

The Legal Implications of Erroneous GNSS Signal, Resulting from Harmful Interference

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Abstract

There are two Global Navigational Satellite Systems (GNSS) in operation: The United States' Global Positioning System (GPS), the first GNSS structure which became operational and the Global Orbiting Navigation Satellite System (GLONASS) operated under the auspices of the Russian Federation. In the future, two other structures will start to function as well: Galileo which will operate under the auspices of the European Union and the Chinese system Beidou (Compass). From a technical perspective these navigational satellite systems transmit navigational data (signals) via the use of electromagnetic waves, thus serving many civilian applications on Earth connected to navigation, timing and positioning. Although certain spectrum frequencies have been specially reserved and allocated for GNSS communication, the low strength of the GNSS signal makes it very susceptible to Harmful Interference (HI). The sources of HI can be either intentional or unintentional. The basic underlying idea of the present paper is to demonstrate the close interaction between the phenomenon of HI on the one hand and the provision of GNSS signal-services on the other. Particular attention will be paid to the issue of liability caused by GNSS signal loss resulting from HI. Excluding any other sources of GNSS signal malfunction, this paper will focus on the legal consequences of HI to GNSS systems. To this end, several questions will be asked, particularly from a legal perspective: Could the GNSS operator be held accountable for not being able to manage the harmful interference resulting in GNSS signal loss? Could the causing agent of HI be held accountable? Would there be a difference if the source of the interference was intentional and the causing agent denied any wrongdoing? What are the possible fora to address the question? Which legislation would be applicable when it comes to potential liabilities? The present paper aims at addressing the above questions by examining the current legal framework and illustrating the complex interrelations between different players.

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I. Introduction and Background

A noteworthy international legal document was signed in December 2012 – a Memorandum of Cooperation (MOC) between the International Civil Aviation Organization, based in Montreal, Canada and the International Telecommunications Union, with its seat in Geneva, Switzerland. The agreement concerned a framework for enhanced cooperation regarding the protection of the Global Navigation Satellite System (GNSS) from Harmful Interference with a potential impact on aviation safety.¹ Both the ICAO and the ITU are specialized agencies of the United Nations. ICAO's mandate is to codify principles and techniques of international air navigation as well as to promote the development and sustainable growth of international air transport.² The ITU, on the other hand, is responsible for issues related to information and communication technologies – it coordinates the global use of the radio spectrum and the assignment of satellite orbits. Following these elements, the question which must be asked is as follows: what is the connection between the two organizations and why the need for such a MOC?

ICAO is the global agency responsible for developing Standards and Recommended Practices for the use of GNSS by international civil aviation including such on resistance to interference. The ITU, on the other hand is at the forefront of communication efforts to eliminate harmful interference between stations of different countries – this includes, but is not only limited to GNSS signals.³ Indeed, ever since its creation in 1947, ICAO's operations, goals and mission have been interdependent on the work of the ITU – the demands of civil aviation on aeronautical telecommunications services were always there and ever-increasing.⁴

Even though this paper does not deal specifically with the particular problems of the aviation industry and GNSS, this MOC is a relevant demonstration of the increasing problems that GNSS operators are facing, together with the attempted legal solutions on an international level. The problematics that are examined in this paper deal with the broader legal framework surrounding the issues of GNSS and Harmful Interference. Granted, this MOC serves

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- 1 Memorandum of Cooperation between ICAO and ITU providing a framework for enhanced cooperation regarding the protection of the Global Navigation Satellite System from Harmful Interference with a Potential Impact on Aviation Safety, December 2012. Available at www.itu.int. Accessed on 20 August 2015.
 - 2 ICAO website, Available at www.icao.int. Accessed on 20 September.
 - 3 Memorandum of Cooperation between ICAO and ITU providing a framework for enhanced cooperation regarding the protection of the Global Navigation Satellite System from Harmful Interference with a Potential Impact on Aviation Safety, December 2012. Available at www.itu.int. Accessed on 20 August 2015.
 - 4 ICAO, *The Postal History of ICAO, ICAO and the International Telecommunication Union*. Available at www.icao.int/secretariat/postalhistory/icao_and_the_international_telecommunication_union.htm. Accessed on 10 September 2015.

as an illustration of the pertinence and importance of the subject, but it does not put forward legally binding obligations to States, public or private users. And it is exactly these binding and enforceable legal commitments that this article is concerned with. More specifically, the article addresses the potential scenario whereby a GNSS system malfunctions as a direct result of Harmful Interference – who could be held liable and how? Therefore, the paper outlines and explains the basic technical concepts and then provides the relevant legal framework. Building on this, follows the examination of the possible scenario where a GNSS signal fails as a result of Harmful Interference. Can someone be held responsible in such a situation and if so, who and how?

II. Definitional and Technical Considerations

To answer the above questions and before examining the relevant legal documents and the resulting consequences, the paper begins its analysis by providing a brief introduction to the technical terms and processes.

II.1. GNSS

In 2011 the British Royal Academy of Engineering published a report on the reliance and vulnerabilities of GNSS systems, raising important questions on society's increasing dependence on such systems for position, navigation and timing data.⁵ According to the chairman of Royal Academy “we have become almost blindly reliant” on the data and information thereby provided.⁶ GNSS is the generic term for satellite based operations that broadcast electromagnetic signals used to provide position, navigation and timing services – collectively known as PNT. The best known such system in operation is the US military GPS (Global Positioning System), but the Russian GLONASS (Global Orbiting Navigation Satellite System) should also be considered. In addition, concomitantly, there are two other systems in development – the European Galileo and the Chinese Compass Navigation System.

In brief, the functioning of the GNSS systems can be divided into three segments: ground, space and user segments. The ground one is used to uplink data to satellites, to track them, to synchronize the time across the constellation of satellites and enable orbit determination. It is used for uploading navigation data and for monitoring the signals transmitted across the globe. The space component consists of a multitude of satellites in various orbital planes, which carry signal generation units, amplifiers, antennas and clocks. Lastly, the user segment is made up of receivers or antennas that obtain the signal

5 Satellite Alert. We've become increasingly reliant on global navigation systems. So what would happen if they disrupted by jamming of bad weather in space? In *Professional Engineering Magazine*, April 2011, Vol 24:4, pp. 40-46.

6 *Ibid.*

and decode it to provide PNT information.⁷ This last segment is rather diverse and uncoordinated, which means that certain problems affecting the signal could be felt by some users, but not by all.

II.2. Applications of GNSS

The applications of GNSS are multiple and growing. Satellite navigation actually builds upon terrestrial-based navigation, which had been used by the shipping industry for more than 100 years⁸ – and even nowadays – the industry continues to make use of that for navigation, port approach and harbour entrance for example. Aircraft use PNT signal for in air steering, approach and departure manoeuvres. In addition, PNT is used in the rail sector for speed profile calculations, train location information, level crossing protection and power supply control. Car navigation is something almost most of us have taken advantage of, as have transport companies for their logistic operations. In addition, GNSS is also used even in the agricultural sector for yield and plot mapping.⁹

II.3. Potential Problems with GNSS

Although the GNSS technology is advantageous, GNSS signals transmission is very weak. In an attempt to comparatively illustrate this to non-engineers, scientists equate it to a light bulb shining thousands of miles away. Typically, the signal is less than 100W and is delivered from a distance of about 20,000 to 25,000km. Upon reception on the Earth's surface, the signal could be more than ten times weaker. Thus, very little is needed to interfere with this signal – be it on purpose or unintentionally.¹⁰ Such interference could “easily defeat the signal recovery of overload the receiver circuitry.”¹¹ One example of an unintentional interference with GNSS happened on the Isle of Man, when a poorly installed CCTV camera caused the GPS system to malfunction with a radius of 1 kilometre.¹² Commercial high-power transmitters, ultra-wideband radar and personal electronic devices can cause similar problems. In 2004, the GPS system encountered a problem, which led to position errors up to 40 kilometres in Europe and the maritime automatic identification

7 Ibid.

8 Camacho-Lara, Sergio, *International Committee on GNSS*, in Pelton, Joseph, Madry, Scott, Camacho-Lara, Sergio, *Handbook of Satellite Applications*, Springer: New York, 2013, pp. 603-615.

9 Ibid.

10 Satellite Alert. We've become increasingly reliant on global navigation systems. So what would happen if they disrupted by jamming of bad weather in space? In *Professional Engineering Magazine*, April 2011, Vol 24:4, pp. 40-46.

11 Ibid., p. 43.

12 Ibid.

system actually showed ships faring on land.¹³ Interference could also be malicious and intentional. Special devices, jammers are easily available and have already been used by criminals when it comes to theft of expensive vehicles or simply avoidance of road charges.¹⁴ Numerous journalists have also warned of the threat of terrorist activities, aided by the use of GNSS jamming.

II.4. Harmful Interference

Having illustrated the potential grave impact that Harmful Interference could have on the GNSS systems, the following paragraphs will examine in more detail the phenomenon of HI. In brief, it can occur along the lines of any of the three GNSS segments: ground segment, space segment as well as at user's level. To reiterate, the problem of Harmful Interference is of particular significance when it comes to GNSS, because the particular signal strength is very low and thus, disruption is more likely to occur.

In order for the GNSS signals to be received and processed accurately, they need to travel at a specific frequency through space. Thus, the radio spectrum is one of the most important requirements for the safe operations of a system – communications, navigation, position reports and datalinks could not function without an uninterrupted and interference-free access to spectrum frequencies. The Radio spectrum is a limited resource and it needs to be shared and coordinated with other users. It is also a non-exhaustible resource simultaneously requiring a fixed position for the satellite in space and an interference-free electromagnetic signal transmission.¹⁵

Most broadly, interference can be defined as an alteration to the reception of the signal, which makes it unacceptable. The international organization, whose function is the coordination of the use of the spectrum and frequency resources, whereby this interference can occur, is the International Telecommunications Union. It is an active organization on a technical as well as policy – creation level. Technically, the ITU defines 'Interference' as "the effect of unwanted energy due to one or a combination of emissions, radiations, or inductions upon reception in a radio-communication system, manifested by any performance degradation, misinterpretation, or loss of information which could be extracted in the absence of such unwanted energy."¹⁶ Further on, in addition to Harmful Interference, technicians use terms such as permissible interference and accepted interference. This article is, however, concerned

13 Last DavId., *GNSS: The Present Imperfect*, *GNSS Forum*, Available at www.insidegnss.com/auto/may10-Last.pdf. Accessed on 15 September 2015.

14 Satellite Alert. We've become increasingly reliant on global navigation systems. So what would happen if they disrupted by jamming of bad weather in space? In *Professional Engineering Magazine*, April 2011, Vol 24:4, pp. 40-46.

15 Rothblatt, Martin A., *Satellite Communication and Spectrum Allocation*, *The American Journal of International Law*, 76:1, 1982, pp. 56-77.

16 ITU, Radio Regulations, art 1.166. Available at www.itu.org. Accessed 1 August 2015.

with Harmful Interference only, which is legally defined as that which “endangers the functioning of a radio-navigation service or of other safety services or seriously degrades, obstructs, or repeatedly interrupts a radio-communication service operating in accordance with the Radio Regulations.”¹⁷

III. ITU, GNSS and HI

III.1. ITU

The ITU is made up of three big sectors, with different responsibilities and lines of activity: The Radio-Communication Sector (ITU-R), the Telecommunication Standards Sector (ITU-T) and the Telecommunication Development Sector (ITU-D). The mission of the ITU-R is of particular importance here: “to ensure the rational, equitable, efficient and economical use of the radio-frequency spectrum by all radio-communication services, including those using satellite orbits.”¹⁸

No legal analysis on HI can be undertaken without a reference to the ITU, its Radio-communications Sector and the process through which frequencies are assigned for a particular use – such as navigation, mobile services, broadcasting etc. To put it succinctly, the ITU reserves certain frequencies for use by GNSS services with the aim to protect these from Harmful Interference. Thus, it is important to understand how these frequencies are allocated and what is the legal significance of this process. What do ITU’s powers derive from?

As a UN agency, the International Telecommunication Union is made up of 193 Member States that have subscribed to its Constitution and Convention.¹⁹ Thereby, these two documents have the legal status of International Treaties, enforceable in International courts and tribunals. The preamble to the Constitution recognizes the “sovereign right of each State to regulate its telecommunications”, while article 1 of the said document expressly states the purpose of the Union as that of maintaining international cooperation for the “rational use of telecommunications of all kinds”.²⁰ States have recognized the need for enhanced cooperation in the field and for a centralized technical frequency allocations body, which would be able to put forward legally enforceable and valid technical decisions. These technical decisions are mostly contained in the Radio Regulations (RRs) of the ITU, which comple-

17 ITU, Convention, Annex, art 1003. Available at www.itu.org. Accessed 1 August 2015.

18 Restrepo, Joaquin, *ITU-R: Basics*; Available at www.itu.int/en/ITU-R/seminars/rrs/Documents/Intro/IUT-R-Basics.pdf. Accessed on 10 September 2015.

19 ITU, About Us; Available at www.itu.org/about. Accessed on 15 September 2015.

20 ITU Constitution; Available at www.itu.org. Accessed on 14 September 2015.

20 ITU, About Us; Available at www.itu.org/about. Accessed on 15 September 2015.

ment the Constitution and the Convention of the organization. The RRs have the same legal status – of an International Treaty.

III.2. Frequency Allocations and GNSS

The process of frequencies allocation by the ITU is twofold. First, certain portions of the spectrum are allocated to specific services. These are published in a Table of Allocations.²¹ From then on, different frequency channels are assigned to Member States for terrestrial or space communication services.²² All this information is put together in a Master International Frequency Register. Once an assignment is granted and entered in the said register, legally, it is deemed protected from Harmful Interference. Article 5.28 of the Radio Regulations reminds that stations of secondary service “shall not cause harmful interference to stations of primary services to which frequencies are already assigned or to which frequencies may be assigned at a later date.”²³ In addition assigned services can claim protection from harmful interference.²⁴

Within the ITU system, GNSS²⁵ falls under the definitions of a radio-navigation-satellite service: A radio determination-satellite service used for the purpose of radio-navigation. This service may also include feeder links necessary for its operation.²⁶ In addition, radio-navigation as such is also defined – as radio determination used for the purposes of navigation, including obstruction warning.²⁷ Thus, it is rather clear that GNSS services fall within the scope of application of the ITU treaties. Further than that even, Member States recognize that the safety aspects of radio navigation require special measures to ensure their freedom from harmful interference; it is necessary therefore to take this factor into account in the assignment and use of frequencies.²⁸

III.3. ITU and Harmful Interference

Having illustrated the importance of the GNSS segment within the ITU framework, the paper proceeds to point out the relevant provisions that legally protect the frequencies against Harmful Interference. In this context, the first provision that needs to be examined is article 45 of the ITU Constitu-

21 ITU, *Master International Frequency Register*, Available at www.itu.org. Accessed on 15 September 2015.

22 Bender, R., *Launching and Operating Satellites, Legal Issues*. The Hague: Kluwer, 1998.

23 ITU Radio Regulations, art. 5.29. Available at www.itu.org. Accessed 14 September 2015.

24 *Ibid.*, Art. 5.31.

25 GNSS is a primary service in the ARNS/RNSS frequency band 1559-1610 MHz. The other frequency bands used by GNSS are co-primarily allocated between radio navigation and other services.

26 ITU Radio Regulations, art 1.43. Available at www.itu.org. Accessed 14 September 2015.

27 ITU Radio Regulations; Available at www.itu.org. Accessed 14 September 2015.

28 *Ibid.*, art. 4.10.

tion.²⁹ It provides that “All stations, whatever their purposes must be established and operated in such a manner as not to cause harmful interference to the radio services or communications of other Member States [...] which operate in accordance with the provisions of the Radio Regulations.” In other words, once a frequency allotment has been made for GNSS at the international level within the ITU framework, this service should have the enforceable legal right to be protected against Harmful Interference.

Having said that, we need to clarify that the ITU does not have any enforcement powers, nor does it provide for sanctions in cases of violations. Article 56 of the Constitution puts forward a dispute resolution procedure of “negotiation, through diplomatic channels, or according to procedures established by bilateral or multilateral treaties concluded between them for the settlement of international disputes, or by any other method mutually agreed upon.”³⁰ If none of these methods is adopted, then there can be recourse to arbitration or to the Optional Protocol³¹ on the Compulsory Settlement of Disputes.³² In practice, however most disagreements pertaining to harmful interference are settled pursuant to art. 15 of the Radio Regulations. Section VI of the respective article outlines the appropriate coordination and notification procedures that parties need to undertake in order to resolve cases of HI. This is a procedure entirely based on good will and amicable cooperation, and there is no mention of responsibility, liability or compensations.

An obvious, but important last clarification needs to be made before we examine the possible real life scenarios, pertaining to liability, GNSS and HI. It pertains to the applicability of the ITU rules. It is sovereign Member States that have subscribed to the Convention that bear the responsibility for observing the provisions. The Radio Regulations stipulate that “no transmitting station may be established or operated by a private person or by any enterprise without a license issued in an appropriate form and in conformity with the provisions of ` by the Government of the country to which the station in question is subject.”³³

The ITU Regulations and Recommendations, however, are further implemented into national law. Different countries additionally impose civil or criminal penalties for interference or sometimes even stricter guidelines or control mechanisms. These penalties can and have included monetary forfei-

29 ITU Constitution; Available at www.itu.org. Accessed on 14 September 2015.

30 ITU Constitution; Available at www.itu.org. Accessed on 14 September 2015.

31 This protocol is applicable only for Member States that have acceded to it; it has never been used until now.

32 Jakhu, Ram, *Dispute Resolution under the ITU Agreements*, available at <http://swfound.org/media/48115/Jakhu-Dispute%20resolution%20under%20the%20ITU%20agreements.pdf>. Accessed on 20 May 2014.

33 ITU Radio Regulations; Available at www.itu.org. Accessed on 1 May 2015.

tures or other civil and even criminal penalties for certain types of violations. In addition, governments have often also opted to prohibit the manufacture, importation, marketing, and/or use of devices causing harmful interference.³⁴ It is in this indirect way that many of the ITU rules are being enforced within Member States

IV. International Legal Framework on GNSS and Harmful Interference – Focus on Liability

One of the specificities of the GNSS technique is its inherent international dimension. Consequently, when a GNSS dispute or problem arises, this will certainly have global effects with international dimension.³⁵ We have already outlined the basic ITU regulations pertaining to GNSS and HI. As such, in this section, we examine other possible applicable legislation with a focus on potential liability claims.

IV.1. Space Law Perspective

Presently, all states providing GNSS services are parties to the Outer Space Treaty,³⁶ the Liability Convention³⁷ and the Registration Convention.³⁸ Hence, the general conclusion which can be reached from an international space law perspective is that the field of GNSS will be subjected to the normal rules as to the use of Outer Space.³⁹ In a general context, international space law is comprised of five United Nations Space Treaties which essentially provide the legal framework for the exploration and exploitation of Outer Space. Nonetheless, not all of the abovementioned Treaties would be pertinent when examining issues of damage and dispute resolution. More substantially, only two of the abovementioned Treaties encompass provisions with respect to responsibility, liability and dispute resolution mechanisms in the possible scenario that a space related dispute arises, in other words the Outer Space Treaty and the Liability Convention. More substantially:

34 National Coordination Office for Space-Based Positioning, Navigation and Timing (US), *Spectrum Allocation Assurance*, Available at www.gps.gov/governance/advisory/meetings/2014-06/wg1.1.pdf. Accessed on 20 September 2015.

35 Schubert, Francis. *An International Convention on GNSS liability: When does desirable become necessary?*, XXIV Annals of Air and Space Law, 1999, p. 245, esp. p. 248-251.

36 The Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and other Celestial Bodies (hereinafter Outer Space Treaty) 1967, 610 UNTS 205, 18 UST 2410, TIAS 6347.

37 Convention on International Liability for Damage Caused by Space Objects 1972, 961 UNTS 187, 24 UST 2389, TIAS 7762.

38 Convention on Registration of Objects Launched into Outer Space, 1975 1023 UNTS 15, 28 UST 895, TIAS 8480.

39 Lyall, Francis and Paul Larsen, *Space Law: A Treatise*, Ashgate, 2009, esp. pp. 402-406.

IV.1.1. Outer Space Treaty

When it comes to responsibility and liability under the provisions of the Outer Space Treaty, articles VI and VII would be of importance.

Articles VI and VII of the Outer Space Treaty provide for the principles of international responsibility and international liability of states for their national activities carried out in Outer Space. Given that GNSS will be subjected to the normal rules as to the use of Outer Space, as well as considering the fact that the field of satellite navigation would qualify as a space activity, the principles of international responsibility and liability of states as provided for by the Outer Space Treaty would also be applicable to the field of satellite navigation.

However, it should be noted that there is one major deficiency within the aforementioned provisions; these principles as provided by the Outer Space Treaty are general in nature. In other words, they are further elaborated by other legal instruments which contain more detailed and specific provisions compared to those contained within the Outer Space Treaty. Whereas according to the Outer Space Treaty, there is a general principle of responsibility and liability of states, there are no specific provisions relevant for the attribution of liability, monetary compensation, plus specific dispute settlement mechanisms.⁴⁰ Hence, recourse should be made to other legal instruments which elaborate further on these issues. One example worth mentioning in this regard is the Liability Convention for Damage Caused by Space Objects.

In particular, the said instrument further elaborates the principle of liability as provided under article VII of the Outer Space Treaty.⁴¹ An additional aspect which should be noted is that concerning the judicial settlement of disputes relating to Outer Space recourse can, *inter alia*, be made based upon other international mechanisms i.e. judicial settlement under the competence of the International Court of Justice would be an example. In a general context, apart from the particular *lex specialis* provisions under the international space law perspective, recourse can also be made to other international law instruments in light of the fact that general international law would be applicable in the general context of space activities. Finally, and given the fact that public international law is characterized by the principle of subsidiarity to national legal systems, national-domestic legal provisions may have a certain relevance and applicability as well.

40 Von der Dunk, Frans, *Evaluating Regulatory Instruments*, in 3rd Workshop of Satellite Communications on Harmful Interference, University of Luxembourg, May 2014, esp. slide number 4, www.en.uni.lu/media/files/evaluating_regulatory_instruments_von_der_dunk, last accessed on 29.06.2014; “Evaluating Regulatory Instruments”, in 3rd Workshop of Satellite Communications on Harmful Interference, University of Luxembourg, May 2014, esp. slide number 4.

41 Ibid.

In the context of the subject of Harmful Interference and the OST, an important side remark needs elaboration. In its article IX, the Treaty mentions the exact term “harmful interference” twice, but in relation to such interference with the activities of other State Parties. A very broad and contemporary interpretation of the text, could lead to an association of this term with that of electromagnetic interference, discussed in the previous part of this article. In light of the exact formulation and historical situation at the time of signature, the intentions of the contracting parties was simply to extend the accepted international law principle of non-interference into the domestic affairs of another state to Outer Space. Having described the most pertinent provisions of the OST, it would be now opportune to examine more thoroughly the Liability Convention for Damage Caused by Space Objects.

IV.1.2. Liability Convention for Damage Caused by Space Objects

The Liability Convention for Damage Caused by Space Objects further elaborates the principle of liability of States as provided under article VII of the Outer Space Treaty. More precisely, the Liability Convention addresses issues of damage – and dispute resolution – caused by space objects. In short, under this Convention there is the adoption of a two tier system for the attribution of liability. First, in relation to damage caused on the surface of the Earth or to aircraft in flight, there is the provision of an absolute liability system, irrespective of fault.⁴² Secondly, for situations of damage occurred in other places rather than the surface on Earth or on aircraft in flight, the Liability Convention stipulates for a fault based liability system i.e. cases of collision of satellites.⁴³ Alongside the two different tiers of liability, it is important to underline that the Convention also foresees a specific dispute settlement mechanism to be activated upon the occurrence of a dispute among the parties in relation to the application of the Convention’s provisions (the so called Claims’ Commission⁴⁴). One that note, then, the following question appears especially from a GNSS perspective: Is there any probability for the dispute settlement mechanism as provided for by the Liability Convention to be used for the resolution of disputes caused during the provision of navigational services? Most importantly, would the liability convention cover damage scenarios caused by harmful interference, causing erroneous broadcast navigational signals?

According to the prevailing views of legal scholars until today, the Liability Convention does not cover all the types of space related disputes but only those that meet the definition of “*damage caused by a space object*”. In other words, the majority of legal scholars suggest a strict and literal interpretation of the term space object. Although some attempts have been initiated for a

42 Article II of the Liability Convention.

43 Article III of the Liability Convention.

44 Article XXII of the Liability Convention.

broader interpretation of the notions “damage” and “space object”,⁴⁵ most of the legal scholars advocate for a strict – literal – interpretation of these terms.⁴⁶ Hence, they advocate the view that the Convention only applies to situations of damage caused directly by satellites and liability therefore (i.e. collisions of navigational satellites could be a possible example); in other words, it applies only to cases of direct damage, attributable to a crashing space object or a collision between space objects in Outer Space. However, it is worth bearing in mind that the language of the Liability Convention does not specifically dictate such a narrow interpretation only. Some scholars are of the opinion that the Convention could also be applicable to direct and indirect damage caused by a space object.⁴⁷ Moreover, quite recently, during the proceedings of the 56th International Institute of Space Law Colloquium on the Law of Outer Space, two young scholars also drew attention to the fact that the literal interpretation of the Liability Convention is not the only way of interpreting the Convention, but in contrast, there are also possibilities of applying other interpretation criteria that may ultimately lead to different interpretation results, for instance a possible broader interpretation of the notions of “damage” and “space objects” under the Liability Convention.⁴⁸

IV.1.3. ITU Law

Although highly specialized the ITU legal order constitutes an important branch of public international law and it complements the aforementioned Space Law treaties. As such an examination of these legal documents becomes necessary. As already delineated, the documents upon which the Union is based – the Convention, Constitution and Regulations have the legal status of International Treaties. The ITU regime is particularly relevant to issues concerning GNSS and Harmful Interference, but also rather weak when it comes to liability and responsibility. It is article 36 of the Convention that exempts State parties of international liability: “Member States accept no responsibility towards users of the international telecommunication services, particularly as regards claims for damages.” Even though, the specific term liability is not utilized as such, the specification of ‘responsibility for claims for damages’ purports exactly to international liability. Thus, pursuant to the ITU mecha-

45 B.D.K Henaku, *The Law on Global Air Navigation by Satellite: An Analysis of Legal Aspects of the ICAO CNS/ATM System*, 1998, p. 221.

46 Vienna Convention on the Law of Treaties (hereinafter VCLT), done at Vienna on 23rd of May 1969 and entered into force on 27th of January 1980, United Nations Treaty Series, vol. 1115.

47 B.D.K Henaku, *The Law on Global Air Navigation by Satellite: An Analysis of Legal Aspects of the ICAO CNS/ATM System*, 1998, p. 221.

48 Carpanelli, Elena and Brendan Cohen, *The Notion of Damage caused by a Space Object under the 1972 Liability Convention*, 56th International Institute of Space Law Colloquium on the Law of Outer Space, 64th International Astronautical Congress, Beijing, China, 2013, esp. pp. 3-10.

nisms, it would be difficult to seek redress or compensations. In addition to that, although ITU law could be enforced at various international fora, the organization itself relies rather on cooperation and coordination procedures for the settlement of disputes based on its legal order. Article 56 of the Constitution puts it forward that “Member States may settle their disputes (..) by negotiation, through diplomatic channels, or according to procedures established by bilateral or multilateral treaties concluded between them for the settlement of international disputes, or by any other method mutually agreed upon.” Additionally, the ITU framework also provides an option to accede to a Protocol for the Compulsory Settlement of Disputes, but not only have very few Member States signed it, nor has this Protocol ever been used in practice. Thus, practically speaking even in cases where damage has been caused by Harmful Interference, the ITU legal order would hardly be useful for damages claims or enforcement proceedings.

IV.2. International Law Perspective

At this point, a few remarks are worth mentioning about other international law instruments. As indicated already, several instruments from other branches of international law may play a role as long as a GNSS related dispute occurs; the fields of air law or maritime law are two examples. Additionally, traditional instruments coming from the field of general public international law may be important as well.

At the present period of time, there is no uniform legal mechanism for a global liability regime for damages caused by global navigational satellite systems under any international convention. But still, if the malfunction of the GNSS technique causes loss, other branches of international law might be activated. For example, if the use of erroneous broadcasted navigational signals causes the loss of lives following an aircraft crash or pollutes the environment through a shipwreck, air and maritime law conventions may come into play. In the worst case scenario such as that of a nuclear accident resulting from a GNSS failure, nuclear conventions might come into play as well.⁴⁹ It suffices to say that these legal instruments will – most likely – not address damage scenarios from a GNSS failure in a sufficient manner. They have been drafted in so as to address potential liabilities of the air carrier, of the ship owner or the operator of a nuclear installation. As such, they are not expected to address GNSS liability risks.

49 From the field of Air Law See for example: “Convention on International Civil Aviation” Chicago, December 7th, 1944. From the field of Maritime Law See in more detail “The United Nations Convention on Civil Liability for Damage Caused during Carriage of Dangerous Goods by Road, Rail and Inland Navigation Vessels” Geneva, October 10th, 1989. See also “the International Convention on Liability and Compensation for Damage in Connection with the Carriage of Hazardous and Noxious Substances by Sea”, London, May 3rd, 1996 (Hereinafter the HNS Convention).

In diverting from other specific branches of public international law, it should be noted that disputes in relation to satellite navigation and Harmful Interference more particularly may also be resolved under traditional dispute settlement mechanisms as provided under general public international law instruments; negotiations, enquiry mediation, arbitration and judicial settlement are just to name a few. The relevance of these mechanisms in the context of Outer Space activities is explicitly recognized by article III of the Outer Space Treaty. Under this particular provision, general public international law becomes directly applicable also in the context of Outer Space activities. Satellite navigation is qualified as a space activity and as such the applicability of Article III of the Outer Space Treaty may be brought to light.

It suffices to say that the efficacy of general international law provisions is expected to be rather moot point for the resolution of GNSS related disputes. Although general international law instruments would be pertinent within the context of the provision of navigational services, to date, practice has revealed states' tendency to be reluctant to accept adversarial forms of disputes such as judicial settlement. In addition, it is worth mentioning that the International Court of Justice has never been asked so far to intervene for the resolution of a dispute relating to Outer Space activities.

IV.3. National Law Perspective

Finally, a few remarks are mentionable concerning domestic dispute settlement mechanisms (i.e. mainly national tort law or third party liability provisions). A clear indicator for the possible applicability of national legal provisions for the field of Outer Space is explicitly recognized under the Liability Convention. In particular, under article XI, the Convention clearly stipulates the possibility to exploit domestic legal mechanisms as an alternative to its own dispute settlement mechanisms.⁵⁰ Therefore, national contract and tort law provisions could be applicable as soon as a GNSS liability law incident occurs. At this point, it should be highlighted the fact that due to the inherent international dimension of GNSS, recourse should be made to the rules of private international procedural law and private international law before any substantive national tort and contract law to be applied. The general rule – with certain exceptions – under private international law dictates the application of the law of the country where the incident occurred, the so called *lex loci delicti*.⁵¹ Given that GNSS will have global dimension and will be used worldwide, GNSS loss can be sustained in every country of the world, thus, making the national laws of every country potentially relevant.

50 See Article XI (2) of the Liability Convention.

51 See in more detail Regulation EC No 864/2007 of the European Parliament and of the Council on the law applicable to non-contractual obligations of 11th of July 2007. The Rome II Regulation, esp. Article 5.

V. Case Study

In order to practically illustrate the abovementioned issues and problems related to liability for wrong and erroneous GNSS signals ultimately caused by Harmful Interference, at this stage we consider an imaginary, but highly possible scenario. Given the complex nature technical nature of the phenomena in question and the possible involvement of both private and public actors, a number of assumptions are also necessary.

In the fictional case study, we have a large private cargo ship, *Hermes*, carrying goods of high material value. In dark and foggy weather, the ship relies on GNSS signal to find its course. As a result of Harmful Interference, however, the GNSS signal malfunctions and *Hermes* crashes into rocks. This leads to huge material damages. What are the possible recourse mechanisms that *Hermes*' proprietors could invoke in this case?

The relevant actors would thus be:

- *Hermes*'s owner company and the State of its domicile and registration – State A.
- The provider of the GNSS signal. While no particular existing service provider is considered, given the current reality where public entities (mainly states) provide GNSS services, we assume that this a public entity – State B. It is this state that has holds the relevant frequency allocations.
- The source of the Harmful Interference – a private broadcasting company, integrated in and operating from State C.

Further to that, we also take for granted that the interference was not directed or intentional⁵² and that the GNSS operator has traced it to the activities of the broadcaster.⁵³

Two perspectives are examined – that of the GNSS operator and the ship owner. It is noted that in cases, where private parties are involved, it would be the relevant State that could invoke the ITU and Space Law provisions. Article VI and VII would be the strongest grounds for actions as they provide for the principles of international responsibility and international liability of states for their national activities carried out in Outer Space. Even if the broadcaster that transmitted the signal that cause the Harmful Interference, still the responsibility for its actions would fall upon the State that authorized and regulated its activities.

The ITU legal order would certainly come in handy as to classifying the Harmful Interference as unauthorized and illegal, but it would not be possible

52 Actually, the ITU provisions do not differentiate between intentional and non-intentional Harmful Interference and thus, within this framework intent is not a matter of consideration anyhow.

53 From a technical perspective, Harmful Interference can often be traced, with a reasonable amount of certainty, but legally speaking, this is highly unlikely, mostly impossible.

to go further than that in assigning liability or demand damages. This is also one of the biggest shortcomings, ascribed to the Union as it does not have any monitoring or enforcement capabilities. In recent years, the ITU has intensified efforts on that front, but these still remain to be developed and integrated within the legal order. Thus, especially when it comes to claims for damages, the likelihood of success for the GNSS operator when invoking ITU rules is negligible. The same goes for ship operator.

In addition, the Liability Convention will not be applicable either given the fact that the damage was caused by the navigational signal (indirect damage) and not from the navigational satellites directly (direct damage). Moreover, if the victims choose general international law instruments, they will be obliged to prove fault and causation; this task will certainly be quite challenging, not to say even impossible, for the case of satellite signals. Lastly, other international conventions from the field of maritime or air law may also come into play but still their relevance remains questionable. Given the fact that these instruments address issues of liability for the ship owner, they do not have many chances of success in addressing liability issues for the GNSS operator or the broadcaster of the signal that caused the Harmful Interference. At the disputes in question, the error was introduced at the level of the GNSS provider/operator and thus, these instruments will not be relevant as such.

VI. Conclusions

This article has aimed to demonstrate the increasing relevance and need for enforceable international legal provisions in relation to GNSS and Harmful Interference. A specificity of both subjects is their close connection to technological advancements. The latter, however are not always linked to a simultaneous development of the associated legal order.

The issues pertaining to GNSS and Harmful Interference are in their nature international and can thus, be covered by a variety of international legal provisions. At the same time, however, these are very technical and closely regulated within the auspices of the ITU, which provide a multitude of scientific definitions and procedures for GNSS operations and for avoidance of Harmful Interference. At the same time, however, the legal order of the ITU is not equipped with sufficient enforcement mechanisms or liability provisions in cases of violations. Other international treaties – such as the OST and the Liability Convention do put forward provisions and mechanisms for dealing with potential disputes, but their applicability to electromagnetic signals is not particularly straight-forward.

This gap needs to be addressed either through additions to the existing internationally enforceable framework in relation to liability or by updating the ITU treaties so as to introduce State responsibility for violations of the basic regulations.