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GNSS AUGMENTATION : LEGAL ISSUES

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I. Background

GNSS is a satellite positioning and navigation system which provides worldwide three dimensional position, velocity and time data. Users are drawn from a great varriety of professions. The GNSS provided by the United States, known as the Global Positioning System (GPS; in the following discussion the words GPS and GNSS will be used interchangably) provides two kinds of service: Standard Positioning Service (SPS) and Precise Positioning Service (PPS). The less precise of the two services is the Standard Positioning Service. It is freely available to all users worldwide. It became operational for all uses in 1993. By contrast, the Precise Positioning Service is only available for military users and is not here relevant for discussion except to mention that the United States has decided that the Precise Positioning Service will become generally available in the year 2006. In fact it could become available as early as the year 2000 if the U.S. Department of Defense (DOD) cannot justify its exclusive use. However, neither SPS nor PPS may satisfy all users. GPS systems need to be sufficiently precise to satisfy the very demanding requirements of both transportation and non-transportation users. GPS augmentation will be necessary for additional GNSS signal precision. When sufficiently augmented to satisfy the requirements for accuracy, coverage, availability and integrity, the GNSS will become the primary U.S. radionavigation system. 1/ A description of the technical environment within which legal issues arise, follows.

A. U.S. Aviation Augmentation Program

The aviation industry and the Federal Aviation Administration (FAA) are very keen to make augmented GPS the primary radionavigation system. Therefore the FAA has begun to augment GPS. The FAA's Wide Area Augmentation System (WAAS) will provide the accuracy, integrity and availability that are necessary for GPS to become the primary radionavigation system for all kinds of flight from enroute flight to Category I approaches. 2/ First WAAS availability for use is scheduled for 1999 and in that year WAAS will be certified by the FAA as the primary means of navigation for en route flight and for terminal operations and for limited precision approach service. Full WAAS capability is planned for the year 2001. The Local Area Augmentation System (known as LAAS and consisting of ground reference stations) will provide additional accuracy, integrity and availability for Category II and Category III approaches. (See Appendix I for accuracy requirements for air navigation; in particular note the great accuracy required for Category III landings). The FAA has canceled the so-called Microwave Landing System in reliance on availability of a GPS stand-alone navigation system in the future. In the year 2003 the FAA will decide whether to terminate other existing ground based systems, depending on how well the WAAS and the LAAS perform. The FAA also will take into consideration how well users accept the new technology and the extent to which users have the necessary new equipment on board. Needless to say the FAA is motivated by budget constraints to eliminate redundant services. 3/

B. U.S.Maritime Augmentation Program

A maritime augmentation system was declared operational by the U.S. Coast Guard in 1996. It is already functioning successfully. The maritime augmentation system provides service along the U.S. coasts and on navigable rivers such as the Mississippi River. Maritime augmentation operates by use of radionavigation beacons. The maritime augmentation system is based on 4/

"accurate knowledge of the geographic location of one or more reference stations, which is used to compute corrections to GPS parameters, error sources, and/or resultant positions. These differential corrections are then transmitted to GPS users, who apply the corrections to their received GPS signals or computed positions. For civil users of SPS, differential corrections can improve navigational acuracy from 100 meters (2drms) to better than 7 meters (2drms)."

The maritime augmentation system may well be extended inland in the United States. One important reason is that several serious train accidents have caused concern with rail safety and there is interest in using the maritime augmentation system to effect positive train control. Many other potential users also could use this augmentation. Great public benefits would result from such a nationwide augmentation system. For surface traffic the maritime system has significant advantages over the WAAS system. The maritime augmentation system can better reach surface vehicles; because WAAS is specifically designed to meet the needs of aircraft in flight. (See Appendix II for accuracy requirements for land transport positioning and navigation, and see Appendis III for accuracy requirements for surveying, timing and other applications)

C. European Augmentation

The European Commission, Eurocontrol and ESA have agreed to cooperate to implement a European GNSS augmentation system, the European Geostationary Navigation Overlay System, known as EGNOS. Based on a December 1994 European Union Council Resolution, the European Commission, EUROCONTROL and ESA agreed to augment GPS and GLONASS for the purpose of civilian users. The planned augmentation service will use Satellites in Geostationary Orbit (GSO) to provide " supplementary ranging signals, integrity and differential correction data;" 5/ EGNOS is a multimodal satellite service. The Commission provides political and financial support under the Telematics Research Program to demonstrate the feasibility of GNSS augmentation for air, sea and surface uses, in particular for traffic management. ESA provides the ground segment and operates EGNOS during the initial testing phase. EUROCONTROL will develop the aviation certification requirements. EGNOS has obtained access to the navigation payloads of INMARSAT III by virtue of an ESA agreement with INMARSAT though Deutsche Telekom and France Telecom. 6/

The EGNOS action plan contemplates possible extensions of EGNOS to other regions including Africa, India, Eastern Europe and China. 7/ Furthermore, the Commission engages in extensive consultation and coordination with the United States on GPS issues. 8/

D. Japanese Augmentation

Japan is a heavy user of GPS for multiple purposes, including disaster monitoring, intelligent vehicles and for air and maritime navigation. Therefore the Japanese Ministry of Transport will provide supplemental service though its Multifunctional Transport Satellite program. The service is known as the MTSAT Satellite-based augmentation system. The MTSAT-1 satellite is scheduled to be launched in 1999. Specifications generally are based on the U.S. WAAS described above. Thus WAAS and the MTSAT Satellite-based Augmentation System (MSAS) have been coordinated. Japan will study and intends to coordinate its multitude of needs for satellite positioning and navigation. Within that study Japan will consult closely with the

United States and other interested parties regarding future developments. 9/

E. Other Augmentation

Many other countries, especially including India and China 10/ are studying GNSS and its augmentation as they become potential users of satellite positioning and navigation. Clearly this is a rapidly expanding area of technology.

F. GPS and GLONASS Coordination

Improved GNSS availability and thus improved positioning and navigation accuracy may also be obtained by combined use of GPS and the corresponding Russian GNSS system called GLONASS. The United States and Russia have entered into agreement, therefore, on a combined GPS/GLONASS receiver which would take advantage of all the 48 satellites of the two systems. 11/

II Legal Issues

A. Introduction

GNSS augmentation concerns the establishment of additional reference points which are used to improve the accuracy of navigation and positioning. GPS users such as airplanes and ships receive signals directly from the GNSS satellite. Additionally, GPS users (airplanes and ships) receive augmented satellite information indirectly via another object whether that other object be a radio beacon located on earth, such as in the maritime augmentation system described above; or whether it is processed via a satellite as in the case of the WAAS. The new legal consideration with augmented GNSS is that it introduces the additional consideration of satellite information received via other sources. For example in the case of the WAAS there is the additional factor of possible erroneous processing of the GNSS information because either the processing itself, or the manufacture of processing instrumentation, is negligent.

B. Legal Institutions for Augmentation.

1. International Institutions.

GNSS augmentation by an international institution such as EGNOS represents interesting possibilities which were discussed at a conference at Leyden University in 1996. 12/ EGNOS itself, as an international institution, may have international legal status. Otherwise the contracting countries themselves and the international institutions (EUROCONTROL, ESA , European Union) would form the legal basis for the augmentation . During the interim period while EGNOS becomes operational the sponsoring countries and organizations may provide the institutional basis.

The International Civil Aviation Organization (ICAO) and the International Maritime Organization (IMO) are also relevant international organizations because they establish standards for use of navigation satellites by aircraft and by ships. 13/ Furthermore, the International Telecommunication Union (ITU) is relevant because it develops world telecommunication standards and registers GNSS radio frequencies .

International government organizations, that provide augmented GPS, such as EGNOS, as discussed during the University of Leyden Proceedings, would be immune from liability, unless they permit themselves to be held liable by national or international laws.

2. National Organizations

Under the Federal Aviation Act, 14/ the FAA is charged with maintaining air safety; this law provides the FAA's legal basis for operating the WAAS and for the LAAS systems. Under Federal maritime legislation, 14 USC 2 and 81-90, the U.S. Coast Guard is provided the legal basis for the U.S. maritime augmentation system (DGPS). Both systems may be extended to uses other than aviation and maritime if other legal authority is provided either by new legislation or by the existing legal authority of other organizations, for example the Federal Railroad Administration's authority for positive train control. 15/

In the United States the FAA establishes standards for aviation uses of augmented GPS. Likewise the Coast Guard oversees the use of augmented GPS by ships. The Federal Communications Commission (FCC) regulates the use of radio frequencies. 16/ Because there are many uses of GPS, other than navigation, a number of additional Government agencies have oversight functions.

Because the FAA and the Coast Guard, as operators of the augmented GPS, are U.S. Government agencies, they are subject to the U.S. Federal Tort Claims Act (FTCA). 17/ The FTCA provides that the U.S. Government is immune from liability for its negligent acts unless the FTCA specifically waives immunity. The FTCA waives immunity of the FAA for negligent acts except for discretionary acts. Air traffic control is defined by case law as not being discretionary. Thus the FAA can be held liable. Likewise the Coast Guard can be held liable for negligent maritime navigation control. 18/ Consequently, the FAA and the Coast Guard may be held liable for augmented GPS to the extent that the FAA's operation of WAAS and LAAS, and the Coast Guard's operation of its maritime augmentation system are legally analogous to traffic control of airplanes and of ships. 19/

3. Private Organizations.

There are several private augmentation systems. 20/ Their legal bases are the charters of their corporations and national legislation. Private organizations would be subject to government oversight of their augmentation services

Private organizations providing augmentation services would not have immunity for their negligent augmentations. They could be held liable for negligent augmentation under the applicable law of Torts. Sometimes the ascertainment of the applicable torts law would require a conflict of laws analysis. 21/

III. GNSS Augmentation and the 1967 Outer Space Treaty

This is the thirtieth anniversary of the 1967 Treaty on Principles Governing the Activities of States in the Exploration and use of Outer Space, including the Moon and Other Celestial Bodies. 22/ The treaty is the 'Constitution' for outer space activities. This year we are specially encouraged to review space activities from the perspective of the treaty and to consider how space activities may be better assisted and accommodated by, or under, the 1967 Outer Space Treaty.

Augmented GNSS is quickly on its way to replace cumbersome surface-based traffic controls of transportation. Analogy can be made to satellite communication which in a short time relieved communication from dependence on earthbound copper wires. Augmented GNSS likewise appears to constitute a great leap forward. Augmented GNSS should quickly become available to all countries. GNSS is one of the most financially promising outer space activites. U.S. studies estimate future economic activities in the range of 30 billion dollars annually. 23/ The treaty, Article 1, states that use of outer space "shall be carried out for the benefit and in the interest of all countries, irrespective of their degree of economic or scientific development." This may be a suitable subject for implementation of Art. 1 of the 1967 Outer Space Treaty. I have previously proposed 24/ that the great variety of users of GNSS give rise to a great variety of institutions that regulate GNSS and that only one institution has competence to consider all the GNSS uses without giving preference to one over another -- that is the United Nations Committee for the Peaceful Uses of Outer Space (UNCPUOS) Thus I have proposed that UNCPUOS consider preparing overarching principles, as it did for remote sensing satellites in 1987. Such principles could insure the use of GNSS for the benefit of all countries, irrespective of their degree of development. In particular I point to principles on non-discriminatory access to GNSS, technical assistance, protection of the earth's environment, warning of disasters, international responsibility and dispute resolution. 25/ Overall U.N. guidance would leave specialized agencies and governments free to focus on technical issues. 26/

IV. Conclusion

GPS is a valuable tool which promises to be of great benefit to mankind. As uses become more diverse there needs to be refinements of the basic GNSS service. Augmented GNSS is not only a refinement but also an improvement of the basic GNSS service. Legally, augmented GNSS is a GNSS service for which international organizations, such as EGNOS, national governments, or private companies have assumed responsibility. The international and national reponsibilities for augmented GNSS are similar to those for GNSS. In the future further efforts may be required to standardize augmented GNSS. International technical standardization would take place through specialized agencies such as ICAO and IMO. Finally, the United Nations Committee for Peaceful Uses of Outer Space should consider establishing some basic overarching principles including non-discriminatory access to GNSS, technical assistance, protection of the earth's environment, warning of disasters, international responsibility and dispute settlement.

*) The views expressed in this article are the author's and should not be attributed to any organization with which he is associated.

1. 1996 Federal Radionavigation Plan(FRP) at 1-10. The FRP is available through the National Technical Information Services, Springfield,Virginia 22161. The FRP is updated biennially. It describes policies and plans for radionavigation services provided by the U.S. Government. The three appendixes to this paper are from the FRP; Appendix I at 2-5, Appendix II at 2-20, and Appendix III at 2-38.

2. Definition: The WAAS, system consists of WAAS certified aircraft receiving a signal-in-space providing 1: integrity data on GPS and Geostationary Earth Orbit (GEO) satellites; 2. differential corrections of these satellites to improve accuracy; and 3, a ranging capability improving availability and continuity. The GPS satellite data is processed by wide-area master stations "which process the data to determine the integrity, differential corrections, residual errors, and ionospheric information for each monitored satellite and generate GEO satellite parameters. This information is sent to a ground earth station and uplinked along with the GEO navigation message to the GEO satellites. The GEO satellites downlink this data on the GPS L1 frequency with a modulation similar to that used by GPS." The WAAS " will result in area navigation for all phases of flight and a ten-fold increase in runways approved for precision approaches." See Federal Radionavigation Plan at 3-11.

3. Federal Radionavigation Plan, id.

4. Id. at A-9.

5. Barbance, Bergquist, Cheli, Hood and Nordlund, Satellite Navigation Activities, The International Context, 1996 Space Communications, at 158.

6. Id.

7. Id. at 159.

8. Madrid Agreement between the European Union and the United States creates a consultation subcommittee.

9. 1996 Space Communications, supra n. 5, at 160-161. The Japanese augmentation service is known as the MSAT Satellite-based Augmentation System (MSAS).

10. Id.

11. Federal Radionavigation Plan, at 3-24.

12. Proceedings of the 1996 Leyden University Conference.

13. Larsen, Positioning Satellites: Current Institutional Issues, Proceedings of the 1994 Proceedings of the Colloquium on the Law of Outer Space, at 32.

14. 49 USC 40101, et seq..

15. 49.USC 103.

16. 47 USC 151 et seq.

17. Federal Tort Claims Act (FTCA), 28 USC 2671, et seq.. Larsen, Liability for Global Positioning Navigation Satellite Systems, Proceedings of the 36th Colloquim on the Law of Outer Space, at 70-71.

18. Dalehite v. U.S., 346 U.S. 15 (1952); Eastern Airlines v. Union Trust, 221 F. 2d 62 (affirmed per curiam sub nom. U.S. v. Union Trust, 350 U.S. 907 (1955)); Indian Towing v. U.S., 350 U.S. 61 (1955).

19. Id. supra n. 17. Note that the FTCA does not apply outside of the United States.

20. Federal Radionavigation Plan supra n. 1.

21. Restatement of the Law of Conflicts.

22. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, 18 UST 141; hereinafter the 1967 Outer Space Treaty.

23. National Academy of Public Administration Report.

24. Larsen, supra n. 13,

25. 1967 Outer Space Treaty, Art. VI.

26. Larsen, supra n. 13.

Table 2-1. Controlled Airspace Navigation Accuracy Requirements

PHASE	SUB-PHASE		ALTITUDE FL/FT	TRAFFIC DENSITY	ROUTE WIDTH (nm)	SOURCE ACCURACY CROSS-TRACK (95%, nm)	SYSTEM USE ACCURACY CROSS-TRACK (95%, nm)
EN ROUTE/ TERMINAL	Oceanic		FL 275 to 400	Normal	60*	12.4*	12.6*
	Domestic		FL 180 TO 600	Low	16	2.8	3.0
				Normal	8	2.8	3.0
			500 FT to FL 180	High	8	2.8	3.0
	Terminal		500 FT to FL 180	High	4	1.7	2.0
APPROACH AND LANDING	Nonprecision		250 to 3,000 FT	Normal	N/A	0.3	0.6
	Precision	CAT I	N/A	Normal	N/A	+/-18.2 ** / +/-7.7 to +/-4.4 *** CAT I Decision Height Point ****	N/A
		CAT II	N/A	Normal	N/A	+/-6.5 ** / +/-1.7 *** CAT II Decision Height Point ****	N/A
		CAT III	N/A	Normal	N/A	+/-4.1 ** / +/- 0.6 *** At Runway Threshold ****	N/A

* North Atlantic Track System requirements.
** Lateral position accuracy in meters.
*** Vertical position accuracy in meters.
**** Assumes a 3° glideslope and 8,000 ft. distance between runway threshold and localizer antenna. It may be possible to meet CAT III touchdown performance requirements while applying the CAT II requirement down to the runway.

Table 2-3. Current Maritime User Requirements/Benefits for Purposes of System Planning and Development - Harbor Entrance and Approach Phase

REQUIREMENTS	ACCURACY (meters, 2drms) PREDICTABLE	ACCURACY (meters, 2drms) REPEATABLE	COVERAGE	AVAILABILITY	RELIABILITY	FIX INTERVAL	FIX DIMENSIONS	SYSTEM CAPACITY	AMBIGUITY
	MEASURES OF MINIMUM PERFORMANCE CRITERIA TO MEET REQUIREMENTS								
SAFETY OF NAVIGATION LARGE SHIPS & TOWS	8-20***	-	US harbor entrance and approach	99.7%	**	6-10 seconds	Two	Unlimited	Resolvable with 99.9% confidence
SAFETY OF NAVIGATION SMALLER SHIPS	8-20	8-20	US harbor entrance and approach	99.9%	**	***	Two	Unlimited	Resolvable with 99.9% confidence
RESOURCE EXPLORATION	1-5*	1-5*	US harbor entrance and approach	99%	**	1 second	Two	Unlimited	Resolvable with 99.9% confidence
ENGINEERING & CONSTRUCTION VESSELS HARBOR PHASE	.1****-5	.1****-5	Entrance channel & jetties, etc.	99%	**	1-2 seconds	Two and Three	Unlimited	Resolvable with 99.9% confidence

BENEFITS	MEASURES OF MINIMUM PERFORMANCE CRITERIA TO MEET REQUIREMENTS								
FISHING, RECREATIONAL & OTHER SMALL VESSELS	8-20	4-10	US harbor entrance and approach	99.7%	**	***	Two	Unlimited	Resolvable with 99.9% confidence

* Based on stated user need.
** Dependent upon mission time.
*** Varies from one harbor to another. Specific requirements are being reviewed by the Coast Guard.
**** Vertical dimension.

Table 2-8. Requirements for Surveying, Timing and Other Applications

Surveying

TASK	MINIMUM PERFORMANCE CRITERIA								Remarks
	Accuracy - 1 Sigma				Coverage %	Availability %	Interval		
	Position						Measurement Recording (seconds)	Solution Fix	
	Absolute (m)		Relative (cm)						
	Horizontal	Vertical	Horizontal	Vertical					
STATIC SURVEY	0.3	0.5	1.0	2.0	99	99	5	30 min.	0 - 25 km
GEODETIC SURVEY	0.1	0.2	1.0	2.0	99	99	5	4 hrs.	0 - 6000 km
RAPID SURVEY	0.3	0.5	2.0	5.0	99	99	1	5 min.	0 - 20 km
"ON THE FLY" KINEMATIC SURVEY	0.3	0.5	2.0	5.0	99	99	0.1 - 1.0	0.1 - 1.0 sec.	0 - 20 km Real Time
HYDROGRAPHIC SURVEY			300	15	99	99	1	1 sec.	

Timing and Other Applications

REQUIREMENTS	MEASURES OF MINIMUM PERFORMANCE CRITERIA TO MEET REQUIREMENTS								
	ACCURACY (2 drms)			COVERAGE	AVAILABILITY	FIX INTERVAL	FIX DIMENSION	SYSTEM CAPACITY	AMBIGUITY
	PREDICTABLE	REPEATABLE	RELATIVE						
COMMUNICATIONS NETWORK SYNCHRONIZATION	-	1 part in 10^{-10} (freq)*	-	Nationwide	99.7%	Continuous	N/A	Unlimited	N/A
SCIENTIFIC COMMUNITY	-	1 part in 10^{-10} (freq)	-	Worldwide	99.7%	Continuous	N/A	Unlimited	N/A
METEOROLOGY	Velocity 1m/sec	-	-	-	TBD	TBD	TBD	-	TBD
POWER NETWORK SYNCHRONIZATION	-	1ms**	-	North America	99.7%	1 second	Two	Unlimited	Resolvable with 99.9% confidence

* Proposed ITU Standard based on American Telephone and Telegraph "Stratum 1 Requirement".

** At any substation. 8ms (1/2 cycle) systemwide.