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3 International Space Law for GNSS
Civil Liability: the ideal vs the real

3.1 Introduction

Technology will never stand still,¹ even though no technological development ever occurs in a legal vacuum. GNSS is no exception.² In view of the fact that law is a maze rather than a motorway,³ we are compelled to find appropriate law and to apply it in a positive manner. Old laws may fit new technology such as GNSS, but a legal gap between the ideal and the real cannot be denied since most pre-existing laws did not anticipate, when stakeholders were fighting intensely for their adoption, the essential role and, in particular, the risks of GNSS (see 1.3). A careful review is necessary to determine whether current civil liability regimes, from an international perspective, can respond properly to the ongoing challenges in the GNSS era, especially challenges arising from the international character of GNSS civil liability (see 2.5).

As GNSS is a key element of space systems, international space law, among other branches of modern international law such as in terms of aviation (see Chapter 4), merits the first attempt at a response to the challenges of GNSS. Therefore, this chapter first aims to link GNSS with the legal sources under international space law (see 3.2), then to ascertain the actual relationship between those sources and GNSS civil liability by basically answering the following two key questions (see 3.3 & 3.4): (i) whether the liability regime for damage caused by space objects applies to GNSS damage; and (ii) if that regime applies, whether it is an adequate and appropriate mechanism for GNSS civil liability. This chapter concludes with some closing remarks (see 3.5).

³ *Morris v CW Martin and Sons Ltd* [1966] 1 QB 716, at 730.
Chapter 3

3.2 GNSS UNDER INTERNATIONAL SPACE LAW

3.2.1 Overview of international space law

As the name implies, space law is the law that regulates space-related activities.4 Space activities commonly occur in an international domain5 and those parts of space law thus fall within international law,6 thereby leading to the term ‘international space law’. International space law may be nevertheless ambiguous when applying its general rules on responsibility and liability to such specific space activities as satellite remote sensing and satellite navigation.7 It appears that only few legal documents and provisions of international space law address legal issues of satellite navigation.8 Therefore, we first need to examine whether the provisions of GNSS services or signals could be qualified as ‘space activities’, and only then apply international space law.9

3.2.2 The term ‘space activity’ in the context of GNSS

The term ‘space activity’ frequently appears in treaties, domestic legislation and academic papers, although its specific definition is seldom found.10 Yet, by referring to the definition of space law11 and the wording of outer space

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5 Armel Kerrest & Caroline Thro, Liability for damage caused by space activities, in Ram S. Jakhu & Paul Stephen Dempsey (Eds.), Routledge Handbook of Space Law (Routledge, 2017), at 59.
7 Assuyo Ito, Legal Aspects of Satellite Remote Sensing (Koninklijke Brill NV, 2011), at 244.
9 Whether a GNSS provider provides a service or a signal to users is discussed in Chapter 5. Regardless of the classification, GNSS service is of course not within the scope of space object.
10 There is rarely a definition of the term ‘space activity’ in space law documents and academic publications, and to the author’s knowledge only one relevant definition is found, in Section 103 of the US National Aeronautics and Space Act of 1958: “the term ‘aeronautical and space activities’ means (A) research into, and the solution of, problems of flight within and outside the Earth’s atmosphere, (B) the development, construction, testing, and operation for research purposes of aeronautical and space vehicles, (C) the operation of a space transportation system including the Space Shuttle, upper stages, space platforms, and related equipment, and (D) such other activities as may be required for the exploration of space.”
11 E.g., Francis Lyall & Paul B. Larsen, Space Law: A Treatise (Ashgate, 2009), at 2: “At its broadest space law comprises all the law that may govern or apply to outer space and activities in and relating to outer space.”
treaties\textsuperscript{12} and relevant international documents,\textsuperscript{13} the author believes that it is reasonable to define the term ‘space activity’ as follows:

all human activates for the purpose of exploration of outer space including the Moon and other celestial bodies, and it ranges from the research, development, manufacture, operation and use of space infrastructure.

Furthermore, GNSS is a space-based system\textsuperscript{14} and a space asset,\textsuperscript{15} and its characteristics are similar to those of satellite remote sensing systems and satellite communication systems. Even though the operation activities are purely terrestrial undertakings, this does not reduce the space-based characteristics of a space system.\textsuperscript{16} Therefore, GNSS-related activities ranging from launching navigation satellites to operating the whole navigation system qualify as ‘space activities’ as defined above, and thus render international space law applicable. This line of reasoning can be confirmed by the fact that most GNSS powers incorporate activities associated with satellite navigation to the authorisation and supervision scope of national space agencies, as well as by the fact that GNSS constitutes one of the competence

\begin{itemize}
  \item \textsuperscript{12} E.g., Article I of the Outer Space Treaty: “Outer space . . . shall be free for exploration and use by all States . . . in accordance with international law.”
  
  \item \textsuperscript{13} E.g., OECD, \textit{Handbook on Measuring the Space Economy} (OECD, 2012), at 19: “The space sector includes all actors involved in the systematic application of engineering and scientific disciplines to the exploration and utilisation of outer space, an area which extends beyond the earth’s atmosphere.”
  
  \item \textsuperscript{14} GNSS was defined as follows in UNISPACE III Report: “Global navigation satellite system (GNSS) are space-based radio positioning systems that provide 24-hour three-dimensional position, velocity and time information, in any weather conditions, to suitably equipped users anywhere on the surface of Earth, as well as airborne and space users.”
  
  \item \textsuperscript{15} Joan Johnson-Freese, \textit{Space Warfare in the 21st Century} (Routledge, 2017), at 5.
  
  \item \textsuperscript{16} For example, ‘remote space activities’ is defined as “the operation of remote sensing space systems, primary data collection and storage stations, and activities in processing, interpreting and disseminating the processed data” and although all the above activities are ground-based, this does not run counter to the nature of space-based systems of satellite remote sensing systems as they fall within the reach of ‘Principles Relating to Remote Sensing of the Earth from Outer Space’, which is an important element of international space law. See Principle I of the Principles Relating to Remote Sensing of the Earth from Outer Space, adopted by the United Nations General Assembly in its resolution 41/65 of 3 December 1986; Fabio Tronchetti, \textit{Legal aspects of satellite remote sensing}, in Frans von der Dunk and Fabio Tronchetti (Eds.), \textit{Handbook of Space Law} (Edward Elgar Publishing, 2015), at 520.
\end{itemize}
items of UNOOSA. Further, GNSS application was recognised as one of the great space applications by UNISPACE III. However, “merely receiving signals or information in some other form from objects in outer space is not designated as space activities”, and this is also consistent with the argument which excludes liability for malfunction of user equipment from the GNSS civil liability regime in this research (See 2.2).

3.2.3 Sources of international space law concerning GNSS civil liability

Compared with other branches of international law such as the law of the sea, international space law – the body of law governing space-related activities is much younger and has less legal instruments since the ‘space age’ is but a recent happening. The development of space law has been deadlocked for several decades since the Cold War. Currently, only the five space treaties, with legal binding effect, address the issue of fundamental rules on the exploration of outer space, namely the 1967 Outer Space Treaty, the 1968 Rescue Agreement, the 1972 Liability Convention, the 1975 Registration Convention and the 1979 Moon Agreement. Nevertheless, international liability was placed in a quite important position in the drafting history of the Outer Space Treaty and the Liability Convention, and the positions of the Soviet Union and the US were unusually aligned on

19 Section 1 of the Swedish Act on Space Activities.
20 UNOOSA, supra note 4.
26 Stephan Hobe, Bernhard Schmidt-Teddl & Kai-Uwe Schrogl (Eds.), Cologne Commentary on Space Law: Volume 1 (Carl Heymanns Verlag, 2009), at 130.
whether to include the issue of responsibility and liability in the discussion, even though their positions on many other issues were widely divergent.27

As the ‘constitution’ of outer space, the Outer Space Treaty lays down the basic regulations and framework of outer space law, including liability for damage caused by space objects. Article VII of the Outer Space Treaty provides the legal basis to international claims for compensation,28 and states that each launching State (see (v) of 3.4) shall be

“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 space or in outer space, including the Moon and other celestial bodies.”

The Liability Convention establishes specific provisions and categories of liability for space activities. It does so with reference to its legislative basis – Article VII of the Outer Space Treaty – which was considered to be insufficiently explicit about liability beyond its general provisions.29

In addition, the international space law community recognises the inherently ultra-hazardous nature of space activities.30 As a result, strict/absolute liability is applied for damage on the surface of the Earth or in the aircraft in flight,31 thereby excluding claimants from sharing the burden of proof of fault, to favour the interests of victims; fault-based liability regime is however applied for damage being caused in outer space.32

Liability under the Outer Space Treaty and the Liability Convention is geographically and financially unrestricted, and it provides maximum protection to potential victims.33 Moreover, these two treaties impose international liability squarely and only on those States which qualify as launching States,34 which ensures an efficient scheme for identifying the liable party and defendant. In addition, the Liability Convention elaborates relevant definitions, settlement of disputes procedure, joint liability regime and other specific elements.

28 Hobe, Schmidt-Tedd & Schrogl, supra note 26, at 142.
29 Ibid, at 136.
31 Article VII of the Outer Space Treaty; Article II of the Liability Convention.
32 Article III of the Liability Convention.
33 Hobe, Schmidt-Tedd & Schrogl, supra note 26, at 136.
34 Article VII of the Outer Space Treaty; Article II of the Liability Convention.
This victim-oriented civil liability regime established by both the Outer Space Treaty and the Liability Convention constitutes legal sources to analyse the matter of GNSS civil liability in international space law. Furthermore, since increasing State practice has seemingly furnished the necessary opinio juris, the author supports the viewpoint which asserts the status of customary international law of Article VII of the Outer Space Treaty, in which case non-member States could also apply a civil liability regime based on this provision.

Besides international treaties, the sources of international law recognised by the International Court of Justice (ICJ) also include: (i) customary international law, (ii) general principles of law, and (iii) works of highly qualified publicists. Scholars generally hold that the source of international space law must be the same as general international law. Items (i) and (ii) are usually presented by general practice and national legal systems, and are discussed in section 3.3.2 of this research. Item (iii) works as subsidiary means for the determination of rules of law. Furthermore, soft law has played an important role from the very beginning of space activities to the present. Even though the non-binding characteristic of soft law in outer space does not always make it useful or appropriate for all international law jobs, it at least can be used as a subsidiary means for settlement of disputes and supporting materials for the interpretation of conventions on international space law.

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36 It should be noted here that (i) the status of customary international law only increases the scope of application to non-member States, and does not affect the applicability of the Outer Space Treaty to damage caused by GNSS, which will be determined by the discussion in section 3.3 of this research; (ii) the question of whether the status of customary international law of Article VII of the Outer Space Treaty extends to the Liability Convention remains open and needs further discussion, but is outside the scope of this research.
37 Article 38 of the Statute of the International Court of Justice, annexed to the UN Charter.
38 Article 38(1) of the Statute of the International Court of Justice, annexed to the UN Charter; N. M. Matte, Space Activities and Emerging International Law (McGill University, 1984), at 74; HE Qizhi, Outer Space Law (Law Press-China, 1992), in Chinese, at 21.
3.3 IDEALISTIC: A POSSIBLE WAY TO APPLY INTERNATIONAL SPACE LAW TO GNSS CIVIL LIABILITY

3.3.1 Arguments on the applicability of international space law to GNSS civil liability

In reply to the question of whether the civil liability regime of international space law, i.e., Article VII of the Outer Space Treaty and the Liability Convention, can apply to damage caused by GNSS, two opposing views exist in academia. One holds that the current space law regime does offer civil remedy to GNSS damage. The other rules out the applicability of the current space law regime to GNSS civil liability. The author can neither support nor oppose either of these views since international space law can cover GNSS civil liability in a political sense, rather than legal.

Indeed, the core meaning of Article VII of the Outer Space Treaty could be construed as launching States bear international liability for damage caused by space objects, and the validity of this conclusion is supported by the full title of the Liability Convention – Convention on International Liability for Damages Caused by Space Objects – where the core words are ‘damage caused by space objects’. Therefore, applicability depends on the understanding or interpretation of the phrase ‘damage caused by space objects’. Consequently, the notions ‘damage’ (see 3.3.3), ‘caused by’ (see 3.3.4) and ‘space object’ (see 3.3.2) are discussed individually so as to seek the possibility of applying international space law to GNSS civil liability.

41 Before any further discussion, it should be noted that the author holds that what the Outer Space Treaty and the Liability Convention regulate are civil liability, as opposed to administrative liability arising from maladministration or negligence of supervision and regulation (see 2.3.2). The reason is that: to favour the interest of victims, Article VII of the Outer Space Treaty and the Liability Convention require the State to be liable for the compensation resulting from the activities of its nationals regardless of whether or not that State is liable for maladministration. State liability in international space law is in nature a vicarious liability for the civil damage caused by space objects based on private law theory, and therefore such national space legislation as the Swedish Act on Space Activities (Section 6) allow a State which has been designated for reimbursement from the persons who have carried on the space activity. Even the nature of State liability under the Liability Convention is civil liability; claimants still could not ask for compensation directly to the liable State based on the Liability Convention, as this Convention is for the claim presented by a State. However, an opposing opinion does exist, which distinguishes the terms ‘State liability’ and ‘civil liability’ and advocates that the liability regime under the Liability Convention is not civil liability. See OECD Nuclear Energy Agency, Liability and Compensation for Nuclear Damage: An International Overview (OECD, 1994), at 10.

42 Pablo Rodriguez-Contreras Perez, GNSS Liability issues: Possible solutions to a global system (McGill University, 2002), at 58.

3.3.2 Definition of ‘space object’

At the time when the Liability Convention was concluded there existed no generally accepted legal definition of the term ‘space object’.\(^{44}\) Although Article I of the Liability Convention lays down that “the term ‘space object’ includes component parts of a space object as well as its launch vehicle and parts thereof”, most scholars recognise this provision as an expression rather than a full definition of space object,\(^ {45}\) or as a partial definition.\(^ {46}\) From a legal standpoint, it is without question that navigation satellites including their components are space objects here,\(^ {47}\) but it is questionable whether a signal transmitted by those navigation satellites could fall within the term ‘space object’ according to that expression.

For the above question, there are three schools of thought about this confusion. The first school insists that a space object itself would have both material and physical properties which excludes a signal.\(^ {48}\) The second school argues that damage from intangible electromagnetic waves was not absolutely excluded in the interpretation of the Liability Convention even though physical damage caused by tangible parts of a space object was of foremost concern.\(^ {49}\) The third school, while not popular with scholars, directly recognises that the signal emitted from the space object is indeed a space object.\(^ {50}\) Therefore, a proper interpretation to determine whether a space object must be tangible or material is essential in applying GNSS civil liability cases to the Outer Space Treaty and the Liability Convention.


\(^{50}\) Henaku, *supra note* 45, at 165.
Unlike the United Nations Convention on the Law of the Sea\textsuperscript{51} and the Convention on International Civil Aviation (see 4.4.3)\textsuperscript{52}, the treaties on outer space themselves were not intended to be a permanent code but, in a more modest way, they were intended to articulate principles.\textsuperscript{53} Further, they neither offer a mechanism for the interpretation of their provisions in general, nor do they design a remedy for the settlement of disputes understanding those provisions.\textsuperscript{54} In this case, we have to make reference to the rules of interpretation laid down in general international law: Articles 31 to 33 of the Vienna Convention on the Law of Treaties (Vienna Convention)\textsuperscript{55} which represents the final and authoritative achievement of decades of efforts on treaty interpretation.\textsuperscript{56}

The interpretation rules set down by the Vienna Convention stipulate that a treaty must be interpreted by the ordinary meaning of its terms with reference to the context and the object and purpose thereof.\textsuperscript{57} In other words, the following three primary means of interpretation that can be used by an interpreter citing Article 31 are (i) conventional language, (ii) the context, and (iii) the object and purpose of a treaty.\textsuperscript{58}

(i) Conventional language. Determining the ordinary meaning of the term ‘object’ is the point of departure for understanding the term ‘space object’ used by the Outer Space Treaty and the Liability Convention. This term is


\textsuperscript{52} Article 84, Chapter XVIII of the Chicago Convention.


\textsuperscript{55} Here may arise a question of how the interpretation of a preceding treaty, for example, the Outer Space Treaty taking effect in 1967, apply rules codified by a later treaty, the Vienna Convention taking effect in 1980. For this question, certain scholars have already made a convincing point of view and case analysis by the following words: “The International Court of Justice (ICJ) has on several occasions confirmed that both Article 31 and Article 32 of the Vienna Convention reflect customary international law and has applied these rules to treaties that predated the Vienna Convention. For example, in 1999, the Court interpreted and applied the rules codified in Article 31 and 32 of the Vienna Convention, when considering the meaning of a treaty was concluded in 1890.” Ram S. Jakhu & Steven Freeland, \textit{The Relationship between the United Nations Space Treaties and the Vienna Convention on the Law of Treaties}, 55 Proceedings of the International Institute of Space Law 2012, at 386-387.


\textsuperscript{57} Article 31 of the Vienna Convention reads as follows: “A treaty shall be interpreted in good faith in accordance with the ordinary meaning to be given to the terms of the treaty in their context and in the light of its object and purpose.”

\textsuperscript{58} Linderfalk, supra note 56, at 153.
in daily usage, and it usually refers to a material thing that can be seen and touched with a fixed shape or form. However, non-tangible radiations, where GNSS signals are included, are a series of radio waves with electronic information, and hence they are not even ‘objects’, let alone a ‘space objects’. In addition, although the author agrees that Article 1(d) of the Liability Convention does not qualify as a definition of the term ‘space object’, it indeed may serve as a basis to understanding the meaning of that term. The non-definition is the result of the Legal Sub-committee of UNOOSA believing that the term ‘space object’ had a reasonably clear meaning and it was only necessary to emphasise that all the component parts and launching devices were included besides a space object itself. In this sense, the minimum requirement of a space object is a physical nature, otherwise no component parts or launching devices thereof could be included.

(ii) The context. The terms of a treaty are not drafted in isolation, and we must consider their normal meaning within the entire treaty text. In the context of Article VII of the Outer Space Treaty and the Liability Convention, phrases such as ‘the launching of an object to outer space’, ‘a space object is launched’, ‘launch a space object’, and ‘the operation of that space object’ are frequently used, and this seems that a space object is usually connected with ‘launching’ and ‘operating’ activities (see (v) of 3.4) even though those activities may not be essential for each space object. This argument could also be supported by the academic definition of the term ‘space object’, which reads that “anything that human beings ‘launch’

59 Gorove, supra note 46, at 25.
61 Collins, supra note 60, at 1448; Oxford, supra note 60, at 1291; Longman, supra note 60, at 1335; Webster’s, supra note 60, at 1333; Macmillan, supra note 60, at 1306.
62 Gorove, supra note 46, at 25.
63 Hobe, Schmidt-Tedd & Schrogl, supra note 45, at 115.
66 E.g., Article VII of the Outer Space Convention.
67 E.g., Article I of the Liability Convention.
68 E.g., Article V of the Liability Convention.
69 Gorove, supra note 46, at 17-18.
or attempt to ‘launch’ into space’. More broadly, though still within the system of UN Treaties on Outer Space, the Registration Convention shares the same expression and meaning of space object word for word. Article IV (d) thereof states that the basic orbital parameters including nodal period, inclination, apogee and perigee concerning each space object shall be carried on the registry of each State, and in this sense it seems clear that the term ‘space object’ excludes GNSS signal as it has nothing to do with those orbital parameters. Another similar situation in the Moon Agreement is with the phrase such as ‘land their space objects on the moon and launch them from the Moon’. Of course, based on the analysis above, the author does not argue that each space object must be able to be ‘launched’, ‘operated’, ‘registered’, ‘returned’ and ‘landed’, but at least these expressions show a strong implication for the physical needs of a space object within the context of UN outer space treaties, particularly the Outer Space Treaty and the Liability Convention.

(iii) The object and purpose. The author agrees that the purpose of the civil liability regime under international space law, in particular the Liability Convention, is to ensure the prompt, adequate and equitable compensation to victims for damage caused by space objects. Based on this victim-oriented character, someone may argue or support the opinion that a broad interpretation to encompasses damage from ‘intangible electromagnetic waves’ would be reasonable. The author does not share this view. The purpose of interpretation is to determine the original meaning of terms or provisions so that interpreters may not make new rules or revise the convention without the approval of all contracting States. It should be noted that only when a particular treaty provision is ambiguous that an interpretation would be necessary. A treaty must be interpreted under the principle of good faith, and it would be inappropriate to ‘read into’ that provision certain rules so as to reflect what should be, particularly as such rules go beyond the normal meaning within the treaty context as required by Article 31.1 of the Vienna Convention.

70 Cheng, supra note 45, at 297.

Professor Vladimir Kopal also made a similar but a bit complicated definition to the term ‘space object’ as follows: “As ‘space object’ should be considered any object launched by man for a mission into outer space, be it into orbit around the Earth or beyond /ie. into interplanetary space, to and around the Moon and other celestial bodies of the Solar system, or into deep space.” Vladimir Kopal, Some Remarks on Issues Relating to Legal Definitions of “Space Object”, “Space Debris” and “Astronaut”, 37 Proceedings of the International Institute of Space Law 1999, at 101.

71 Article 1 (b) of the Registration Convention.

72 E.g., Article 8 of the Moon Agreement.

73 Preface of the Liability Convention.

74 Chatzipanagiotis & Liperti, supra note 45, at 165; Smith, supra note 49, at 585.

75 Jakhu & Freeland, supra note 55, at 387.
Literally speaking, it seems clear that a space object must be physical and hence excludes GNSS signal in its definition. However, if we look at Article 31.4 of the Vienna Convention which allows a special meaning of a treaty term, a question may arise as to whether it is possible to understand, in this way, that a non-material object, including a GNSS signal, was intentionally put into a special meaning of the term ‘space object’ by the drafters. The right answer to that question depends on whether “the parties so intended”. The intention to give an unusual meaning to a treaty term must be supported by direct evidence, in particular the travaux préparatoires which are the official records of a negotiation. The past tense of the term ‘intended’, used in Article 31.4 of the Vienna Convention, also directs us to examine the historical materials as well.

Even though the Outer Space Treaty (Article VII), including its predecessor entitled ‘Declaration of Legal Principles Governing the Activities of States in the Exploration and Use of Outer Space (Item 9)’, and the Liability Convention finally selected the term ‘object’ or ‘space object’, the starting point in their draft documents submitted by individual member States were such terms as (i) damage caused by ‘space vehicles’, ‘space devices’ and ‘the launching of objects into outer space’, and (ii) liability for a ‘space vehicle accident’. Those terms imply that what the delegations looked into was the civil liability for damage resulting from a physical object itself, mainly in a space vehicles accident, particularly at the moment of launching, rather than the intangible data, application or product emanating from

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76 Article 31.4 of the Vienna Convention.
77 Richard K. Gardiner, Treaty Interpretation (Oxford University Press, 2015), at 70.
81 Christol, supra note 48, at 355; Roderick D van Dam, GNSS and Aviation: Eurocontrol’s Perspective, Outer Space Committee Newsletter, 2000, at 48; Henaku, supra note 45, at 164.
82 Hobe, Schmidt-Tedd & Schrogl, supra note 45, at 102.
that object. The author found no evidence, in the historical context of international space law, which showed the drafters’ intention to establish a connection between an intangible signal with a liability mechanism. Taking a step back, even though early GNSS – TRANSIT (see 1.2.1) – had been in operation at the time of drafting the liability provisions of international space law, at the beginning of the space era large-scale application, particularly in such a safety-of-life field as aviation, was more like science fiction. The author therefore believes that there were few possibilities for the drafters, in particular of the Liability Convention, to even recognise the necessity to make civil liability regulations for an intangible GNSS signal.

The author would of course not deny the possibility of applying old law to new technology or situations, but the above arguments show that no historical context supports the intention to add a special meaning to the treaty term ‘space object’.

When taking a further step toward State practice, one scholar found that, while the majority of States do not define the term ‘space object’ in their national law, certain space powers simply copied the expression of space object from Article I of the Liability Convention, and only a few States give it a specific definition. Similar to international treaties on outer space activities, national legislation and academic viewpoints thereof also make the term ‘space object’ a collective term that includes ‘space vehicle’, ‘spacecraft’, ‘spaceship’, ‘satellite’, and ‘space station’ (see (iii) The object and purpose). This scholar also concluded seven common elements of the definition of the term ‘space object’ in national laws, namely: (i) object, (ii) intent to launch, (iii) launched, (iv) launch vehicle, (v) payload, (vi) physical component parts and parts thereof, and (vii) satellite. In this scenario, the author does not see any major difference on the content of regulations between international treaties and State practice, regardless of whether or not those practices could be recognised as customary international law or general principles of law.

83 Stephen Gorove, Some Thoughts on Liability for the Use of Data Acquired by Earth Resources Satellites, 15 Proceedings of the International Institute of Space Law 1972, at 109; Hobe, Schmidt-Tedd & Schrogl, supra note 45, at 111.
85 The author agrees that old law could be applied to new technology but the key point is to see whether the new technology is merely a change in degree, an improved version of something that already exists, or a change in kind, something else entirely with a new capability. See Rebecca J. Rosen, The Thorny Combination of Old Laws and New Tech, https://www.theatlantic.com/technology/archive/2011/11/the-thorny-combination-of-old-laws-and-new-tech/248111/, last accessed 2 May 2017.
87 Ibid.
88 Ibid.
Therefore, here we can draw a simple conclusion that both international treaties on outer space, which are the Outer Space Treaty and the Liability Convention, and State practice, which may be recognised as customary international law or general principles of law, show no support for the viewpoint of interpreting and adding an intangible GNSS signal to the physical term ‘space object’.

3.3.3 Broad interpretation of the term ‘damage’

In order to apply the Liability Convention in the case of an accident caused by the failure of GNSS, within the context of ‘damage caused by space objects’, certain scholars try to interpret the term ‘damage’ broadly, which latter term is considered by academics as one of the most controversial aspects of legal history. They incorporate the notion of indirect damage, and hence argue that damage caused by GNSS could be recognised as indirect damage, which is covered by the Liability Convention.

Even though the term ‘damage’ is clearly defined in Article I of the Liability Convention as “loss of life, personal injury or other impairment of health; or loss of or damage to property of States or of persons, natural or juridical, or property of international intergovernmental organizations”, many scholars still insist that this definition is ambiguous, particularly in terms of whether that term includes only direct damage or, inter alia, indirect damage as well. Indeed, during the drafting of the Liability Convention, the inclusion of direct damage and delayed damage was such a thorny question that it did not result in an agreement being reached.

On the one hand, the US delegation expressed that the Liability Convention “does not cover what some delegations earlier called remote or indirect

90 The typical case on ‘indirect damage’ in international space law is the crash of the U.S.S.R.’s Cosmos 954 Satellite, where Canada claimed the recovery of cleaning costs due to the nuclear contamination of vast stretches of Canadian territory. See Bryan Schwartz & Mark L. Berlin, After the Fall: An Analysis of Canadian Legal Claims for Damage Caused by Cosmos 954, 27 McGill Law Journal 1982, at 716.
91 Carpanelli & Cohen, supra note 44, at 45; Henaku, supra note 45, at 170; Chatzipanagiotis & Liperi, supra note 45, at 165.
damage and for which there is only a hypothetical causal connection with a particular space activity” 94 and pointed out that the question of indirect damage could cause great difficulties in practice. 95 Certain scholars have supported this argument. 96 In the context of GNSS damage, the opinion based on the above position is also popularly accepted, 97 for example:

“Neither the language of the Convention, the negotiations leading to this Convention, nor State practice support such a claim [that the Liability Convention applies to indirect damage arising from the use of navigational satellite services].” 98

On the other hand, a few delegations, for example India, 99 were not satisfied with such a narrow interpretation as above, and certain scholars further support them as well. 100 They believe that the notion of damage in Article I of the Liability Convention generally covers both direct and indirect damage, 101 and only in this way could the Liability Convention live up to its

98 Lagarrigue, supra note 43, at 32.
100 Lyall & Larsen, supra note 11, at 405; Hurwitz, supra note 1, at 15; Christol, supra note 48, at 362; Carpanelli & Cohen, supra note 44, at 39.
101 Hobe, Schmidt-Tedd & Schwgl, supra note 45, at 112; Carpanelli & Cohen, supra note 44, at 35.
victim-oriented nature. More importantly, many scholars share the above as specific to GNSS damage, for example:

"The conclusion that GNSS satellite damage other than collision is covered by the Liability Convention is not only correct from the reading of the provision but is also supported by the travaux préparatoires".  

To comment or make a choice between these two opposing arguments, the first thing needed is to understand what constitutes indirect damage in the context of space law. Indeed, the term ‘indirect damage’ is opposed to ‘direct damage’, but the distinction between them has been long criticised for its complexity and confusion, and case law states that there should be no place for the theory of indirect damage in international law. Nevertheless, since the possibility to recognise an intangible GNSS signal as a space object was disconfirmed (see 3.3.2), the author would like to discover whether the notion of indirect damage could be an alternative solution which is established on a different legal basis, with the help of a hypothetical case model as follows:

An aircraft with 300 passengers crashed into a farmer’s house because the GNSS Landing Systems (autonomous Landing) broke down due to defective GNSS signals, and all the crew, passengers and the farmer lost their lives.

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103 Henaku, supra note 45, at 170.


105 See Hobe, Schmidt-Tedd & Schrogl, supra note 45, at 129.

106 The author finds a similar case in the context of satellite communication which is the response to the US delegation who explained that indirect damage does not apply the Liability Convention, and this case and opinion is quite helpful to the research. The original words are as follows:

"Only when damage results from this interference is the Convention applicable: thus, if for example a space object of one state interrupts the transmission of radio signals from a communications satellite to an aircraft in flight, which makes that aircraft veer off course and crash, the first-mentioned state may be held liable by virtue of article II of the Convention."

Peter van Fenema, The 1972 Outer Space Liability Convention (McGill University, 1973), at 62. The opinion which supports to apply the Liability Convention for damage caused by radio interference please see also Hurwitz, supra note 1, at 20.
The defective GNSS signal resulted from the malfunctioning of GNSS satellites because of (1) their collision with a space object (A); (2) the radio-interference from a space object (A); or (3) an accounting error, defective components and other defects of GNSS itself.

This case model could also be illustrated by Figure 3-1 as follows:

![Figure 3-1 Case Model](image)

In this case model, it is not important what makes GNSS signals defective, but what is important is the fact that neither GNSS satellites nor Space Object (A) caused the damage with a direct and physical connection, which is not the usual way of ‘damage caused by space objects’. Further, it is quite clear that GNSS satellites qualify as space objects regulated by Article VII of the Outer Space Treaty and the Liability Convention, and damage includes the personal casualty (passengers, crew and the famer) as well as the loss of property (aircraft and house) in compliance with Article I (a) of the Liability Convention. Therefore, the key point here is not the question of whether indirect damage constitutes ‘damage’ as required by the Liability Convention, but whether we could say that damage is ‘caused by’ those GNSS satellites or Space Object (A), and hence the Liability Convention applies.

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107 In the pictures used in this Chapter, all full lines refer to the fact that physical connect exists between heading and ending points, and by contrast all dotted lines mean that no physical connect exists.
Regardless of the difficulty of finding an exact definition of the term ‘indirect damage’, it is more or less right to say that it is the damage which is caused indirectly. In this sense, the author holds that the nature of the question of whether ‘damage indirectly caused by GNSS satellites’ can be regarded as ‘damage caused by space objects’ depends more on the debate about the causal link between effect and activity and what degree of causality is required to bring about liability, rather than on the pros and cons of the definition of damage (direct damage vs indirect damage) in outer space treaties. And this argument is at least supported by some delegates if we look into the travaux préparatoires of the Liability Convention. For example, after repeating the uncertainty of the term ‘indirect damage’ in general international law and the case law of international arbitration, the Japanese delegation believed that:

“all damages which have an adequate relationship of cause and effect with the space activities should be covered in this convention. In order to avoid endless discussion on whether to include those terms of ‘indirect damage’ or ‘delayed damage’ in the definition of damage, we should discuss the problem of these two terms not in which the damage occurred, by introducing the notion of adequate relationship of cause and effect or so called ‘the existence of proximity’ in the Anglo-American laws.”

Although no text was finally added to clearly state that the Liability Convention covers indirect damage, it seems unclear whether this means that the delegations finally decided to exclude the applicability of damage caused indirectly, or whether they simply refused to accept Japan’s proposal. Therefore, it is reasonable to argue that the difference between direct and indirect damage is a matter of adequate causation, which was not expressed in the

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108 The notion of direct damage is emphasised from different perspectives in space law as well as the law of GNSS among international scholars. For example, Professor Smith and Professor Kerrest direct this notion to be “caused after an interval, an intervening event or events that are a consequence of the initial ‘impact’”. Professor Masutti addresses indirect damage from the perspective of ‘loss of profit’; Professor Mendes de Leon and Professor van Traa indicate that indirect damage, in the context of GNSS, refers to “damage caused by the signals in contrast with damage caused by the space object”; Dr. Andreas Loukakis holds that indirect cases of damage are resulted from “the use of capabilities of a space object” rather than the space object as such, where damage caused by defective signals emitted by GNSS satellites qualify as a typical example. See respectively: Hobe, Schmidt-Tedd & Schragl, supra note 45, at 127; Masutti, supra note 89, at 53; Pablo Mendes de Leon & Hanneke van Traa, Space Law, in Jessica Schechinger (Eds.), The Practice of Shared Responsibility in International Law (Cambridge University Press, 2017), at 475 (note 75); Loukakis, supra note 84, at 31.

109 Christol, supra note 48, at 360.


Liability Convention. A few scholars have extended this argument to the context of GNSS civil liability, while the majority of scholars were still focusing on the definition of damage itself, i.e., whether GNSS damage could be included in the term ‘damage’ under the Liability Convention. The author shares the minority view and believes that, if the claim for GNSS damages intends to qualify under the outer space treaties, then the only matter to be proven lies in the causation between damage and GNSS satellite/Space Object (A) (see 3.3.4), particularly in the sense of the phrase ‘damage caused by space objects’.

3.3.4 The matter of causation

For the matter of causation, it is quite difficult to agree on a common definition in one specific convention where the conflict between common law and civil law has to be coordinated. That difficulty in turn leaves broad discretion for the dispute settlement body to identify that causation on a case-by-case basis in light of the intent and purposes of the convention, as well as by observing justice and equity. Unlike the air law system where the exact meaning or test of causation is usually for domestic tribunals to decide, it seems that outer space law has to deal with the matter of causation in a more international sense, and the reason for this refers to two aspects. On the one hand, the outer space treaties do not give a general answer for the causation, but Article XII of the Liability Convention provides that the compensation “shall be determined in accordance with ‘international law’ and the principles of justice and equity”. On the other hand, claims under the Liability Convention must be based on the model of State-vs-State by a Claims Commission, rather than by a municipal court (see 3.4).

Focusing on the context of GNSS civil liability, the matter of causation depends on the understanding of the term ‘caused by’ under the phrase ‘damage caused by space objects’; more specifically ‘damage caused by GNSS satellites’. The term ‘caused by’ is actually greatly favoured by the

114 E.g., Perez, supra note 42, at 46 and 61; Perez, supra note 102, at 252.
115 See Hobe, Schmidt-Tedd & Schrogl, supra note 45, at 191.
116 Kayser, supra note 96, at 48-49.
118 Matte, supra note 110.
119 See Article XIV, the Liability Convention.
120 As discussed above in section 3.3.2, there are few possibilities to interpret ‘GNSS signal’ as ‘space object’, so here the author will not discuss the causation between ‘damage’ and ‘GNSS signal’ under the phrase ‘damage caused by space objects’.
international community since it could resolve the vexing question of causation so as to 

“allow for different tests of remoteness and causality which may be appropriate for different obligations or in different contexts, having regard to the interest sought to be protected by the relevant primary rule.”\(^{121}\)

This means that causation, in the context of GNSS damage, is open to being examined and tested on the basis of discretion and under each theory of causation in international law, which mainly refers to the criterion of ‘directness’,\(^{122}\) ‘foreseeability’\(^{123}\) or ‘proximity’.\(^{124,125}\)

For the criterion of ‘directness’, the international community, including the United Nations Compensation Commission (UNCC),\(^{126}\) has started to abandon knowledge accumulated from old arbitral decisions\(^{127}\) which qualify damage not immediately caused by the wrongful act as ‘indirect’, and exclude this kind of damage for compensation.\(^{128}\) Contrastingly, it has started to hold that ‘directness’ only focuses on the presence of a clear and unbroken causal link between cause and effect.\(^{129}\) Also, the Mixed Claims Commission (United States and Germany)\(^{130}\) insisted that:

“it matters not how many links there may be in the chain of causation […], provided there is no break in the chain […].”\(^{131}\)

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123 See Portuguese Colonies case (Nauilhia incident), in United Nations, Reports of International Arbitral Awards: vol. II (Sales No. 1949.V.1), at 1031.


126 The United Nations Compensation Commission (UNCC) was created in 1991 as a subsidiary organ of the United Nations Security Council under Security Council resolution 687 (1991) to process claims and pay compensation for losses and damage suffered as a direct result of Iraq’s unlawful invasion and occupation of Kuwait in 1990-91. For more information, please see http://www.uncc.ch/, last accessed 16 August 2017.


128 Damage not immediately related to the wrongful act such as loss of earnings or profits has been clearly stated to be compensated by UNCC. See paras. 5 and 20 of the Governing Council Decision no. 7, S/AC.26/1991/7/Rev.1, 17 March 1992.


130 The Mixed Claims Commission (United States and Germany) was set up to deal with the compensation of the US nationals for damage caused in the Lusitania disaster from the German Government, under the Treaty of Berlin, signed August 25, 1921.

In more academic language, the author enunciates that as long as the damage can be clearly and unmistakably traced back, link by link, to the act as the exclusive cause through a connected, though not necessarily direct, chain of events, the damage must be compensated. This could be better understood with the following conclusion, after checking the cases containing the discussion of direct or indirect damages (see 3.3.3):

“It is only true to say that in the majority of cases, in which the epithets ‘direct’ and ‘indirect’ are applied to describe the consequences of an unlawful act, they are in fact being used synonymously with ‘proximate’ and ‘remote’.”

What the author could read from this conclusion was that the usage of ‘direct’ or ‘indirect’ has nothing to do with the criterion of ‘directness’, which means that the causal link is unbroken, but the remoteness of damage, i.e., ‘proximate’ or ‘remote’.

For the criterion of ‘foreseeability’, in tort law it is generally required that the existence or type of damage must be reasonably foreseeable by a reasonable person at or before the time the accident occurred, and it does not matter whether the liable person actually expected that damage or not and whether the extent of that damage has been foreseen.

The notion of ‘proximity’ or ‘proximate cause’ does not have a generally accepted meaning in practice, and its definition is still in progress with too much disagreement among courts and scholars, even though this notion is one of ancient ‘vintage’ in legal history. Therefore, judges in the court often instead to determine that whether the damage is ‘not proximate’ or ‘too remote’. It should be noted here that the criterion of ‘proximity’ itself does not exclude all ‘remote’ causes, but only those which are ‘too remote’.

Actually, neither international law, nor national law shows a general standard or theory for the matter of causation, and there is no clear line to make an exact judgment on the notions of ‘directness’, ‘foreseeability’ and ‘proximity’ respectively. This fact urges us not to focus on one criterion mechanically, but to remain flexible as long as the principles of justice and equity, which are

134 Helen Gubby, English legal terminology (Eleven International Publishing, 2016), at 133.
136 William C. Bryson, Cause and Consequence in the Law, in Rom Harre & Fathali M. Moghaddam (Eds.), Questioning Causality: Scientific Explorations of Cause and Consequence across Social Contexts (ABC-CLIO, 2016), at 331.
also stipulated in Article XII of the Liability Convention, are duly observed. Therefore, the author holds that while the criterion of ‘directness’ intends to establish a factual causation, the criteria of ‘foreseeability’ and ‘proximity’ will transfer that factual causation to a legal one albeit with some limitations; this so as to avoid an infinity of possible parties liable for even minor acts of negligence, and to restrict it from going too far beyond what the generally shared sense of justice would support.\textsuperscript{138}

Based on the analysis above, we could now try to test causation in the hypothetical case mentioned above (see 3.3.3). In this hypothetical case, the three possible causes of GNSS malfunctioning – which, notably, the author believes cover most cases concerning GNSS civil liability – can be summarised as follows.

(i) Collision with Space Object (A). In this case, the damage is actually caused by the collision between Space Object (A) and GNSS satellites. The causal link between Space Object (A)/GNSS satellites and damage must be established to claim compensation. While determining whose fault it is that caused the collision is critical for the identification of the liable party and the division of compensation in outer space\textsuperscript{139} it only makes a small difference to the causation test: if the collision were caused by Space Object (A), then the causal link would be illustrated as in Figure 3-2-A; if the collision were caused by GNSS satellites, the causal link would be illustrated as in Figure 3-2-B; and if the collision were caused jointly by Space Object (A) and GNSS satellites, the causal link would be illustrated as in Figure 3-2-C.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{Figure3-2}
\caption{Figure 3-2 Causation (I)}
\end{figure}

Compared with the typical case in space law, Figure 3-2 does not show any physical connection between the space object in question and damage, yet the causal link is unbroken and this complies with the criterion of ‘directness’. If there is no other factor intervening in this causal link, a reasonable person would be aware, especially after the accident of the ‘Iridium

\begin{itemize}
\item \textsuperscript{138} Bryson, supra note 136, at 330.
\item \textsuperscript{139} Article III & IV of the Liability Convention.
\end{itemize}
33 and Cosmos 2251 Collision’ which indicated the possible interruption in communication service,\textsuperscript{140} that the collision between a space object and GNSS satellites may interrupt GNSS signals or services.\textsuperscript{141} This means that the criterion of ‘foreseeability’ also fits here. The only thing that needs to be further discussed is whether the causal link is too remote or not under the criterion of ‘proximity’. As there is no clear standard for the notion of ‘proximity’, we have to make a weighing of interests, through the principles of justice and equity, between victims and potential liable parties.

It is clear that the Liability Convention favours third parties (see (ii) of 3.4) who are not involved in highly dangerous space activities,\textsuperscript{142} and requires the liable party to provide compensation to the extent of placing the one being compensated in the situation that one would be in had the damage not occurred.\textsuperscript{143} This notwithstanding, it would not be fair to hold the party liable for any consequence which is not very closely related to the starting point of the causal link. Bearing the above victim-oriented nature in mind, the author however believes that, since all the causal links in Figure 3-2 are simple, proximate and not too remote, it is fair enough, in the sense of joint liability in outer space as shown by Figure 3-2-C, to hold the party who or whose fault caused that collision to make prompt and full compensation to the victims in this case.

(ii) Radio-interference from Space Object (A). In this case, the damage is caused by the radio interference from Space Object (A), and what is required for the claim is the causal link between Space Object (A) and damage, as shown in Figure 3-3-A.\textsuperscript{144} The structure and remoteness of a causal link in this case is similar to the one in Figure 3-2-A, and the only big difference is between collision and interference, i.e., physical connection and remote effect. However, the matter of causation never requires a ‘physical’ link as an essential element. For example, in the ‘Cosmos 954 Claim’, the nuclear damage was not caused by a direct hit and connection, but by radiation contamination which was accepted as the proximate cause of harm,\textsuperscript{145} while the compensation was finally granted by the U.S.S.R. \textit{ex gratia} without normative content despite

\begin{footnotesize}
\begin{enumerate}
\item The space segment is a constellation of more than 20 satellites, and the collision or malfunction of a few satellites may not interrupt the GNSS service as a whole but it is still not impossible. The lack of enough satellites that function well at least makes a difference to the performance of GNSS signals, which may cause an air accident.
\item Article XII of the Liability Convention.
\item The Figure 3-3-B and Figure 3-4-B will be discussed with Figure 3-7 in section 3.4, below.
\item Christol, \textit{supra note} 48, at 389.
\end{enumerate}
\end{footnotesize}
Canada’s claim based on the Liability Convention.\textsuperscript{146} It seems too narrow, to be fair enough, to restrict the notion of damage to the damage caused exclusively by direct contact, and this argument is also shared by the theory of general law where air law is also included.\textsuperscript{147} Actually, the key point is not whether the damage is suffered through physical impact with a space object, or whether it results from biological, chemical or radiological contamination emanating from a space object.\textsuperscript{148}

Therefore, the author believes that if the causal link could be established for the damage caused by the collision between Space Object (A) and GNSS satellites (see above), there is no reason to deny the causal link for the damage caused by radio-interference from Space Object (A), in particular considering that the damage at the end of that causal link complies with the consequence referred to in the Liability Convention.\textsuperscript{149}

(iii) Malfunction of GNSS itself. In this case, the damage is caused by the GNSS itself, including its satellites,\textsuperscript{150} where the causal link between GNSS satellites and damage has to be established for a relevant claim for compensation. Admittedly, the case of this model already existed,\textsuperscript{151} and the author believes

\begin{figure}[h]
    \centering
    \includegraphics[width=\textwidth]{figure3-3.png}
    \caption{Causation (II)}
\end{figure}


\textsuperscript{147} See Diederiks-Verschoor & Mendes de Leon, supra note \textsuperscript{117}, at 302.

\textsuperscript{148} Foster, supra note 45, at 155.

\textsuperscript{149} Kayser, supra note 96, at 48.

\textsuperscript{150} One may argue in this case that the problem may arise from the ground control segment crashing rather than the failure GNSS satellites themselves, but this does not affect the civil liability issues of GNSS satellites under international space law, as all users get (defective) signals from those satellites rather than ground transmitters. However, defective signals solely from a ground-based augmentation system do not in any way apply to the outer space treaties (see (v) of 3.4), but it may be involved in legal disputes as the operator or provider has to prove its innocence, which is quite difficult.

that it would continue to be the most possible way to happen in practice, compared with collision and radio interference in outer space. Compared with the above two models, the difference in this case is that no other space object but GNSS satellites could be blamed for the damage, and this makes the causal link (see Figure 3-4-A) even simpler and less remote, which is a good point for the victim.

It is clear that there is no physical connection between space objects (GNSS satellites) and damage, but as discussed above, it does not affect the establishment of causal link. To support the author’s argument, an analogy of the causal link between a case of damage caused by GNSS and a case by Air Traffic Control (ATC) could be made with reference to the well-known ‘2002 Überlingen mid-air collision’, in which case the main cause was attributed to the ATC service provider. The main causal link in the ‘2002 Überlingen mid-air collision’ could be simply illustrated as in Figure 3-5-A.

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It is quite apparent that the structure and remoteness of the causal link in Figure 3-5-A is almost the same as the one in Figure 3-5-B (Figure 3-4-A), and the only difference lies in the fact that, while ATC controls an aircraft by the ‘command’ to the ‘pilot-in-command’, GNSS satellites control an aircraft by the ‘signal’ or ‘data’ to the ‘GNSS Landing System’ which could be regarded as an ‘auto-pilot’. Therefore, if the causation in Figure 3-5-A could be widely accepted by air law practitioners,\textsuperscript{153} then there will be no reasonable excuse for space law experts to deny the one in Figure 3-5-B (Figure 3-4-A).

3.3.5 Brief conclusion

Based on the analysis above, it could be briefly concluded that GNSS damage may apply the Liability Convention, as well as its legal basis that is Article VII of the Outer Space Treaty, as long as the causal link between that damage and a GNSS satellite – not GNSS signal – is unbroken, logical, foreseeable, not too remote and, finally, accepted in diplomatic negotiations or by the Claim Commission on a case-by-case basis. Technically speaking, the author also admits that it will be quite challenging in practice to prove the matter of causation in the case concerning GNSS damage, but it is still not impossible with the help of, for example, technical experts.

In addition, the term ‘space object’ is of both a material and a physical property, and therefore a GNSS signal is excluded. The discussion on whether GNSS damage qualifies as indirect damage, and whether the Liability Convention covers indirect damage is irrelevant to the applicability of GNSS damage to outer space treaties.

3.4 Realistic: a less feasible mechanism for GNSS civil liability

Arising from the ultra-hazardous nature of space activities, international space law intends to protect third-party victims mostly by a victim/claimant-oriented liability framework such as a strict liability system, and an easily identifiable liable party. Unfortunately, certain gaps always exist between the ideal and the real. For one thing, we have to admit that, for

\textsuperscript{153} The compensation issues between Bashkirian Airlines (whose aircraft crashed and who paid compensation to most victims in the crash according to air law) and the Federal Republic of Germany (which transferred its part of sovereignty in terms of ATC service to Skyguide and which is legally responsible for the ATC liability) reached an out of court settlement around 2013. See F. Schubert, \textit{The Liability of Air Traffic Control Agencies – The Ueberlingen Midair Collision Case Study}, Presentation to the Institute of Air and Space Law, McGill University, October 2014, at 51.
the delegations of outer space negotiations and drafting of relevant treaties, which were mostly matters of 30 years ago, GNSS legal issues were at least, if not unpredicted, not obvious concerns. For the other thing, what an expected regime of GNSS civil liability requires does not lie only in the fair, prompt and adequate compensation for all potential victims, but also in the weighing of interests between users and providers as well as GNSS sustainable development from a long-term perspective. In this sense, the author holds that current international space law is neither an adequate, nor a fair mechanism for GNSS civil liability, despite the author having made herculean efforts as above to find a possible way to apply GNSS damage to Article VII of the Outer Space Treaty and the Liability Convention. The main reasons lie in the following aspects.

(i) Imperfect relationship between Article VII of the Outer Space Treaty and the Liability Convention. It is generally accepted that the civil liability regime under international space law is jointly composed of Article VII of the Outer Space Treaty and the Liability Convention; the former being the legislative basis, the latter being the implementing rules thereof. The author does not intend to make any negative comments on the status of the Outer Space Treaty and the Liability Convention, although it seems clear that there are a number of States that are parties to the one but not the other. This fact matters to GNSS civil liability, bearing in mind that the opinion to separate the discussion of the applicability of the Outer Space Treaty and the Liability Convention in the case of GNSS damage already exists. Article VII of the


156 As of 1 January 2018, there are 107 and 95 Member States of the Outer Space Treaty and the Liability Convention respectively. Although not all States own a space industry and only a few States qualify as GNSS farmers, each State and its nationals is part of GNSS users group and potential victims suffering from GNSS damage. Even though it is our best wish to include the actors as much as possible in an international legal framework, we have to admit that we may not expect too much as both Outer Space Treaty and the Liability Convention have already made great achievements in terms of the number of member States, especially compared with the Moon Agreement. See UNOOSA, *Status of International Agreements relating to activities in outer space as at 1 January 2018*, A/AC.105/C.2/2018/CRP.3, 9 April 2018.

157 Ibid; Hurwitz, supra note 1, at 10.

158 See Perez, supra note 42, at 45.
Outer Space Treaty is too general to define the nature, and to detail rules, of international liability itself, but this generality may be used as an excuse to escape from the regulation of the Liability Convention. For a member State of the Outer Space Treaty — or if we accept the status of customary international law, for any State — which is not a member State of the Liability Convention, specific terms of a victim-oriented nature such as the absolute liability regime under the Liability Convention may not be binding, and this would decrease the victim’s wish to apply international law as a whole in the case of GNSS damage.

(ii) Inadequate scope of application. If we recall the constitution of GNSS (see 1.2.2 and Figure 1-2), both space-based and ground-based augmentation systems are part of GNSS. It seems that there is no question about the applicability of international space law to space-based augmentation systems based on the nature of space systems. Yet, neither the Outer Space Treaty nor the Liability Convention applies to the damage caused solely by a ground-based augmentation system, since it itself is not a space system, and the augmented signal is transmitted from ground facilities. In addition, the Liability Convention uses a third-party liability system. The Liability Convention also does not apply to nationals of the liable launching State of GNSS satellites, and it excludes foreign nationals who are involved in the launching and operation of GNSS satellites. This situation would not benefit the case of GNSS. The reason is that the scope of the launching State may be so comprehensive by virtue of the term ‘procures’, which could refer to the State itself or its nationals who provide the financial capital for the launch, that it would leave too much room for different interpretations. For example, not only have EU member States and States such as the Swiss Confederation, Ukraine, Norway and China participated in both the development and operation of the EU’s Galileo particularly in the form

162 Article VIII of the Liability Convention.
163 Article VII of the Outer Space Treaty; Article I of the Liability Convention.
164 Hurwitz, supra note 1, at 22.
165 Hobe, Schmidt-Tedd & Schrogl, supra note 45, at 114.
of funding, but in the future, the scope of cooperation partners is likely to be enlarged. Involvement in Galileo is so wide-ranging that the scope of application of the Liability Convention will be constricted too much. If we expect a civil GNSS whose program partner may come from every corner of the globe, where certain GNSS users may also be included, the above negative effect would be exacerbated.

(iii) State-vs-State liability system. For ultra-hazardous activities of a global nature such as those about nuclear, oil pollution and outer space, the treaty practice prefers a State liability regime, where

"States have been held liable for injuries caused to other States and their nationals as a result of activities occurring within their territorial jurisdiction or under their control."

Considering the fact that a State, compared with a private legal entity, is much more identifiable and with abundant capital, a State liability system is seemingly one of the best solutions to protect victims in a disaster caused by space objects as well. Although it is without question that Article VII of the Outer Space Treaty, and especially the Liability Convention, is based on the premise of State liability, this is rather unique. Claims must be

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167 The EU has neither signed nor ratified outer space treaties as an international organisation, but most member States of the EU and the ESA (co-partner in the Galileo program) are under the governance of outer space treaties. Also, the ESA itself made a declaration of acceptance of the Rescue Agreement, the Liability Convention and the Registration Convention. See respectively: Andreas Loukakis, EU as Owner of Galileo Satellites: Consequences for Registration and Liability, in Mahulena Hofmann & Andreas Loukakis (eds.), Ownership of Satellites: 4th Luxembourg Workshop on Space and Satellite Communication Law (Nomos, 2017), at 131; ESA, Declaration of Acceptance of the Astronauts Agreement, the Liability Convention and the Registration Convention, adopted by the ESA Council on 12 December 1978, deposited on 2 January 1979.

168 The term ‘State liability’ in this research is different with the one established by the European Court of Justice. For the latter, please see Francovich and Bonifaci v. Italy, Case C-6/90 and C-9/90, [1991], E.C.R. I-5357; Sheila Bone (eds.), Osborn’s Concise Law Dictionary (Sweet & Maxwell Limited, 2001), at 360.

169 UN Secretariat, Survey of liability regimes relevant to the topic of international liability for injurious consequences arising out of acts not prohibited by international law, Document A/CN.4/543, at 154-156.

170 Christian Brünner (Eds.), National Space Law: Development in Europe-Challenges for Small Countries (Böhlau Verlag Wien, 2008), at 68.

brought by a ‘State’ against another ‘State’,\(^\text{172}\) and the Liability Convention
does not grant a private party the right to present a claim for compensation
so much so that the individual must petition his/her government to make
that claim.\(^\text{173}\) The problem however is that the States from both sides may
not respectively be the actual liable party and the actual victim, and this
leads to too many negative situations in practice.

First, taking so many political interests and deals between States into con-
sideration, it is possible that the State, as is its right, decides not to present a
claim for the injured party including individuals or private organizations,\(^\text{174}\)
in which case there is no other alternative way for the injured party in
question but to submit a claim in the courts or administrative tribunals or
agencies of a launching State.\(^\text{175}\) By doing so the victim-oriented liability
regime under the Liability Convention has no standing since that regime is
only for State-vs-State claims, and the Liability Convention itself does not
offer any juridical rules for a claim based on either international or domestic
private law. Furthermore, the possibility for the victim to pursue a domestic
remedy indicates in turn, to some extent, that the Liability Convention itself
may not be adequate as the legal remedy, as opposed to diplomatic channels,
for victims.

Second, at the first stage the Liability Convention only supports the State to
raise a claim through traditional diplomatic negotiations, rather than juridi-
cal proceedings which have a more legally binding effect.\(^\text{176}\) At the second
stage, although a Claim Commission, also by States, could be established
after diplomatic negotiations have failed, the decision of the Claim Com-
misson would be only binding “if the parties have so agreed”,\(^\text{177}\) and the
implementation procedure of that decision remains open.

\(^\text{172}\) Article VII of the Outer Space Treaty is too general to understand whether its nature is a
State-vs-State liability system. There is one opinion in the Cologne Commentary on Space
Law (Volume I) which indicates that the Outer Space Treaty may be used for a claim by
an individual victim before a national court. However, the author agrees with Professor
Paul B. Larsen’s opinion that “The 1967 Outer Space Treaty is not intended to cover the issue
of the jurisdiction of national courts.” Also, as the Liability Convention qualifies as imple-
menting rules based on regulation based on Article VII of the Outer Space Treaty, we will
not separate them too far in such terms as the status of international customary law and
the nature of State-vs-State liability system, otherwise much more legal uncertainty will
be created. See respectively: Hobe, Schmidt-Tedd & Schrogl, supra note 26, at 135; Paul B.
Larsen, UNIDROIT Space Protocol: Comments on the Relationship between the Protocol and
Existing International Space Law, 44 Proceedings of the International Institute of Space Law

Punnakanta, Space Torts: Applying Nuisance and Negligence to Orbital Debris, 86 Southern

\(^\text{174}\) Hurwitz, supra note 1, at 49-50.

\(^\text{175}\) Article XI (2) of the Liability Convention.

\(^\text{176}\) Article IX of the Liability Convention; Milde, supra note 48.

\(^\text{177}\) Article XVIII (2) of the Liability Convention.
Third, States or international intergovernmental organizations, rather than their nationals who may be the actual liable party, are the only entities which can possibly incur international liability under the Liability Convention.\textsuperscript{178}

Fourth, no clear procedure in the Liability Convention requests the State that successfully presents a claim to transfer the compensation funds to the actual victims, even though, while still not impossible, it is unlikely to happen.

Fifth, the Liability Convention’s short limitation period of one year may also constitute an incentive to bring claims before national courts,\textsuperscript{179} but again, the Liability Convention has no standing in a national court for private compensation.

It is true that the above aspects are general problems of the civil liability regime under the Liability Convention, but the risk of not presenting claims and transferring compensation as well as the uncertainty of traditional diplomatic channels can only be more obvious in the case of GNSS damage than in the case of the direct crash or collision of space objects. Victims in the context of GNSS have to go through a ‘tedious’ diplomatic process under the Liability Convention, as illustrated by Figure 3-6-A, which should have been very simple juridical proceedings against the liable party or appropriate State, as illustrated in Figure 3-6-B and Figure 3-6-C.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure36.png}
\caption{Figure 3-6 Claim Procedure}
\end{figure}


\textsuperscript{179} Chatzipanagiotis & Liperi, supra note 45, at 166.
(iv) Figure 3-6 Claim Procedure

Serious legal uncertainty. As discussed above, so far, no general standard or theory for the matter of causation exists to draw lines between two sides (yes and no) of the notions of ‘directness’, ‘foreseeability’ and ‘proximity’. The interpretation of these notions and terms appearing in outer space treaties will finally be the task of negotiating teams in diplomatic channels, or of the Claims Commission which can be established if those diplomatic actions to settle the claim fail. On the one hand, the diplomatic channels themselves refer to much uncertainty for victims in the jungle of legal politics; on the other hand, it would not be surprising if the Claims Commission were to deny the proximity of those causal links outlined in Figure 3-2, Figure 3-3-A and Figure 3-4-A as it is true that neither the collision between Space Object (A) and GNSS Satellites, nor the radio interference from Space Object (A) is the nearest cause of the damage, but rather it is the final aircraft crash. This conflict results from different understandings of remoteness of causal link in the context of GNSS cases, thus creating serious legal uncertainty; such a situation would be a nightmare both for victims and the potentially liable party.

In addition, the analysis in section 3.3.4 is reasonable only if there are no external factors which are neither initiated by Space Object (A), nor by GNSS satellites that break the causal link. For example, if we say the aircraft control was taken over by the pilot in command after the alarm of either GNSS Landing system or other onboard system, or if the pilot in command does not (duly) take action after those alarms, the causal links will be interrupted by the factor of the pilot in command, as illustrated in Figure 3-7, Figure 3-3-B and Figure 3-4-B. In this sense, the ‘directness’ of causation does not exist anymore, and at least it will not be appropriate to claim absolute causation between the damage and GNSS satellites or Space Object (A). This would definitely challenge the applicability of the Liability Convention as well as the Outer Space Treaty in the case of GNSS damage.

![Figure 3-7 Causation (V)](image_url)

180 Hurwitz, supra note 1, at 51.
It should also be noted that neither Article VII of the Outer Space Treaty, nor the Liability Convention establishes a clear rule to calculate compensation; it would have been difficult for most States to support the Convention on the one hand,\textsuperscript{181} and may lead to different standards for that calculation in the same or similar cases, thereby constituting another kind of legal uncertainty about the expected amount of compensation.

(v) Launching State vs Operating State. According to the current civil liability regime under international space law, the identification of the liable party is focused on the launching activities.\textsuperscript{182} However, some damage does occur long after those launching activities because of maloperation of in-orbit space objects, rather than the failure of the launching task before the operation period. Since launching activities do not continue for the life of the orbit, it would be unfair to make a launching State conceivably liable for the damage caused by a space object and its payload, particularly in the sense of launching a foreign rocket in its territory.\textsuperscript{183} As only the party having effective control can limit the risk of an accident,\textsuperscript{184} it would only make sense to make the operator or operating State, rather than the launching State, responsible and liable for the damage caused by the operation of a space object during its life in orbit. This is similar to the regime under Article II of the Convention on the Liability of Operators of Nuclear Ships (Brussels, 1962) where it is operators who are supposed to be liable for the damage, rather than the manufacturer of nuclear ships.

In the context of GNSS, the situation above is particularly true as the damage is actually caused by space object operations and not the space object itself. On the one hand, when the malfunctioning of a GNSS satellite results from the crash of ground facilities or defective uplink data from those facilities, it clearly has nothing to do with the launching State which is too far from the control over those ground facilities in some cases.\textsuperscript{185} Hence, it is very inappropriate to make the launching State liable for that damage. On the other hand, damage caused by GNSS is mostly during the operation of GNSS satellites, rather than during the period of launching. If we recall the hypothetical case model (see 3.3.3), the damage caused by GNSS is mainly incurred from the malfunctioning of GNSS itself during the operation process (see 1.3 & (iii) of 3.3.4), even though, in the case of a collision between Space Object (A) and GNSS satellites and radio interference from Space Object (A) in outer space, the damage is beyond the control of the launching

\textsuperscript{181} Hurwitz, supra note 1, at 53.
\textsuperscript{182} Article VII of the Outer Space Treaty; Article I (c), Article II and Article III of the Liability Convention.
\textsuperscript{183} Hobe, Schmidt-Tedd & Schrogie, supra note 26, at 137.
\textsuperscript{184} Kerrest & Thro, supra note 5, at 61.
\textsuperscript{185} It is true that certain launching State is the State which operating the ground facilities of GNSS but that is not true for all.
States, but is within the control of the operating States of Space Object (A) or GNSS satellites.

Both the Outer Space Treaty and the Liability Convention attribute liability to the launching State. However, the author argues that a launching State does not play a critical role in the malfunctioning of GNSS, and it seems the operating State is the more obvious liable party. GNSS users may recognise the provider of GNSS signals and they usually do not care who launched those GNSS satellites. Moreover, the launching State does not necessarily undertake responsibility, as provided by Article VI of the Outer Space Treaty, to supervise the operation of GNSS including its satellites and ground facilities. In the development of both new technologies such as GNSS, which addresses operation, and new practices such as ownership transfer of in-orbit space objects, the legal ground of the launching State liability system under international space law seems increasingly outdated.

(vi) Against GNSS sustainable development. GNSS is often viewed as a key enabler to support sustainable development of the world, even though itself and the relevant industry also need sustainable development, perhaps with the support from the national ‘GNSS Sustainable Development Authority’ (see (v) of 1.4.2.2). The core nature of sustainable development is to ensure a better future for human beings, but it is read from different perspectives such as national governing philosophy, environment protection and prosperity for all. Specific to the context of GNSS, the principle of sustainable development could be expressed simply as long-term sustainability of GNSS. Although it is our priority to protect victims’ interests because of their innocence, it should not be an excuse to opt for a tragedy which ‘kills the goose that lays the golden egg’.

186 Armel Kerrest, Legal Aspects of Transfer of Ownership and Transfer of Activities, in Mahulena Hofmann & Andreas Loukakis (Eds.), Ownership of Satellites: 4th Luxembourg Workshop on Space and Satellite Communication Law (Nomos, 2017), at 77.
189 The Theory Bureau of the Publicity Department of the Central Committee of the Communist Party of China, Introduction to the Scientific Outlook on Development (Central Compilation & Translation Press, 2006), at 40.
192 For more information on this proverb, please see R. Worthington (translator), Aesop’s Fables (The Floating Press, 2008), at 98.
The concept of sustainable development does imply limits, although it does not mean absolute limits.\textsuperscript{193} The competing interests between potentially liable party and victim should be duly coordinated in the context of GNSS civil liability for the long-term development of GNSS. In spite of its victim-oriented nature, the preamble of the Liability Convention has already indicated that compensation should not only be full, but also equitable.\textsuperscript{194} Nevertheless, neither Article VII of the Outer Space Treaty, nor the Liability Convention has set limits in terms of compensation; the issue with this is that different limits hold for the affordability of GNSS providers, and this may cripple GNSS industries. An ideal GNSS civil liability regime should ensure sustainable benefits for all, including the future generations, by such regimes as the two-tier liability in air law system, limitation of liability, compulsory insurance or compensation fund, while guaranteeing adequate compensation for victims. From this perspective, the absolute liability regime without limitation adopted by international space law is not a practical choice in the context of GNSS civil liability regime, unless this unlimited liability is insured by valiant insurers which is unlikely to happen.

\subsection*{3.5 Concluding remarks}

International space law is practising in the gap between the ideal and the real in terms of GNSS civil liability. While a possible way to apply Article VII of the Outer Space Treaty and the Liability Convention to the case concerning damage caused by GNSS satellites does exist, it is however less feasible to guarantee prompt, adequate and equitable compensation to victims of damage caused by GNSS.

It is beyond question that the development and operation of GNSS qualify as space activities, meaning that international space law applies. Yet, the author believes that international space law is quite reticent to broadly interpret GNSS signals under the term ‘space object’. The questions of (i) whether indirect damage is covered by Article VII of the Outer Space Treaty and the Liability Convention, and (ii) whether GNSS damage qualifies as indirect damage have seriously troubled the space community for quite a while, even though the answers to those two questions are not a case in point to apply civil liability regime under the Outer Space Treaty and the Liability Convention. The real crux lies in the establishment of causation, on a case-by-case basis, between damage and space objects where GNSS satellites are included, with reference to the criterion of ‘directness’, ‘foreseeability’ and/or ‘proximity’ under the sense of general international law.

\textsuperscript{193} World Commission on Environment and Development, \textit{supra note} 190, at 2-1.
\textsuperscript{194} Hurwitz, \textit{supra note} 1, at 9.
The author admits that, this notwithstanding, when both the Outer Space Treaty and the Liability Convention were formulated, it was far too early to handle or even foresee such ‘new’ (comparatively speaking) space technology concerns as GNSS civil liability. Current international space law provides neither an adequate, nor a fair mechanism for GNSS civil liability. This is particularly so when considering its unique nature of State-vs-State liability and the launching-State-focused liability system without limitation, as well as legal uncertainty arising from different understandings of the matter of causation especially in the case of the intervention of external factors.