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Item No. 8 on the agenda: Triennial Work Programme of the Organisation
(a) Possible future work on third party liability for Global Navigation Satellite System (GNSS) services

(Memorandum prepared by the Secretariat)

Summary	*Consideration of possible future work in the area of third party liability for Global Navigation Satellite System (GNSS) services*
Action to be taken	*Consider the desirability of including the topic in the Work Programme 2011 – 2013*
Mandate	*C.D.(88) 17, p. 13*
Priority level	*To be determined*
Related documents	*C.D.(86) 20, 22; C.D. (87) 23; C.D. (88) 7 Add. 4.*

EXECUTIVE SUMMARY

1. At the 85th session of the Governing Council, held in 2006, the President of UNIDROIT briefly indicated that the Institute might envisage adding a project on third pary liability for services provided by satellite navigation systems (GNSS) to its work programme, and that the Italian Government supported such a project. He indicated that a failure or malfunction of GNSS might cause damage that might become source of civil liability which could even hamper the diffusion of the system. As in many areas of activity with global impact (i.e. transports, nuclear activities, pollution), an international uniform legal discipline might address a range of problems (jurisdiction, difficulty of identifying the responsible party, effective loss restoration mechanisms, coordination with existing convention regimes). In view of the 86th session, held in 2007, the Secretariat prepared a brief memorandum for the Council (C.D. (86) 20) to which was appended a feasibility study by Prof. Carbone *et al*. on "The civil liability and compensation for damage resulting from the performing of European GNSS Services"; this study mainly focussed on the problems of third-party liability connected with the envisaged European system Galileo. The Council considered the topic of great interest, underlined its wide implications from many points of view, and concluded that: "*The Council took note, with great interest, of the reports on recent meetings submitted by Professor Carbone as well as communications from the Italian Government received by the President. The Council agreed that, in view of that interest on the one hand and concerns regarding the wide-ranging implications on the other hand, informal discussions with all potentially interested*

Governments should be held with a view to commissioning, should those consultations have a positive outcome, a broad comparative feasibility study".[1]

2. With a view to allowing the Council to further evaluate this proposal, the Secretary-General asked Prof. U. Magnus to prepare a study on the subject, which was submitted to the Governing Council at its 87th session in 2008, under the title "Civil Liability for Satellite-based Services"; another study was presented by Dr. H.G. Bollweg, "Initial Considerations regarding the Feasibility of an International Unidroit Instrument to Cover Liability for Damage Caused by Malfunctions in Global (Navigation) Satellite Systems".[2] After a thorough discussion, the Council asked Dr. Bollweg, Prof. Carbone and Prof. H. Gabriel to form an *ad hoc* Committee and adopted the following conclusions: "*As regards work on an instrument on civil liability for malfunctions in satellite-based services, definite decisions will be taken on the basis of further consultations carried out by an ad hoc committee set up by the Council*".[3]

3. At the 88th session of the Governing Council, the Secretariat prepared a brief memorandum including the Report of the debates of the *ad hoc* Committee;[4] Prof. Carbone presented another study, "The Rationale for an International Convention on Third Party Liability for Satellite Navigation Signals".[5] The debate which took place during that session underlined the interest of the subject but also its complexities; the Council thus adopted the following conclusions: "*The Governing Council mandated the Secretariat to prepare a detailed feasibility study focusing in particular on gaps in liability resulting from malfunction of satellite-based navigation systems under existing conventions on carriage of goods and passengers by air, rail, road and sea, as well as conventions governing liability for environmental damage and third party liability by those modes of transport, including related insurance and reinsurance arrangements. The Secretariat was requested to submit its study to the ad hoc committee for review prior to finalising the study for consideration by the Council at its 89th session in 2010"*.[6]

4. The Secretariat sent a draft of the study at the beginning of November 2009 to MM. Bollweg, Carbone and Gabriel, members of the *ad hoc* Committee, and finalized it according to their suggestions. The study is now presented in this document.

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5. *The Governing Council is requested to consider whether it should recommend to the General Assembly the inclusion in the Work Programme of the Institute of a project concerning third party liability for global navigation satellite systems services. Such an instrument might, following the example of most liability instruments, set a liability limit, that would also help the insurability of the activities, and cover aspects such as liability channelling, provision for supplementary compensation to guarantee satisfactory recovery of losses, and criteria for identifying the competent jurisdiction*.

[1] C.D. (86) 22, p. 13

[2] The two studies were published in the *Uniform Law Review/Revue de droit uniforme*, issue 4/2008.

[3] C.D. (87) 23, p. 20.

[4] C.D. (88) 7 Add. 4.

[5] Which was published in the *Uniform Law Review/Revue de droit uniforme*, issue 1-2/2009

[6] C.D. (88) 17, p. 13

An instrument on third party liability for damages caused by Global Navigation Satellite System services: a preliminary study[7]

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[7] This note was prepared using public sources only, i.e. books, journal and non restricted websites. All websites have been last visited in January 2010.

I. Background

1. Following a discussion initiated at its 85th session, upon proposal of the President, the Governing Council at its 88th session held in 2009 discussed, also on the light of some considerations presented by an *ad hoc* Committee, the possible inclusion in the Work Programme of the Institute might envisage of a project on the civil liability for services provided by satellite navigation systems (GNSS). The debate which took place during that session underlined the interest of the subject but also its complexities; the Council thus mandated the Secretariat to prepare a detailed feasibility study focusing in particular on gaps in liability resulting from malfunction of satellite-based navigation systems under existing conventions on carriage of goods and passengers by air, rail, road and sea, as well as conventions governing liability for environmental damage and third party liability by those modes of transport, including related insurance and reinsurance arrangements, and to submit it to the *ad hoc* committee for review prior to finalising the study for consideration by the Council at its 89th session in 2010".[8]

2. A failure or malfunction of GNSS could provoke damages which could be source of third party liability and could even hamper the diffusion of the system. As in many areas of activity with global impact (i.e. transports, nuclear activities, pollution), an international uniform regime might address a range of problems (jurisdiction, difficulty of identifying the responsible party, effective loss restoration mechanisms, co-ordination with existing conventional instruments).

3. The envisaged project concerns the drafting of such an instrument, which, in whatever form deemed appropriate, might, following the example of most liability instruments, set a liability limit that would also facilitate the insurability of the relevant activities, and cover aspects such as liability channelling, provision for supplementary compensation to guarantee satisfactory recovery of losses, and criteria for identifying the applicable jurisdiction.

II. Technical description of GNSS

4. Global Navigation Satellite Systems (GNSS) can be defined as "space-based positioning and navigation systems designed to provide worldwide, all weather, passive, three-dimensional position, velocity and timing data".[9] GNSS allows receivers to determine their location – longitude, latitude and altitude – using time signals transmitted along a line-of-sight by radio signals from satellites.[10] Therefore, precise timing is one of the basic components of satellite navigation; satellites are equipped with atomic clocks that are extremely accurate and provide Coordinated Universal Time (UTC). GNSS, in spite of their appellation which points solely to navigation, as we will see more in detail *infra*, are also used for positioning and timing.

5. GNSS is made of three parts: satellites orbiting the Earth; control and monitoring stations on the ground; receivers owned by users.

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[8] C.D. (88) 17, p. 13

[9] F. LYALL, P.B. LARSEN, *Space Law. A Treatise*, 2009, Farnham/Burlington, p. 389 (quoting: E. D. KAPLAN, C. HEGARTY, *Understanding GPS: Principles and Applications*, 2nd ed., Boston, 2005).

[10] A very accurate description of the technical aspects of the GNSS is offered at: http://en.wikipedia.org/wiki/Global_Positioning_System, which takes as a basis the U.S system.

6. For the time being, the space parts of GNSS consist of two core constellations: the NAVSTAR Global Positioning System (GPS) of the United States and the Global Navigation Satellite System (GLONASS) of the Russian Federation. In the near future, other similar systems will be operational: two of them are designed to have a global coverage, i.e. the European Union's Galileo and the proposed COMPASS-Beidou 2 Navigation System of China; others will be regional GNSS, i.e. the Indian Regional Navigation Satellite System (IRNSS) of India and the Japanese Quasi-Zenith Satellite System (QZSS)[11].

Operational Core Constellations

The U.S. NAVSTAR Global Positioning System (GPS).

7. The Department of Defence of the United States of America developed a global navigation satellite system in the early 1970's named **NAVSTAR Global Positioning System (GPS)**. GPS is managed by the United States National Space-Based Positioning, Navigation, and Timing (PNT) Executive Committee.[12]

Operational since 1978 and globally available since 1994, GPS is currently the world's most utilized satellite navigation system.

8. GPS was developed for military purposes; however, following the shooting down of a plane of the Korean Air Lines 007 in 1983, which had strayed, by mistake, into Soviet Union air space, President Reagan announced that GPS would be made available for civilian uses once it was completed. Since then, GPS has become widely used worldwide.

Initially the highest quality signal was reserved for military uses, while the signal available for civilian use was intentionally degraded. In 1996, the Clinton Administration presented a document on the U.S. GPS Policy outlining a strategic vision for the future management and use of GPS, addressing a broad range of military, civil, commercial, and scientific interests, both national and international. [13] As a result, the select availability was ended in 2000, improving the precision of civilian GPS from about 100 m to about 20 m.

9. The Bush Administration instituted the National Executive Committee for Space-Based Positioning, Navigation, and Timing (PNT) and adopted a new policy for GPS; its dual usage – military and civilian - was reaffirmed.[14]

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[11] A thorough description of the existing and planned systems was offered at the Third Meeting of the Providers Forum of the International Committee United Nations Office for Outer Space Affairs, Pasadena, United States of America, 7, 11 and 12 December 2008; the presentations can be viewed at: http://www.unoosa.org/oosa/SAP/gnss/icg/pf/03/pres.html

[12] The space and ground parts are developed and operated by the US Air Force. GPS utilizes a constellation of up to 32 Medium Earth Orbit satellites (the exact number of satellites varies as older satellites are retired and replaced), orbiting, in six different orbital planes, at about 20,200 km in the circular orbit, that transmit precise microwave signals, enabling a receiver to determine its location, speed, direction and time

[13] Press Release - U.S. Global Positioning System Policy. Office of Science and Technology Policy National Security Council 29 March 1996, Fact Sheet U.S. Global Positioning System Policy, at: http://clinton4.nara.gov/textonly/WH/EOP/OSTP/html/gps-factsheet.html.

[14] "The United States Government recognizes that GPS plays a key role around the world as part of the global information infrastructure and takes seriously the responsibility to provide the best possible service to civil and commercial users worldwide" (U.S. Policy Statement Regarding Civil GPS Availability, 21 March 2003), at: http://pnt.gov/public/sa/sa.shtml; "The United States Government shall... Provide on a continuous, worldwide basis civil space-based positioning, navigation, and timing services free of direct user fees for civil, commercial, and scientific uses and for homeland security through the Global Positioning System and its augmentations, and provide open, free access to information necessary to develop and build equipment to use these services." (*President George W. Bush, U.S. National Space-Based Positioning, Navigation, and Timing Policy, December 2004), at: http://www.gps.gov/systems/gps/index.html.* See B. Orschley, "Assessing a GPS-Based Global Navigation Satellite System within the Context of the 2004 U.S. Space-Based Positioning, Navigation, and Timing Policy", *Journal of Air Law and Commerce*, Fall 2005, p. 309.

The Russian GLONASS.

10. Development of the **GLONASS** (acronym for **GLO**bal **NA**vigation **S**atellite **S**ystem) began in 1976 with a goal of global coverage by 1991.[15] Beginning on 12 October 1982, the core constellation for GLONASS was fully operational in 1995. However, GLONASS rapidly fell into disrepair; in 2001 only 8 satellites were still operational. A special-purpose federal programme named "Global Navigation System" was then undertaken by the Russian Government, according to which the GLONASS system was to be restored to fully-deployed status (i.e. 24 satellites in orbit and continuous global coverage) by 2011; on January 2010 the operational satellites were 18.[16]

11. The Russian Government has planned to open the system up to other nations as well.

12. On 18 May 2007, President Vladimir Putin signed a decree officially providing open access to the civilian navigation signals of GLONASS free of charge and without limitations to both Russian and foreign consumers.[17] The Russian President also directed the Federal Space Agency to co-ordinate work to maintain, develop and enable the system for civilian and commercial needs.

Proposed Core Constellations with Global Coverage

The European Union's Galileo

13. **Galileo** is currently being put in place by the European Union (E.U.) with the technical support of the European Space Agency (ESA). The E.U. Council of Ministers approved the programme on 26 March 2002, following a Resolution adopted in 1994.[18] The action plan of the Union was illustrated in a White Paper in 2003[19] and in a Green paper in 2006.[20]

14. On 30 November 2007 the E.U. Transportation Ministers of the 27 member States reached an agreement that Galileo should be operational by 2014.[21] In April 2008, the E.U. Transportation Ministers approved the Galileo Implementation Regulation. This allowed the issuing of contracts to start construction of the ground station and satellites.

15. In July 2008 the E.U. Parliament and Council adopted Regulation (EC) No. 683/2008 of the European Parliament and of the Council of 9 July 2008 on the further implementation of the European satellite navigation programmes (EGNOS [22] and Galileo).[23] A Report on the implementation of the programme was presented by the E.U. Commission to the Parliament and the Council in June 2009.[24]

[15] For a complete description of GLONASS, see the official site of the Russian Space Agency: http://www.glonass-ianc.rsa.ru; see also http://informatica.unime.it/morey/geoloca/GLONASS.pps.

[16] The space segment of GLONASS consists, as of January 2010, of 22 satellites, of which 18 are operational; each satellite operates in circular 19,100 km orbits. The Ground Control Centre and Time Standards is located in Moscow and the telemetry and tracking stations are in the Russian cities of St. Petersburg, Eniseisk, Komsomolsk-na-Amure and in Ternopol (Ukraine). Source: Russian Space Agency, at http://www.glonass-ianc.rsa.ru.

[17] The news, reported from RIA Novosti, can be found on the website of GPSdaily, 21 May 2007, at: http://www.gpsdaily.com/reports/Putin_Makes_Glonass_Navigation_System_Free_For_Customers_999.html.

[18] Council Resolution of 19 December 1994 on the European contribution to the development of a Global Navigation Satellite System (GNSS) (94/C 379/02), O.J.E.U., C 379, 31 December 1994, p. 2.

[19] Space: a new European frontier for an expanding Union An action plan for implementing the European Space policy, Brussels, 11 November 2003, COM(2003) 673.

[20] Green Paper on Satellite Navigation Applications, Brussels, 8 December 2006, COM(2006) 769 final.

[21] The political aim, which was openly affirmed, is to provide an independent positioning system upon which European nations can rely even in times of war or political disagreement, since Russia or the USA could disable use of their national systems by others (through encryption).

[22] See *infra*, § 37-38.

[23] Official Journal of the European Union, L 196, 24 July 2008.

[24] Report from the Commission to the European Parliament and the Council on the implementation of the GNSS programmes and on future challenges pursuant to Article 22 of Regulation (EC) No 683/2008, /* COM/2009/0302 final */. All the official documents concerning Galileo are available on the website of the E.U. Commission: http://ec.europa.eu/transport/galileo/documents_en.htm.

16. Galileo will be a constellation of 30 satellites, orbiting, in three different orbital planes, at about 23,200 km from the surface of the Earth. When in operation, it will have two ground operations centres, one near Munich, Germany, and another in Fucino, Italy. [25] Since 18 May 2007, the E.U. took direct control of the Galileo project from the private sector group of eight companies called European Satellite Navigation Industries, which had abandoned the project in early 2007.

17. According to the E.U. press releases, Galileo is intended to provide more precise measurements than those currently available through GPS or GLONASS (it should be accurate up to one metre) including altitude above sea level and better positioning services at high latitudes.

18. Use of basic open Galileo services will be free for everyone. However, more qualified services will be accessible with pecuniary or military restrictions.

19. After four years of intense negotiations between the E.U. and the U.S., an agreement on major issues, including interoperability of both systems, was reached in February 2004.[26]

The Chinese Beidou 2 - COMPASS Navigation System

20. The **Beidou 2**[27] **- COMPASS system** is a Chinese project, of military origin and under military operational control, to develop an independent satellite navigation system.[28] The current Beidou-1 system (made up of 4 geostationary satellites) is experimental and has limited coverage and application.

21. With the Beidou 2 - COMPASS system, China plans to develop a truly global satellite navigation system.[29] Two satellites for Beidou 2 - COMPASS were launched in early 2007. In the next few years, China plans to continue experimentation and to setup system operations.

22. It should be noted that China has entered an agreement with the E.U. for the use of Galileo; in this context, the project Beidou 2 - COMPASS could be adjusted.

Proposed Core Constellations with Regional Coverage

The Japanese Quasi-Zenith Satellite System (QZSS)

23. **Quasi-Zenith Satellite System (QZSS)** is a proposed satellite regional time transfer system and enhancement for the GPS that would be receivable within Japan.[30] The first satellite is currently scheduled to be launched in 2010[31]. Japan has many mountainous regions and urban areas with narrow roads surrounded by tall buildings as a geographical feature and is located in middle latitude. In such conditions, mobile vehicles and mobile phones can barely receive signals from satellites, especially from geostationary orbit satellites (GSO). The elevation angle of QZS is

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25 Two satellites (Giove-A and Giove-B) for the Galileo "In Orbit Validation Phase" were launched in 2005 and 2008. In June 2009 ESA and Arianespace signed a contract for the launch of the first four operational Galileo satellites on two Soyuz launch vehicles from Europe's Spaceport in French Guiana For more information, see the ESA website: http://www.giove.esa.int.

26 See: http://www.eurunion.org/news/press/2004/200400104.htm.

27 The Beidou Navigation System is named after the Big Dipper constellation (Ursa Major), which is known in Chinese as *Běidǒu*, and which helps to find the North Star.

28 For more information, see the following websites: http://www.sinodefence.com/space/spacecraft/beidou2.asp; http://www.insidegnss.com/aboutcompass; http://www.globalsecurity.org/space/world/china/beidou.htm.

29 It will consist in a constellation of 35 satellites, which include 5 geostationary orbit (GEO) satellites and 30 medium Earth orbit (MEO) satellites, that will offer complete coverage of the globe. According to the information available on public sources, there will be two levels of service provided; free service for those in China, and licensed service for the military. The free service will have a 10 meter location-tracking accuracy, will synchronize clocks with an accuracy of 50 ns, and measure speeds within 0.2 m/s. While the licensed service will be more accurate than the free service, it can be used for communication and will supply information about the system status to the users.

30 See the brochure prepared by the Japan Aerospace Exploration Agency on QZSS: http://www.jaxa.jp/pr/brochure/pdf/04/sat12.pdf.

31 See http://asmagg.com/news/qzss-progress.

much higher than GSO; this is the origin of the name, "Quasi-Zenith Satellite System"[32]. QZSS will not work in a stand-alone mode; it is intended to be supplementary to and interoperable with GPS and is based on co-operation with the U.S.[33]

The Indian Regional Navigational Satellite System (IRNSS)

24. The Government of India approved the **Indian Regional Navigational Satellite System Project (INRSS)** in May 2006.[34] Space segment, ground segment and user receivers are all being built in India, also in thanks to the experience developed by India in creating the GAGAN system (see *infra* § 40).

25. In May 2009, India announced its plan to start launching satellites by December 2009 and having the whole constellation in orbit by 2012.[35]

26. IRNSS will function under civilian control.

Currently, there are only two operational systems, GPS of the United States and GLONASS of the Russian Federation; in a very near future the GNSS will be enriched by other global or regional constellations developed by various countries.

III. Global coverage of GNSS

27. The global coverage of GNSS permits enhancement of its applications through regional projects. We will give some examples of regions that are not, at present, developing their own GNSS; however, these are only examples, taken from public sources, because these projects are in development and are continuously expanding.

28. Following the 5th Space Conference of Americas and in preparation for the 6th, a United Nations/Colombia/U.S. Workshop on the Applications of Global Navigation Satellite Systems took place in Medellin in June 2008; experts of different Latin American countries made presentations on GNSS applications and case-studies.[36]

29. This was one of a series of five regional Workshops, co-sponsored by the United Nations Programme on Space Applications and the Government of the U.S., that had been organized; the first regional workshop was held in Malaysia in August 2001 for countries in Asia and the Pacific, followed by the second one held in Vienna, Austria, from 26 to 30 November 2001 for the benefit

[32] QZSS will consist of several QZS (Quasi-Zenith Satellites) and ground segment comprised of master control station, monitoring stations, and satellite tracking and control stations; see M. KISHIMOTO, "Quasi-Zenith Satellite System: Status and Design", *Location Magazine*, 2007, http://www.location.net.in/magazine/2007/jan-feb/30_1.htm.

[33] http://www.america.gov/st/washfile-english/2004/November/20041123112318ajsrom0.9599115.html.

[34] See the announcement at: http://www.india-defence.com/reports/1894. As with the European Galileo, the motivation for an independent satellite navigation system came primarily from the fact that access to GNSS that are under foreign control, cannot be guaranteed in hostile situations. The Indian policy is illustrated by R. KAUL, "Liability in Context to the Air Navigation Service Provider", 2009, expanded version of a paper presented at the workshop "International Conference on Contemporary Issues in Air Transport, Air law and Regulation", April 21-25, 2008, New Delhi, India, at: http://www.mcgill.ca/files/iasl/C09-Ranjana_Kaul-Liability_of_India_ANSP.pdf.

[35] IRNSS will consist of a constellation of 7 satellites and the ground segment and user receivers. 3 of the satellites in the constellation will be placed in geostationary orbit and the remaining 4 in geosynchronous inclined orbit of 29° relative to the equatorial plane; all 7 satellites will thus have continuous radio visibility with Indian control stations. In pursuit of a highly independent system, an Indian standard time infrastructure would also be established. See Sagar KULKARNI, "India to develop its own version of GPS", *Rediff India Abroad*, 27 September 2007, at: http://www.rediff.com/news/2007/sep/27gps.htm.

[36] The presentations can be seen at http://www.oosa.unvienna.org/oosa/SAP/act2008/colombia/presentations.html.

of countries in Eastern Europe. The third regional workshop was held in Santiago, Chile, from 1 to 5 April 2002 for the benefit of countries in Latin America and the Caribbean. The fourth Workshop was held in Lusaka, Zambia in July 2002 for the benefit of countries in Africa. The fifth and final Workshop was the one held in Medellin - United Nations/Azerbaijan/U.S./ESA Workshop on the Applications of Global Navigation Satellite Systems - took place in Baku in May 2009.[37]

30. In **Africa**, the "African Geodetic Reference Frame (AFREF) was conceived as a unified geodetic reference frame for Africa to be the fundamental basis for the national and regional three-dimensional reference networks fully consistent and homogeneous with the International Terrestrial Reference Frame (ITRF). ITRF is the global reference frame system for the earth as adopted by the International Association of Geodesy (IAG). When fully implemented, it will consist of a network of continuous permanent GPS stations such that a user anywhere in Africa would have free access to GPS data and products and would be at most 1,000 km from such stations. (...) The realization of AFREF has vast potentials for geodesy, mapping, surveying, geo-information, natural hazards mitigation, earth sciences, etc. Its implementation will provide a major springboard for the transfer and enhancement of skills and knowledge in surveying, geodesy and especially Global Navigation Technologies (GNSS) with its applications".[38]

31. The European Commission is promoting Galileo in Latin America by way of a joint consortium called LATINO. "LATINO is a consortium of European and Latin American institutions that has been chosen by the Galileo Joint Undertaking to lead the creation of a Galileo Information Centre for Latin America. The Centre - hosted in the Regional Centre for Space Science and Technology Education for Latin America and the Caribbean (CRECTEALC) - is created for the benefit of cooperation with all Latin American countries and aims to constitute a focal point for the promotion of GALILEO services and applications in the region. Its main mission is to implement information and training activities and to facilitate interaction between GNSS actors in Latin America and Europe".[39]

32. The E.U. has also launched the "Euro-Mediterranean Satellite Navigation (GNSS) Project", which sets up training and demonstration activities among Mediterranean partners (Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Malta, Morocco, Palestinian Territories, Syria, Tunisia and Turkey) and is also aimed at identifying potential national partners for GALILEO among them.[40]

GNSS augmentation systems

33. GNSS augmentation systems are means of improving the navigation system's attributes such as accuracy, reliability, and availability, through the integration of external information into the calculation process. There are many such systems in place and they are generally named or described based on how the GNSS sensor receives the external information.[41]

34. The positioning services offered by the GPS or GLONASS constellations for civil aviation fall short of the accuracy, integrity, availability and continuity of service requirements of air navigation services for landing. As such, augmentation systems have been developed for the core GPS constellation for purposes of enhancing the services provided by these core constellations to meet air navigation requirements for various phases of flight - from *en route* to the precision approach for a landing.

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[37] See the programme of the workshop and the presentations at http://www.oosa.unvienna.org/oosa/SAP/gnss/index.html.

[38] Quoting from http://geoinfo.uneca.org/afref/.

[39] More information is available on the website of the Galileo Information Center for Latin America, at http://www.galileoic.org/la/?q=tr/node/29.

[40] See the topic "satellite navigation" on the website of the Euro-Mediterranean transport project: http://www.euromedtransport.org/3.0.html.

[41] Some systems transmit additional information about sources of error (such as clock drift, ephemeris, or ionospheric delay), others provide direct measurements of how much the signal was off in the past, while a third group provides additional vehicle information to be integrated in the calculation process.

These systems can be grouped in "Ground-Based Augmentation Systems" and "Satellite Based Augmentation System (SBAS)".

Ground-based Augmentation Systems

35. Ground-based augmentation systems (GBAS) use radio towers to transmit corrections to the GNSS receiver. There are hundreds of ground-based augmentation systems around the world transmitting in a wide array of frequencies, from 162.5 kHz to 2.95 MHz[42].

Satellite-based Augmentation System (SBAS)

such as:

a) Wide Area Augmentation System (WAAS) of U.S.

36. The Wide Area Augmentation System (WAAS) is an air-navigation aid developed by the Federal Aviation Administration to augment GPS. Essentially, WAAS is intended to enable aircraft to rely on GPS for all phases of flight, including precision approaches, to any airport within its coverage area.[43]

WAAS is made up of a ground segment (i.e. a network of ground-based reference stations, in North America and Hawaii) and a space segment made up of two commercial geostationary satellites; the satellites broadcast the correction messages provided by the ground-based reference stations back to Earth, where WAAS-enabled GPS receivers use the corrections while computing their positions to improve accuracy.

b) European Geo-stationary Navigation Overlay Service (EGNOS) of Europe

37. The European Geostationary Navigation Overlay Service (EGNOS) is a SBAS which is currently under development by the ESA, the E.U. and Eurocontrol.[44]

38. EGNOS is Europe's first venture into satellite navigation. It augments the two existing GNSS (GPS and GLONASS) and makes them suitable for safety-critical applications such as flying aircraft or navigating ships through narrow channels.[45] It allows users in Europe and beyond to determine their position to within 2 metres, compared with about 20 metres for GPS and GLONASS alone.

EGNOS is intended to supplement GPS, GLONASS and Galileo (when it becomes operational) by reporting on the reliability and accuracy of the signals.

The system, which started its initial operations in July 2005, entered into operation on 1 October 2009[46] and should be certified for use in safety-of-life applications in 2010.[47]

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[42] As an example, in the United States there are the several different system aimed at increasing the accuracy of the GPS, intended for different uses, amongst which can be quoted the Nationwide Differential GPS system (NDGPS) operated by the US Coast's Guard (see http://www.navcen.uscg.gov/ndgps/default.htm dedicated to maritime navigation, the Local Area Augmentation System (LAAS) promoted by the US Federal Aviation Administration (see http://www.faa.gov/about/office_org/headquarters_offices/ato/serviceunits/techops/ navservices/gnss/laas/, intended for air navigation.

[43] For more information see the website of the Federal Aviation Administration: http://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/waas/.

[44] Additional information available on the ESA website: http://www.esa.int/esaNA/egnos.html.

[45] It will consist of 3 geostationary satellites and a network of ground stations; EGNOS will transmit a signal containing information on the reliability and accuracy of the positioning signals sent out by GPS and GLONASS.

[46] See the announcement made by the European Commission Vice-President for Transport Policy, at: http://esa.int/esaNA/egnos.html.

[47] During the 5th stage of the Tour de France in 2005, between Chambord and Montargis, receivers were carried by a number of cyclists, making it possible to determine their exact position and speed along the 183 kilometre-long stage by means of EGNOS; the system in the future will give the organisers an instant, complete overview of the competition and which will help team managers to coordinate the efforts of their cyclists and refine their strategies. This was the second set of trials for EGNOS at the Tour de France. During the 'against

c) MTSAT Satellite Augmentation System (MSAS) of Japan

39. MSAS is a Japanese SBAS, designed to supplement GNSS by reporting and improving the reliability and accuracy of the signals. It provides coverage for the hemisphere centred on 140° East; this includes Japan and Australia.[48]

MSAS generates GPS augmentation information by analyzing signals from GPS satellites received by monitor stations on the ground. This augmentation information consists of GPS-like ranging signal and correction information on GPS errors caused by the satellites themselves or by the ionosphere.[49] Ground stations of MSAS are located in Kobe and Hitachiota, Japan.

d) GAGAN of India

40. The **G**PS **A**ided **G**eo **A**ugmented **N**avigation system (**GAGAN**[50]) is a planned implementation of a regional SBAS by the Government of India.[51] It is a system to improve the accuracy of a GNSS receiver by providing reference signals.

The project is being implemented by the Airport Authority of India and by the Indian Space Research Organization. GAGAN will provide navigation aid for all phases of flight over Indian airspace and adjoining areas. It will meet the performance requirements of international civil aviation regulatory bodies. GAGAN should be fully operational by 2011.

e) Commercial SBAS

41. There are, at present, two commercial SBAS: the **StarFire** navigation system, operated by John Deere (http://www.deere.com)[52], and the systems offered by Fugro, i.e. **Starfix**, **Seastar**, **Omnistar** and **Omnitrack**[53] (http://www.fugro.com/).

The GNSS will extend its global coverage and also its international character by way of augmentation systems and co-operation agreements developed in many regions.

the clock' stage at Alpe d'Huez in 2004, receivers were positioned in vehicles following behind the race. The aim of the project is to track all competitors in real time. This tool could potentially be used in other sports.

[48] MSAS is based on the Multifunctional Transport Satellites (MTSAT), a series of weather and aviation control geostationary satellites, owned and operated by the Japanese Ministry of Land, Infrastructure and Transport and the Japan Meteorological Agency.

[49] More information can be obtained in the website of the Kobe Aeronautical Satellite Centre of the Japan Civil Aviation Bureau, at: http://www.kasc.go.jp/_english/msas_01.htm.

[50] Gagan is the transliteration of a Hindi/Sanskrit word for "sky".

[51] "India approves GAGAN System", *Asian Surveying and Mapping*, 15 September 2008, at: http://www.asmmag.com/news/india-approves-gagan-system.

[52] StarFire offers its commercial services for Land Survey, Offshore Positioning, Precision Agriculture, Aerial Photogrammetry, and LIDAR, GIS and Asset Mapping, Machine Control (see: http://www.navcomtech.com/StarFire). It is publicized as follows: "this global satellite-based augmentation system (GSBAS) provides decimeter positioning accuracy on a worldwide basis, completely independent of geographical boundaries, allowing users to roam freely while maintaining the most precise positioning information... StarFire utilizes a network of more than 60 GPS reference stations around the world to compute GPS satellite orbit and clock corrections".

[53] Quoting from http://www.fugro.com/survey/satellite/intro.asp: "Fugro maintains a world-wide infrastructure for augmentation of existing Global Navigation systems (GNSS) that enables us to offer and range of precise positioning products for both in-house operations and in-house use. The Fugro infrastructure includes more than 110 reference stations dispersed on all continents, to measure and compare navigation satellite data. All reference data is collected in two fully independent Network Control Centers and correction messages are compiled to build different augmentation products. All correction services are made available on more than 10 communication satellites, thus providing fully redundant positioning coverage around the clock and around the globe. Fugro offers a range of services tailored to the particular application and market environment to ensure a cost effective, fit for purpose solution under every circumstance, be it on land, offshore or in the air".

IV. Compatibility and interoperability

42. Each GNSS, with its constellation of 20/30 satellites, while having global coverage, cannot satisfy users worldwide, especially in remote or mountainous regions, as well as urban areas. As we have seen for special applications, like air navigation, in particular for approaching airports and landing, augmentation systems – ground-based and satellite-based – have been developed; the key for having a real global system is, however, to be found in the compatibility and interoperability of the systems.[54]

43. Compatibility and interoperability are thus major issues in the establishing of a global system. The International Committee for GNSS of the United Nations Committee for Space Affairs (ICG) instituted a "Working Group A on Compatibility and Interoperability".

44. The definition of the two issues can be given by quoting from the "Providers' Forum principles of compatibility and interoperability and their further definition":[55]

> *"a) **Interoperability** refers to the ability of global and regional navigation satellite systems and augmentations and the services they provide to be used together to provide better capabilities at the user level than would be achieved by relying solely on the open signals of one system:*
>
> *(i) Interoperability allows navigation with signals from different systems with minimal additional receiver cost or complexity;*
>
> *(ii) Multiple constellations broadcasting interoperable open signals will result in improved observed geometry, increasing end-user accuracy everywhere and improving service availability in environments where satellite visibility is often obscured;*
>
> *(iii) Geodetic reference frames realization and system time steerage standards should adhere to existing international standards to the maximum extent practical;*
>
> *(iv) Any additional solutions to improve interoperability should be encouraged.*
>
> *b) **Compatibility** refers to the ability of global and regional navigation satellite systems and augmentations to be used separately or together without causing unacceptable interference and/or other harm to an individual system and/or service:*
>
> *(i) The International Telecommunication Union provides a framework for discussions on radiofrequency compatibility. Radiofrequency compatibility should involve thorough consideration of detailed technical factors, including effects on receiver noise floor and cross-correlation between interfering and desired signals;*
>
> *(ii) Compatibility should also respect spectral separation between each system's authorized service signals and other systems' signals. Recognizing that some signal overlap may be unavoidable, discussions among providers concerned will establish the framework for determining a mutually acceptable solution;*
>
> *(iii) Any additional solutions to improve compatibility should be encouraged".*

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[54] G. Hein, "GNSS interoperability, *Achieving a Global System of Systems or 'Does Everything Have to Be the Same'?"*, *Inside GNSS*, Working Papers, January/February 2006, http://www.insidegnss.com/auto/0106_Working_Papers_IGM.pdf. See the U.S. Statement from UN−COPUOS, 19 February 2008, according to which: "The United States strongly supports compatibility and interoperability among current and future space-based PNT systems.... As agreed at the Providers Forum meeting at Bangalore, India, in September 2007, the U.S. understands that "compatible" means, *inter alia*, the ability of different space-based PNT systems to be used separately or together without interfering with each individual service or signal. We further understand that compatibility should also involve spectral separation between each system's authorized service signals and other systems' signals. The members also agreed that "interoperable" means the ability of different civil space-based PNT systems to be used together to provide the user better capabilities than would be achieved by relying solely on one service or signal".

[55] United Nations, General Assembly, Committee on the Peaceful Uses of Outer Space, Third Meeting of the International Committee on Global Navigation Satellite Systems, Note by the Secretariat, A/AC.105/928, 22 December 2008, Appendix.

Compatibility and interoperability of augmentation systems

45. The augmentation systems are designed to be compatible and interoperable. Firstly and mostly, they are compatible with GNSS, of which they increase the accuracy and reliability. But they are also compatible and interoperable among themselves; although all SBAS are regional systems, SBAS providers co-operate with each other and co-ordinate their actions so as to make each system more effective and to ensure that all the systems can be integrated into a seamless worldwide navigation system. SBAS co-operation is currently co-ordinated through the Interoperability Working Groups EGNOS/MSAS and EGNOS/WAAS. Interoperability tests are regularly organised.[56]

46. As an example, an aircraft with a suitable receiver could operate in any of these areas have continuous satellite navigation support available, without changing equipment.

Compatibility and interoperability of GNSS.

47. Although combined GPS/GLONASS receivers already exist in the market,[57] full compatibility and interoperability of different GNSS involve a number of technical issues that must be solved in order, first, to avoid interference between the systems and, secondly, to permit them to operate together. The interest of the subject has been illustrated by the "call for input" issued by the Woking Group A of the United Nations International Committee on GNSS (ICG).[58]

48. If it is true that compatibility and interoperability issues are mostly technical, legal and political aspects are also important.[59]

49. On the political level, interest in compatibility and interoperability was recently reaffirmed.

50. The U.S. Government, through the GPS International Working Group, has entered in a number of co-operative activities related to space-based Positioning, Navigation and Timing systems (PNT). In many cases, such co-operation is intended to ensure compatibility and interoperability between GPS and other space-based PNT systems. In particular, co-operation was established with Australia, the E.U., India, Japan and Russia, together with several international Organisations.[60]

51. With the agreement reached in 2004 between the U.S. Government and the E.U., "GPS and Galileo services will be fully compatible and interoperable" and, therefore, the agreement "makes the joint use of GPS and Galileo and the manufacturing of equipment much easier and cheaper".[61]

52. A Joint Announcement made in 2006 on U.S.-Japan GPS Co-operation underlined that the U.S. - Japan GPS/QZSS Technical Working Group, which was established for close co-operation during development of QZSS, concluded that GPS and QZSS are designed to be fully interoperable and compatible.[62]

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[56] See the information on the ESA website: http://www.esa.int/esaNA/ESAF530VMOC_egnos_0.html; see also J. Nieto, J. Cosmen, I. García, J. Ventura-Traveset, I. Neto, B. Tiemeyer, N. Bondarenco, K. Hoshinoo, "Interoperability Test Analysis between EGNOS and MSAS SBAS Systems", EGNOS/ESTB Publications, 1999, http://www.egnos-pro.esa.int/Publications/GNSS%201999/GNSS99_MSAS.pdf.

[57] See the intervention of W.J. Klepczynski, "Panel Discussion on GNSS Interoperability", *36th Annual Precise Time and Time Interval (PTTI) Meeting*, p. 4, at http://tycho.usno.navy.mil/ptti/ptti2004/panel.pdf.

[58] See http://www.gsa.europa.eu/go/news/global-call-for-opinions-on-gnss-interoperability and the Questionnaire issued by the ICG Workshop on Interoperability: http://www.oosa.unvienna.org/pdf/icg/2009/questE.pdf.

[59] See N.B. Koshelyaevsky, "Last Updates of GLONASS Program and GLONASS Interoperability with Galileo and GPS", at http://www.congrex.nl/07a06/abstracts/CXNL_07A06_914861.htm.

[60] See http://pnt.gov/international.

[61] See Delegation of the European Commission to USA, News Release, 26 June 2004, http://www.eurunion.org/News/press/2004/200400104.htm.

[62] 27 January 2006, at: http://tokyo.usembassy.gov/e/p/tp-20060127-77.html.

53. Under the U.S.-Russian Federation co-operation (established in 2004),[63] Working Group 1 on GPS-GLONASS compatibility and interoperability was established; a joint statement was issued in December 2006.[64]

54. Under the U.S.-India Joint Statement on GNSS Cooperation, issued in February 2007 in Washington, technical meetings focused on GPS-IRNSS compatibility were held in 2008 and 2009.[65]

55. A co-operative agreement was signed in 2006 by the European Commission and Russia's Federal Space Agency (FSA) to address the concerns of other GNSS providers, leading to the creation of a Steering Board for discussions between the E.U., the ESA and the FSA, with a view to examining various issues related to space co-operation, particularly system interoperability between Galileo and GLONASS.[66]

The different constellations and augmentation systems are designed and implemented so as to be interoperable and fully compatible; thus, an international uniform instrument could offer users one single regime, whichever the signal provider.

V. Applications of GNSS

56. GPS and GLONASS were developed for military purposes, which remains an essential part of their applications. This paper will focus on civilian applications, which can be divided schematically into three groups: navigation, positioning and timing. However, the three groups are interlinked and the illustrations given below will not always precisely pertain to one group only; this paper will give a brief overview of the most common applications, divided in large areas of intervention.[67]

Applications connected to Navigation

Marine navigation and industry

57. GNNS is primarily known for being the fastest and most accurate method for mariners to navigate, measure speed and determine location worldwide.

58. The main applications in the marine industry are the following:

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[63] The Joint Statement on cooperation is available on the website of the US National Executive Committee for Space-Based Positioning, Navigation, and Timing (PNT) at: http://pnt.gov/public/docs/2004/russia.shtml.

[64] The text of the Joint Statement is available on the website of the Russian Space Agency (http://www.glonass-ianc.rsa.ru/i/glonass/joint_statement_eng.pdf) as well as on the website of the US PNT (http://pnt.gov/public/docs/2006/russia.shtml) and states: "Working Group 1 met on December 13-14, 2006, in Yaroslavl, Russia, and discussed a range of issues. This was the third meeting of the working group. The meeting was highly successful and resolved many questions regarding interoperability and compatibility between the GPS and GLONASS systems. Both sides noted that concerning the question of the use FDMA and CDMA significant progress was made in understanding the benefit to the user community of using a common approach. The Russian side noted that a decision in this regard would be made by the end of 2007. Both sides agreed that the planned International Satellite Forum 2007 to be held April 9-10, 2007, in Moscow will be a unique opportunity to demonstrate the benefits of GLONASS and GPS interoperability in the Russian Federation for civil applications".

[65] See A. WONG, "U.S. Space-Based PNT International Cooperation and Support in Africa", *Satellite Navigation Science and Technology*, Trieste, Italy, 31 March 2009.

[66] See http://ec.europa.eu/enterprise/newsroom/cf/itemlongdetail.cfm?item_id=1628.

[67] It may be interesting to consult a document on the perception of potential benefits of GNSS by European citizens, commissioned by the European Commission; see *General public survey on the European Galileo Programme*, *Analytical Report*, 2007, http://ec.europa.eu/transport/publications/doc/2007_galileo_eurobarometer_analytical_report.pdf

- access to accurate position, course and speed information for more efficient traffic routing, which permits the saving of time and fuel;
- improving precision and efficiency of buoy positioning, sweeping and dredging operations;
- enhancing efficiency and economy for container management in port facilities;
- increasing safety and security for vessels using the AIS.[68]

Space

59. The GNSS have deeply enhanced operations in space, from guidance systems for crewed vehicles to the management, tracking and control of communication satellite constellations, to monitoring the Earth from space. Applications of GNSS include:[69]

- navigation solutions, by providing high precision orbit determination and minimum ground control crews with existing space-qualified GNNS units;
- attitude solutions, by replacing high cost on-board attitude sensors with low-cost multiple-GPS antennae and specialized algorithms;
- timing solutions, by replacing expensive spacecraft atomic clocks with low-cost, precise-time GNSS receivers;
- constellation control, by providing single point-of-contact for the control and orbit maintenance of large numbers of space vehicles such as telecommunication satellites;
- formation flying, by allowing precision satellite formations with minimal intervention by ground crews;
- virtual platforms, by providing automatic "station-keeping" and relative position services for advanced science tracking manoeuvres such as interferometry;
- launch vehicle tracking, by replacing or augmenting tracking radars with higher precision, lower-cost GNSS units for range safety and autonomous flight termination.

Aviation

60. The application of GNSS to aviation enables three-dimensional position determination for all phases of flight, from departure, en route and arrival to airport surface navigation.

GNSS applications allow aircraft to fly user-preferred routes from waypoint to waypoint, where waypoints do not depend on ground infrastructure; this is especially important in areas that lack suitable ground based navigation aids or surveillance equipment.

In many cases, aircraft flying over data-sparse areas such as oceans have been able to safely reduce their separation between one another, allowing more aircraft to fly more favourable and efficient routes, saving time, fuel and increasing cargo revenue.

The main applications of GNSS in air navigation are the following:[70]

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[68] This is a description of AIS: "GPS information is embedded within a system known as the Automatic Identification System (AIS) transmission. The AIS, which is endorsed by the International Maritime Organization, is used for vessel traffic control around busy seaways. This service is not only vital for navigation, but is increasingly used to bolster the security of ports and waterways by providing governments with greater situational awareness of commercial vessels and their cargo. AIS uses a transponder system that operates in the VHF maritime band and is capable of communicating ship to ship as well as ship to shore, transmitting information relating to ship identification, geographic location, vessel type, and cargo information -- all on a real-time, wholly automated basis. Because the ship's GPS position is embedded in these transmissions, all essential information about vessel movements and contents can be uploaded automatically to electronic charts. The safety and security of vessels using this system is significantly enhanced" (quoted from http://www.gps.gov/applications/marine/index.html).

[69] Quoting from http://www.gps.gov/applications/space/index.html

[70] Quoting from http://www.gps.gov/applications/aviation/index.html.

- continuous, reliable, and accurate positioning information for all phases of flight worldwide;
- safe, flexible and fuel-efficient routes for airspace service providers and airspace users, reduced aircraft delays due to increased capacity made possible through reduced separation minimums and more efficient air traffic management, particularly during inclement weather;
- potential decommissioning and reduction of expensive ground based navigation facilities, systems and services;
- increased safety for surface movement operations made possible by situational awareness;
- increased safety-of-life capabilities such as EGPWS.[71]

Rail

61. Rail systems in many parts of the world use GNSS in combination with various sensors, computers and communication systems to improve safety, security and operational effectiveness.

Unlike most other modes of transportation, there is little flexibility in managing rail traffic. Most rail systems are comprised of long stretches of a single set of tracks. Trains bound for thousands of destinations must simultaneously share the use of these single line tracks; therefore, precise knowledge of where a train is located is essential to prevent collisions, maintain smooth flow of traffic and minimize costly delays due to waiting for clearance for track use.

GNSS contributes to dependable scheduling through train location awareness and the enhancement of connectivity with other modes of transportation, such as rail station to airport transfers.

62. The main applications of GNSS in rail transportation are the following:[72]

- dependable schedule and equipment location awareness;
- improved track, traffic and train sensor information that flows together and produces a constantly updated plan to manage operations, thus increasing capacity, efficiency and safety for all rail users.

Road

63. GNSS offers increased efficiency and safety for vehicles using highways, streets and mass transit systems because it enables vehicle location and in-vehicle navigation systems to be widely used throughout the world today by combining GNSS position technology with systems that can display geographic information or with systems that can automatically transmit data to display screens or computers. Consequently, it is widely used by cars, taxis, buses and trucks. [73]

64. A geographic information system stores, analyzes and displays geographically referenced information provided in large part by GNSS. This enables monitoring vehicle location, making possible effective strategies that can keep transit vehicles on schedule and inform passengers of precise arrival times. Mass transit systems use this capability to track vehicles to improve on-time performance.[74]

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[71] Enhanced Ground Proximity Warning System; it is a system that can be mounted on an airplane and gives an alert and provides pilots with timely awareness of terrain in flight situations.

[72] Quoting from: http://www.gps.gov/applications/rail/index.html.

[73] Quoting from http://www.gps.gov/applications/roads/index.html.

[74] Using GNSS technology to help track and forecast the movement of freight has made a logistical revolution, including an application known as time-definite delivery. In time-definite delivery, trucking companies use GNSS for tracking to guarantee delivery and pickup at the time promised, whether over short distances or across time zones. When an order comes in, a dispatcher punches a computer function, and a list of trucks appears on the screen, displaying a full array of detailed information on the status of each of them. If a truck is running late or strays off route, an alert is sent to the dispatcher.

Applications connected to Timing[75]

65. Each GNSS satellite contains multiple atomic clocks that contribute very precise time data to the GNSS signals.[76] The receivers decode these signals, effectively synchronizing each receiver to the atomic clocks; this enables users to determine the time to within 100 billionths of a second.

66. Timing by GNSS is applied to many economic activities, like communication systems, electrical power grids and financial networks, which all rely on precision timing for synchronization, cryptation and operational efficiency.

Banking and financial networks

67. Companies use GNSS to time-stamp business transactions, providing a consistent and accurate way to maintain records and ensure their traceability. Major investment banks use GNSS timing services to synchronize their network computers located around the world; this permits the tracking, updating and managing of multiple transactions made by a global network of customers, all of which require accurate timing information available through GNNS and with global synchronization.

68. Many on-line services offered by banks and other financial institutions make use of one-time passwords (OTP), i.e. passwords that are valid only for a very short period of time. OTPs, in contrast to static passwords, are not vulnerable to replay attacks. If a potential intruder manages to record an OTP that was already used to log into a service or to conduct a transaction, he will not be able to abuse it since it will no longer be valid; the changes require very precise on time-synchronization between the authentication server and the client providing the password. Thus, timing can be provided with a high level of accuracy and global synchronization through the GNSS timing services.

69. Some future applications could also help to prevent fraudulent use of bank cards and credit cards.[77]

Telecommunications

70. Telecommunications make wide use of GNSS timing services; for example, wireless telephone and data networks use GNSS time to keep all of their base stations in perfect synchronization. This allows mobile handsets to share limited radio spectrum more efficiently.

71. Similarly, digital broadcast radio services use GNSS time to ensure that the bits from all radio stations arrive at receivers in lockstep. This allows listeners to tune between stations with minimum delay.

Encryption

72. Encryption is the process of transforming information to make it unreadable to anyone except those possessing special knowledge, usually referred to as a key. Encryption is specially used to protect data in transit, for example data being transferred via networks (e.g. the Internet, e-commerce), mobile telephones, wireless microphones, wireless intercom systems, Bluetooth

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75 See R. BEARD, "The Measure of Time", *InsideGNSS*, July-August 2008, p. 12, at: http://www.insidegnss.com/node/735

76 See the information as well as commercial solutions based on Timing based on GNSS at: http://www.spectracomcorp.com/Applications/GPSClockSynchronization/tabid/100/Default.aspx.

77 See the information provided in June 2009 by Ericsson, according to which the possibility to locate by GNSS the user of a bank or credit card could help prevent fraudulent use, of which a high percentage are performed in countries different from the one in which the user is located (information given by the on-line magazine APC in August of 2009).

devices and bank automatic teller machines. Some encryption systems need very accurate synchronisation, which can be provided by GNSS.[78]

Applications based on Positioning

73. GNSS provide precise and reliable three-dimensional positioning for natural and artificial features that can be displayed on maps and models of everything in the world - mountains, rivers, forests, endangered animals, precious minerals and many other resources.

Applications of positioning cover many different fields, including:

Fishing industry

74. GNSS help fishermen to return to the spots where fish is located.

Agriculture

75. Many farmers use GNSS-derived products to enhance operations in their farming businesses.

The main applications are the following:[79]

- accurately monitored yield data enables future site-specific field preparation;
- precision soil sampling, data collection and data analysis enable localized variations of chemical applications and planting density to suit specific areas of the field;
- accurate field navigation minimizes redundant applications and skipped areas and enables maximum ground coverage in the shortest possible time, also in low visibility field conditions.

Geodesy and building industry

76. Using the near pinpoint accuracy provided by the GNSS with ground augmentations, highly accurate surveying and mapping results can be rapidly obtained and, thus, it is now being adopted by professional surveyors and mapping personnel throughout the world. A major project for Africa is AFRER (quoted above § 30).

GNSS is frequently used by the building industry. Notably, it was used during the construction of the Eurotunnel.[80]

Disaster relief

77. GNSS positioning applications permit, *inter alia*, the delivery of disaster relief to areas in a more timely and accurate manner, saving lives, restoring critical infrastructure and providing position information for the mapping of disaster regions where little or no mapping information is available; the enhancement of capabilities for flood prediction and the monitoring of seismic precursors and events; the providing of the positioning of individuals with mobile phones and vehicles in case of emergency.

Public order and public safety

78. GNSS applications permit the tracking of stolen vehicles; it might also enable police to use GNSS tracing devices, even for people, in maintaining public order.

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[78] See the "Hannover project", described in BLANCHI, ZANELLO, CANTELMO, SCARDA, "Galileo Timing Applications", 39th Annual Precise Time and Time Interval (PTTI), 2007, at: http://tycho.usno.navy.mil/ptti/ptti2007/paper42.pdf.

[79] Quoting from http://www.gps.gov/applications/agriculture/index.html

[80] During the construction of the tunnel under the English Channel, British and French crews started digging from opposite ends: one from Dover, England, and one from Calais, France. They relied on GPS receivers outside the tunnel to check their positions along the way and to make sure they met exactly in the middle. Otherwise, the tunnel might have been crooked; source: http://www.aero.org/education/primers/gps/uses.html.

Research and scientific applications

79. GNSS are used in many fields connected with geography, environmental sciences, earth dynamics, polar studies and glaciology, volcano studies and monitoring, etc.[81]

Recreational activities (biking, trekking, fishing, etc.)

80. The GNSS permit makes many recreational activities easier and safer, such as biking, trekking, climbing, skiing etc.

New applications

81. Other applications are developed on a continuous basis; it may be interesting to consult the website of the U.S. NASA, which collects information on new applications.[82]

GNSS has a variety of applications, hence the possible sources of liability are equally varied. Many human activities rely on GNSS on a daily basis, and their number will progressively increase. It would therefore be extremely difficult for GNSS providers to foresee all possible events, each subject to different rules.

An international uniform instrument could offer a single liability regime applicable to all possible fields, also in case of new applications.

VI. Liability regimes applicable to damage caused by failure of GNSS

82. As Prof. Magnus pointed out in his article,

> *"situations may be envisaged where a failure or defect in the transmission of the satellite-based information causes loss. Such loss need not, but may reach disastrous proportions, for instance where the system's failure or defect causes an aircraft to crash into a densely inhabited area or causes a fully booked ocean cruiser to be sunk.... loss scenarios caused by failures of global navigation satellite systems, indeed sometimes catastrophic losses are quite easy to imagine. If, for instance, means of transport such as ships, aircraft or trains – whatever their (commercial or recreational) purpose – are navigated or steered relying on such satellite-based information systems, then any systems malfunction may cause the loss of hundreds or even thousands of lives and of property due to collision or wreckage. If, e.g., an oil tanker is involved its wreckage may also cause tremendous damage to the environment and the coastline of several States.*
>
> *However, catastrophic losses need not be the rule. Where satellite navigation is used in daily motor traffic, a system's failure causing a car's navigation system not to work properly will probably not result in instant accidents but only in traffic congestion and delay. Such failure is unlikely to cause immediate bodily harm; the loss will probably be of an economic nature. Taken singly, such losses may also be fairly limited. It is when taken together that the economic losses of all people involved may be considerable.*
>
> *Damage to persons can also occur where the satellite-based positioning system is used in rescue operations and does not work, so that the ambulance, police, fire-brigade or whatever cannot provide assistance in good time. Damage to persons and to property can also follow from a system's failure where criminals would have been detected or caught had the system worked properly.*

81 Some examples are described in: http://facility.unavco.org/general-info/science/science.html.

82 See http://gpshome.ssc.nasa.gov/

Death or bodily injury would be a less likely consequence of the failure of a global navigation satellite system with respect to the further uses at present envisaged by the promoters of Galileo (use in the financial sector, for prospecting, surveying, etc.). Yet economic loss could always ensue. Damage, again of an economic nature, may also result insofar as permanent failures or changes in the satellite navigation system impairs existing receivers which may become useless and unsaleable".

83. These scenarios open the issue of liability and compensation for such losses and damages that have so far raised a high level of attention, which is evident by the rich bibliography on the subject.[83] The perspective of this paper, corresponding to the envisaged project, is to address the issue of third party liability and not of contractual liability.[84]

This paper will take, as a point of departure, the actual status of the applicable regime by, first, examining the existing instruments, both general and particular, then analysing some very general questions linked to the GNSS services.

GNSS failure or malfunction can provoke errors in the signal, which may be source of accidents in the different areas of activity that rely on those signals. These accidents could provoke loss and damages which, in the worst scenario, could even be catastrophic.

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[83] H.G. BOLLWEG, "Initial considerations regarding the feasibility of an international UNIDROIT instrument to cover liability for damage caused by malfunctions in global (navigation) satellite systems", *Uniform Law Review/Revue de droit uniforme*, 2008, p. 917; L. BOND, "The GNSS Safety and Sovereignty Convention of 2000 AD", *Journal of air law and commerce*, 2000, p. 445; P.R. BOWER, "Current Legal Issues relating to GNSS", *Proceedings of the Forty-sixth Colloquium on the Law of Outer Space*, 2004, p. 385; S. CARBONE, E. DE MAESTRI, "The Rationale for an International Convention on Third Party Liability for Satellite Navigation Signals", *Uniform Law Review/Revue de droit uniforme*, 2009, p. 38; COPELAND, "Overview of System Architectural Implications of Third-Party Liability and Government Indemnification for GPS Augmentation", *Navigation*, 2000, p. 7; F.G. VON DER DUNK, *Liability for Global Navigation Satellite Services: a Comparative Analysis of GPS and Galileo*, in Journal of Space Law, 2004, p. 429; F.G. VON DER DUNK, "The European equation: GNSS= multimodality+ liability", *Luft- und Weltraumrecht im 21. Jahrhundert*, 2001; B. E. EHRHART, "A technological dream turned legal nightmare: potential liability of the United States under the Federal Tort Claims Act for operating the global positioning system", *Vanderbilt journal of transnational law*, 2000, p. 371; J.M. EPSTEIN, "Global Positioning System (GPS): Defining the Legal Issues of its Expanding Civil Use", *Journal of Air Law and Commerce*, 1995, p. 269; E. GIEMULLA, O. HEINRICH, "Haftungsrisiken und Haftungsmanagement im Sat-Nav-Bereich (Galileo)", *Zeitschrift für Luft- und Weltraumrecht*, 2008, p. 25; B.D.K. HENAKU, "The International liability of the GNSS Space Segment Provider", *Annals of Air & Space Law*, vol. XXI, 1996, p. 143; B.D.K. HENAKU, *The law on global air navigation by satellite: a legal analysis of the ICAO CNS/ATM system*, Leiden, 1998; J. HUANG, "Development of the Long-Term Legal Framework for the Global Navigation Satellite System", *Annals of Air & Space Law*, vol. XXII, 1997, p. 585; S. KOZUKA, "Third Party Liability arising from GNSS-related Services", IAC-09.E8.3.4., 2009; P. LARSEN, "Legal Liability for Global Navigation Satellite Systems", *Proceedings of the Thirty-Sixth Colloquium on the Law of Outer Space*, 1993, p. 69; P.B. LARSEN et al., "Global Navigation Satellite Systems: Universal Technologie under Divisive Legal Regimes", *Annals of Air and Space Law*, 2002, p. 387; U. MAGNUS, "Civil Liability for Satellite-based Services", *Uniform Law Review/Revue de droit uniforme*, 2008, p. 935; P. MANZINI, A. MASUTTI, "An International Civil Liability Regime for the Galileo Services: A Proposal", *Air and Space Law*, 2008, p. 114; M. MILDE, "Solutions in search of a problem?: Legal problems of the GNSS", *Annals of air and space law*, 1997, p. 195; B. POULAIN, "La situation juridique internationale du futur service public européen de radionavigation « Galileo »", *L'Europe des transports: actes du colloque d'Agen*, Université Montesquieu-Bordeaux, 2005, p. 615; P.A. SALIN, "An Update on GNSS Before the Next ICAO Experts Meeting on the Legal and Technical Aspects of the Future Satellite Air Navigation Systems", *Annals of Air & Space Law*, vol. XXII, p. 505; D.H. SANG WOOK, "Global Administrative Law: Global Governance of the Global Positioning System and Galileo", *Journal of International and Comparative Law*, 2008, p. 571; F.P. SCHUBERT, "An International Convention on GNSS Liability: When does desirable become necessary?", *Annals of Air and Space Law*, vol. XXIV, 1999, p. 246; K.K. SPRALDING, "The International Liability Ramifications of the U.S. Navstar Global Positioning System", *Proceedings of the Thirty-Third Colloquium on the Law of Outer Space*, 1990, p. 93; C. VIDELIER, "Legal Qualification of Signal in Space and Relevant Liability Regimes", *Proceedings of the Forty-fourth Colloquium on the Law of Outer Space*, 2002, p. 212.

[84] For a detailed description of the different types of liability in connection with GNSS, see F.G. VON DER DUNK, "Liability for Global Navigation Satellite Services: a Comparative Analysis of GPS and *Galileo*", *Journal of Space Law*, 2004, p. 129, spec. p. 132.

VII. International instruments: general regimes on liability

84. Space activities are governed by a set of international rules; it may be interesting to examine if they apply to accidents caused by GNSS failure or malfunction.

Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty), London, Moscow and Washington, 1967

Convention on International Liability for Damage Caused by Space Objects, New York, 29 March 1972

85. The ***Outer Space Treaty*** was adopted by the General Assembly of the United Nations on 19 December 1966 and opened for signature in London, Moscow and Washington on 27 January 1967.[85] It applies to the space activities of individual States, national entities, joint State activities and to the activities of international organisations. The Treaty applies to all activities in outer space and, therefore, to GNSS, and contains a provision on liability for such activities,[86] which, however, does not cover events connected with the failure or malfunctions that those activities might provoke but covers only physical damages caused by the space objects or their component parts.[87]

86. Considering that the issue of liability needed a more specific regulation, in 1972, the ***Convention on International Liability for Damage Caused by Space Objects*** (the 1972 Convention) was adopted. The Convention establishes that the "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" and, accordingly, does not provide a liability regime applicable to GNSS failures.[88] The applicability of this Convention to GNSS was discussed within ICAO;[89] however, it does not seem that the Convention would apply in cases other than physical collisions.[90]

87. Reference can also be made to the:

Draft Principles on International liability in case of loss from transboundary harm arising out of hazardous activities (Draft principles), adopted by the International Law Commission of the United Nations at its 58th session

88. Article 1, "Scope", of the ***draft principles*** states that "The present articles apply to activities not prohibited by international law which involve a risk of causing significant transboundary harm through their physical consequences". These draft principles have not been adopted yet and it may, therefore, be interesting to follow future developments; however, they deal with liability in inter-State relationships and will not apply to civil liability towards third parties.

None of the existing general international liability regimes applies to third party liability for accidents caused by GNSS failure or malfunction in transmitting the signal.

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85 See F. LYALL and P.B. Larsen, *Space Law. A Treatise*, cit., p. 53.

86 Article VII: Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or to its natural or juridical persons by such object or its component parts on the Earth, in air or in outer space, including the moon and other celestial bodies.

87 See F. LYALL and P.B. LARSEN, *Space Law. A Treatise*, cit., p. 104.

88 HURWITZ, State Liability for Outer Space Activities in Accordance with the 1972 Convention on International Liability for Damage Caused by Space Objects (1992) p. 18 ss.

89 As reported by J. HUANG, "Development of the Long-Term Legal Framework for the Global Navigation Satellite System", *Annals of Air and Space Law*, vol. XXII-I, 1997, p. 595.

90 See, on this respect, F. LYALL and P. LARSEN, *Space Law. A Treatise*, cit., p. 112-113; S. CARBONE, E. DE MAESTRI, "The Rationale for an International Convention on Third Party Liability for Satellite Navigation Signals", *Uniform Law Review/Revue de droit uniforme*, 2009, p. 38.

VIII. International regimes on liability in the transport sector

89. As is well known, many international conventions provide special regimes for liability connected to specific kinds of transport. It is thus important to examine these regimes in order to verify whether they would be applicable and to what extent it might apply to liability connected with GNSS.

90. This paper will refer only to international instruments having a universal character; there are, however, regional systems that may be of some interest for our purposes.[91]

Air Navigation liability regime

91. The Air Navigation liability regime is subject to two different sets of agreements.

Convention on Damage Caused by Foreign Aircraft to Third Parties on the Surface, Rome, 7 October 1952 and Protocol to Amend the Convention on Damage Caused by Foreign Aircraft to Third Parties on the Surface signed at Rome on 7 October 1952, Montreal, 23 September 1978

Convention on Compensation for Damage Caused by Aircraft to Third Parties, Montreal, 2 May 2009

92. The first group of instruments (the ***Rome Convention of 1933*** and its Brussels ***Protocol*** of 1938, the ***Rome Convention of 1952*** and its ***Montreal Protocol*** of 1978, which replaced the Rome Convention of 1933 and its Brussels Protocol of 1938, as well as the new Montreal Convention of 2009,[92] not yet in force) deals with **damages suffered by third parties on the ground** as a consequence of air transportation, excluding all claim of contractual liability. These instruments are based on the following principles:

- the liable entity is as a general rule the "operator" of the aircraft;
- compensation is limited;
- according to the principle of strict liability, proof of damage and attribution in principle – and with very narrow exculpatory clauses – are sufficient for liability to arise;
- the claim must be introduced within a short time-bar.

93. These instruments will apply in case of an aviation accident causing damage to third parties in the ground, even if the accident is caused by a GNSS failure or malfunction, because they do not contain any provision preventing their application in such a case. Accordingly, the aircraft operator will encounter strict liability and may be condemned to compensate the third parties.

94. If, however, the operator can prove that the accident and the consequent damage were caused by a GNSS failure or malfunction, he will be able to exercise a right of recourse towards the GNSS operator, because Article 10 of the Rome 1952 Convention provides that: "Nothing in this Convention shall prejudice the question weather a person liable for damage in accordance with its provisions has a right of recourse against another person"; Article 13 of the Montreal 2009 Convention has a very similar provision.

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[91] For references to some regions, see C. FRESNEDO DE AGUIRRE, "Unifying the Law of Carriage of Goods: a View from MERCOSUR", *Uniform Law Review/Revue de droit uniforme*, 2003, p. 241; S. KOZUKA, "Carriage of Goods and Legal Uniformity in the Asia-Pacific Region", *Uniform Law Review/Revue de droit uniforme*, 2003, p. 155; J. PUTZEYS, "Les tendances unificatrices et désunificatrices dans le droit des transports de marchandises: perspectives. Vue d'ensemble", *Uniform Law Review/Revue de droit uniforme*, 2003, p. 233. Some unification has been achieved by the "Union Economique et Monétaire Ouest Africaine (UEMOA)"; see, for instance, the "Règlement N° 02/2003/CM/UEMOA relatif à la responsabilité des transporteurs aériens en cas d'accident" du 19 mars 2003.

[92] The text of this Convention was published on the *Uniform Law Review/Revue de droit uniforme*, n. 3/2009, with an Introduction by Gilles LAUZON.

Convention for the Unification of Certain Rules relating to International Carriage by Air, Warsaw, 12 October 1929) and its Protocols

Convention for the Unification of Certain Rules for International Carriage by Air (Montreal, 28 May 1999)

95. A second group of instruments are the so-called **Warsaw system**,[93] which is actually being replaced by the **Convention for the Unification of Certain Rules for International Carriage by Air (Montreal, 28 May 1999)**, which now has 92 State Parties.[94] Taking this second instrument as an example, its scope of application is indicated as follows in Article 1:

> *"This Convention applies to all international carriage of persons, baggage or cargo performed by aircraft for reward. It applies equally to gratuitous carriage by aircraft performed by an air transport undertaking".*

96. The Montreal Convention is based on the following principles:

- ❖ liability of the carrier for death and injury of passengers and damage to baggage (Article 17), for damage to cargo (Article 18) as well as for delay (Article 19);
- ❖ the regime of liability is one of strict liability;
- ❖ *quantum* of compensation in case of death or injury of passengers: the Convention "removes the antiquated and unjustified limitation of liability for death and personal injury of passengers"; it "accepts a two-tier system of compensation: up to SDR 100,000 the carrier is strictly liable and cannot exclude or limit his liability"[95] a part from when the exoneration clause applies. "Beyond that sum, the liability is based on fault with reversed burden of proof... In view of the technical and operational complexity of aviation, the burden of proof will never be easy to discharge – the complicated chain of facts and their mutual causal nexus in aircraft accidents frequently leaves doubt as to the complete absence of any negligence, wrongful act or omission".[96]
- ❖ exoneration clause: "the carrier may be fully or partly exonerated from its liability if it proves that the damage was caused or contributed to by negligence or other wrongful act or omission of the claimant".[97]

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[93] The Warsaw system is based on the Warsaw Convention (Convention for the unification of certain rules relating to international carriage by air, Warsaw, 12 October 1929), its protocols (Protocol to amend the Convention for the unification of certain rules relating to international carriage by air, signed at Warsaw on 12 October 1929, The Hague, 28 September 1955; Protocol to Amend the Convention for the Unification of Certain Rules Relating to International Carriage by Air signed at Warsaw on 12 October 1929 as Amended by the Protocol done at The Hague on 28 September 1955, Guatemala City, 8 March 1971, not in force; Additional Protocol no. 1 to amend Convention for the unification of certain rules relating to international carriage by air signed at Warsaw on 12 October 1929, Montreal, 25 September 1975; Additional Protocol No. 2 to Amend the Convention for the Unification of Certain Rules Relating to International Carriage by Air signed at Warsaw on 12 October 1929 as Amended by the Protocol done at The Hague on 28 September 1955, Montreal, 25 September 1975; Additional Protocol No. 3 to Amend the Convention for the Unification of Certain Rules Relating to International Carriage by Air signed at Warsaw on 12 October 1929 as Amended by the Protocols done at The Hague on 28 September 1955 and at Guatemala City on 8 March 1971, Montreal, 25 September 1975, not in force; Montreal Protocol No. 4 to Amend the Convention for the Unification of Certain Rules Relating to International Carriage by Air signed at Warsaw on 12 October 1929 as Amended by the Protocol done at The Hague on 28 September 1955, Montreal, 25 September 1975, as well as the Convention, Supplementary to the Warsaw Convention, for the Unification of Certain Rules Relating to International Carriage by Air Performed by a Person Other than the Contracting Carrier, Guadalajara, 18 September 1961, which extends the Warsaw system to charters. The Warsaw systems is based on the following principles: liability of the carrier for death and injury of passengers and damage to baggage, to cargo as well as for delay; the liability of the carrier is based on its fault/negligence, but the Convention adopted a boldly progressive attitude by embodying a presumption of such fault/negligence and reversing the burden of proof; the carrier can be exonerated only if he proves that he and his agents have taken all necessary measures to avoid the damage or that is was impossible for him or them to take such measures"; limitation of compensation.

[94] In general on these instruments, see M. CLARKE, *Contracts of Carriage by Air*, London/Hong Kong, 2002. On the Convention, see M. MILDE, "Liability in international carriage by air: the new Montreal Convention", *Uniform Law Review/Revue de droit uniforme*, 1999, p. 835.

[95] *Ibidem*, p. 854 s.

[96] *Ibidem* p. 855.

[97] *Ibidem*, p. 854.

97. It is now possible to make some comments on this regime and to indicate some gaps in protection:

a) scope of application: the regimes apply only to contracting Parties and only to international flights;

b) liability: b1) according to the Rome and Warsaw regime, the carrier may prove that the loss or damage was not due to its fault/negligence; this will be difficult to prove, but not impossible if the accident is due to a malfunction of the GNSS, and will depend depend on (i) the circumstances of the case and (ii) the characteristics of the signal, which is linked to the development of the technology and on how widespread its use is; b2) according to the Montreal regime, the liability is strict for the 1st tier, but the same conclusion under b1) could apply to 2nd tier liability;

c) right of recourse: the liable party maintains a right of recourse against other persons (Article 37 of the Montreal states that "Nothing in this Convention shall prejudice the question whether a person liable for damage in accordance with its provisions has a right of recourse against any other person") and therefore, in case of accident due to a GNSS failure or malfunction, the aircraft operator will be able to sue the GNSS operator for recovering the sums paid in compensation.

The 1944 Chicago Convention on International Civil Aviation and CNS/ATM systems

98. We will examine the ***Chicago Convention on International Civil Aviation*** because, although it does not provide a system of liability, it contains provisions for the regulation of the navigation aids and accordingly indicates the requirements that must be met by each State in this respect in adopting in this sector the facilities offered by GNSS.

99. The Convention, adopted in Chicago on 7 December 1944, regulates safety in the air at the international level. Its Article 28 requires ICAO Parties to provide air navigation facilities in their territories that comply with the international standards and practices which ICAO establishes under powers conferred by Article 37.[98] Accordingly, navigation aids, including those based on GNSS, must comply with ICAO requirements and fall into the duties and the responsibility of each State.

100. In particular, the second aspect may raise difficulties, because the majority of States do not have control over the space segments of the GNSS; it may thus be difficult to rely on GNSS for providing navigation facilities without compatibility between the implementation of GNSS and the duties under the Chicago Convention being reached. ICAO, in developing satellite-based civil

[98] "Article 28. *Air navigation facilities and standard systems.* Each contracting State undertakes, so far as it may find practicable, to: (a) Provide, in its territory, airports, radio services, meteorological services and other air navigation facilities to facilitate international air navigation, in accordance with the standards and practices recommended or established from time to time, pursuant to this Convention; (b) Adopt and put into operation the appropriate standard systems of communications procedure, codes, markings, signals, lighting and other operational practices and rules which may be recommended or established from time to time, pursuant to this Convention; (c) Collaborate in international measures to secure the publication of aeronautical maps and charts in accordance with standards which may be recommended or established from time to time, pursuant to this Convention". Quoting from Murray K., "The Law Relating to Satellite Navigation and Air Traffic Management Systems – A View from the South Pacific", *Victoria University of Wellington Law Review*, 2000, p. 384: "Article 28 is actually highly significant concerning the infrastructure issues raised by the new ATM systems. Although its wording suggests the obligation applies to infrastructure in the state's territory, in practice Article 28 is the starting point for numerous Annex provisions which deal with infrastructure, not only for flight operations within the state's territory, but also for services provided outside a state's territory. The infrastructure obligation is limited by the words "so far as states may find practicable". However, to the extent that states can comply this is to be in accordance with the standards and recommended practices (SARPS) established under the Convention. This suggests that ICAO can, under the existing Chicago Convention provisions, promulgate safety standards for the new technologies. There is a jurisdictional issue so far as the space-based systems are concerned. However the space-based systems provide signals for aeronautical use and Article 37, which provides for the adoption of SARPS, is conveniently open-ended. After listing a number of subjects requiring adoption of SARPS, ICAO's competence is extended to making SARPS dealing with "…such other matters concerned with the safety, regularity and efficiency of air navigation as may from time to time be appropriate"."

aircraft navigation systems, called the Communication, Navigation Surveillance/Air Transport Managements Systems (CNS/ATM), must take these issues into account.[99]

101. The activity undertaken by ICAO is developed further *infra*, § 209 ff.

Maritime transportation liability regimes.

102. The liability regimes for maritime transportation in international waters are complex. Many instruments have been adopted, mostly under the auspices of IMO or the Comité maritime international, and apply to special events; the following will apply to specific accidents provoked by a malfunction of the GNSS.

Convention relating to the Carriage of Passengers and their Luggage by Sea (PAL), Athens, 13 December 1974[100]

103. If a GNSS failure or malfunction causes a maritime accident, provoking damage to the passengers of a ship and/or to their luggage, the ***Athens Convention (PAL)*** will apply. "The Convention is designed to consolidate and harmonize two earlier Brussels conventions dealing with passengers and luggage and adopted in 1961 and 1967 respectively. The Convention establishes a regime of liability for damage suffered by passengers carried on a seagoing vessel. It declares a carrier liable for damage or loss suffered by a passenger if the incident causing the damage occurred in the course of the carriage and was due to the fault or neglect of the carrier. However, unless the carrier acted with intent to cause such damage, or recklessly and with knowledge that such damage would probably result, he can limit his liability. For the death of, or personal injury to, a passenger, this limit of liability is set at 46,666 Special Drawing Rights (SDR) (about US$61,000) per carriage. The 2002 Protocol, when it enters into force, will substantially raise those limits. As far as loss of or damage to luggage is concerned, the carrier's limit of liability varies, depending on whether the loss or damage occurred in respect of cabin luggage, of a vehicle and/or luggage carried in or on it, or in respect of other luggage".[101]

In 2002 a Protocol was adopted, which is not yet in force; it "introduces compulsory insurance to cover passengers on ships and raises the limits of liability. It also introduces other mechanisms to assist passengers in obtaining compensation, based on well-accepted principles applied in existing liability and compensation regimes dealing with environmental pollution. These include replacing the fault-based liability system with a strict liability system for shipping related incidents, backed by the requirement that the carrier take out compulsory insurance to cover these potential claims".[102]

The Convention is based on the following principles:

- ❖ liability of the carrier for damage (to persons and/or luggage) that occurred in the course of the carriage, due to the fault or neglect of the carrier or of his servants or agents acting within the scope of their employment;
- ❖ the burden of proof shall lie with the claimant; but:
- ❖ presumption of fault or neglect: the fault of neglect shall be presumed, unless the contrary is proven, if the loss or damage to the passengers or the cabin luggage arose from or in connection

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[99] See J. HUANG, "Development of the Long-Term Legal Framework for the Global Navigation Satellite System", *Annals of Air and Space Law*, vol. XXII-I, 1997, p. 585; in particular on the issues of sovereignty and liability see R. KAUL, "Liability in Context to the Air Navigation Service Provider", 2009, expanded version of a paper presented at the workshop "International Conference on Contemporary Issues in Air Transport, Air law and Regulation", April 21-25, 2008, New Delhi, India, at: http://www.mcgill.ca/files/iasl/C09-Ranjana_Kaul-Liability_of_India_ANSP.pdf.

[100] See A. MANDARAKA-SHEPPARD, *Modern Maritime Law and Risk Management*, 2nd ed., London etc., 2007, p. 924 ss.

[101] IMO website: https://www.imo.org/Conventions/mainframe.asp?topic_id=256&doc_id=663.

[102] Ibidem.

with the shipwreck, collision, stranding, explosion or fire, or defect in the ship; for other luggage, the fault or neglect are presumed, notwithstanding the nature of the accident;

- limitation of liability;
- time-bar for actions;
- exclusivity of the regime vis-à-vis the carrier: "No action for damages for the death of or personal injury to a passenger, or for the loss of or damage to luggage, shall be brought against a carrier or performing carrier otherwise than in accordance with this Convention" (Article 14).

104. The Convention will apply in case of a maritime accident causing damage to passengers and/or their luggage also when the accident is caused by a GNSS failure or malfunction, because it does not contain any provision preventing its application in such a case.

105. The following remarks can be made on this regime:

a) scope of application: the Convention applies "to any international carriage if: (a) the ship is flying the flag of or is registered in a State Party to this Convention, or (b) the contract of carriage has been made in a State Party to this Convention, or (c) the place of departure or destination, according to the contract of carriage, is in a State Party to this Convention"; therefore, it will not apply to *cabotage* and non-international navigation in general; it should also be underlined that the Convention, insofar as it has only 32 State Parties, represents approx 40% of the world fleet;

b) according to its provisions, liability arises from fault or neglect and, therefore, the carrier might be able, by proving that the loss or damage was not due to him or his agents, but to a GNSS failure or malfunction, to be exonerated from liability; this will depend on (i) the circumstances of the case and (ii) the characteristics of the signal, which is linked to the development of the technology and on how widespread its use is;

Carriage of goods

106. A GNSS failure or malfunction could cause a maritime accident, provoking the loss or damage to the carried goods, or provoking delay, that may be source of liability. A plurality of instruments governs liability in maritime carriage of goods: the 1924/1968 Hague-Visby Rules; the 1978 Hamburg Rules; the freshly adopted 2009 Rotterdam Rules. Some States are still parties only to the Hague Rules; some to the Hague Rules as amended by the Visby Protocol; some have acceded the Hamburg Rules, and therefore denounce the Hague or the Hague-Visby instruments. The new Rotterdam Rules have been drafted, as we will see, in order to provide a completely new instrument capable of being largely accepted and therefore offer a uniformity of discipline in the field of the carriage of goods totally or partly by sea.

107. Although the different instruments present differences under many aspects, this paper will only briefly discuss the main characters of these various instruments.[103]

a) Hague-Visby Rules.

108. These Rules are based on the International ***Convention for the unification of certain rules of law relating to bills of lading ("Hague Rules")*** (Brussels, 25 August 1924) and its two protocols: ***Protocol to amend the international convention for the unification of certain rules of law relating to bills of lading signed in Brussels on 25 august 1924 ("Visby Rules")*** (Brussels, 23 February 1968) and ***Protocol amending the International Convention for the unification of certain rules of law relating to bills of lading of 25 August 1924, as***

[103] For a general presentation on the economic, legal and social background of these different regimes, see J.A. ESTRELLA FARIA, "Uniform Law for International Transport at UNCITRAL: New Times, New Players, New Rules", *Texas International Law Journal*, Spring 2009, p. 277.

amended by the Protocol of 23 February 1968) (SDR Protocol) (Brussels, 21 December 1979).

109. The State Parties to the Hague Rules are 74; 27 are parties also to the Visby Protocol (many countries which had acceded to these Rules have denounced them by acceding to the Hamburg Rules).

110. The Hague-Visby regime does not provide the basis for liability itself, which is to be considered as existing under other basis. Its provisions deal with the exceptions to liability; 20 exceptions are listed under Article IV, one of which has a wide scope: "*Any other cause arising without the actual fault or privity of the carrier, or without the fault or neglect of the agents or servants of the carrier, but the burden of proof shall be on the person claiming the benefit of this exception to show that neither the actual fault or privity of the carrier nor the fault or neglect of the agents or servants of the carrier contributed to the loss or damage*". It can be concluded that a GNSS failure would probably fall under this provision, which provides an exception to liability with a reversed burden of proof, i.e. the carrier must prove the absence of fault (with some exceptions that are not relevant here).[104]

111. The Hague-Visby Rules would apply to loss or damage to carried goods also when the accident is caused by a GNSS failure or malfunction. Remarks on this regime:

a) according to Article X, the Rules apply only to international carriage and thus national carriage is not covered;[105]

b) according to Article IV.2.(q), the carrier which may prove that the loss or damage was not provoked by its own fault will not be considered liable under the Rules; this will depend on (i) the circumstances of the case and (ii) the characteristics of the signal, which is linked to the development of the technology and on how widespread its use is.

b) Hamburg Rules

112. The ***United Nations Convention on the carriage of goods by sea (Hamburg Rules)***, Hamburg, 31 March 1978, has 33 State parties.

113. It applies to international carriage of goods by sea, as stated in Article 2.[106] According to Article 5.1, Basis of liability, "The carrier is liable for loss resulting from loss of or damage to the goods, as well as from delay in delivery, if the occurrence which caused the loss, damage or delay took place while the goods were in his charge as defined in article 4, unless the carrier proves that he, his servants or agents took all measures that could reasonably be required to avoid the occurrence and its consequences". The principle is a presumption of fault with a reversed burden of proof.

114. Remarks on this regime:

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104 For a detailed analysis of this provision, see S. PING-FAT, *Carrier's Liability under the Hague, Hague-Visby and Hambourg Rules*, The Hague/London/New York, 2002, p. 82.

105 "The provisions of these Rules shall apply to every bill of lading relating to the carriage of goods between ports in two different States if (a) the bill of lading is issued in a contracting State, or (b) the carriage is from a port in a contracting State, or (c) the contract contained in or evidenced by the bill of lading provides that these Rules or legislation of any State giving effect to them are to govern the contract; whatever may be the nationality of the ship, the carrier, the shipper, the consignee, or any other interested person".

106 Article 2, Scope of Application. The provisions of this Convention are applicable to all contracts of carriage by sea between two different States, if: (a) the port of loading as provided for in the contract of carriage by sea is located in a Contracting State, or (b) the port of discharge as provided for in the contract of carriage by sea is located in a Contracting State, or (c) one of the optional ports of discharge provided for in the contract of carriage by sea is the actual port of discharge and such port is located in a Contracting State, or (d) the bill of lading or other document evidencing the contract of carriage by sea is issued in a Contracting State, or (e) the bill of lading or other document evidencing the contract of carriage by sea provides that the provisions of this Convention or the legislation of any State giving effect to them are to govern the contract.

a) according to Article 1, the Rules apply only to international carriage, and thus domestic carriage is not covered;

b) according to Article 5.1, the carrier may prove that he, his servants or agents took all measures that could reasonably be required to avoid the occurrence and its consequences will not be considered liable under the Rules; in case of an accident due to a GNSS failure or malfunction, this will depend on (i) the circumstances of the case and (ii) the characteristics of the signal, which is linked to the development of the technology and on how widespread its use is.

c) Rotterdam Rules

115. The ***United Nations Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea (Rotterdam Rules)*** was adopted by the General Assembly of the United Nations on 11 December 2008.[107]

116. This Convention, which is not yet in force (it was opened to signature in Rotterdam on 23 September 2009), will apply, according to Article 5 (General scope of application), to "contracts of carriage in which the place of receipt and the place of delivery are in different States, and the port of loading of a sea carriage and the port of discharge of the same sea carriage are in different States" if *a)* the place of receipt, *(b)* the port of loading, *(c)* the place of delivery, or *(d)* the port of discharge are located in a Contracting State. This Convention "applies without regard to the nationality of the vessel, the carrier, the performing parties, the shipper, the consignee, or any other interested parties".

117. For the applicability of this Convention to multimodal transport, see *infra*, § 163-164, "The provisions on multimodal transport of the Rotterdam Rules".

118. This Convention provides for the liability of the carrier "for loss of or damage to the goods, as well as for delay in delivery, if the claimant proves that the loss, damage, or delay, or the event or circumstance that caused or contributed to it took place during the period of the carrier's responsibility as defined in chapter 4"; the carrier "is relieved of all or part of its liability pursuant to paragraph 1 of this article if it proves that the cause or one of the causes of the loss, damage, or delay is not attributable to its fault" or to the fault of any person referred to in Article 18 (i.e. any performing party; the master or crew of the ship; employees of the carrier or a performing party; or any other person that performs or undertakes to perform any of the carrier's obligations under the contract of carriage, to the extent that the person acts, either directly or indirectly, at the carrier's request or under the carrier's supervision or control).

119. Remarks on this regime:

a) according to Article 5, the Rules apply only to international carriage, and thus domestic carriage is not covered;

b) according to Article 17, the carrier who proves that he or the other persons in charge of performing the contract of carriage have no fault will not be considered liable under the Rules; in case of an accident due to a GNSS failure or malfunction, this will depend on (i) the circumstances of the case and (ii) the characteristics of the signal, which is linked to the development of the technology and on how widespread its use is.

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[107] See K. LANNAN, "The United Nations Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea – A General Overview", *Uniform Law Review/Revue de droit uniforme*, 2009, p. 290, as well as the articles by Manuel ALBA FERNANDÉZ, Francesco BERLINGIERI, Diego CHAMI, Philippe DELEBECQUE, Cecilia FRESNEDO Y AGUIRRE, Chester D. HOOPER, Rafael ILLESCAS ORTIZ, Kate LANNAN, SI YUZHOU / HENRY HAI LI , Michael STURLEY, Gertjan VAN DER ZIEL, Alexander VON ZIEGLER, Stefano ZUNARELLI, *ibidem*.

Convention on Limitation of Liability for Maritime Claims (LLMC), 1976, and 1996 LLMC Protocol

120. In case of compensation of loss and damages occurred in a maritime accident connected with a GNSS failure or malfunction, the shipowner will be able to invoke the application of the ***Convention on Limitation of Liability for Maritime Claims (LLMC)***, which allows shipowners to limit their liability to pay compensation for general ship-sourced damage. The LLMC Convention applies to claims for loss of life and personal injury, as well as loss of or damage to property. It also applies to pollution damage where no other Convention applies. This Convention replaces the International Convention Relating to the Limitation of the Liability of Owners of Seagoing Ships, which was signed in Brussels in 1957, and came into force in 1988. Limitations are established for two types of claims: claims for loss of life or personal injury and property claims (such as damage to other ships, property or harbour works).

121. In this Convention, the limitations on liability, or limitation amounts, are expressed in terms of units of account. Each unit of account is equivalent in value to the Special Drawing Right (SDR) as defined by the International Monetary Fund (IMF), although States which are not members of the IMF and whose law does not allow the use of SDR may continue to use the old gold franc (referred to as "monetary unit" in the Convention).

122. The limits were raised by the 1996 LLMC Protocol, which entered into force in 2004.

123. The Convention provides for a virtually unbreakable system of limiting liability. It declares that a person will not be able to limit liability only if "it is proved that the loss resulted from his personal act or omission, committed with the intent to cause such a loss, or recklessly and with knowledge that such loss would probably result".[108]

124. Remarks on this regime:

a) The LLMC will apply also to compensation of loss and damages caused by GNSS failure or malfunction.

b) It is therefore to be underlined that when it can be proved that the maritime accident causing loss and damages has been provoked by a GNSS failure or malfunction, the claimants - whose compensation under the LLMC regime would only be partial – are likely to sue the GNSS provider in order to obtain full compensation.

Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material (NUCLEAR), 1971

125. It is possible that a maritime accident, caused by a GNSS failure or malfunction, involves carriage of nuclear material. The purpose of the ***1971 Convention (NUCLEAR)*** "is to resolve difficulties and conflicts which arise from the simultaneous application to nuclear damage of certain maritime conventions dealing with shipowners' liability, as well as other conventions which place liability arising from nuclear incidents on the operators of the nuclear installations from which or to which the material in question was being transported.

126. The 1971 Convention provides that a person otherwise liable for damage caused in a nuclear incident shall be exonerated for liability if the operator of the nuclear installation is also liable for such damage by virtue of the Paris Convention of 29 July 1960 on Third Party Liability in the Field of Nuclear Energy; or the Vienna Convention of 21 May 1963 on Civil Liability for Nuclear Damage; or national law which is similar in the scope of protection given to the persons who suffer damage".[109]

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[108] See F. BERLINGIERI, "La Convenzione LMMC 1976 al vaglio della giurisprudenza", *Il diritto marittimo*, 1999, pp. 542-546.

[109] Quoted from the IMO website, http://www.imo.org/Conventions/contents.asp?topic_id=256&doc_id=662.

This Convention reinforces one of the basic principles of the nuclear conventions - that of channelling all liability on to the operator of the nuclear installations concerned, to the exclusion of any other person's liability - and aims at removing one of the main obstacles in the way of international nuclear trade.

127. Remarks on this regime:

a) The Convention will also apply to accidents due to GNSS failure, discharging the shipowner from all liability and channelling the liability to the operator of the nuclear installation concerned (see *infra*, § 180 ff.)

b) However, the application of the Convention will not exempt the GNSS provider of being sued by the operator of the nuclear installation concerned which paid the claimed compensation and decides to exercise a right of recourse.

International Convention on Civil Liability for Oil Pollution Damage (CLC), 1969

128. A maritime accident involving an oil-carrying vessel can provoke an environmental damage, which will be governed by the ***International Convention on Civil Liability for Oil Pollution Damage (CLC)***. This instrument "was adopted to ensure that adequate compensation is available to persons who suffer oil pollution damage resulting from maritime casualties involving oil-carrying ships.

The Convention places the liability for such damage on the owner of the ship from which the polluting oil escaped or was discharged.

Subject to a number of specific exceptions, this liability is strict; it is the duty of the owner to prove in each case that any of the exceptions should in fact operate. However, except where the owner has been guilty of actual fault, they may limit liability in respect of any one incident to 133 Special Drawing Rights (SDR) for each ton of the ship's gross tonnage, with a maximum liability of 14 million SDR (around US$18 million) for each incident. (1 SDR is approximately US$1.28 - exchange rates fluctuate daily).

The Convention requires ships covered by it to maintain insurance or other financial security in sums equivalent to the owner's total liability for one incident".[110]

129. Remarks:

a) this Convention will apply to oil pollution damage provoked by a sea accident due to a GNSS failure because none of the specific exceptions seem to cover such a failure;[111]

b) according to Article III.5, "Nothing in this Convention shall prejudice any right of recourse of the owner against third parties"; in case of accident due to a GNSS failure or malfunction, this will entitle the shipowner to sue the signal provider to recover the sums that were paid as compensation.

International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage (FUND), 1971, and 1992 Protocol replacing it

130. The ***FUND Convention*** establishes a fund for providing compensation for oil pollution incidents beyond that provided for by the CLC Convention.[112] The Fund Convention set up an

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[110] Quoted from the IMO website, http://www.imo.org/Conventions/mainframe.asp?topic_id=256&doc_id=662.

[111] According to Article III.2: "No liability for pollution damage shall attach to the owner if he proves that the damage: (a) resulted from an act of war, hostilities, civil war, insurrection or a natural phenomenon of an exceptional, inevitable and irresistible character, or (b) was wholly caused by an act or omission done with intent to cause damage by a third party, or (c) was wholly caused by the negligence or other wrongful act of any Government or other authority responsible for the maintenance of lights or other navigational aids in the exercise of that function".

international organisation, the International Oil Pollution Compensation Fund (IOPC Fund), to administer the system of compensation created by that Convention.

International Convention on Civil Liability for Bunker Oil Pollution Damage, 2001

131. A maritime accident caused by a GNSS failure or malfunction can provoke oil spillings from the vessels' bunkers; this kind of damage is covered by the ***2001 Bunkers Convention***. This instrument was adopted to ensure that adequate, prompt and effective compensation is available to persons who suffer damage caused by oil spills when carried as fuel in ships' bunkers. The Convention applies to damage caused on the territory, including the territorial sea, and in exclusive economic zones of States Parties. This Convention applies to pollution damages in cases in which the 1969 Civil Liability Convention (CLC) would not apply.

132. Remarks:

a) Like in the case of the CLC, this Convention should apply to bunker oil pollution damage provoked by an accident due to a GNSS failure because none of the specific exceptions would apply to such a failure.

b) As in case of the CLC, Article III.5 provides that "Nothing in this Convention shall prejudice any right of recourse of the owner against third parties"; in case of accident due to a GNSS failure or malfunction, this will entitle the shipowner who has compensated the damage to sue the signal provider to recover the sums paid as compensation.

International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS), 1996

133. A maritime accident caused by a GNSS failure or malfunction may involve a ship carrying hazardous or noxious substances, provoking loss or damage to persons, property and the environment that will be covered, once in force, by the ***International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea (HNS Convention)***. The Convention was adopted by the IMO in May 1996. It aims to ensure adequate, prompt and effective compensation for damage that may result from shipping accidents involving hazardous and noxious substances.[113]

134. This Convention, which is not yet in force, will entitle claimants to compensation for loss or damage to persons, property and the environment caused by incidents involving cargoes of oil, gases and chemicals, plus other substances which are hazardous in packaged form. Pollution damage caused by persistent oils already covered by the CLC and Fund Convention is excluded, as is damage caused by radioactive materials and coal. The HNS Convention is modelled on the CLC and Fund Convention. Thus, the shipowner is strictly liable for first tier compensation whereas the second tier comes from a fund levied on cargo receivers in all Contracting States on a post-event basis.

135. Shipowner's liability ranges from SDR 10 million (about US$ 16 million) for ships up to 2,000 GT, rising linearly through SDR 82 million (about US$ 128 million) for ships of 50,000 GT, to a maximum of SDR 100 million (about US$ 156 million) for ships over 100,000 GT. It is compulsory for all ships over 200 GT to have insurance to cover the relevant amount.

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[112] The IOPC Fund is financed by contributions paid by any person who has received in the relevant calendar year more than 150,000 tonnes of crude oil or heavy fuel oil (contributing oil) in ports or terminal installations in an IOPC Fund Member State after carriage by sea. The levy of contributions is based on reports on oil receipts in respect of individual contributors which are submitted to the Secretariat by Governments of Member States. The contributions are paid by the individual contributors directly to the IOPC Fund. Governments are not responsible for these payments, unless they have voluntarily accepted such responsibility. For an outline of the international regime established by the CLC and the FUND Conventions see M. JACOBSSON, "Oil Pollution Liability and Compensation: an International Regime", *Uniform Law Review/Revue de droit uniforme*, 1996, p. 260.

[113] See M. GÖRANSSON, "The HNS Convention", *Uniform Law Review/Revue de droit uniforme*, 1997, p. 249.

136. An HNS Fund (which will most likely be administered by the Secretariat of the IOPC Funds; see above, § 129) provides compensation up to a total of SDR 250 million (US$ 390 million), inclusive of shipowner's liability but irrespective of ship size.

137. Article 41 (Subrogation and recourse) states that "The HNS Fund shall, in respect of any amount of compensation for damage paid by the HNS Fund in accordance with article 14, paragraph 1, acquire by subrogation the rights that the person so compensated may enjoy against the owner or the owner's guarantor" and that "Nothing in this Convention shall prejudice any rights of recourse or subrogation of the HNS Fund against any person, including persons referred to in article 7, paragraph 2(d), other than those referred to in the previous paragraph, in so far as they can limit their liability. In any event the right of the HNS Fund to subrogation against such persons shall not be less favourable than that of an insurer of the person to whom compensation has been paid".

138. In 2009, the IMO Legal Committee approved a draft Protocol to the HNS Convention, designed to address the practical problems that have prevented many States from ratifying the original Convention.[114]

139. Remarks:

a) once in force, the Convention will apply to all damages, without exception, and to accidents due to a GNSS failure;

b) as stated by Article 41, the shipowner and the FUND will have a right of recourse; accordingly, in case of accident due to a GNSS failure or malfunction, the shipowner or the Fund that have paid a compensation will be entitled to exercise this right of recourse and sue the GNSS providers for recovering the sums paid.

Road regimes

140. Due to its very nature, it may be difficult, at least for the time being, to imagine that road accidents would be provoked by GNSS malfunctions because the navigation systems that are on board vehicles cannot undermine the responsibility of the driver. The situation is, therefore, different from sea, air and rail, where the drivers/pilots rely on instruments and aids, the failure of which can be in and of itself the source of accidents.

It is, however, quite possible that other events, such as delays, can be attributed to GNSS failures, and it is thus worthwhile to examine what the applicable regime would be.

Liability issues connected with road transportation are usually dealt with by very general liability regimes, developed from locally oriented approach.

141. The international efforts toward a uniform system, applicable to international road transportation, had, as a result, the CMR Convention of 1956, together with its 1978 and 2008 Protocols, and the 1973 CVR Convention, the former dealing with the transport of goods and the latter with passengers.

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[114] Among the obstacles has been the requirement for States to report the quantities of HNS received to IMO, which has proved difficult, in part, due to the sheer range and diversity of hazardous and noxious substances that will be governed by the HNS Convention. The draft Protocol is set to address this problem as well as others thought to be acting as barriers to ratification of the Convention. The IMO Council has endorsed the Legal Committee's recommendation that a diplomatic conference be convened in April 2010 for the purpose of considering and adopting the Protocol; see the website of the International Tanker Owners Pollution Federation Limited (ITOPF), http://www.itopf.com/spill-compensation/hns-convention/index.html.

Convention on the Contract for the International Carriage of Goods by Road (CMR), 19 May 1956, and Protocols[115]

142. The ***Convention on the Contract for the International Carriage of Goods by Road (CMR)***, 19 May 1956, and its ***two Protocols*** (Protocol to the Convention on the Contract for the International Carriage of Goods by Road (CMR), of 5 July 1978; Additional Protocol to the CMR concerning the electronic consignment note (e-CMR), Geneva, 20 February 2008), according to Article 1, "shall apply to every contract for the carriage of goods by road in vehicles for reward, when the place of taking over of the goods and the place designated for delivery, as specified in the contract, are situated in two different countries, of which at least one is a Contracting country, irrespective of the place of residence and the nationality of the parties".

143. This Convention provides that "The carrier shall be liable for the total or partial loss of the goods and for damage thereto occurring between the time when he takes over the goods and the time of delivery, as well as for any delay in delivery"[116], and adds that "The carrier shall however be relieved of liability if the loss, damage or delay was caused (...) through circumstances which the carrier could not avoid and the consequences of which he was unable to prevent".[117]

144. Remarks on this regime:

a) the Convention is in force in 55 States, mostly European, and, therefore, the other regions of the world are not covered;

b) the Convention applies only to international transport and all local transport is excluded from its scope, and thus falls under the domestic regimes;

c) the Convention applies only when there is a contract for the carriage of goods and, therefore, does not apply to events involving people travelling by road, for tourism or for business, in their own vehicle;

d) the Convention exempts the carrier when the liability occurs "through circumstances which the carrier could not avoid and the consequences of which he was unable to prevent", which can be the case of the GNSS failure; this will depend on (a) the circumstances of the case and (b) the characteristics of the signal, which is linked to the development of the technology and on how widespread its use is.

Convention on the Contract for the International Carriage of Passengers and Luggage by Road (CVR), Geneva, 1 March 1973, and its 1978 Protocol

145. The ***Convention on the Contract for the International Carriage of Passengers and Luggage by Road (CVR)***, Geneva, 1 March 1973, and its Protocol to the Convention on the Contract for the International Carriage of Passengers and Luggage by Road (CVR), of 5 July 1978, according to Article 1, Scope of application, apply "to every contract for the carriage of passengers, and, where appropriate, of their luggage in vehicles by road when the contract provides that the carriage shall take place in the territory of more than one State and that the place of departure or the place of destination, or both these places, shall be situated on the territory of a Contracting State, irrespective of the place of residence and the nationality of the Parties".

146. According to Article 11, "The carrier shall be liable for loss or damage resulting from the death or wounding of or from any other doily or mental injury caused to a passenger as a result of an accident connected with the carriage and occurring while the passenger is inside the vehicle or is entering or alighting from the vehicle, or occurring in connexion with the loading or unloading of luggage"; however, the carrier "shall be relieved of this liability if the accident was caused by circumstances which a carrier, using the diligence which the particular facts of the case called for, could not have avoided and the consequences of which he was unable to prevent".

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[115] See M.A. CLARKE, *International Carriage of Goods by Road: CMR*, 4th ed., London/Hong Kong, 2003.

[116] Article 17.1.

[117] Article 17.2.

147. Similar rules apply to the loss or damages to luggage.

148. The remarks on this regime, very similar to those formulated in connection with the CMR, are the following:

a) the Convention is in force in 8 States, all European, and, therefore, the other regions of the world are not covered;

b) the Convention applies only to international transport and all the local transport is excluded from its scope and, thus, falls under the domestic regimes;

c) the Convention applies only when there is a contract for the carriage of goods and, therefore, does not apply to events involving people travelling by road, for tourism or for business, in their own vehicle;

d) the Convention exempts the carrier when the liability occurs "through circumstances which the carrier could not avoid and the consequences of which he was unable to prevent", which can be the case of GNSS failure; this will depend on (a) the circumstances of the case and (b) the characteristics of the signal, which is linked to the development of the technology and on how widespread its use is.

Rail regimes[118]

149. Train accidents could be caused by a GNSS failure or malfunction and provoke loss or damage. In this domain, for obvious geographic reasons, there are only regional instruments. We will examine those adopted under the auspices of OTIF.

Convention concerning International Carriage by Rail (COTIF), 9 May 1980, and Protocol of 20 December 1990 for the Modification of the Convention concerning International Carriage by Rail (COTIF) of 9 May 1980 (1990 Protocol).

Protocol of 3 June 1999 for the Modification of the Convention concerning International Carriage by Rail (COTIF) of 9 May 1980 (Vilnius Protocol)

150. The ***COTIF Convention***, as amended by the 1999 Vilnius Protocol, is in force in 37 States, mostly European.[119] It provides, in Article 6, *Uniform Rules*, that:

"So far as declarations are not made in accordance with Article 42 § 1, first sentence, international rail traffic and admission of railway material to use in international traffic shall be governed by:

a) the "Uniform Rules concerning the Contract of International Carriage of Passengers by Rail (CIV)", forming Appendix A to the Convention,

b) the "Uniform Rules concerning the Contract of International Carriage of Goods by Rail (CIM)", forming Appendix B to the Convention,

c) the "Regulation concerning the International Carriage of Dangerous Goods by Rail (RID)", forming Appendix C to the Convention,

d) the "Uniform Rules concerning Contracts of Use of Vehicles in International Rail Traffic (CUV)", forming Appendix D to the Convention,

e) the "Uniform Rules concerning the Contract of Use of Infrastructure in International Rail Traffic (CUI)", forming Appendix E to the Convention,

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118 On rail regimes in general, see G. MUTZ, "Vers un nouveau droit du transport international ferroviaire", *Uniform Law Review/Revue de droit uniforme*, 1996, p. 442.

119 On the COTIF Convention, see M. KOPECKY, "La nouvelle COTIF ou l'espace juridique ferroviaire en mutation", *European Transport Law*, 2005, p. 53.

f) the "Uniform Rules concerning the Validation of Technical Standards and the Adoption of Uniform Technical Prescriptions applicable to Railway Material intended to be used in International Traffic (APTU)", forming Appendix F to the Convention,

g) the "Uniform Rules concerning Technical Admission of Railway Material used in International Traffic (ATMF)", forming Appendix G to the Convention,

h) other systems of uniform law elaborated by the Organisation pursuant to Article 2".

It expressly states that "The Uniform Rules, the Regulation and the systems listed in § 1, including their Annexes, shall form an integral part of the Convention".

This paper will focus on CIV and CIM Uniform Rules.

Uniform Rules concerning the Contract of International Carriage of Passengers by Rail (CIV Uniform Rules)

151. A train accident could be caused by a GNSS failure or malfunction and provoke loss or damage to the passengers. In this case, if the accident falls within their scope of application (the territory of its 37 Contracting Parties), the ***CIV Uniform Rules*** apply to "every contract of carriage of passengers by rail for reward or free of charge, when the place of departure and the place of destination are situated in two different Member States, irrespective of the domicile or the place of business and the nationality of the parties to the contract of carriage". Special rules specify the applicability of the Rules when part of the carriage includes carriage by road or internal waters.

152. In respect of liability, the CIV Rules state in Article 26, *Basis of liability*, that "The carrier shall be liable for the loss or damage resulting from the death of, personal injuries to, or any other physical or mental harm to, a passenger, caused by an accident arising out of the operation of the railway and happening while the passenger is in, entering or alighting from railway vehicles whatever the railway infrastructure used".

153. The carrier will be exonerated from liability if "the accident has been caused by circumstances not connected with the operation of the railway and which the carrier, in spite of having taken the care required in the particular circumstances of the case, could not avoid and the consequences of which he was unable to prevent".

154. In case of GNSS failure that results in an accident or a delay, it is likely that the circumstances would be connected with the operation of the railway and, therefore, the carrier would not be exonerated from liability.

155. Similar rules apply to liability for luggage as well as for liability in case of cancellation, tardiness of trains or missed connections; this last type of liability is one that is most likely to be caused by a GNSS failure and would entail the liability of the carrier "for loss or damage resulting from the fact that, by reason of cancellation, the late running of a train or a missed connection, his journey cannot be continued the same day, or that a continuation of the journey the same day could not reasonably be required because of given circumstances. The damages shall comprise the reasonable costs of accommodation as well as the reasonable costs occasioned by having to notify persons expecting the passenger" (Article 32).

156. Remarks on this regime:

a) the CIV Rules apply only to international transport, and therefore domestic transport would not be covered;

b) in case of an accident due to a GNSS failure or malfunction, the carrier would be able to exercise a right of recourse towards the GNSS provider if he can prove that the accident was caused by a signal failure.

Uniform Rules Concerning the Contract of International Carriage of Goods by Rail (CIM Uniform Rules)

157. A train accident due to a GNSS failure or malfunction can provoke loss or damage to the carried goods. In this case, if the accident falls within their scope of application (the territory of its 37 Contracting Parties), the ***CIM Rules*** will apply - according to Article 1, *Scope* - to "every contract of carriage of goods by rail for reward when the place of taking over of the goods and the place designated for delivery are situated in two different Member States, irrespective of the place of business and the nationality of the parties to the contract of carriage". When the place of taking over of the goods and the place designated for delivery are situated in two different States, of which at least one is a Member State, the Rules apply if the parties agree that the contract is subject to them.

158. The CIM Rules state in Article 23, *Basis of liability*, that "The carrier shall be liable for loss or damage resulting from the total or partial loss of, or damage to, the goods between the time of taking over of the goods and the time of delivery and for the loss or damage resulting from the transit period being exceeded, whatever the railway infrastructure used"; § 2 of the same Article provides that "The carrier shall be relieved of this liability to the extent that the loss or damage or the exceeding of the transit period was caused by .... circumstances which the carrier could not avoid and the consequences of which he was unable to prevent". According to Article 25, Burden of proof, "The burden of proving that the loss, damage or exceeding of the transit period was due to one of the causes specified in Article 23 § 2 shall lie on the carrier".

159. The carrier accordingly can be exonerated from liability if he proves that the loss or damage was caused by "circumstances" that he "could not avoid and the consequences of which he was unable to prevent"; GNSS would probably fall under this exemption.

160. Remarks on this regime:

a) the CIM Rules apply only to international transport, domestic transport would not be covered;

b) in case of GNSS failure, the carrier would be exonerated from liability if he can prove that the loss or damage was caused by "circumstances" that he "could not avoid and the consequences of which he was unable to prevent". Again, this will depend (i) on the circumstances of the case and (ii) on the characteristics of the signal, which is linked to the development of the technology and on how widespread its use is.

Multimodal transport

161. Today, it is becoming increasingly common for a carrier to enter into a contract for a multimodal carriage of goods, i.e. for performing "carriage of goods by at least two different modes of transport from the place where the goods are taken in charge to a place designated for delivery",[120] accepting responsibility for the whole carriage. This is encouraged by the so-called containerization of carriage of goods.

The existing discipline

162. "The current situation regarding carrier liability in multimodal transport operations presents picture of far greater uncertainty and confusion than is the case with the various forms of unimodal carriage";[121] the United Nations decided to establish a legal regime by adopting the 1980 Convention that will be briefly outlined *infra*, which has not yet entered into force.

163. For the time being, each leg of the carriage will be submitted to the rules applicable to that specific form of transport; this is far from being ideal because the same contract will be subject to

[120] The definition is due to R. DE WIT, Multimodal Transport. Carrier Liability and Documentation, London, 1995.

[121] *Ibidem*, p. 331.

a "patchwork" of rules, with the major risk of leaving "liability gaps" that a unified system would avoid.[122]

The provisions on multimodal transport of the Rotterdam Rules

164. It is useful to recall that an attempt to ameliorate this situation is provided for by the Rotterdam Rule,[123] which will also apply to multimodal transport, as stated by Article 1, Definitions, according to which the "Contract of carriage" .... "shall provide for carriage by sea and may provide for carriage by other modes of transport in addition to the sea carriage". The provisions of the Rules do, however, take into account the existence of unimodal instruments that could apply and "In order to ensure absolute clarity in respect of the interaction between the Rotterdam Rules and unimodal inland conventions, the Convention also includes a provision that prevents it from affecting the application of inland conventions in respect of the carriage of goods by air, road, rail, or inland waterway that regulate the liability of the carrier for loss of or damage to the goods, and that could apply to a contract of carriage subject to the Rotterdam Rules";[124] this solution offers a solution to possible gaps without imposing a unified solution that would likely have been difficult to attain.

The United Nations Convention on International Multimodal Transport of Goods (Geneva, 24 May 1980)

165. The ***United Nations Convention on International Multimodal Transport of Goods***, which is not yet in force, provides under Article 16, *Basis of liability*, that: "The multimodal transport operator shall be liable for loss resulting from loss or damage to the goods, as well as from delay in delivery, if the occurrence which caused the loss, damage or delay in delivery took place while the goods were in his charge as defined in article 14, unless the multimodal transport operator proves that he, his servants or agents or any other person referred to in article 15 took all measures that could reasonably be required to avoid the occurrence and its consequences". It is the application of the principle of *prima facie* liability, i.e. liability for negligence with reversed burden of proof.[125]

166. Should this Convention come in force, it would not entail the liability of the multimodal transport operator in case of loss-damage due to a GNSS failure because the operator would probably be in the condition of proving that the he and his agents "took all measures that could reasonably be required to avoid the occurrence and its consequences". This will depend a) on the circumstance of the case and b) on the characteristics of the signal, which is linked to the development of the technology and on how widespread its use is.

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[122] *Ibidem*, p. 513.

[123] In the Preamble this is stated as follows: "*Noting* that shippers and carriers do not have the benefit of a binding universal regime to support the operation of contracts of maritime carriage involving other modes of transport..."; see G. VAN DER ZIEL, "Multimodal Aspects of the Rotterdam Rules", *Uniform Law Review/Revue de droit uniforme*, 2009.

[124] K. LANNAN, "The United Nations Convention on Contracts for the International Carriage of Goods Wholly or Partly by Sea – A General Overview", *Uniform Law Review/Revue de droit uniforme*, 2009, p. 308. The relevant provision is Article 26 – *Carriage preceding or subsequent to sea carriage:* "When loss of or damage to goods, or an event or circumstance causing a delay in their delivery, occurs during the carrier's period of responsibility but solely before their loading onto the ship or solely after their discharge from the ship, the provisions of this Convention do not prevail over those provisions of another international instrument that, at the time of such loss, damage or event or circumstance causing delay: *(a)* Pursuant to the provisions of such international instrument would have applied to all or any of the carrier's activities if the shipper had made a separate and direct contract with the carrier in respect of the particular stage of carriage where the loss of, or damage to goods, or an event or circumstance causing delay in their delivery occurred; *(b)* Specifically provide for the carrier's liability, limitation of liability, or time for suit; and *(c)* Cannot be departed from by contract either at all or to the detriment of the shipper under that instrument".

[125] R. DE WIT, *Multimodal Transport*, cit., p. 515.

Carriage of dangerous goods

Convention on Civil Liability for Damage Cause during Carriage of Dangerous Goods by Road, Rail and Inland Navigation Vessels (CRTD), Geneva, 1 February 1990.

167. The ***CRTD Convention***, which is not yet in force, was prepared by UNIDROIT and adopted by the Inland Transport Committee of the Economic Commission for Europe at its fifty-first session, held in Geneva, from 2 to 10 October 1989.

168. At its seventy-first session (Geneva, 5-9 November 2001), the Working Party on the Transport of Dangerous Goods, having considered the conclusions of the *ad hoc* group of experts on the basis of the questionnaire on the CRTD Convention, recommended to the Inland Transport Committee that it establish an *ad hoc* Meeting of Experts on the CRTD, with a view to drafting a reviewed text of the CRTD. A draft text was adopted by the *ad hoc* Meeting of Experts in 2003.

Concluding remarks on international carriage instruments

169. As we have seen, almost each transport sector, as well as the nuclear trade sector, has instruments dealing with third party liability.

170. Quoting from Prof. Magnus paper:

> "*These conventions deal with the liability of the air carrier, of the shipowner or the operator of a nuclear installation only. They do not deal with the liability of third persons who in turn may have caused the air crash, ship wreckage or nuclear incident. In part, they cover damage caused by the malfunction of a global navigation satellite system, in part they do not (...) Where these instruments are applicable and where they cover liability for damage even through GNSS failures there is no need for further protection of the victims. However, the scope of these conventions is limited insofar as only a limited number of countries have ratified them and by no means all cases are covered where the malfunction of a global navigation satellite system may possibly cause damage*".

171. To these observations, we may add that even when the liability regime covers this kind of event, the air carrier, the shipowner etc. will be able to exercise their right of recourse towards the signal provider.

The general comments that these instruments may raise are the following.

Scope of application

172. The majority of instruments covers only **international transport**, and excludes internal transport from the scope of application. This can be generally acceptable, because most of the accidents concerning internal transport will not, at least generally, present international relevance and will thus usually be governed by domestic regimes. In case of damage due to GNSS failure or malfunction, due to the global nature of the system, there will be a high chance that also accidents concerning internal transport present international aspects, and therefore raise problems of jurisdiction and applicable law.

173. Since they are limited to the compensation of specific categories of loss and damages, these instruments they do not cover direct losses and damage incurred by the transport operators as well as loss and damage to non contemplated categories. In case of a train accident, the COTIF Conventions cover the loss and damage to passengers, luggage and carried goods, but not the loss of the train itself or damages to third parties, i.e. damage to the ground; in case of a maritime casualty, none of the existing instruments covers the loss of the ship itself; in case of an aviation crash, the different applicable regimes cover the loss and damages of the passengers, the luggage, the third parties on the ground, but do not cover the loss of the aircraft. These issues, as well as all the other damages not falling within the scope of the existing instruments, will thus be governed by domestic rules.

Liability for fault

174. Some of the instruments cover only **liability for fault** and, therefore, in the event of GNSS failure, insofar as it can be proven that the losses and damage were not caused through the fault of the transport operator, the international regime would not apply. It must be stressed that this is a complex issue; much may depend on the specificities of each particular case. It is to be expected that, as recourse to GNSS becomes more common, a failure of the signal may exonerate the transport operator. This will also depend on the specific sector involved.

Right of recourse

175. The relevant legal instruments do not generally prejudice any **right of recourse** of the party liable against third parties, i.e. the GNSS provider. In some cases, the instruments expressly reserve the right of recourse; in other cases there is no express provision, but this right must be implicitly recognised.

Non exclusivity of the international regimes

176. The regimes created by these instruments are non exclusive, i.e. they coexist with the general rules on liability. Therefore, it is possible in case of a damage caused by a GNSS failure, and although the particular activity falls within the scope of application of an international instrument providing a discipline of liability, that claimants address directly the GNSS providers.

177. The international regimes provided by the instruments that we have seen create a balance between the interests of the transport operator, on the one hand, mainly by providing a limitation of compensation, and the interests of the damaged parties on the other, by channelling liability and imposing the principle of strict liability and/or the reversed burden of proof. However, it is quite possible that the damaged parties, notwithstanding the fact that the damage falls within the scope of the convention, address not the transport operator but another person or entity. Accordingly, nothing can prevent a damaged party from suing the GNSS operator directly with a view to obtaining higher compensation. An example is the 1974 air crash of a DC-10 of the Turkish Airlines in Ermenonville, France, where the plaintiffs decided not to sue the aviation operator in order to "escape the Warsaw Convention's notoriously low damages ceiling and jurisdictional limitations", and recovered "almost forty times the maximum amount recoverable under the Warsaw Convention" by suing directly the aircraft manufacturer.[126]

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[126] See F. JUENGER, "Eason-Weinmann Center for Comparative Law Colloquium: The Internationalization of Law and Legal Practice: Forum Shopping, Domestic and International", *Tulane Law Review*, 1989, p. 560 ss.: "A striking example of the American judicial systems' attraction as a tort haven is the litigation following the crash near Paris of a DC-10 owned by a Turkish airline. The plane, en route from Paris to London, plunged into the forest of Ermenonville shortly after takeoff, killing 330 passengers from 5 continents and the 13-member Turkish crew. The widow of an English victim retained a New York firm, which filed a complaint in a federal court in Los Angeles fifteen days after the accident. Seminars conducted by American experts on aviation cases persuaded English solicitors to send their clients' cases to the United States, and the relatives of victims from other nations followed suit. To escape the Warsaw Convention's notoriously low damages ceiling and jurisdictional limitations, the plaintiffs' attorneys recast the plane crash as a products liability suit. Their primary targets were the manufacturer of the aircraft, McDonnell Douglas, and its subcontractor, General Dynamics. Actions filed in various states, primarily New York and California, were consolidated by the Judicial Panel on Multidistrict Litigation. Ultimately more than eleven hundred plaintiffs from all over the world appeared in a Los Angeles federal courtroom.

The United States District Court for the Central District of California offered procedures far superior to those available in France, England, and Japan - not to mention Turkey - for litigating a complex products liability case. American-style pretrial discovery, in particular, is largely unknown in civil-law countries. Even compared to English law, the discovery possibilities afforded by the Federal Rules of Civil Procedure are much broader. In the Paris aircrash case, discovery was conducted for over a year, and it proved to be damning to the defendants. After McDonnell Douglas' motion to dismiss on forum non conveniens grounds was denied, the defendants saw the handwriting on the wall and agreed not to contest liability. The only major issue left was the amount of damages. The first - and only - jury verdict, rendered in favor of the two orphaned infant daughters of an English couple, awarded one and one-half million dollars, almost forty times the maximum amount recoverable under the Warsaw Convention. That figure provided a benchmark for settling the other cases."

178. The same, with the obvious adjustments, could of course happen in case of an air, or sea, or rail accident connected with a GNSS failure or malfunctioning; despite the existence of an international regime for that particular domain of transportation, the plaintiffs could decide to sue directly the GNSS operators, precisely for the reason that, in the absence of a special liability regime, they would not encounter any limitation in compensation.

Gaps in protection and questions left open

179. As we have seen, under some regimes transport operators are liable in case of fault/negligence, while under other regimes they have a strict liability. The following remarks can be made.

(a) When carriers are liable *for their own fault*, damage resulting from GNSS failure would have to be "attributable" *to the carrier or its agents*;

(i) this could be the case if carrier chooses to use GNSS for navigation purposes for its own convenience or hires this service under contract;

(ii) the consequence would be that damage would be subject to the liability limits set in the conventions; Carriers would either self-insure or purchase insurance to cover compensation paid to cargo owners;

(iii) insurers might have a recourse action against GNSS operators;

(iv) in that case, there might be a "gap"

a. for the injured party - corresponding to the difference between the actual damage and the compensation paid by the carrier under the conventions;

b. for the carrier's insurer - if the GNSS operator cannot be held liable (e.g. State immunity) or has contractually disclaimed or limited liability for use of its services;

(v) could there be a subsidiary direct action against the GNSS provider for the "gap"?

(a) The same conclusions as under (a) could be driven when the international regime provides that the carrier encounters strict liability;

(b) Since carriers are generally *not* liable when the damage was caused by a third party, they would be free from liability if damage resulting from GNSS failure would *not* be "attributable" the carrier; This could be the case, for example, if it is generally accepted as commercially reasonable for carriers to use GNSS for navigation purposes (even if "open");

(i) the consequence would be that the carrier would be exempt from liability;

(ii) the damage therefore would *not* be subject to the liability limits set in the conventions;

(iii) cargo owners would either self-insure or (more often) purchase cargo insurance to cover for loss not covered by compensation obtained from the carriers;

(iv) insurers might have a recourse action against GNSS operators;

(v) in that case, there might be a "gap":

a. for the injured party if that party's cargo insurance does not cover this type of damage;

b. for the cargo insurer if the GNSS operator cannot be held liable or has generally disclaimed liability for use of its productsc.

(vi) Could there be a subsidiary direct action against the GNSS provider for the "gap"?

Notwithstanding the existence of a variety of instruments in the transport sector, a number of accidents provoked by GNSS failure or malfunction could fall outside their scope of application.

The transport operator would maintain a right of recourse of the transport operator in respect of the GNSS signal provider.

These instruments all provide for a limitation of compensation; in the absence of such a limitation for GNSS activities, the plaintiffs might be induced to address the GNSS provider directly in order to obtain higher compensation.

The existing regimes can present gaps in protection, and leave open the questions of the subsidiary direct action against the GNSS provider for these "gaps".

IX. International regimes governing liability for nuclear damage

180. It is possible that a GNSS failure might cause nuclear damage. This could happen, for instance, in case of an accident involving vehicles transporting nuclear substances. Prof. Magnus points out in his paper that "In the worst scenario, that of a satellite systems failure causing an aircraft to crash into a nuclear power plant and triggering a nuclear incident, the nuclear conventions become applicable". It is, however, important to underline that although it is possible, albeit not likely due to the high safety standards required in this domain, that a GNSS failure might cause a nuclear damage (i.e., as mentioned above, in case of accidents involving vehicles carrying nuclear substances), the "worst scenario" evoked by Prof. Magnus (the crash of an aircraft into a nuclear power plant) is extremely unlikely because nuclear power plant installations are made with high safety standards and would resist an aircraft crash.

181. In case of a nuclear damage caused by a GNSS failure or malfunction, the existing international instruments that could come into play are the following:

Convention on Civil Liability for Nuclear Damage, Vienna, 21 May 1963 ("Vienna Convention")

Convention on Third Party Liability in the Field of Nuclear Energy, Paris, 29 July 1960, as amended by the Additional Protocol of 28 January 1964 and by the Protocol of 16 November 1982 ("Paris Convention")

Joint Protocol Relating to the Application of the Vienna Convention and the Paris Convention, Vienna, 21 September 1988

Protocol to Amend the 1963 Vienna Convention on Civil Liability for Nuclear Damage, Vienna, 1997

Convention on Supplementary Compensation for Nuclear Damage, Vienna, 1997

182. "As the accident at Chernobyl illustrated, the geographical scope of damage caused by a nuclear accident is not necessarily confined to national boundaries. In the event of a nuclear accident causing damage in more than one country, it is desirable that the protection accorded to victims by a third party liability regime be distributed equitably among affected countries. Although the high safety standards of the nuclear industry mean that the risk of an accident is very low, the possible magnitude of damage from a nuclear accident is such that insurance coverage of liability requires international collaboration between national insurance pools. These considerations were recognised in the early years of the nuclear power industry and inspired States to develop the existing international regimes. Furthermore, there is a significant amount of transboundary

transport of nuclear materials. Such international movement is both better regulated and facilitated by being subject to one uniform regime.

183. There are two basic international regimes for nuclear third party liability in force: the Convention on Third Party Liability in the Field of Nuclear Energy ("the Paris Convention") was established on 29 July 1960 under the auspices of the NEA and covers most West European countries, while the Convention on Civil Liability for Nuclear Damage ("the Vienna Convention") was established on 21 May 1963 under the auspices of the International Atomic Energy Agency (IAEA) and is worldwide in character".[127]

184. The international liability regime was embodied primarily in two instruments, i.e. the ***Vienna Convention*** (in force in 36 Countries) and the ***Paris Convention*** (in force in 16 Countries), linked by the ***Joint Protocol*** adopted in 1988. The Joint Protocol (in force in 26 Countries) was adopted following the Chernobyl accident; it establishes a link between the Conventions, combining them into one expanded liability regime. Parties to the Joint Protocol are treated as though they were Parties to both Conventions; a choice of law rule is provided to determine which of the two instruments should apply, to the exclusion of the other, in respect of the same incident.

185. These Conventions share the following main principles:

- liability is channeled exclusively to the operators of the nuclear installations;
- liability of the operator is absolute, i.e. the operator is held liable irrespective of fault;
- liability is limited in amount;
- liability is limited in time. Compensation rights are extinguished under both Conventions if an action is not brought within a certain period of time from the date of the nuclear incident.
- the operator must maintain insurance of other financial security for an amount corresponding to his liability; if such security is insufficient, the installation State is obliged to make up the difference up to the limit of the operator's liability;
- jurisdiction over actions lies exclusively with the courts of the Contracting Party in whose territory the nuclear incident occurred;
- non-discrimination of victims on the grounds of nationality, domicile or residence.

186. The ***1997 Protocol*** and the ***1997 Convention on Supplementary Compensation for Nuclear Damage*** were adopted under the auspices of IAEA; the Protocol sets the possible limit of the operator's liability at not less than 300 million Special Drawing Rights (SDRs) (roughly equivalent to $US400 million). The Convention on Supplementary Compensation defines additional amounts to be provided through contributions by States Parties on the basis of installed nuclear capacity and the UN rate of assessment. The Convention is an instrument to which all States may adhere regardless of whether they are parties to any existing nuclear liability conventions or have nuclear installations on their territories. The Protocol contains *inter alia* a better definition of nuclear damage (now also addressing the concept of environmental damage and preventive measures), extends the geographical scope of the Vienna Convention, and extends the period during which claims may be brought for loss of life and personal injury. It also provides rules on jurisdiction and applicable law.

187. Concluding remarks: Liability in this field being absolute, the damage will be compensated by the operator of the nuclear plant; however, in turn, the operator might exercise a right of recourse and sue the GNSS provider in order to recover the sums paid as reparation of the damage.

[127] Quoted from Nuclear Energy Agency (NEA) press room, *Press kit: International nuclear third party liability*, http://www.nea.fr/html/general/press/press-kits/nuclear-law.html.

An international instrument on GNSS liability could address the nuclear risk and indicate the relationship of the regime that it creates with the existing instruments in this field.

X. Regimes governing GNSS liability for applications not covered by the existing instruments

Scope of the existing international regimes and GNSS applications

188. As we have seen *supra* in Chapter V, GNSS applications cover many domains, most of which do not fall under any special regime.

189. Some of the activities relying on GNSS, i.e. telecommunications, which are based on satellite signals for their synchronisation, even in case of a GNSS malfunctioning, will not be the source of catastrophic loss, involving loss of lives, but could nevertheless cause damages of economic character, as Prof. Magnus indicated in his paper: "*Death or bodily injury would be a less likely consequence of the failure of a global navigation satellite system with respect to the further uses at present envisaged by the promoters of Galileo (use in the financial sector, for prospecting, surveying, etc.). Yet economic loss could always ensue".* A practical example of possible damage connected to GNSS applications based on Positioning concerns the geographic surveys.[128]

190. We can also mention the financial sector: a malfunctioning of the signal, on which many of these systems rely for timing their files, could entail significant economic losses, deriving from inaccurate record of transactions even of very high value.

Applicable rules in the absence of an international regime

191. In the absence of an international regime, or in cases where the losses and damages fall out of the scope, either subjective or objective of the international regime (see *supra*, § 172-173), or when claimants prefer, for various reasons, as we have seen under § 176-178, not to invoke the existing international regime, domestic law will apply, raising issues of private international law in order to ascertain the applicable rules and the competent jurisdiction.

192. The issues of jurisdiction and conflict of laws in the field of civil liability are highly controversial and have given rise to a lively debate. The traditional rule of *lex loci commissi delicti* has been questioned, and partially rebuffed in favour of other solutions, both because in many cases the "locus" itself may be difficult to ascertain, and also because it may not always be the more appropriate solution. The relevant differences in the various domestic legislations, both on the establishing of the liability and in fixing the amounts of compensation, can lead to *forum shopping*. To add further complexity to this already intricate situation, it should be underlined that GNSS liability may present some peculiarities in comparison to other fields of possible source of liability. We quote the interesting comment made in that respect by Prof. Magnus in his paper:

> *"An additional fact further complicates the situation, namely the complexity of global navigation satellite systems themselves. As indicated, a number of institutions, businesses and persons contribute to their functioning. Although State authorities at present dominate the GNSS, private manufacturers are also involved. In the event of damage caused by malfunction of the system any, or even all, of those involved may therefore be responsible for that malfunction. Thus, if a person who has suffered damage claims compensation it is necessary to determine the competent jurisdiction and the applicable law with respect to each possible defendant."*[129]

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[128] J.L. PHILLIPS, "Information Liability: The Possible Chilling Effect of Tort Claims against Producers of Geographic Information Systems Data", *Florida State University Law Review*, Spring, 1999, p. 743.

[129] U. MAGNUS, op. cit., p. 7.

193. These considerations are further developed by Prof. Carbone and Ms De Maestri in their paper, in which they state that:

> *"Clearly, the main deficiencies of the present framework of the liability regimen applicable to G.N.S.S. are due not only to the complete absence both of specific substantive provisions in this area and of compensation channels for all situations but also to the ambiguous interaction between the existing tools which it might be possible to use in this connection (...)*
>
> *In respect of third party liability, even though some common principles can be found at the international level (see, for example, the existing civil liability conventions), each State has its own rules to identify the party liable, to establish the onus of proof, to quantify the compensation of damage, etc.*
>
> *Moreover, in cases of damage incurred by third parties outside any contractual relation, many international conventions on civil liability already grant compensation to the injured party, even where the damage is caused by a system malfunction in satellite navigation; obviously such conventions are connected to a particular industry (*i.e. *oil pollution, transport of nuclear materials …), notably for a specific kind of damage that can interfere with the provision of a relevant signal".*

194. It should also be stressed that, due to its global nature, a single GNSS failure or malfunction can entail a variety of accidents:

> *"Considering the variety of applications for G.N.S.S. technology and the consequent variety of international and national regimens that could be applied, the authors of this article contend that it would be better to set up a convention that protects victims of a system malfunction in all cases, not leaving the chance of finding an adequate regimen for their compensation to fate. It is not difficult to imagine how a system malfunction can cause different kinds of damage, e.g., an accident involving ships may result in an oil spill, while a car crash may damage a third party's goods. In the former case, the victims would benefit from the international uniform liability regimen, whereas in the latter, they would find compensation only through the applicable national law, with all the consequences that this approach implies in terms of the compensatory amount and the evidentiary rules.*
>
> *At the same time, a single system malfunction could cause different types of damage to one and the same person, who would be obliged to claim compensation from different subjects under different normative rules."* [130]

An international instrument on GNSS liability could provide a sound and uniform regime for all accidents caused by a failure or malfunction of the system, both for those covered and for those not covered by existing international regimes.

XI. Other legal issues on GNSS liability

Causes of GNSS failure or malfunction

Fault and negligence of the GNSS provider

195. The GNSS failure or malfunction can be caused by a variety of factors. Without any pretence of comprehensiveness, and leaving aside the fraudulent intervention of a third person,[131] we can

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[130] S. CARBONE, E. DE MAESTRI, "The Rationale for an International Convention on Third Party Liability for Satellite Navigation Signals", *Uniform Law Review/Revue de droit uniforme*, 2009, p. 40 and 48.

[131] The GNSS signals are rather weak, for the very simple reason that they come from the Outer Space, and can therefore be "jammed", i.e. interfered, both inadvertently and fraudulently; see BOND L., "The GNSS Safety and Sovereignty Convention of 2000 AD", *Journal of air law and commerce*, 2000, p. 446.

quote the following: fault or negligence of the provider; defect of one of the GNSS component parts; *force majeure*.

Force majeure.

196. Whereas the fault or negligence of the GNSS provider, either in the implementation of the system or in its management and running, will normally be considered as a source of liability for the providers, it is disputable if - under the international existing regimes and under the domestic applicable law – *force majeure* (i.e. interruption or errors in the signal due to particular conditions, such as Sun activity[132]; interferences with other conflicting signals) will be considered a cause of exoneration; this may depend on the predictability of that particular event, which can be source of controversy.

Liability for defective product

197. It could be argued that in case of a GNSS failure or malfunction, the GNSS provider could be considered liable for defective product, because the GNSS signal could be qualified as a product. In some jurisdictions, this would lead to strict liability of the provider. In order to reach such a conclusion, it would be necessary to qualify the GNSS signal as a product. This seems rather unlikely, because the signal should not be qualified as a good, but as a service.[133]

198. The regime of liability of the manufacturer could, on the contrary, come into play in case of **defect of one of the GNSS component parts** – satellites, ground stations, and receivers. It is difficult to predict if the alleged defect of one of the GNSS components could entail a cause of exoneration of the GNSS provider (of course when manufacturer and provider do not coincide). In the absence of an international uniform regime, it is possible that in such cases there will be a joint and several liability both of the GNSS provider and of the component manufacturer; the GNSS provider who has compensated the damage will be able to exercise a right of recourse and sue the manufacturer for the recovering of the sums paid in compensation.

199. In this case, the Convention on the Law Applicable to Products Liability, The Hague, 2 October 1973 could be applicable.

The Convention, adopted under the auspices of the Hague Conference on Private International Law, applies to "the liability of the manufacturers and other persons specified in Article 3" – i.e. manufacturers of a finished product or of a component part, producers of a natural product, suppliers of a product, and other persons, including repairers and warehousemen, in the commercial chain of preparation or distribution of a product, as well as the agents or employees of the persons specified above – "for damage caused by a product, including damage in consequence of a misdescription of the product or of a failure to give adequate notice of its qualities, its characteristics or its method of use". The Convention has only 11 Contracting States, all European.[134]

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[132] See, for instance, http://news.bbc.co.uk/2/hi/science/nature/8494225.stm, where is explained the influence of Sun activity on satellite signals.

[133] The E.U. Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products (OJEU, L 210, 7 August 1985), amended by Directive 1999/34/EC (OJEU L 283, 6 November 1999) indicates in Article 2 that "'product' means all movables even if incorporated into another movable or into an immovable. 'Product' includes electricity". According to this definition, a GNSS signal could not be considered as a product. One should note that the express inclusion of electricity indicates a deviation from the rule that cannot be source of analogy (moreover, this inclusion is connected with the qualification of electricity as a good by the European Court of Justice, for the purpose of including it in the regime of the free circulations of goods; see ECJ Judgment of 23 October 1997, *Commission v. Italy*, Case C-158/94, European Court Reports, 1997, p. I-05789).

[134] The regime of the Convention is complex and has raised many critics because it is rather unbalanced in favour of the manufacturer. As principal connecting factor, the Convention indicates "the law of the State of the habitual residence of the person directly suffering damage", if in the same country a) the person claimed to be liable has his principal place of business and/or b) the person directly suffering damage has acquired the product. When the requirements for applying that law are not met, the applicable law is the law of the country of the place of injury (the traditional rule of *lex loci commissi delicti*), provided that the case present at least

Insurance and insurability issues

200. Possible damage to third parties caused by potentially dangerous activities is often covered by insurance. Sometimes, the binding nature of such civil liability insurance towards third parties in a given sector is laid down by the law, or else it may flow from international conventions. In other cases, there is no legal obligation to insure and the operators of the relevant activities themselves, acting in their own best interests, will tend to take out insurance against the risk.

201. In some cases, the users of GNSS services will be insured against damage to third parties, for example, operators in economic sectors such as transport, finance, and others. They may also be insured against damage to their own assets: a ship, or an aircraft, may have an accident due to a malfunctioning of the GNSS. If the owner has taken out comprehensive insurance, the damage will be covered by that insurance. The insurers and, as the case may be, the re-insurers are, however, entitled to take recourse action against the GNSS operators who, in turn, would be well-advised to take out insurance which, in its turn, could be covered by re-insurance.

202. Pursuant to the doctrine of subrogation, the insurer takes the place of the person liable, "steps into his shoes"; as a consequence, the fact that a given activity is covered by insurance should not, at least in principle,[135] modify the substance of the liability regime. On the other hand, some aspects of the liability regime do have an impact on the insurability of the relevant activities and this, in turn, may affect the expansion and development of these activities.

203. In international transactions, one obstacle to the insurability of activities is uncertainty as to the applicable law. It is a fact that the rules governing civil liability differ widely from one jurisdiction to the next, both as regards the way in which the liability itself is attributed and the way in which damages are settled. It is hardly surprising, therefore, that the first insurance contracts to make their appearance, back in the Middle Ages, referred to a sector that was international by definition: shipping,[136] and that they developed along highly original lines over the centuries, responding to the need for convenience in an overall setting characterised by widely accepted uniform practice. Likewise, there is no doubt that an activity such as aviation, a relative newcomer on the scene, owes its swift expansion to the Warsaw Convention [137] which, by laying down a uniform liability system, has facilitated the insurability of air transportation.

204. Another possible stumbling-block to the insurability of certain activities is the level of risk. If the ceiling is set too high, or is impossible to assess, difficulties might arise in stipulating insurance: premium costs might become excessive or even make the activity itself unprofitable.[138] Maritime debts have always been subject to a limitation (typically, the practice of the abandonment of the ship) which is reflected in the LLMC Convention (see *supra*, § 120 ff.) and which has

another connecting factor with that country. If also this law is not applicable, then "the applicable law shall be the internal law of the State of the principal place of business of the person claimed to be liable, unless the claimant bases his claim upon the internal law of the State of the place of injury". The Convention must be now coordinated with the European *Regulation (EC) No 864/2007 of the European Parliament and of the Council of 11 July 2007 on the law applicable to non-contractual obligations (Rome II)* (see: TH. KADNER GRAZIANO, "La coordination des règlements européens et des conventions internationales en matière de droit international privé", *Revue suisse de droit international et européen*, 2006, p. 279) as well as with the E.U. Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products (OJEU, L 210, 7 August 1985), amended by Directive 1999/34/EC (OJEU L 283, 6 November 1999).

[135] Some studies appear to show that there might after all be a link between liability and insurance regimes, and this is hardly surprising considering that, according to a comparative analysis of the jurisprudence of several countries, some 95% of compensation payments in various sectors are covered by insurance; see T. BAKER, "The View of an American Insurance Law Scholar : Six Ways that Liability Insurance Shapes Tort Law", in *Tort Law and Liability Insurance* (ed. by G. Wagner), Wien-New York, 2005, p. 295.

[136] Risk-sharing systems in the shipping sector are to be found even in ancient times; see. F. AGUIRRE RAMÍREZ, C. FRESNEDO DE AGUIRRE, *Seguros marítimos, Curso de derecho del transporte*, Montevideo, 1999, p. 11 ; S. FERRARINI, *Le assicurazioni marittime*, 3ème éd., Milano, 1991, p.1 ss.

[137] See R.D. MARGO, *Aviation Insurance*, London, 1980, p. 2.

[138] This is an aspect that has awakened the interest of "law & economics" theories; see, for example, M. FAURE, "The View from Law and Economics", in *Tort Law and Liability Insurance* (ed. by G. Wagner), Wien-New York, 2005, p. 239.

facilitated the growth of insurance in this important economic sector. The same is true in the aviation sector, as we have seen, where the liability limit laid down by the Warsaw Convention makes it possible to calculate the risk from a strictly economic standpoint. In cases where the risk itself is liable to take on catastrophic proportions, some international instruments (for example, in the field of hydrocarbon pollution or nuclear risk) provide for a two-tier system in which the first tier applies to the operators responsible for the damage, with a liability limit and usually involving an obligation to take out insurance or some other financial guarantee, while the second tier is guaranteed by the installation State (nuclear risk) or by a Fund set up for the purpose (hydrocarbons).

Legal implications of the GNSS providing "open services"

205. It may be argued that as GNSS services are, at least for the time being, provided to users free of cost, no liability could be attached to loss caused or damage suffered by users on account of failure or inaccuracy of the systems, because those who make use of the systems do so at their own risk.

Although there might be differences under this respect in different jurisdictions, it is possible to affirm that liability would exist on the following grounds.

206. As we have seen *supra* in Chapter II, the dual purposes of the existing GNSS, GPS and GLONASS, – civil and military – was clearly stated by the Governments' authorities in both cases. It is thus possible to affirm that those who make use of the two systems are officially authorised to do so and will rely on the accuracy of the signal.

207. It may be useful to add that, generally, and when no causes of exemption exist (as we have seen is the case with many international instruments), third party liability is based on the notion of "harm" and not on the notion of "fault".[139]

An international instrument could address the issues of:

- fraudulent intervention of a third person;
- *force majeure*;
- qualification of GNSS signal as a service;
- liability in case of failure-malfunction caused by a defective component of the GNSS.

An international uniform regime on GNSS liability could facilitate the insurability of GNSS activities.

It could also address the issue of open services with respect with GNSS activities and clarify it.

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[139] J. DOLINGER, "Evolution of principles for resolving conflicts in the field of contracts and torts", *Recueil des Cours de l'Académie de droit international de La Haye*, vol. 283, 2000, p. 199. In common law, in spite of the recourse to the word "tort", it may be assumed that: "Be the exceptions more or less numerous, the general purpose of the law of torts is to secure a man indemnity against certain forms of harm to person, reputation, or estate, at the hands of his neighbors, not because they are wrong, but because they are harms" (O. W. HOLMES, *The Common Law*, Boston, Little, Brown and Co., 1881). We may add that also the recent *Regulation (EC) No 864/2007 of the European Parliament and of the Council of 11 July 2007 on the law applicable to non-contractual obligations (Rome II)* puts the accent on the "damage".

XII. The legal work on GNSS issues undertaken by international organisations

208. Some international Organisations have devoted their attention to the different legal issues connected with the development of GNSS. This paper will give a brief outline of some of their more relevant activities. It may be noted that other Organisations may have an interest in GNSS, particularly the European Group of Institutes of Navigation, the Bureau International des Poids et Mesures (BIPM) and the International Federation of Surveyors (FIG).

International Civil Aviation Organisation (ICAO) and European Civil Aviation Conference (ECAC)

209. In 1998, according to Resolution A32-19, the ICAO Assembly adopted the "Charter on States' rights and obligations with respect to GNSS services", and, under Resolution A32-20 "Definition and establishment of an appropriate legal framework in the long term governing GNSS implementation", the Assembly instructed the ICAO Council and the Secretariat "to consider the elaboration of an appropriate long term framework to govern the operation of GNSS systems, including consideration of an international convention for this purpose".

210. In respect of the concerns that the work done by ICAO and ECAC should address, it is useful to quote from Dr. Bollweg's article:

> "The development of a legal framework to govern the implementation of GNSS has been on the Work Programme of the Legal Committee of the International Civil Aviation Organization (ICAO) since 1992. First of all, a committee of legal and technical experts was established by the ICAO Council in 1995 which led to the adoption of a charter on the rights and obligations of States relating to GNSS services at the 32nd ICAO Assembly in 1998. However, this alone was not considered adequate, as several aspects related to certification, operating structures, administration, cost recovery and, most importantly, liability were not addressed. The liability aspects in particular were found to merit further examination. The 32nd ICAO Assembly in 1998 set up a new Study Group, the Secretariat Study Group on Legal Aspects of CNS/ATM Systems, which reported to the 33rd ICAO General Assembly in 2001. The 33rd Assembly mandated the ICAO Secretariat Study Group to finalise a contractual framework, focussing predominantly on model clauses (ICAO doc A36-WP/140, para. 1.1).
>
> The main purpose of the contractual framework was to provide a number of legal and institutional provisions that were deemed necessary to address GNSS at the regional level. The contractual framework is based on a two-tier approach. On one level, it offers a regulatory agreement dealing with public law matters including certification, liability and jurisdictional matters. Another level consists of private contractual agreements between the various stakeholders in which they would have a very large degree of autonomy, subject to certain mandatory elements determined by the regulatory agreement (ICAO doc A36-WP/140, para. 1.2).
>
> The author of this article was himself a member of the EUROCONTROL Legal Task Force on GNSS Liability from 1999 to 2001. These consultations were, however, not concluded, being incorporated instead in the work of the ICAO Study Group on Legal Aspects of CNS/ATM Systems.
>
> The Study Group submitted its final report in 2004. The report had the following to say, *inter alia*, about the issue of liability (ICAO doc. C-WP/12197):
>
> *"3.3.2 Approaches to the issue of liability*
>
> *3.3.3 The Group identified three possible approaches to the problem of liability relating to GNSS:*

(a) to ensure that the doctrine of sovereign immunity and related principles will not be an obstacle to bringing all potential defendants, including all parties involved in the provision of the GNSS services, into legal proceedings before the court where the victim of an accident involving failure or malfunction of GNSS has brought action;

(b) to establish an adequate recourse action mechanism for the tate having jurisdiction under article 29 and the aircraft operator to take recourse against the other party or parties (mainly the primary signal provider and the augmentation signal provider) involved in the provision of the services, to the extent that such other party or parties have been negligent in the provision of the signals; or

(c) to ensure adequate compensation coverage through compensation fund arrangements, as have been set up in the field of maritime transport and other fields.

3.3.4 The group had detailed and lengthy discussions concerning the possible approaches to the problem of liability. A part of the group believed that, in order to achieve universality and certainty of the new air navigation system, the issue of liability should be dealt with under a universal regime and should not be left to national law. Another part of the group, however, did not consider it necessary to establish a new universal liability system or a liability convention for GNSS, since there was no indication that the current liability regime under domestic law could not cope with GNSS, and further, since there was no connection between GNSS and the perceived gaps in the liability system.

4.1 Pursuant to its mandate as confirmed by the 33rd Session of the ICAO Assembly, the Study Group also focussed on the consideration of a contractual framework as an interim framework for CNS/ATM systems.

[…]

4.3 Elements of contractual framework

[…]

4.3.6 Liability

4.3.6.1 Article 6 provides that the liability of each party for failure to perform its obligations under this contract shall be governed by the liability regime applicable to its activity. This clause focusses on liability between parties in the contractual context, without addressing the issue of liability towards a third party.

[…]

5.2 Discussion of an international convention in the Study Group

[…]

5.2.2 One view was that since a great number of states would have to authorize the use of GNSS signals, over which they have no control, the only way to secure confidence in the system would be by committing both providers and users to accept certain rights and obligations in the form of a binding international legal instrument. In the view of these members, the international convention should set out, inter alia, such principles as the acknowledgement of the paramount importance of the safety of international civil aviation, unlimited access to GNSS services on a non-discriminatory basis, the sovereign right of every state to control operations of aircraft and enforce safety regulations within its airspace and the obligation of providers to assure continuity, availability, accuracy, transparency and liability of GNSS services. It was further pointed out that the liability issue is an essential element of the legal framework of GNSS, particularly in view of the multiplicity of the players and possible litigations taking place at the same time for the same event in a number of countries. According to this view, the implementation of a worldwide seamless and interoperable system such as CNS/ATM would not be compatible with a scattered liability system. These members supported the development of an international convention which they believed had been an option favoured by the vast majority at the Rio Conference, and the 32nd and 33rd Sessions of the Assembly. They saw the contractual framework as a flexible interim solution from which an international convention or other binding instruments might evolve.

5.2.3 A second view was that ICAO's existing legal framework, namely the Chicago Convention, its Appendixes and the other elements[ ], including applicable domestic law, offered continued serviceability and no deficiencies had been found to impede the implementation of CNS/ATM Systems. It was unnecessary to establish a new universal liability system or a liability convention for GNSS, since there was no indication that the current liability regime under domestic law could not cope with GNSS, and further, since there was no connection between GNSS and the perceived gaps in the liability system. While legal issues had been discussed in various bodies of ICAO, at no point had any ICAO body achieved consensus on a proposal for new global conventional law. At the same time, every ICAO body which had considered legal issues relating to CNS/ATM had been careful to state that work on legal issues must not be permitted to delay technical implementation of CNS/ATM systems.

[…]

5.2.6 At the end of the discussion on the subject of a draft convention and its specific clauses most members present observed that since the implementation of GNSS was in progress, there was not enough experience on which the drafting of an international convention could be based. It was therefore advocated not to pursue this matter, pending further development of GNSS."

This report was presented to the 35th ICAO General Assembly in 2004 for its attention and the adoption of a resolution (ICAO doc. A35-WP/75).

The European Civil Aviation Conference (ECAC), acting on behalf of its 41 members, also submitted a working paper (ICAO doc. A35-WP/125) to the 35th ICAO General Assembly. The draft of a "contractual framework" was first presented as Appendix B to this working paper, which states the following:

"4.1 A contractual framework which addresses GNSS must provide a unified structure capable of addressing both public law and private law arrangements between the various stakeholders. It needs to be comprehensive in coverage, addressing the full range of issues that concerns those stakeholders. The contractual framework proposed by the ECAC States is attached in Appendix B. It is not new. It was already presented and discussed at the 33rd Assembly, which asked for this completion as an interim step towards the development of a possible convention.

4.2 It is based on a two-tier approach. On one level, it offers a regulatory agreement dealing with public law matters including certification, liability and jurisdictional matters. The second level is private contractual agreements between the various stakeholders in which they would have a very large degree of autonomy subject to certain mandatory elements determined by the regulatory agreement. These mandatory elements would focus, inter alia, on compliance with SARPs with regard to continuity, availability, integrity, accuracy, reliability, recognition of (strict) liability, compulsory risk coverage, recourse to arbitration, waiver of right to invoke sovereign immunity. Harmonisation of these essential parts of the contracts would help achieve a framework where the roles and responsibilities of all players involved are clear to all and where relationships are defined.

4.3 The two main elements of this contractual framework, therefore, are the private law contracts to be concluded between the parties involved in the chain of implementation, operation provision and the use of GNSS signals and systems and the public law agreement between states involved to ensure these contracts are harmonised in order to contain the same essential provisions on safety, certification, liability etc. In this way, the necessary distinction between the public and private law elements of this proposed contractual framework will be ensured.

4.4 The contractual framework being proposed by ECAC states is not a GNSS Convention. While it includes binding elements, it also creates a flexible and readily available framework to cover all legal and institutional elements relating to GNSS at the regional level and harmonises contractual relationships between the parties involved, providing clarity and legal certainty. It may, however, provide experience and know-how and represents a first step, which could evolve into a long-term focussed and precise global instrument of international law under the aegis of ICAO."

By way of a long-term solution, the ECAC further submitted a draft convention in the form of Appendix C to this working paper, which states the following:

"5.2 The objective would be to achieve a dedicated convention limited to the essential common elements for legally and institutionally adequate provision of GNSS services. It would address, in particular, liability, including the issue of third party liability which cannot be adequately addressed through the contractual framework solution. This convention is foreseen to be the most appropriate way to address all parties affected by such a global system in the long term."

The 35th ICAO General Assembly in 2004 resolved to finalise a "contractual framework" in line with the ECAC proposal.

This issue was discussed again at the 36th ICAO General Assembly in 2007, although this time no longer as a separate item on the agenda but as part of the "Work Programme" item. To this end, ECAC again submitted a working paper (ICAO doc. A36-WP/140), which has the following to say on liability:

"2.7 The issue of liability has been widely debated in the context of the Galileo and EGNOS programmes over the past three years. The most important topics have been Third Party Liability, Design Risk, liability associated to the system operations and the Allocation of Liability. This illustrates the need for a framework as presented by the ECAC states in order to channel liability."

The working paper ends with the following conclusions:

"3.1 The contractual framework proposed by the ECAC States has already been recognized by ICAO in Assembly Resolution A 35-3 as a mechanism to create a flexible and readily available framework to cover all legal and institutional elements related to GNSS at the regional level and harmonises contractual relationships between the parties involved, providing clarity and legal certainty.

3.2 Developments in Europe with regard to EGNOS and Galileo confirm the need for such a contractual framework and highlight the need to align the said framework to take on board the need for harmonisation of, inter alia, international standards, certification, interoperability, liability allocation in a multi-State environment, particularly in the context of the European Single Sky legislation.

3.3 The contractual framework will be refined in the light of these developments and presented as soon as possible to the ICAO Secretary General and Council, as foreseen in the resolution. It is envisaged that the framework will satisfy the needs widely voiced in ICAO regarding GNSS and will assist in clarifying many of the difficult issues faced and serve as a useful basis for ongoing discussions in the Legal Commission."

However, the 36th ICAO General Assembly in 2007 no longer regarded the finalisation of the "contractual framework" as a task for the ICAO, seeing responsibility for it as resting exclusively with the ECAC. The report of the 36th General Assembly in 2007, Legal Commission (ICAO doc. A36-WP/297) has the following to say on this matter:

"47.9 The Commission noted its understanding that once a model of a regional framework is developed by the members of the European Civil Aviation Conference, such model could be distributed through ICAO to its member states, and interested states may use the information as guidance material to develop their own regional legal framework as appropriate."

Finally, the 36th ICAO General Assembly in 2007 downgraded the priority of this project from 1 to 3. Such low priority in effect means that the ICAO has washed its hands of the project.

At the meeting of Directors General held in Erevan (Armenia) from 28 August to 1 September 2008, the ECAC, at the instigation of EUROCONTROL, then looked at the liability issues of the Galileo project, giving priority to third party liabilities. Taking into account UNIDROIT's consideration of whether to adopt this kind of project as part of its own Work Programme, it was decided to approach the ICAO (Legal Committee) once again and to draw attention to the urgency of establishing a "Framework Agreement"

(ECAC doc. DGCA/57(SP)-SD, p. 6). It is, however, doubtful whether - following the decisions of the 36th General Assembly (see supra) - the ICAO will ever deal with the matter again."

International Maritime Organization (IMO)

Revised Maritime Policy and Requirements for a Future Global Navigation Satellite System (GNSS)

211. The **International Maritime Organization** adopted in November 2001 Resolution A.915(22) concerning its "Revised Maritime Policy and Requirements for a Future Global Navigation Satellite System (GNSS)",[140] which also addresses the issue of liability.

212. In this Resolution, the IMO Assembly,

> *"RECOGNIZING the need for a future civil and internationally-controlled global navigation satellite system (GNSS) to contribute to the provision of navigational position-fixing for maritime purposes throughout the world for general navigation, including navigation in harbour entrances and approaches and other waters in which navigation is restricted,*
>
> *RECOGNIZING ALSO that the maritime needs for a future GNSS are not restricted to general navigation only; that requirements for other maritime applications should also be considered, as a strict separation between general navigation and other navigation and positioning applications cannot always be made; and that intermodal use of GNSS is expected to increase in the future,*
>
> *RECOGNIZING FURTHER the need to identify at an early stage the maritime user requirements for a future GNSS, to ensure that such requirements are taken into account in the development of such a system",*

illustrates

> *"the maritime requirements for a future GNSS [that] can be subdivided into the following: general, operational, institutional and transitional requirements".*

In relation to institutional requirements, the Resolution states that:

> *"IMO itself is not in a position to provide and operate a GNSS. However, IMO has to be in a position to assess and recognize the following aspects of a GNSS:*
>
> *- provision of the service to maritime users on a non-discriminatory basis;*
>
> *- operation of the GNSS in respect of its ability to meet maritime user requirements;*
>
> *- application of internationally established cost-sharing and cost-recovery principles; and*
>
> *- application of internationally established principles on liability issues".*

International Telecommunications Union (ITU)

213. The interest of the **International Telecommunications Union** in GNSS is of a technical nature; on the one hand, ITU must provide frequencies for the space segment of the GNSS and, on the other hand, GNSS can improve the standard of telecommunications with its signal.[141]

214. Moreover, ITU provides the standards for the signal accuracy that must be met for some special applications, i.e. for aviation.[142]

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140 IMO, A 22/Res.915, 22 January 2002.

141 ITU Radiocommunication Assembly decided in 2009 (QUESTION ITU-R 248/7) to undertake a study on "Timing Information from Global Navigation Satellite Systems (GNSS) and their augmentations"; see http://www.itu.int/publ/R-QUE-SG07.248-2009/en.

142 See "Air Force Secures ITU Filing with GPS L5 Signal Transmission", *Inside GNSS News*, 10 April 2009, at http://www.insidegnss.com/node/1433#Baseband_Technologies_Inc_

215. So far, no special discussion on the subject of liability has been undertaken by ITU.

United Nations (UN)

216. The activity undertaken by the United Nations so far on GNSS is mostly directed towards co-operate for the development of this technology, addressing in particular the needs of some regions in which GNSS is not yet fully realised. Although the legal implications are not outside the scope of these activities, liability issues as such have not raised special attention. The most important achievements can be summarised as follows.

International Committee on Global Navigation Satellite Systems (ICG)

217. The **International Committee on Global Navigation Satellite Systems (ICG)** was established on a voluntary basis as a forum to promote co-operation, where appropriate, on matters of mutual interest to its members related to civil satellite-based positioning, navigation, timing and value-added services, as well as co-operation on the compatibility and interoperability of global navigation satellite systems, and to promote their use to support sustainable development, particularly in developing countries; it has held its first meeting in Vienna on 1 and 2 November 2006, its second meeting in Bangalore, India, from 4 to 7 September 2007; its third meeting in Pasadena, California, United States of America, from 8 to 12 December 2008; it will held its fourth meeting in Saint-Petersburg, Russian Federation, from 14 to 18 September 2009.[143]

218. The ICG set up various working groups: Working Group A: Interoperability and Compatibility; Working Group B: Enhancement of performance of Global Navigation Satellite Systems services; Working Group C: Information Dissemination; Working Group D: Interaction with national and regional authorities and relevant international Organizations; Working Group on Satellite-based Augmentation System (SBAS) certification.

Providers' Forum

219. A **Providers' Forum** was established at the second meeting of ICG in Bangalore, India, with the aim to promote greater compatibility and interoperability among current and future providers of GNSS. The current members of the Providers Forum, including China, India, Japan, the European Union, the Russian Federation and the United States, addressed key issues such as ensuring protection of the GNSS spectrum and matters related to orbital debris/orbit de-confliction.

220. As we have seen *supra*, § 42, the Provider's Forum, amongst other achievements, has adopted the "Providers' Forum principles of compatibility and interoperability and their further definition".

Action Team on Global Navigation Satellite Systems (GNSS)

221. In June 2001, the U.N. Committee on the Peaceful Uses of Outer Space (COPUOS) established an Action Team on GNSS, co-chaired by Italy and the United States. 38 member States and 15 intergovernmental and nongovernmental Organizations joined the GNSS Action Team. A Report of the activity of the Action Team was published in 2004.[144]

European Union (E.U.)

Activity of E.U. as GNSS provider

222. The activity of the E.U. as international organisation is somewhat peculiar, because the E.U. will be a direct actor of GNSS in implementing Galileo. For the relevant legal regime adopted so far and other activities see *supra*, § 13 ff.; for the international co-operation with other GNSS providers and with third Countries see *supra*, § 19, 31, 32, 51 and 55.

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[143] See for more information the website of the ICG: http://www.unoosa.org/oosa/en/SAP/gnss/icg.html.

[144] Available at: http://www.galileoic.org/la/files/GNSS%20UN%20document_0.pdf.

E.U. Discussion Forum on GNSS: Extra-contractual liability

223. The European Commission Directorate-General for Energy and Transport, Unit G.5 – E.U. satellite navigation programmes: Legal and Financial aspects, decided to create a Discussion Forum on GNSS Extra-contractual liability. The first meetings took place in September and October 2009.

Provisions on liability in Agreements with third Countries.

224. It may be interesting to note that the E.U. addresses the issue of liability in the agreements with third countries; for example, the "Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) between the European Union and its Member States and the State of Israel" contains the following provision: Article 13, *Liability and cost recovery*, "The Parties will cooperate, as appropriate, to define and implement a liability regime and cost recovery arrangements in order to facilitate the provision of civil GNSS services". Similar provisions are included also in the agreements entered by the E.U. and its member States with other Countries, such as China, Korea, Morocco, Ukraine.

An international instrument could be negotiated in cooperation with other international organisations which, in a way or in the other, take interest in GNSS systems, and making use of their expertise.

* * *

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