

LEGAL ASPECTS RELATING TO SATELLITE NAVIGATION IN AIR TRAFFIC MANAGEMENT WITH SPECIFIC REFERENCE TO GAGAN IN INDIA

Muhamed Mustaque

Advocate, High Court of Kerala

Currently student of Institute of Space and Telecommunications law (IDEST)

University of Paris XI, Paris

FRANCE

mushiamm@gmail.com

Abstract

Satellite based navigation systems have totally changed our concept of regulation in Air traffic Management as the legal regime or liability regime hitherto applicable for territorial service seems to no longer support new global or atleast regional ATM services offered by the various Providers. The legal issues related to satellite navigation vary and depend up on numerous factors including precise commercial application. The satellite navigation will be one of the key enabling technologies of future transportation and airspace management system. Thus this paper addresses the legal issues in air traffic management based on SATELLITE BASED AUGMENTED SYSTEM (SBAS).

This paper will address the issue of responsibility of the State in the light of Liability Convention 1972 and Chicago convention besides examining responsibility of State under international law. The Liability of service provider under private law as to the accuracy of the satellite signal, So also under Product liability law have become important in the light of commercialized application of the ATM system.

When air transport industry is looking for Global sky, interoperability of various ATM systems and GNSS required for common air navigation services poses new institutional and legal challenges. This paper examines the issue and suggests for broader regulation on GNSS.

India's ambitious project GAGAN to cater to the satellite navigation augmentation requirements for air craft operators and air traffic services providers in the Indian air space and in future to the Asia pacific region will soon become a reality. This paper addresses the legal position as to the liability on failure to provide GPS service. Finally criminal liability of the officials of service provider for negligence and their liability under the Indian penal code are also examined.

The growth and advancement of space technology and its application could not be adequately anticipated in various space treaties. This paper recommends for comprehensive regulation for ATM based on SBAS.

Introduction

The current Air Traffic Management system (ATM) is based on ground navigational aids, radar, and voice communications, and will eventually be unable to cope with the predicted air traffic growth. The ATM system is experiencing growing difficulties as air traffic around the world continues to increase. The air traffic is predicted to grow at the rate of more than five percent annuallyⁱ. Therefore the industry must find a new air traffic management system that provides greater capacity. It must be capable to render total service committed for required surveillance in a given air space. The potential solution is found on Satellite Based Navigation System (hereinafter referred as system) which will reduce the delay, increase safety and will be most cost effective. This system is capable to handle ATM service, objective of which is to provide complete solution from the movement on the ground to take off, en-route flying and landing in all weather conditions, and ensuring the level of safety that will be required to cope with increasing air traffic. The major current systems, which either became operational or will soon become operational, are WAAS of USA, EGNOS of EUROPE, MSAS of JAPAN and GAGAN of INDIA.

The legal issues related to satellite navigation in general would vary and depend up on numerous factors including precise commercial application. Thus for ATM service, legal issues are surmounted on the interface of Space and Air law. The compliance as to Standard And Recommended Practice (SARP)ⁱⁱ under ICAO ⁱⁱⁱ(International Civil Aviation Organization) will place satellite based system on road nevertheless ICAO is incapable to address the legal issues that are

related to space object or related to outer space.

In a world of consumer, essence of regulatory measures is to protect consumer in whatever form. Nucleus of such Rights is fortified in national legislation or international convention like Vienna convention 1982 or under mandates of UNCITRAL^{iv} or UNIDROIT^v. The accuracy of signal from the satellite essentially depends on many factors; infact technology adopted for particular system is based on location of the atmosphere. Thus assurance to the customer and responsibility is a matter of legal touchstone.

Indian project GAGAN (GPS and GEO AUGMENTED NAVIGATION) has been designed to meet ICAO SARP as well interoperable with existing Satellite based augmentation system of WAAS of USA, EGNOS of Europe and MSAS of Japan. The GAGAN is also interoperable with other GNSS, GLONASS and GALILEO. Airports Authority of India (AAI) and Indian Space Research Organization (ISRO) have jointly undertaken this programme for the development and implementation. The AAI also have entered into an agreement with Federal Aviation Administration (FAA) of USA. Since 2000, the FAA has assisted the government of India in research and development of global navigation satellite systems and supported modernization of India's GAGAN project, in which India has invested \$100 million^{vi}. Support for the certification of GAGAN for use in India's airspace is the first step under the agreement signed on 13 November 2006.

The legal issues that would bind GAGAN when it becomes operational are not different from the one applicable globally. However the stand taken by GPS with regard to switching off would be a worrying factor for AAI when it is confronted with beneficiary of service.

Secondly, the product liability that exists in India is to be examined.

The progress of the system globally though in a fragmented manner is slowly demanding a single global sky. The system prevalent and coming is all interoperable. The issues of responsibility and liability of the interoperable system are matters of concern for the service provider. Thus in this backdrop, legal aspects of satellite navigation in Air Traffic Management assumes importance.

How does it work

Signals from Core Constellations either from GPS or GLONASS are received by ground reference stations and any errors in the signals are identified. Each station in the network relays the data to master station where correction information for specific geographical areas is computed, correction message is prepared and uplinked to a Geo stationary communication satellite via ground uplink station. This message is broadcasted to receivers on board of aircraft flying within coverage area of the system.

Legal issues

The essence of space law that distinguishes from air law is on a boundary of sovereignty though physical certitude of which is yet to be drawn^{vii}. ICAO is a global public international organization and its mandate originated from Chicago convention. Hence ICAO cannot embark up on to legislate on non sovereign area of outer space. The responsibility to provide air navigation facility rests on the state under Chicago convention^{viii}. The aim and objectives of the ICAO is to develop the principles and techniques of international air navigation and interalia includes insure the safe and orderly growth of international civil aviation throughout the world; encourage

the development of airways, airports, and air navigation facilities for international civil aviation power; promote safety of flight in international air navigation^{ix} etc; The annexure to convention developed by Air Navigation Bureau^x and GNSS manual issued by ICAO would enable certification process of ATM system to ensure international standards, safety and traffic management and thus thrusting responsibility thereon. The responsibility and liability of Airline carrier towards passenger, cargo consignor etc. is covered by air law. Therefore in case of any damage or loss arising from aircraft owing to any reasons including defective signal or loss of signal or for any reasons attributable and claims thereon are having legal foundations on various conventions from Warsaw^{xi} to Montreal^{xii}. However it is not necessary to avail air navigation facilities through the contract.^{xiii} The interesting question perhaps the whole thrust of this paper is about *what is the recourse of the Carrier as against or Service provider as against Signal provider* in a circumstances of resultant loss for the reasons of failure of satellite(etymological for any reasons like switching off GPS, interference of signal ,jamming etc).The state shall bear international responsibility for national activities in outer space^{xiv}. The state in which activities of signal provider has been authorized shall bear accountability but that does not put state on foothold of liability under Liability Convention 1972^{xv}. There are two kinds of claims that are likely to arise against Signal provider, they are, 1) The claim of service provider or service availed or carrier 2) third party claim. The third party is having limited remedy against Airline carrier under Rome convention 1952^{xvi}. In many countries where Rome convention does not apply, law applicable to damage done by aircraft on the surface usually based up on fault/negligence or law specifically designed for damage

done by aircraft on the surface, usually based on strict liability (such as in France, Germany and the UK)^{xvii}. In countries where national Laws would apply and Rome Convention is not applicable there is possibility of claim by third party conjointly against joint tortfeasors vis a vis aircraft carrier, service provider and signal provider. In countries where Rome Convention is applicable the third parties cannot resort for other remedies^{xviii}. Status of signatories to Rome convention is only 49^{xix}. In such backdrop what are other remedies? Does the Liability convention 1972 provide any measures or foundation for such claims? Some writers argue that action can be brought within Liability convention, though it doesn't contain any provision covering liability aspects of satellite navigation. The issue of liability is generally depend up on fault, who is at fault is a complex vex to dwell up on, for example **Ap** is a signal provider located at country **K**, provides service to **Bp** in **L** another country, the air carrier having nationality of the country called **M** availed service over air space over nation **S**, due to interference from country **J** signal was lost from the satellite of **Re** in country of **F** which is the launching state under Liability Convention; consequently resulted in accident to air carrier causing loss to third party in the country 'S' as well. Liability convention envisages absolute liability on Launching state for the damage caused on earth or flying aircraft^{xx}. Does Liability convention contemplate any liability arising from usage of signal from space object? It would be difficult to cast liability on the country 'F' in the light of provisions in Liability Convention, as the object of thrusting liability under the Liability convention is apparently on different footing.

Legal vacuum or matrix of interpretation? Myriad of reasons results in loss of signal or failure of satellite, which

ultimately leads to accident of aircraft or loss to Airline operator. The internal interference of the satellite itself from adjacent or cross polarized transponder or interference while uplinking or downlinking or interference from neighbouring satellite system which is operating on same or higher frequency can be some of the reasons.

Dr. B.D.K. Henaku is of the view that Article II of the Liability Convention would apply^{xxi}. Article II states that "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". Another author Mr. Kim Murray also has advanced same argument in his article on 'The Law Relating to Satellite Navigation and Air Traffic Management system- a view from the south pacific'^{xxii}. It is also argued by Dr. Abeyrante in his well written article on *state responsibility in classical jurisprudence reflections on the GNSS*^{xxiii} as "Admittedly, neither the outer space treaty nor the Liability convention explicitly provide remedies for damage caused by technology and communication provided through space objects. However the 'common interest' principle and liability provisions of these two conventions can impute culpability to states".

A satellite signal is having independent existence and has definite path. In ATM application the accident is caused by erroneous or bad signal and not by satellite. The origin or source of the signal is the satellite. The cause of erroneous signal can be any of the reasons as highlighted above for e.g. due to error in uplinking or downlinking or jamming etc, if the reasons are attributable it has to be said for the failure in uplinking or down linking or jamming, as the case may be the Liability convention will not apply. In such scenario even though the signal originated from the satellite, it has no link with resultant accident. However, the view as advanced by

learned authors are accepted, in case of error from satellite or switching off, Liability convention would apply. It has to be remembered that Liability convention cast absolute liability for the accident on the surface of earth or to flying aircraft. It didn't distinguish causes for accident resulting in absolute liability. It is clear that Liability convention did not contemplate accident having any origin or source or use arising from satellite. Secondly, on bare reading of Article II it is clear that there is no mention of accident arising from use or operation of space object. Thus it would be travesty to well known principles of interpretation to stretch the liability arising from ATM application based on satellite under Liability convention. The substantial law on claim in the nature mentioned above continues to be in vacuum in space law.

Liability/ principles of duty of care:

Vacuity in substantial law prompts us to think in terms of tort law propounded through principles of duty of care. In most of the countries, the legal system recognizes the remedies for civil wrong, therefore for accident occurred due to error from ground stations or attributable to terrestrial acts would be legally liable except in countries where sovereign immunity principles protects State from such actions. From space law perspective the focal point is how is the State liable for errors from satellite?. It would be difficult to sustain an action based on tortious claim arising from outer space under domestic law if the negligent act is outside territorial sovereignty (For Indian Law see sec 19 of Civil Procedure code). However while drafting Outer Space Treaty the principles of international law "responsibility"^{xxiv} had been accentuated. The principles of duty of care is embodied and couched in article VI of outer space treaty^{xxv}, which brings international responsibility for state for their national

activities in outer space. It is thus possible to take action under international law. To quote Professor Brownlie

"One can regard responsibility as a general principle of international law, a concomitant of substantive rules and of the supposition that acts and omissions may be categorized as illegal by reference to the rules establishing rights and duties. Shortly, the law of responsibility is concerned with the incidence and consequence of illegal acts and particularly the payment of Compensation for loss caused"^{xxvi}

Indian system GAGAN is aided by GPS. Under US Federal Torts Claims Act (FTCA) if the negligent act is committed within US and even if injury or damage occurred outside US, a claim would be sustainable. FTCA does not apply to claims arising from foreign countries^{xxvii}. The situs of negligent act not the location of injury is the basis of the claim under FTCA. In *Smith v United States*^{xxviii} Supreme court of US held that *The FTCA does not apply to tortious acts or omissions occurring in Antarctica. The ordinary meaning of "foreign country" includes Antarctica, even though it has no recognized government. If this were not so, §1346(b)--which waives sovereign immunity for certain torts committed "under circumstances where the United States, if a private person, would be liable (...) in accordance with the law of the place where the act or omission occurred (emphasis added)--would have the bizarre result of instructing courts to look to the law of a place that has no law in order to determine the United States' liability. Therefore negligent act exclusively occurring in outer space from the GPS will not be attracted under FTCA .The claimant*

must be able to show that management/controlling error from the US have caused resultant error from the GPS in order to claim under FTCA. Though US can avoid liability under FTCA nevertheless it is liable under international law as mentioned above because a state cannot take shelter under municipal law to escape from liability under international law. "Before an International Tribunal, a State cannot plead that its municipal law (not even its constitution) contains rules which conflict with international law, nor can it plead the absence of any legislative provision or of a rule of internal law as a defence to a charge that it has broken international law"^{xxxix}.

Product liability: Decision in *Donoghue v Stevenson*^{xxx} eliminated the principle of privity of contract, which has resulted in foundation of product liability. *Donoghue v Stevenson* is now taken as the authority for the proposition that manufacturer of a product will normally owe someone who uses or consumes that product, a duty to take care that the product does not suffer from any latent defects that will render that product unsafe to use or consume in the way it is intended to be used or consumed^{xxxi}. Essentially, most legal systems recognize that the manufacturer including the manufacturer of aeronautical products, has triple duty: a duty to design a safe product, a duty to manufacture a safe product and duty to warn against dangers in using the product^{xxxii}. In the claim based on product liability the claimant need not establish "negligence" of the manufacturer, it is enough to succeed by showing that product was defective. Under article I of EC directive (87/374 EEC)^{xxxiii} on product Liability for European Union, the producer shall be liable for damage caused by defect in his product. This is based on "strict liability". The product liability is normally decided according to the national laws. Satellite based navigation system for ATM

can be termed as a product. It employs various techniques in system design to correct ionospheric impact on signal. Though system is deployed after meeting ICAO SARP and Technology Demonstration System (TDS), the product liability would exist for inaccurate service due to design or defect in the system. The responsibility and liability is on manufacturer of the system. Therefore beneficiary of ATM service, mainly airline carrier will be able to sue for damage suffered on account of defective system.

India does not have Product Liability law, though it recognizes the principles through common law and through statutes like Consumer Protection Act. However Consumer Protection Act in India affords restrictive definition of consumer whereby it excludes buyer of service for commercial purpose. The Indian Consumer protection Act provides alternative Forum for speedy disposal of disputes. Because of the restrictive definition remedy opened to affected airline carrier is to approach Civil Courts of local Jurisdiction. Indian system GAGAN is the result of joint effort of AAI and ISRO, therefore both are liable under product Liability before appropriate civil court. However in modern commercial era there is a shift from individual tort liability to insurance liability. It is an advantage to the manufacturer from financial liability that is likely to arise from product liability.

Other Legal issues

Signal precision and accuracy. Satellite accuracy, integrity, availability are having constraints and limitations. What is prescribed under ICAO SARP is the operational standard for ATM system, though it may be possible to adhere to SARP nevertheless ionospheric scintillation can affect Satellite signal, which results in inaccurate and degraded performance. The

ionizing action of the sun's radiation on the earth's upper atmosphere produces free electrons. These free electrons are sufficient to affect the propagation of electromagnetic waves. This "ionized" region of the atmosphere is plasma and is referred to as the *ionosphere*^{xxxiv}. As GPS signals traverse the ionosphere, they are delayed by an amount proportional to the number of total electron content^{xxxv}. The error introduced by the ionosphere into GPS signal is highly variable and difficult to mode^{xxxvi}. The density of electron in ionosphere is responsible for fluctuation on GNSS signal. In the presence of scintillation, ionospheric modelling can be rendered impractical and receiver performance can be severely degraded^{xxxvii}. The influence of the ionosphere and strategies to isolate its effect are issues of major concern for GPS positioning and navigation application^{xxxviii}. For the last 50 years, ionospheric scientists have carried out ionospheric measurements, to study behaviour and tried to develop models. But none of these models can be used to correct Ionospheric effects in GPS to accuracy better than 0.5m, required in GAGAN implementation^{xxxix}. The inaccuracy or degrading factors are not result of defect or design of the system. In fact the System is designed taking into consideration of ionospheric impact on signal, and therefore it would be a justifiable defence for Service provider to defend themselves relying on principles of "Caveat Emptor" which means "let the buyer beware". Any prudent consumer or customer of ATM service should understand that technological capability has constraints and limitations on account of varying degree of ionospheric effects which is resulted from solar flare.

GPS Switching off. GPS is managed by US Air force. At present, GPS includes a feature called Selective Availability (SA), by which the accuracy of the civilian signal

can be degraded. SA was turned off in May 2000 on the orders of President Clinton, but it could be turned back on again at any time^{xl}. In 2004 US Government issued PNT policy^{xli} in which US Government reiterated objective to improve capabilities to deny hostile use of any space-based positioning, navigation, and timing services, without unduly disrupting civil and commercial access to civil positioning, navigation, and timing services outside an area of military operations, or for homeland security purposes. Unlike GALILEO^{xlii} US Government is non-committal as to guarantee of service^{xliii}. "By statute, the US government is immune from suits arising out of policy decisions involving the weighing factors. Thus decision to turn on or off selective availability (S/A) or choose satellite navigation systems as the sole electronic means of air navigation is almost certainly a discretionary policy decision. However once US sets up a particular system on which users rely, the government may be liable if it fails to maintain the system, warns that it is no longer available, or fails to follow clear and reasonable guidance in a particular circumstance"^{xliv}. GAGAN is aided by GPS; in most unlikely event of switching off GPS and loss thereon, the legal remedies to AAI is perhaps based on principle as stated above and in light of decision of the US Supreme Court in *Indian Towing Co v United States*^{xlv}.

"The Coast Guard need not undertake the lighthouse service. But once it exercised its discretion to operate a light on Chandeleur Island and engendered reliance on the guidance afforded by the light, it was obligated to use due care to make certain that the light was kept in good working order; and, if the light did become extinguished, then the Coast Guard was further obligated to use due care to discover this fact

and to repair the light or give warning that it was not functioning. If the Coast Guard failed in its duty and damage was thereby caused to petitioners, the United States is liable under the Tort Claims Act”.

Interoperability: According to the IEEE^{xlvi} definition, interoperability is “the ability of two or more systems or components to exchange information and to use the information that has been exchanged”^{xlvii}. The concept of globalization perhaps is the driving force behind interoperability of the GNSS and System. In GNSS context, interoperability can be understood such that individual GNSS components should be designed, built, and operated in such a way that they do not “jam” each other and allow one to combine their signals in a navigation service of a superior quality. Obviously, the combination of signals occurs in the user receiver. Nevertheless, it is up to the systems to make this combination easy and efficient^{xlviii}. The object behind interoperability is “seamless operation” which has been defined under EC Frame work regulation 549/2004^{xlix} as operation in such manner that from user’s perspective as if it was a single entity. Thus for a user service is coordinated through out the world. In European Union interoperability of the system is governed by regulation of European Parliament and of the council such as Frame regulation No 549 /2004 for the creation of the single European sky, Regulation No 550 /2004 on the provision of air navigation services in the single European sky, Regulation No551 on the organization and use of the airspace in the single European sky, Regulation No552 on the interoperability of the European Air Traffic Management network etc. Thus legal aspects of interoperability as such governed by regulation like in European Union or bilateral agreement entered between System

providers. Interestingly responsibility and Liability of the failures arising from interoperability of the System may not be an issue to ponder as it falls within the State responsibility under Art. 28 of Chicago Convention. However interoperability of GNSS is a serious question with respect to responsibility and liability. Does space law offer any answer on this score, on whom Liability could be fastened? One who is at fault or on both? “Imputability in the context of state responsibility means “attributable”. A state is only responsible for acts or omissions which can be attributed to it as its own”^l as already stated this would expose the fallacy of the argument that Liability Convention would apply in the case of the failure of signal from GNSS, as Liability Convention does not undertake any enquiry as to who was at *fault* for the damage caused on earth or on flying aircraft.

Criminal liability: Almost all legal systems recognize criminal liability of the person whose negligence results in accident. Though normally the persons who intermeddle or are responsible for handling ATM system alone would be liable under criminal law as he is directly involved in negligence, however Penal code like in India cast liability on Public servants for dereliction or disobedience of law, which results in injury. Under section 166 of Indian Penal Code (IPC) Public servant disobeying law with intent or knowledge that it likely to cause injury to any person shall be punishable with simple imprisonment for a term which may extend to one year or with fine or both. This would be besides liability for active negligence. Thus under IPC Public Servant, though not involved personally but as public servant who is bound to ensure safeguards, will be punished. The State is responsible for ATM service under Chicago convention. The public servant means person who is in service or pay of government and who is

entrusted with any public duty^{li}

Conclusion

The common vision and guiding principles of the space law must be translated into concrete action lines to advance the achievement of space technology and its application in ATM services. The concept that law should not impede technological advancement would be a far-fetched thought when legal issues would unsettle the phase of achievement. When Europe is looking forward to implement *Single Sky*, India wants to broaden its wing through Asia Pacific region, United States seeks to provide technological assistance through FAA, is time not ripe to shape the future on a solid foundation? Do we need to wait till worse would come? It would be difficult to claim compensation under domestic law for private individuals because of sovereign immunity in certain countries, so also private individuals cannot claim under international law before International Court of Justice. The application of system being global and issues being uniformly same, is it not desirable to have an international convention to resolve for a framework to govern the sector? Considering the complex nature of system, which involves multiple parties, the liability regime should be based on fault, so also for the reason that rights and liability of passengers or cargo consignors have already been taken care under the Air law.

ⁱ Source IATA pressroom release. http://www.iata.org/pressroom/facts_figures/fact_sheets/ accessed on 1 September 2007

ⁱⁱ See Art 37 of Chicago Convention: Creating and modernizing SARPs is the responsibility of the International Civil Aviation Organization, or ICAO, the specialized agency of the United Nations whose

mandate is to ensure the safe, efficient and orderly evolution of international civil aviation

ⁱⁱⁱ ICAO has its headquarters in Montreal, Canada, with seven regional offices throughout the world. From its beginning in 1944 it has grown to an organization with over 180 Contracting States. ICAO's aim is the safe and orderly development of all aspects of international civil aeronautics. It provides the forum whereby requirements and procedures in need of standardization may be introduced, studied and resolved.

The charter of ICAO is the Convention on International Civil Aviation, drawn up in Chicago in December 1944, and to which each ICAO Contracting State is a party.

^{iv} United Nations Commission on International Trade Law

^v The International Institute for the Unification of Private Law (UNIDROIT) is an independent intergovernmental organisation with its seat in Rome. Its purpose is to study needs and methods for modernising, harmonising and co-ordinating private and, in particular, commercial law as between States and groups of States.

^{vi} Source

http://www.faa.gov/news/press_releases/news_story.cfm?newsId=7691 accessed on 1 September 2007

^{vii} For further reading see 1) Chp II The Boundaries of Outer Space of An Introduction To Space Law by Prof .Dr.I.H. Ph. Diederiks-Verschoor 2nd Rev.Ed 1999.pub by Kluwer Law International. 2) chp 3.2 of Legal Issues Relating to the Global Public Interest in Outer Space ,paper prepared by prof.RamJakhu.

^{viii} Article 28 of Chicago convention

^{ix} Article 43 *ibid*

^x Part of the Secretariat of ICAO: The Air Navigation Bureau develops technical studies for the Air Navigation Commission as well as recommendations for SARP's

^{xi} Convention for the unification of certain rules relating to International Carriage by Air signed in Warsaw on 12 October 1929.

^{xii} *Ibid* signed at Montreal on 28 May 1999

^{xiii} See Article 15 of Chicago convention.

^{xiv} Treaty on Principles Governing the Activities of State in the Exploration and Use of Outer Space, including Moon and other Celestial Bodies(known as

Outer Space Treaty). opened for signature on 27 January 1967, entered into force on 10 October 1967, 98 ratifications and 27 signatures (as of 1 January 2007); (*Sources*: 18 UST1 2410; TIAS2 6347; 610 UNTS3 205)

^{xv} Convention on International Liability for Damage Caused by Space Objects (known as Liability Convention) opened for signature on 29 March 1972, entered into force on 1 September 1972, 84 ratifications, 24 signatures, and 3 acceptances of rights and obligations (as of 1 January 2007); (*Sources*: 24 UST 2389; TIAS 7762; 961 UNTS 187)

^{xvi} Rome Convention applies only to damage caused by foreign civil aircraft, for damage caused by national aircraft only local law would apply (third party claims) see *The law and policy of Air space and outer space* by P.P.C Haanappel published by Kluwer Law Ed2003 p.86 chapter V

^{xvii} *The law and policy of Air space and outer space* by P.P.C Haanappel published by Kluwer Law Ed2003 p.86 chapter V

^{xviii} See Art 9 of Rome convention 1952

^{xix} <http://www.icao.int/icao/en/leb/rome1952.pdf> accessed on 3rd September 07

^{xx} Art II Liability convention 1972

^{xxi} See p.6 of his article in *Legal Issues Affecting the Use of Navigation Systems*

^{xxii} *Journal of Navigation* (2000), 53: 329-341 Cambridge University Press

^{xxiii} *Annals of Air and Space Law* Vol XXIII (1998)

^{xxiv} See also UN General Assembly Resolution 56/83 dt 12 dec 2001.

^{xxv} Art VI of Outer Space Treaty states that State parties to treaty shall bear international responsibility for national activities in outer space, including the Moon and other celestial bodies, whether such activities are carried on by governmental agencies or by non-governmental entities (remaining part of art. is omitted).

^{xxvi} P.433 *Principles of public international law*, pub. Oxford Clarendon Press

^{xxvii} See 28 Part VI Chapter 171 U.S.C § 2680 (exceptions to US Liability)

^{xxviii} 507 US 197 (1993)

^{xxix} See P.102: *Introduction to International Law* by JG Starke. pub. Butterworths

^{xxx} 1932 AC562

^{xxxi} P.47 chap. 4 *Tort Law* by Nicholas J McBride & Roderick Bagshaw pub. Pearson Education.

^{xxxii} See p. 94 *The Law and policy of Air Space and Outer Space* by Dr .P.P.C Haanappel

^{xxxiii} on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products (OJ L 210, 7.8.1985, p. 29)

^{xxxiv} <http://ion.le.ac.uk/ionosphere/ionosphere.html> hosted by University of Leicester ,accessed on 3rd September 07

^{xxxv} See *Assessment of Ionospheric Impact on LAAS Using WAAS Supertruth Data* by Ming Luo and others Stanford University.

^{xxxvi} *Ibid.*

^{xxxvii} *Effect of Ionospheric Scintillation on GPS Receiver at Equatorial Anomaly Region Bhopal* by Smitha Dubey and others, Bhopal University.

^{xxxviii} *Ibid.*

^{xxxix} *Development of Grid based model for GAGAN* by Rajat Acharya and others , Space Application center .Ahmedabad

^{xl} Source. www.theregister.com accessed on 4th September 07

^{xli} US Space based Positioning, Navigation and Timing policy source. <http://pnt.gov/policy/> viewed on 4th

September 07

^{xlii} Galileo will be Europe's own global navigation satellite system, providing a highly accurate, guaranteed global positioning service under civilian control. It will be inter-operable with GPS and GLONASS, the two other global satellite navigation systems: source

http://www.esa.int/esaNA/GGGMX650NDC_galileo_0.html accessed on 4th septmebr07

^{xliiii} *ibid*

^{xliiv} *The LAW and GPS INDUSTRY* by Jonathan M.Epstein Pub GPS solutions Vol 3 no 4 pp65 -69

^{xliv} 350 U.S. 61 (1955)

^{xlvi} The full name of the IEEE is the Institute of Electrical and Electronics Engineers, a non-profit organization, is the world's leading professional association for the advancement of technology

^{xlvii} IEEE 90 Institute of Electrical and Electronics Engineers. *IEEE Standard Computer Dictionary: A Compilation of IEEE Standard Computer Glossaries*. New York, NY: 1990.

^{xlviii} *Timing aspects of GPS-GALILEO*

Interoperability: challenges and solutions by A.Moudrak and others German Aerospace center.

^{xlix} *Regulation of the European Parliament and of the Council*

^l P.169 *International Law* by Rebecca M.M Wallace Pub: Sweet & Maxwell.

^{li} AIR 1957 SC13