancements and differential corrections, for precision approaches and landings. This system brings many benefits to the international civil aviation community due to its potential to provide reliable, accurate and high integrity global coverage independently. Moreover, it could meet the navigation system requirements as the sole means of navigation for civil aviation. Both the US and the Russian Federation have also made the commitment to maintain these systems "on a continuous worldwide basis" and "on a non-discriminatory basis" to all users of civil aviation.[187] However, they will inform all users six years in advance if they decide to terminate their offers. Consequently, developing countries will benefit directly since both the US and the Russian Federation are offering the use of GPS and GLONASS to the international civil aviation community free of charge. They, therefore, share the benefits of outer space without incurring any major expenses concerning the satellite constellations. It seems impossible that developing countries would be able to initiate such navigation systems by themselves, due to the very high costs associated with such a venture. It costs about US $ 10 billion to set up a satellite constellation and an additional US $ 500 million per year to maintain the entire system.[188]

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[186] See "disadvantages of navigation systems", *supra* note 12.

[187] See "Exchanging of Letters", *supra* note 59.

[188] See Latham, *supra* note 83 at 20.

Most countries increasingly depend on the existing GNSS. They plan to discard the old navigation systems after the transition period and use GNSS as the sole means of navigation, since using GNSS and keeping the old systems at the same time will never help to reduce expenses in this area.

It is not only economic status that plays an important role in the policy of the US and the Russian Federation. Whether or not they will maintain GPS and GLONASS after the commitment period will also depend on their political situations, particularly for the Russian Federation, which has become politically unstable recently. In addition, once GPS becomes the sole means of navigation, the US might use their offer as a bargaining tool to negotiate for something else. Therefore, while enjoying the great benefits of these new systems, developing countries must consider the tremendous changes that might occur if the US and the Russian Federation cease to offer their services to the international civil aviation community in the future.

III. The Alternatives for Developing Countries

At present, developing countries have been enjoying the benefits of utilizing outer space for several activities, particularly the offering of the GPS and GLONASS to the international civil aviation free of charge for a period of time. (GPS for at least 10 years and GLONASS for at least 15 years, of which about two years have already elapsed.) However, a long-term guarantee has never been made to its users. Developing countries should find viable solutions to secure themselves if they decide to abolish their old navigation systems.

First of all, co-operation among all the developing countries needs to actively take place in order to augment their negotiation powers and their financial resources. A lone developing country will never have enough power, either in a political or economic sense, to bargain with developed countries such as the US or the Russian Federation. The two alternatives that should be kept in mind for all the developing countries, although they are unlikely to occur, are: (1) to adopt a Convention with the "service providers"; or (2) to develop a system of their own.

A. Developing a Formal Agreement with the Service Providers

An "exchange of letters" between the governments of the US and the Russian Federation and ICAO has been the only commitment thus far to ensure the continuity and quality of the existing GNSS.[189] These exchanges of letters act only an informal agreement between ICAO and the service providers since the ICAO Council and the Organization itself do not have any legal authority to enter into a formal agreement concerning GNSS. Therefore, attempting to adopt an international convention with the service providers seems to be the best alternative so as to secure the continuity and quality of the services, especially since the GNSS will probably become the sole means of navigation in the near future. However, the experience of the time-consuming and long-lasting efforts to draft and bring into force an international convention on ATC liability demonstrates the enormity of the task of developing such a convention. This experience should act as a valuable lesson for all the developing countries to attempt to avoid similar obstacles when formulating their own agreements.

B. Co-operating for a New System

The other alternative would be to develop their own system, which would operate independently from the monopoly or oligopoly influences of the current service providers. Theoretically, this alternative is the best approach, but is highly unlikely due to the lack of financial resources available to developing countries. It would only be possible to assemble such an enormous amount of money for a new system through co-operative efforts by all the developing countries.

Gathering all the developing countries together is, however, not as simple as it seems because these countries are not precisely defined and their concerns are of a broad and general nature. The general nature of their

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[189] See "Exchanging of Letters", *supra* note 59.

concerns can be attributed not only to their political, social, economic and cultural history, but also to differences in their foreign policies and national priorities.[190] Accordingly, it is difficult to reach a consensus on any of the demands or aspirations of developing countries.

In addition, aviation is and will remain a minority concern (2-5%) for GPS. It would not make economic sense to develop a separate system, whether by the developed or developing countries when such a small percentage of the current users of GPS are from the aviation community. In conclusion, it seems to be a better alternative to assure the continuity and quality of this particular service by reaching a formal agreement with the service providers. A consensus among the developing countries must be reached in order to enhance the countries' negotiating powers. Several problems concerning their foreign policies also need to be solved before negotiating with the US or the Russian Federation.

[190] See Jakhu, *supra* note 184 at 9.

CHAPTER 7

TRIALS AND IMPLEMENTATION PLAN OF THAILAND

I. General Information Concerning Thailand's Aviation

Civil aviation in Thailand has been developing since B.E. 2474 (1931), when the Aerial Transport Company of Siam Limited was established by the Thai government. The first Thai law relating to air navigation was introduced in B.E. 2465 (1922), namely the *Civil Aviation Act* of B.E. 2465 (1922).[191] Nevertheless, this *Act* was superseded by the *Civil Aviation Act* of B.E. 2480 (1937). Fifteen years later the *Civil Aviation Act* of B.E. 2495 (1952) was brought into force, replacing the former one.[192] The latter *Act* is the effective aviation law in Thailand at the moment.

Thailand possesses six international airports, including Bangkok, Chiang Mai, Hat Yai, Phuket, Utaphao, and Chiang Rai, as well as 22 domestic airports. The Second Bangkok International Airport project is predicted to be in operation in the year 2003 to provide service for 20 million passengers per year in the first phase, with a possible expansion of up to 100 million later.[193]

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[191] See T. Leepuangtham, *The Warsaw System: Why Thailand Should Become A Party* (LL.M. Thesis, Montreal: Institute of Air and Space Law, McGill University, 1993) at 67.

[192] See *ibid.*

[193] See *Thailand's CNS/ATM Trials and Implementation Plan*, 3rd ed. (21 October 1997) at 2 [hereinafter *Thailand's Implementation Plan*].

The organization responsible for providing air traffic services in Thailand is the Aeronautical Radio of Thailand, Ltd. (AEROTHAI). It furnishes services to aircraft flying within Thailand's airspace, which consists of the following areas:

1. Bangkok Flight Information Region (FIR) embracing the area of 413,366.40 square kilometres.
2. Area of Responsibility (AOR) in South China Sea, embracing the area of 42,596 square kilometres. This area is dedicated by Vietnam to AEROTHAI to provide air traffic control service to aircraft flying at the altitude of 24,500 feet and higher.
3. Upper Flight Information Region (UIR) over Cambodia's airspace, embracing the area of 100,008 square kilometres. This area is dedicated by Cambodia to AEROTHAI to provide air traffic control service to aircraft flying at the altitude of 19,500 feet and higher.[194]

Accordingly, Thailand provides air traffic services in the area of 555,970.40 km^2, which is approximately 0.1% of the global airspace.[195]

In addition, the national air carrier, Thai Airways International (THAI), flies to 54 destinations in 35 countries in 4 continents of the world. There are currently 76 airlines from 57 countries flying into Thailand. Thailand's CNS/ATM Trials and Implementation Plan states that "the number of international passengers at Bangkok International Airport in 1996 was 22.9 million, which is 9.5% more than the previous year".[196]

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[194] *Ibid.*

[195] See *ibid.*

[196] *Ibid.*

Accordingly, Thailand is a hub for South East Asian civil aviation activities.

II. Transition Period

Recently, the Ministry of Transport and Communications of Thailand realized the magnitude of using satellites for CNS/ATM, which has been developed expeditiously during the last few years. A CNS/ATM Implementation working group has been established in order to develop "Thailand's CNS/ATM Trial and Implementation Plan", which is based on two other plans. The first is the "Global Co-ordinated Plan for Transition to the ICAO CNS/ATM Systems",[197] adopted by ICAO FANS (Phase II) Committee in October 1993. Its objective is

> to develop a global co-ordinated plan, with appropriate guidelines for transition, including the necessary recommendations to ensure the progressive and orderly implementation of the ICAO global, future air navigation system in a timely and cost beneficial manner.[198]

The second is the Asia/Pacific Regional Implementation Plan for the New CNS/ATM Systems, which has been developed by the Asia/Pacific Air Navigation Planning and Implementation Regional Group (APANPIRG) since March 1994.[199] The objectives in developing this Plan are as follow:

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[197] FANS (II)/4, *supra* note 1 at 8-1.

[198] *Ibid*, para. 8.1.1.

1) To clearly identify the target dates for trials and demonstrations and implementation of various elements of the ICAO CNS/ATM system in order for all organizations concerned to progress in a co-ordinated and harmonized way.
2) To function as a benchmark for the evaluation of implementation progress.[200]

This Plan will be modified, as necessary, in the future, depending on changes to the current situations.

However, the ICAO FANS (Phase II) Committee has provided the following broad indication of how the transition plan might proceed:

1990-1997	Developments, trials, preoperational demonstrations (note overlap in time with below).
1993-2000	Gradual implementation and use of various elements of the system. Some aircraft and administration will use the CNS/ATM system with back up from the terrestrial system.
2000-2005	Full CNS/ATM services available in parallel with existing systems so that appropriately equipped aircraft could have operating credits solely on the CNS/ATM system.
2005-2010	The terrestrial system, not required for CNS/ATM, progressively dismantled.
2010-	CNS/ATM is the sole system.[201]

In general, Thailand should be able to provide a basic CNS/ATM system for use by suitably equipped aircraft by 1999. The large majority of aircraft will have to be fitted with the new systems by that time so as to allow the redundant parts of the terrestrial system to be dismantled after

[199] *Thailand's Implementation Plan, supra* note 193 at 1.

[200] *Ibid.*

[201] FANS(II)/4, see *supra* note 1 at 8A-45.

2010.[202] D. Lekhayananda, Senior Air Navigation Facilities Expert of Thailand, has mentioned that there will be no cost benefits taking place for Thai aviation unless the old systems are abolished.[203]

Therefore, the period of a parallel running of the two systems should be kept to the minimum possible in order to reduce costs.

III. Thailand's CNS/ATM Implementation Plan

A. Communication[204]

Currently, air-ground communications for ATS purposes are performed via VHF, when within range, and via HF when outside the VHF range. According to the Plan, air-ground communications will make use of all three modes of communications, which are VHF, AMSS, and SSR Mode S Data Link, to provide all four categories of services, namely ATS, AOC, AAC, and APC, as illustrated in the table below.

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[202] See *Thailand's Implementation Plan, supra* note 193 at 3.

[203] See Interview with D. Lekhayananda, Senior Air Navigation Facilities Expert, Department of Aviation (Thailand, 3 November 1997) [hereinafter *Interview*].

[204] Table of Communication System Implementation is shown in Appendix 1.

CATEGORY	VHF (voice and/or data)	AMSS (voice and/or data)	Mode S[205] (data only)
Air Traffic Services (ATS)	X	X	X
Aeronautical Operational Control (AOC)	X	X	
Aeronautical Administrative Communication (AAC)	X	X	
Aeronautical Public Correspondence (APC)[206]		X	

AMSS, as included in the above table, is accomplished via Inmarsat satellites. The Communications Authority of Thailand (CAT) has set up a ground earth station (GES), at Nonthaburi, to provide all four categories of communications on a worldwide basis. The aforementioned VHF and SSR Mode S Data Link will be operated by AEROTHAI. However, proper SSR Mode S Data Link operations will depend on the development of the technology in the future.

In addition, ATN Routers will be set up in both the air (by THAI) and on the ground (by AEROTHAI, CAT, and THAI) to establish air-ground and ground-ground networks. Accordingly, end users will be able to communicate amongst themselves effectively based an ISO/OSI reference

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[205] Depend on future technological development.

[206] Depend on future requirement.

model. However, "the AEEC (ARINC) 622 specification will be utilized in Thailand as an interim measure in the near future".[207]

B. Navigation[208]

At present, Thailand has already installed a complete network of radio navigation aids, namely NDB, VOR, DME, and ILS, to provide services to aircraft during all phases of flights.[209] However, these radio navigation aids have inherent operational limitations and will eventually be withdrawn.

In the Plan, GNSS, which is now being deployed through GPS and GLONASS satellites, will be used to navigate aircraft during the en route phase instead of using NDB, VOR, and DME.

Before GNSS, Thailand used ILS, which is a ground-based system, for approaches and landings. Usually, the next step in the advancement of technology is MLS. However, the new GNSS technology was introduced while Thailand was deciding whether or not to provide MLS.[210] Since the GNSS technology is apparently beneficial for navigating accurately, with

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[207] *Thailand's Implementation Plan*, *supra* note 193 at 5.

[208] Table of Navigation System Implementation is shown in Appendix 1.

[209] See *ibid.*

[210] *Interview*, *supra* note 203.

no cost for using the system, at least in the foreseeable future,[211] Thailand will adopt GNSS.

Currently, a majority of THAI aircraft have already been equipped with INS/IRS, VOR/DME, Radio Altimeter, ILS and FMS.[212] "THAI is planning to install GNSS and MLS avionics in the near future".[213] However, the old systems will be kept during the transition period for at least 10 years.[214]

C. Surveillance[215]

At present, AEROTHAI is operating four primary radars at Bangkok, Chiang Mai, Hat Yai, and Phuket International Airports and four Mono-Pulse Secondary Radars at Bangkok, Chiang Mai, Ubon Ratchathani and Surat Thani Airports.[216] The coverage of the four SSRs mentioned above will spread over the whole Bangkok FIR. They are capable of being upgraded to Mode S when needed.

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[211] GPS for at least 10 years and GLONASS for at least 15 years. The providers will inform all users six years in advance in case the service will be ceased. See "Exchanging of Letters", *supra* note 59.

[212] See *Thailand's Implementation Plan*, *supra* note 193 at 5.

[213] *Ibid.*

[214] See *Interview*, *supra* note 203.

[215] Table of Surveillance System Implementation is shown in Appendix 1.

[216] See *Thailand's Implementation Plan*, *supra* note 193 at 6.

Once flying in a non-radar coverage airspace, THAI uses a voice position report procedure.[217] However, the Thai Department of Aviation and AEROTHAI are jointly conducting trials and demonstrations on ADS via VHF.

D. Air Traffic Management (ATM)[218]

Thailand's airspace is divided into two parts, known as controlled airspace and uncontrolled airspace. Generally, civil as well as military aircraft flying in the controlled airspace are provided with ATS, which consist of an Air Traffic Control Service, a Flight Information Service, and an Alerting Service.[219] But when flying outside the controlled airspace, they are provided only with a Flight Information Service and an Alerting Service. At present, a minimum longitudinal separation of ten minutes is practised by most airways. There are no co-ordination problems with adjacent FIRs. Generally meteorological information is issued every 30 minutes except when bad weather conditions occur; special reports will be provided in no time, in accordance with ICAO's recommendations.

Once ICAO's CNS/ATM system is introduced, Thailand will be able to reduce the minimum longitudinal separation to as little as five minutes

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[217] See *ibid.*

[218] Table of Air Traffic Management Implementation is shown in Appendix 1.

[219] See *Thailand's Implementation Plan, supra* note 193 at 6.

while maintaining the existing level of safety or better,[220] hence reducing congestion in the air and terminal areas.

[220] See *ibid*.

CHAPTER 8

CONCLUSIONS

GPS and GLONASS have evolved to become the global navigation satellite systems for most civil applications. They presently have millions of users and this number is growing rapidly. This evolution has occurred without an international framework to regulate legal or institutional issues.

The most significant legal and institutional concerns in respect of the current GNSS are liability, and quality and continuity of these services. These concerns have been major issues at several international meetings relating to GNSS. The fact that GPS and GLONASS are strategic military assets funded by the governments of the US and the Russian Federation should concern States and international civil aviation users since the availability of these services might be affected. Taking steps to rectify this situation, several States have attempted to develop a formal instrument to ensure the quality and continuity of the services.

Certification is another legal issue that should be carefully analyzed, due to its objective, which is to maintain safety standards. Additionally, more information should be provided for certification. The problems confronted by States must be more clearly identified in order to resolve them.

It seems impossible to develop a legal framework for the existing GNSS at the present time since both GPS and GLONASS are operated independently by the government of each State without any control by ICAO. Moreover, GPS is, in principle, no different from other radio-navigation systems derived from the US military systems, such as Omega and Loran-C, which have been provided on a free and non-discriminatory basis to civil users for decades. Both these systems have been operated without any formal multilateral legal framework in place.

Developing a civil GNSS that will work independently from monopoly or oligopoly influences is another way for the international civil aviation community to control these services. As long as GPS and GLONASS are maintained by the US and the Russian Federation, there are no economical or practical reasons to develop a civil GNSS only for aviation purposes, especially because of the large amount of money required to develop and maintain a constellations similar to GPS or GLONASS.

The lack of funding is the major problem in this respect, particularly for developing countries. To adopt a formal agreement with the service providers seems to be the best alternatives for developing countries, thereby assuring the availability of these services in the future.

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Appendix 1

Table of Communication System Implementation in Thailand

THAILAND - COMMUNICATION SYSTEM IMPLEMENTATION

	NEAR TERM		MID TERM (1996-2000)					LONG TERM (2001-2010)									
	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
TRIALS & DEMONSTRATIONS																	
Data Link																	
ATN (gnd-gnd)																	
OPERATIONAL USE																	
AMSS			ARINC 622 0														
VHF data link			0														
SSR Mode S data link	(Pending on the outcome of the ICAO APANPIRG NAV/SUR Sub-Group)																
ATN	(Pending on the technological development in the future, but should be before year 2000)																

Appendix 2

Table of Navigation System Implementation in Thailand

THAILAND - NAVIGATION SYSTEM IMPLEMENTATION

	NEAR TERM		MID TERM (1996-2000)					LONG TERM (2001-2010)									
	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
TRIALS & DEMONSTRATIONS																	
GNSS – Enroute																	
GNSS – Terminal																	
GNSS – Non-Precision Approach																	
OPERATIONAL USE																	
GNSS – Enroute					0												
GNSS – Terminal					0												
GNSS – Non-Precision Approach					0												
GNSS – WADGNSS				0													
GNSS – LADGNSS				0													

Appendix 3

Table of Surveillance System Implementation in Thailand

THAILAND - SURVEILLANCE SYSTEM IMPLEMENTATION

	NEAR TERM		MID TERM (1996-2000)					LONG TERM (2001-2010)									
	94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
TRIALS & DEMONSTRATIONS																	
ADS AMSS																	
ADS VHF																	
SSR Mode S	(Pending on the outcome of the ICAO APANPIRG NAV/SUR Sub-Group)																
OPERATIONAL USE																	
ADS AMSS				0													
ADS VHF			0														
SSR Mode S	(Pending on the outcome of the ICAO APANPIRG NAV/SUR Sub-Group)																

Appendix 4

Table of Air Traffic Management Implementation in Thailand

THAILAND - AIR TRAFFIC MANAGEMENT IMPLEMENTATION (CONTINUED)

ATM SUB-SYSTEM	TYPICALLY ILLUSTRATIVE ATM ELEMENT	NEAR TERM		MID TERM (1996-2000)					LONG TERM (2001-2010)									
		94	95	96	97	98	99	00	01	02	03	04	05	06	07	08	09	10
AERODROME OPERATIONS (EXCLUSIVELY)	Arrival Metering, sequencing, spacing					0												
	Integration of departure procedures with arrivals					0												
	Independent IFR aproaches to closely spaced parallel runways						0											
	ENHANCED GROUND SURVEILLANCE AND GUIDANCE:																	
	- Aircraft ident (label tracking)						0											
	- Runway incursion alerts						0											
	- Identification of ground vehicles						0											
	Windshear Detection	0																