Civil liability for damage caused by global navigation satellite system

Kong, D.

2 Defining Civil Liability in the Context of GNSS

2.1 Introduction

Concepts are the base and tools for furthering understanding.[1] In this research, the two most important key words are *GNSS* and *civil liability*. Since the technical concept and general background of *GNSS* were explained in the previous chapter, it is reasonable to expect that this chapter carefully defines, from a more legal perspective, the term *civil liability* in the context of GNSS. Civil liability is a term used in numerous national legislations and international conventions, even though there remains to be seen the question as to whether the combination of *GNSS* and *civil liability* differs to the extent of creating a new paradigm compared with the civil liability in the context of traditional navigation error, the carriage of dangerous goods, and environmental damage.[2]

Therefore, the principal objective of this chapter is to define the term *GNSS civil liability* by clearly outlining what kind of GNSS could be qualified as the origin of GNSS damage (see 2.2) and, after the general introduction of *liability* in the context of GNSS (see 2.3), how to establish *civil liability* at issue (see 2.4). In addition, considering the technical global nature of GNSS as mentioned above, this chapter will continue to discuss how that factor is transferred to GNSS civil liability in a legal sense (see 2.5). The chapter then closes with a few concluding remarks (see 2.6).

2.2 Scope of *GNSS* under the term GNSS civil liability

Although the terms GNSS, RNSS and augmentation system are closely interconnected (see Figure 1-1), how well can they be included in the concept of GNSS civil liability? Furthermore, since many extended or value-added PNT services based on GNSS, ranging from Google Maps to GPS tracking services, are playing an increasing role in modern life, can we resolve civil liability disputes arising from those extended services under the framework of GNSS civil liability?

---

1 W. Michael Reisman, *Soft Law and Law Jobs*, 2 (1) Journal of International Dispute Settlement 2011, at 25.

2 See Michael Milde, *Air Navigation and Safety: Institutional and Legal Problems of the Global Navigation Satellite System*, IV Temas de aviacion comercial y derecho aeronautico y espacial 2000, at 134.

Technically speaking, only a satellite navigation system with global rather than regional coverage can be defined as GNSS.[3] RNSS is technically independent of GNSS with its standalone system constitution and with the transmission of its own signals. However, legally speaking, RNSS and GNSS have no essential difference in terms of civil liability issues. In fact, the major difference between GNSS and RNSS is coverage: the former is global and the latter is regional. However, even for RNSS, its scope of service usually covers more than one State, which is also a form of *international*. This means that RNSS legal issues are involved in different jurisdictions as well, and this is the fundamental feature of GNSS civil liability (see 2.5). Therefore, in this research, the term GNSS civil liability usually includes liability for damage caused by RNSS; the term GNSS civil liability however excludes national navigation satellite system (NNSS) as no *global* or *international* factor exists in NNSS, and it is usually only related to domestic legal systems and has nothing to do with international law.

Similarly, GNSS can provide PNT data alone without any augmentation system. From the perspective of providers, the role of an augmentation system is to aid GNSS in improving its accuracy, integrity and availability and it is not inherently part of GNSS itself.[4] An augmentation system is only a *processor* or *corrector* of basic signal from GNSS, rather than a *producer* of PNT data, therefore from the standpoint of users such as Eurocontrol, GNSSs are divided into core constellation systems, including GPS, GLONASS, Galileo and BDS, and augmentation systems, including ABAS, SBAS and GBAS.[5] ICAO also confirms this in its definition of GNSS and introduction of GNSS elements.[6] In addition, the augmentation system EGNOS was developed as a precursor and integral part of Galileo,[7] both of which are now part of the European GNSS programs managed by the EU;[8] the Russian GLONASS SDCM is being developed as a component of GLONASS.[9] Therefore, an

3 G. Manoj Someswar, et al., *Global Navigation Satellite Systems and Their Applications*, 17 (1) International Journal of Software and Web Sciences 2013, at 18.

4 NCO for Space-Based PNT, *Augmentation Systems*, http://www.gps.gov/systems/augmentations/, last accessed 19 May 2015.

5 Eurocontrol, *GNSS*, https://www.eurocontrol.int/articles/gnss, last accessed 19 May 2015.

6 Annex 10 to the Convention on International Civil Aviation, *Aeronautical Telecommunications*, *Volume I Radionavigations*, sixth Edition, July 2006, at 3-58 to 3-59; ICAO, *Global Navigation Satellite System (GNSS) Manual*, Doc 9849, AN/457, Second Edition-2013, at 1-1.

7 See Communication from the Commission to the European Parliament and the Council: State of Progress of the Galileo Programme, COM/2002/0518 final, 2002/C 248/02, 15.10.2002.

8 GSA, *About EGNOS*, http://egnos-portal.gsa.europa.eu/discover-egnos/about-egnos, last accessed 31 May 2015.

9 Sergey Karutin, *System for Differential Correction and Monitoring Updated*, Proceedings of the 24th International Technical Meeting of the Satellite Division of the Institute of Navigation (ION GNSS 2011), Portland, OR, September 2011, at 1562; C. Boulanger, et al., *Receiver Inter System Bias Impact on SBAS Dual Constellation Positioning and Integrity*, Proceedings of the 26th International Technical Meeting of The Satellite Division of the Institute of Navigation (ION GNSS+ 2013), Nashville, TN, September 2013, at 854.

augmentation system is one of the basic parts of GNSS, and it hence falls under the concept of GNSS civil liability.

However, the liability of a value-added service does not usually belong to the concept of GNSS civil liability. The term 'value-added service' refers to an extended downstream service or application based on GNSS signals in a manner intended to provide additional utility or benefit to the user. This term however excludes the value improvement, in particular the performance and features of a GNSS signal itself, which is actually the augmentation of GNSS.[10] Nowadays, besides the Air Navigation Service based on GNSS, in particular the CNS/ATM being promoted in civil aviation, a typical example of a GNSS value-added service is the navigation service provided by Google Maps or its competitors. Unfortunately, news about what are called 'navigation problems' has been reported frequently,[11] even though most of those problems were caused by map and route planning errors. What GNSS transmits to the receivers is only the signals that contain PNT information, rather than map data, therefore the liable parties in those cases are *map providers*, rather than GNSS providers. If the damage in the navigation were caused by the loss, degradation and defect of GNSS signals, in principle it would be the GNSS providers which should be held liable thereto. The same applies to other extended services or applications based on GNSS.[12]

Although according to the constitution of GNSS, user equipment is technically speaking an essential segment of GNSS (see 1.2.2), liability arising from the malfunctioning of user equipment is legally and generally speaking not GNSS civil liability. First, as an end product the receiver receives GNSS signals which then computes its location itself. If the PNT data offered by GNSS complies with the requirements but the receiver, rather than GNSS provider, computes the data wrongly, the defective receiver or software therein may apply to general rules of tort law or product liability in particular. Second, the space segment and the control segment are controlled and operated by GNSS providers, but the production and sales process of user equipment are conducted by other legal entities; in other words, GNSS providers are not the manufacturer, owner and controller of GNSS user equipment. This has been confirmed by Article 2.2 of Regulation (EU) No 1285/2013, which reads as follows:

10 See Article 2 (q) of the Agreement on the Promotion, Provision and Use of Galileo and GPS Satellite-Based Navigation Systems and Related Applications.

11 See Robert Wabash, *9 Car Accidents Caused by Google Maps & GPS*, http://www.ranker.com/list/9-car-accidents-caused-by-google-maps-and-gps/robert-wabash, last accessed 12 January 2016.

12 For a list of value-added service, please visit http://www.gsa.europa.eu/value-added-services-providers, last accessed 12 January 2016.

> "The system established under the Galileo programme shall be a civil system under civil control and an autonomous global navigation satellite system (GNSS) infrastructure consisting of a constellation of satellites and a global network of ground stations."

At least for the European GNSS program, the user segment is not addressed directly by the EU; it should be the job of private innovators. Therefore, it is unfair to make GNSS providers responsible for those situations that are completely out of their control. If, however, the receivers are malfunctioning fully or partly because of wrong technical information released by such documents as the 'Interface Control Document' provided by GNSS providers,[13] then the issuing body should be liable. Moreover, if the malfunctioning user equipment has been certified or qualified by a GNSS provider or operator, the latter has the responsibility to guarantee the quality of those devices and undertake relevant civil compensation for damages arising from the malfunctioning equipment.

In conclusion, GNSS civil liability includes liability trigged by core GNSSs, augmentation systems and regional systems, but excludes GNSS value-added services and malfunctioning of user equipment. Regardless of the terminal body which caused an accident, as long as the accident is fully or partly resulting from the provision of a *GNSS signal* itself, the concept of GNSS civil liability should and would be applicable.

2.3 Concept of *liability* in the context of GNSS

2.3.1 Responsibility vs. Liability

Responsibility and *liability* are twin legal concepts in general with dual significance. Although there commonly exists an explanation of the difference and similarity between responsibility and liability,[14] and although the two terms have the same single translation in many authentic treaty languages, for example 'responsabilité' in French, 'responsabilidad' in Spanish and '责任' in Chinese[15], a clear distinction needs to be made in the legal sense.[16] Responsibility refers to the legal obligation to fulfil a legal duty imposed by law to take care of something, prior to the situation of liability; liability is the negative effect if one did not fulfil his or her responsibility appropriately.

---

13 E.g., CSNO, *BeiDou Navigation Satellite System Signal In Space Interface Control Document Open Service Signal (Version 2.0)*, December 2013.

14 See e.g., Bryan A. Garner (Eds.), *Black's Law Dictionary* (WEST, 2009), at 1427.

15 Stephan Hobe, Bernhard Schmidt-Tedd & Kai-Uwe Schrogl (Eds.), *Cologne Commentary on Space Law: Volume I* (Carl Heymanns Verlag, 2009), at 104.

16 Liability is a legal term, but responsibility is viewed as a norm in general whether moral, legal, religious, political or any other. Bin Cheng, *Article VI of the 1967 Space Treaty revisited: "international responsibility", "national activities", and the "the appropriate state"*, 26 Journal of Space Law 1998, at 9.

The distinction between responsibility and liability may be understood much clearer as follows:

> "The English legal term "responsibility" means the accountability for a primary obligation of conduct. It is the legal situation which precedes liability, whereas "liability" is attached to a person for the injury resulting from the non-fulfilment of that primary obligation for which he was responsible. He will be subjected to a civil or criminal sanction."[17]

In international law, the demarcation between responsibility and liability is however not always as clear as above, in particular in relation to the regime of obligation in the respect of the injurious consequences arising out of acts not prohibited by international law.[18] The draft articles on the 'Responsibility of States for Internationally Wrongful Acts', approved by the International Law Commission (ILC), defines the 'responsibility of a State for its internationally wrongful acts' as "every internationally wrongful act of a State entails the international responsibility of that State".[19] The legal consequence of an internationally wrongful act includes "reparation, cessation and non-repetition as well as continued duty of performance".[20] Apparently, the ILC's view of State responsibility as a negative legal outcome after the breach of a State's obligation by its wrongful act is the same as the concept of liability of the State (see 2.3.2). In the context of space law, the space law community also shares the same opinion as above.[21]

In the context of GNSS and due to its international characteristics (see 2.5) determined by its technical global (see 1.2.5), the terms responsibility and liability are linked much more to international law. Yet, the terms responsibility and liability have such close ties with the factor of *State* since, currently, most GNSSs are regulated, owned or operated at the same time by the State (for Galileo it is a league of States – the EU, hereafter the same) (see 1.4.3). Even so, in the context of GNSS the demarcation between responsibility and liability should not be vague due to their dual roles in different areas of law.

In private law, the terms responsibility and liability are applied to civil bodies, while, in public law, they are always connected to the State and its representative, i.e., the government. As the provider State combines the

---

17 N.L.J.T. Horbach, *Liability versus responsibility under international law: defending strict state responsibility for transboundary damage* (N.L.J.T. Horbach, 1996), at 24.

18 *Ibid*.

19 Article 1 of the Responsibility of States for Internationally Wrongful Acts, annex to UN Resolution 56/83.

20 Article 28-31 of the Responsibility of States for Internationally Wrongful Acts, annex to UN Resolution 56/83.

21 Bin Cheng, *International Responsibility and Liability for Launch Activities*, 20 Air & Space Law 1995, at 300; Armel Kerrest, *Remarks on the Responsibility and Liability for Damages Caused by Private Activity in Outer Space*, 40 Proceedings on the Law of Outer Space 1997, at 134.

status of *civil body* and *public authority* at the same time, both the terms responsibility and liability in the context of GNSS have two levels of connotation as follows:

For the term responsibility,

- the State, as the regulator in public law, is under the duty of supervising the development and operation of GNSS and the provision of GNSS signals/services within its border or jurisdiction, for example, the authorisation for space activities related to GNSS as required by provisions such as Article VI of the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty);[22]
- the provider State, as GNSS provider, in private law is responsible for ensuring that its provision of GNSS signals/services complies with the required performance parameters (see 1.2.4).[23]

For the term liability:

- the State is liable for its maladministration, which originates from State responsibility for GNSS regulation in public law;
- the provider State is liable for damages caused by the failure of GNSS in private law.

Additionally, when the focus is particularly on space law, the distinction between the terms responsibility and liability is supported by Professor Bin Cheng who defines the former as "answerability" and the latter as "obligation to bear the consequences".[24] The air law community also clearly states that "responsibility under Article 28 should not be seen to be the same as liability", and it does not give private persons a cause of action for compensation in the implementation of GNS/ATM, including GNSS under the Chicago Convention (see 4.4.3.3).[25] Therefore, although the terms responsi-

---

22 As for which activities are space activities in the development, deployment and operation of GNSS and the provision of GNSS signal/service, please see section 3.2.2.

23 In civil aviation sector, as required by Article 15 of the Chicago Convention, each member State of ICAO should provide air navigation facilities, but whether those facilities compulsorily include GNSS signal/service please see section 4.4.3.2.

24 The source text is as follows:
"In law, it (responsibility) applies in particular to a person's answerability for compliance with his or her legal duties, and for any breaches thereof.
The term liability is often used specifically to denote the obligation to bear the consequences of a breach of a legal duty, in particular the obligation to make reparation for any damage caused, especially in the form of monetary payment."
Cheng, *supra note* 16.

25 ICAO, *Report on the Establishment of a Legal Framework with regard to CNS/ATM Systems Including GNSS*, A35-WP/75, LE/5, 28/07/04, at A-4.

bility and liability may be misconstrued particularly in general international law,[26] in the context of GNSS they respectively address *prior obligation* and *afterwards effects*.

2.3.2 Grounds of GNSS liability: criminal, administrative and civil

Liability, also termed as legal liability, is a basic legal concept with double significance. Aside from the distinction between responsibility and liability as discussed above, the definitions of liability are similar:

> "A person is said to be under a liability when he is, or at least may be, legally obliged to do or suffer something. Thus, one may be said to be liable to perform, to pay, to be sued, to be imprisoned, or otherwise to be subject to some legal duty or legal consequence."[27]

In common law systems, liability is composed of *civil* liability and *criminal* liability, which are based on civil law and criminal law respectively.[28] Civil liability is the negative situation after the breach of a compulsory obligation by virtue of, among others, tort law or an agreed obligation subject to contract law, with the legal consequence corresponding *to perform* and/or *to pay* as mentioned above. While civil liability deals with the legal relationship between civil parties with equal status, criminal liability is much more reliant on public power and it is the serious punishment or sanction imposed by a public prosecution organ, in the name of the State, under *nulla poena sine lege (no penalty without a law)* by virtue of criminal law. The legal consequence of criminal liability corresponds to *imprison* or *fine*.

In the context of GNSS, all litigation for civil compensation is without prejudice to parallel criminal proceedings directed against the wrongdoers under national law,[29] where system malfunction or the failure of signal with heavy losses of life and property, and public disorder may trigger criminal liability.[30] For example, China's Criminal Code covers intentional offences such as the 'Crime of disrupting radio communication order' (Article 288), and also non-intentional offences, for example the 'Crime of causing a flight accident' (Article 131), the 'Crime of negligent homicide (Article 233), Crime of major liability accident' (Article 134). The special case of GNSS

---

26 Frans G. von der Dunk, *Liability versus Responsibility in Space Law: Misconception or Misconstruction?*, 34 Proceedings of the International Institute of Space Law 1991, at 363.

27 David M. Walker, *The Oxford Companion to Law* (Clarendon Press, 1980), at 765; Similar definition please see Garner, *supra note* 14, at 997.

28 *Ibid*.

29 EC, Roadmap: Regulation on EU GNSS third-party liability, ENTR.GP2, February 2011.

30 Frans G. von der Dunk, *GNSS applications – Legal implications*, presented to Training Course on Global Navigation Satellite Systems and Location Based Services, 4-29 October 2010, African Regional Centre for Space Science and Technology Education in English (ARCSSTE-E), Ile-Ife, Nigeria.

criminal liability against system owner/operator has at least aroused the EU's awareness.[31]

However, in civil law systems, the liability of administration is treated specially as *administrative liability*, independent of *civil liability* and *criminal liability* (see Figure 1-3).[32] Administrative liability refers to the fact that the State, represented by its government, has *internal* sovereignty to its national affairs (see 1.4.3) but should also be responsible for its *faute de service* through paying compensation to the party suffering loss thereof. In other words, administrative liability is the negative outcome after the State or its government fails to fulfil its responsibility on regulation, so much so that it is also called 'State liability' or 'government liability'. Although civil law systems and common law systems treat administrative cases differently in court proceedings, with the former being in a special court (administrative court) and the latter in an ordinary one (civil court), both of them are in fact predominately fault based and do not have large inherent differences in substantive law.[33] Therefore, in the context of GNSS administrative liability there is no need to distinguish purposely the procedural aspects of two legal systems. However, considering that most GNSS providers are currently governments or their agencies, it is necessary to clearly demarcate between 'GNSS administrative liability' and 'GNSS civil liability'. The core nature of the former lies in the maladministration or negligence of supervision and regulation, rather than the factor of whether the liable party is a government or a civil body. Notwithstanding that it is the government, rather than

---

31 European GNSS Programmes Committee, *Global Navigation Satellite Systems (GNSS): Extra Contractual Liability*, EGPC-09-07-06-02, 24 June 2009.

32 The three-way classification of liability is not the so-called *threefold liability rule* in certain jurisdictions according to which *public officials* may be held civilly, criminally and administratively liable for a violation of their duty or for a wrongful act or omission. However, the term administrative liability in the latter sense is actually an administrative punishment by means of warning, discharge from office or job, monetary penalty, rather than the remedy provided to the party who suffered the negative impact by maladministration. See *Dr. Fernando A. Melendres M.D., Executive Director of the Lung Center of the Philippines [LCP] vs. President Anti-Graft Commission*, et al., G.R. No. 163859, August 15, 2012; *Office of the President v. Cataquiz*, G.R. No. 183445, September 14, 2011, 657 SCRA 681, 706; *Tecson v. Sandiganbayan*, 376 Phil. 191, 198 (1999) and *Veloso v. Sandiganbayan*, G.R. Nos. 89043-65, July 16, 1990, 187 SCRA 504, 509-510; *SECOND TITLE Administrative Liabilities*, Federal Law of Administrative Liabilities of Public Officers, March 13 of 2002, Mexico.
The term *administrative liability* in this research is distinct from *administrative sanction*, which is also usually named as *administrative liability* in some jurisdictions such as China. Administrative sanction is usually imposed on those who fail to comply with the required code of conduct but the event is not serious enough to constitutes a crime, or the legal person who does not follow industry standards required by administrative regulations. See Danny Pieters & Social Security, *An Introduction to the Basic Principles* (Kluwer Law International, 2006) at 118; Prashant Popat, *International Product Law Manual* (Kluwer Law International, 2010), at 646.

33 See Carol Rhian Harlow, *Administrative Liability: A Comparative Study of French and English Law* (University of London, 1979), at 4-6.

a private company, that would be the provider, GNSS malfunction should be subject to civil law and the civil liability regime.[34]

In all the three grounds of liability, civil liability is addressed much more frequently than criminal liability and administrative liability,[35] and it is the same in space law. In defining the term liability, Professor Bin Cheng also places special emphasis on monetary reparation, which is the main form of civil remedy (see above).

In the context of GNSS, it seems that both the legal practice sector and academia seldom make any distinction between 'liability' and 'civil liability', such as the following words in the recommendations made by the 'Panel of Legal and Technical Experts on the establishment of a Legal Framework with Regard to GNSS (LTEP, ICAO)' at the very beginning of GNSS-related legal research:

> "how liability (emphasis added) provisions concerning the operation, provision and use of GNSS services should ensure that damage arising from such services will be compensated in an equitable manner."[36]

It is obvious that the above description shows no intention and indication connecting the damage to criminal sanction and remedy for maladministration except civil compensation. Although few authors noticed this problem and precisely used the term *civil liability* from the very start,[37] most others just use 'Liability for GNSS' or similar expressions to discuss civil liability for damage caused by GNSS.[38] It is hard to say that the established practice

---

34 But this division does not block this research from discussing government liability in the case of GNSS damages caused by a supervisory or a regulatory authority's maladministration or negligence in their supervision duties.

35 Sometimes the term liability is defined directly as civil liability. For example, *Bouvier's Law Dictionary* (1862, v. 2, at 41) defines the term liability as follows:
"LIABILITY. Responsibility; the state of one who is bound in law and justice to do something which may be enforced by action. This liability may arise from contracts either express or implied, or in consequence of torts committed."

36 ICAO, *Global Air Navigation Plan for CNS/ATM Systems*, second edition-2002, Doc 9750, AN/963, at I-11-8.

37 See e.g., Ulrich Magnus, *Civil Liability for Satellite-based Services*, 13 Uniform Law Review 2008, at 935-969; Pietro Manzini & Anna Masutti, *An international civil liability regime for the Galileo services: a proposal*, 33 Air & Space Law 2008, at 114-131.

38 See e.g., Jeffrey A. Rockwell, *Liability of the United States arising out of the Civilian Use of the Global Positioning System* (McGill University, 1996), at iv; Gregory Michael, *Legal Issues including Liability associated with the Acquisition, Use, and Failure of GPS/GNSS*, 52 The Journal of Navigation 1999, at 246-251; Pablo Rodriguez-Contreras Perez, *GNSS liability issues: Possible solutions to a global system* (McGill University, 2002), at 1; Frans G. von der Dunk, *Liability for global navigation satellite services: a comparative analysis of GPS and Galileo*, 30 Journal of Space Law 2004, at 129-167; Hans-Georg Bollweg, *GNSS-Liability by International or European Union Law?*, 59 German Journal of Air and Space Law 2010, at 551-559; Ingo Baumann, *Liability for GNSS Signals and Services*, November/December InsideGNSS 2015, at 38-45; etc.

above constitutes a factual misconception or misconstruction of the law related to GNSS, but it is more related to a habit of expression or simplification; conversely, it however demonstrates the core status of civil liability in the framework of GNSS liability in general.

2.3.3 Structure of GNSS civil liability: contractual and non-contractual

Civil liability is the state of being legally obligated to make good for civil damages, which is imposed by civil law, as opposed to criminal law.[39] Although the term civil liability is deeply involved in international law, including the conventions on air and space law, it is still based on the theory of civil law, even though it is so based from an international perspective with a global scope of application. Civil liability can be either strict/absolute or fault-based; either international, or national, or, in the case of the EU, regional; and either several or joint. In the context of GNSS, civil liability has been a subject in law for a few decades, but few national and international instruments have given a specific definition of GNSS civil liability in both academia and practice. Although ICAO listed certain basic concepts to be considered for further study in relation to the liability regime for GNSS, no mention was made of the concept of civil liability itself.[40] Certain authors may have already noticed this problem, therefore they have introduced the 'concept of liability' as one of the key elements in the proposed 'Liability Regime' of GNSS; however, no further definition is provided.[41] The EU document defines the civil liability in the context of Galileo as follows:

> "'Liability' means the legal accountability of a person or legal entity to compensate for damage caused to another person or legal entity in accordance with specific legal principles and rules. This obligation may be prescribed in an agreement (contractual liability) or in a legal norm (non-contractual liability).[42]

---

39 Garner, *supra note* 14, at 997.

40 The following concepts, among others, should be considered in relation to the liability regime for GNSS which should be further studied:
"a) fair, prompt and adequate compensation;
b) disclaimer of liability;
c) sovereign immunity from jurisdiction;
d) physical damage, economic loss, and mental injury;
e) joint and several liability;
f) recourse action mechanism;
g) channelling of liability;
h) creation of an international fund (as an additional possibility or an option);
i) the two-tier concept, namely strict liability up to a limit to be defined, and fault liability above the ceiling without numerical limits."
ICAO, *supra note* 36.

41 E.g., Bollweg, *supra note* 38.

42 Article 2 of the Cooperation Agreement on a Civil Global Navigation Satellite System (GNSS) – GALILEO between the European Community and its Member States and the People's Republic of China, Beijing, 30 October 2003.

Although the above expression neither makes the liable party clear, nor gives specific considerations to the case of Galileo, it does divide the civil liability into contractual liability and non-contractual liability. In the context of GNSS, contractual liability is based on the privity of contract or agreement and caused by the breach of contractual obligations between contracting parties in the development and deployment of the system, and the provision of PNT signals/services. With regard to the counterpart of contractual liability, this is however being confusingly mingled, to some extent, with the terms of non-contractual liability or extra-contractual liability, tort liability, third-party liability and product liability. The theory regarding GNSS civil liability structure is now represented by *dichotomy* and *trichotomy*.

The dichotomy expresses that non-contractual liability, i.e. tortious liability,[43] and contractual liability are the *complete* pattern of GNSS civil liability. Furthermore, the former is composed of:

- Non-contractual liability vis-à-vis non-users, that is third-party liability;
- Non-contractual liability vis-à-vis users not bound by contract, such as civil liability claimed by open service users (NCL-UNC);
- Non-contractual liability vis-à-vis contractually bound users, such as civil liability claimed by commercial services (NCL-CBU).[44]

In this sense, third-party liability is just one of three subordinate concepts – where product liability is not included – of GNSS civil liability, and the whole pattern is as follows:

Contractual Liability	Non-contractual Liability		
	Third-party Liability	NCL-UNC	NCL-CBU

Table 2-1 Structure of GNSS Civil Liability (Dichotomy-I)

Another author followed the dichotomy of civil liability undertaken by GNSS service providers, with contractual liability to contract users and non-contractual liability to third parties. To some extent, this indicates that third-party liability is the *whole* of non-contractual liability in the context of GNSS,[45] shown as:

43 Hans-Georg Bollweg, *Initial Considerations regarding the Feasibility of an International UNIDROIT Instrument to Cover Liability for Damage Caused by Malfunctions in Global (Navigation) Satellite Systems*, 13(4) Uniform Law Review 2008, at 929.

44 Bollweg, *supra note* 38.

45 Jingjing Nie, *The Future of Uniform Rules on GNSS Liability*, 54 Proceedings of the International Institute of Space Law 2011, at 339-340.

Contractual Liability	Non-contractual Liability || Third-party Liability

Table 2-2 Structure of GNSS Civil Liability (Dichotomy-II)

Unlike the above, the trichotomy divides GNSS civil liability into contractual liability, non-contractual liability and product liability by the "fundamental threefold distinction" between them.[46] This may be understood to mean that the latter two terms are on an equal level but with a 'fundamental' distinction between them. Meanwhile, some authors see tort liability and third-party liability as the equivalents of non-contractual liability in the context of national legislation and international law respectively.[47] This structure is outlined almost in the same way by yet again another author, only with one more reason, i.e. the different conflict-of-law rules applicable to the above three terms. Based on their words, the picture of GNSS civil liability-related terms could be illustrated as:

Contractual Liability	Non-contractual Liability || Tort Liability || Third-party Liability	Product Liability

Table 2-3 Structure of GNSS Civil Liability (Trichotomy)

Although no heated argument has arisen about the *dichotomy* and *trichotomy* of GNSS civil liability and their internal lack of conformity, the disputes related to these are still obvious in the three fairly simplistic tables above, which can be roughly summarised in the form of the following questions:

(i) What is the complementary concept of GNSS contractual liability?

As both 'extra-' and 'non-' are used as negative prefixes in English, which mean 'beyond', 'outside' or 'not', it is safe to say that non-contractual liability and extra-contractual liability are appropriate counter partners, or 'antonyms' in a more informal way, of contractual liability with the same essence but different outward forms. The main divergence concerns the subordination between non-contractual liability and, in particular, tort liability or liability in tort, which is quite complicated, or, let us say, confused, not only in the context of GNSS but also in a broader sense.

46 See von der Dunk, *supra note* 38.
47 *Ibid.*

There is one opinion both in theory,[48] and in practice, i.e., legislation,[49] which views extra-contractual liability and tort liability as just two ways of expressing ideas in civil law and common law respectively.[50] In addition, the latest revised 'Code civil des Français' uses the term 'la responsabilité extracontractuelle' (extra-contractual liability),[51] instead of its predecessor 'des délits et des quasi-délits' (intentional and unintentional wrongs [Of Torts]),[52] and this provides indirect evidence of the fact that, now, French legislation does not distinguish tort liability from non-contractual liability.

However, from the European perspective as a whole, non-contractual liability seems to be a much broader concept than tort liability. The 'Regulation on the law applicable to non-contractual obligations' (Rome II Regulation)' states, in defining the term 'non-contractual liability',[53] that "damages shall cover any consequence arising out of tort/delict, unjust enrichment, *negotiorum gestio* or *culpa in contrahendo*", which corresponds with non-contractual liability arising out of tort/delict, i.e. tort liability, and non-contractual liability arising out of unjust enrichment,[54] *negotiorum gestio* or *culpa in contrahendo.* Consistency with Rome II Regulation is kept to some extent in the draft of the European Civil Code, according to which, the law on non-contractual liability is composed of the law on non-contractual liability for damage (Book VI), the law on unjustified enrichment (Book VII), and the rules on benevolent intervention in another's affairs (Book V).[55] The law of non-contractual liability arising out of damage caused to another, in contrast to other types of non-contractual liability, could be called tort law

48 For example, Daniel Rubiano Rincon, *Environmental Law in Colombia* (Kluwer Law International, 2011), at 149.

49 For example, Federal Law-Civil Law Harmonization Act of Canada, No. 1, S.C. 2001, c. 4, s. 34.

50 See *Bijural Terminology Records*, http://justice.gc.ca/eng/csj-sjc/harmonization/bijurilex/terminolog/not176.html, last accessed 2 March 2015.

51 Ordonnance n° 2016-131 du 10 février 2016 portant réforme du droit des contrats, du régime général et de la preuve des obligations, NOR: JUSC1522466R, https://www.legifrance.gouv.fr/eli/ordonnance/2016/2/10/JUSC1522466R/jo/texte, last accessed 6 May 2016.

52 Chapitre II, Titre IV, Livre III of the Code civil des Français and its English version, https://www.legifrance.gouv.fr/content/download/1950/13681/version/3/file/Code_22.pdf, last accessed 6 May 2016.

53 Article 2 of the Regulation (EC) No 864/2007 of the European Parliament and of the Council of 11 July 2007 on the law applicable to non-contractual obligations.

54 The researcher in common law system calls civil liability for unjust enrichment as maters of restitution which is one of related bodies of law together with tort and contract. See Ward Farnsworth, *Restitution: Civil Liability for Unjust Enrichment* (University of Chicago Press, 2014), at 1.

55 Christian von Bar, et al. (Eds.), *Principles, Definitions and Model Rules of European Private Law Draft: Common Frame of Reference (DCFR)-Outline Edition* (sellier. european law publishers, 2009), at 80.

or the law of tort,[56] even though that is not the whole of non-contractual liability law.[57] Furthermore, the above approach could also find supporting points from the *Bürgerliches Gesetzbuch*[58] and the *Burgerlijk Wetboek*.[59]

Here is not the place to make an evaluation of the merits and demerits of the above two approaches, however technically speaking, the European way is much more logical, particularly when considering that it is backed up by the well-known German precise characteristic, in contrast with French romanticism. Further, taking into account the much broader representative of the *European* way and considering the usage of 'extra-' or 'non-' in the English language, it could be hence concluded that the relationship between non-contractual/extra-contractual liability and tort liability is superior-subordinate rather than parallel; in other words, the former is one of the branches of the latter. Nevertheless, unlike the traditional case of private law, GNSS or its owner/operator shows the connection with unjust enrichment, *negotiorum gestio* or *culpa in contrahendo* next to nothing in the damages caused by GNSS malfunction or failure. Therefore, in the context of GNSS, tort liability indeed constitutes most, but still not the whole picture of non-contractual liability.

(ii) What is the relationship between GNSS third-party liability and GNSS tort liability?

The term third-party liability seems to be recognised more by international organizations and conventions. This is particularly so in the legal regime of nuclear energy[60] and aviation transportation,[61] both of which activities are labelled *ultrahazardous*.[62] Even though it is true that in the text of national

56 Christian v. Bar, *Non-Contractual Liability Arising out of Damage Caused to Another* (sellier. european law publishers, 2009), at 229.

57 Christian von Bar and Ulrich Drobnig, *The Interaction of Contract Law and Tort and Property Law in Europe: A Comparative Study* (sellier. european law publishers, 2004), at 307.

58 Division 3 of Book 2 of the *Bürgerliches Gesetzbuch* is entitled *Schuldverhältnisse aus Verträgen* (Contractual obligations), and title 27 *Schuldverhältnisse aus Verträgen* (Torts) and title 26 *Ungerechtfertigte Bereicherung* (Unjust enrichment) are categorized under Division 8 *Einzelne Schuldverhältnisse* (Particular types of obligations) thereof.

59 Title 4 under Book 6 of the *Burgerlijk Wetboek* is named as *Verbintenissen uit andere bron dan onrechtmatige daad of overeenkomst* (obligations from another legal source than tort or contract) immediately after title 3 *Onrechtmatige daad* (Tort).

60 For example, the Convention on Third-party liability in the Field of Nuclear Energy of 29th July 1960, as amended by the Additional Protocol of 28th January 1964 and by the Protocol of 16th November 1982.

61 For example, the Rome Convention on Damage Caused by Foreign Aircraft to Third Parties on the Surface, on 07 October 1952.

62 Some authors point out that aviation was considered as an ultrahazardous activity, but it is no longer applied in all aviation cases instead some specific types of aviation types such as testing experimental aircraft. See Michael W Pearson & Daniel S. Riley, *Foundations of Aviation Law* (Ashgate Publishing, Ltd, 2015), at 52.

legislation the term third-party liability rarely appears instead of the term tort liability, in the context of GNSS it is neither enough, nor appropriate to say that the two terms have the same meaning.

The author is not going to deny the fact that contributors beyond the national level to GNSS law or policy, such as the International Institute for the Unification of Private Law (Unidroit), the EU and the European Space Policy Institute (ESPI),[63] favour the expression 'third-party liability for GNSS' or 'GNSS third-party liability' much more than they do 'GNSS tort liability'. However, the difference between the term third-party liability and tort liability concerns not only the respective mode of expression in international law or national legislation, and in civil law or common law, but also the definition itself.

The core of the term 'third-party liability', also known as 'tort liability to/for third parties', is 'third party', which refers to "any person who is not a party to a relationship or transaction between any two others."[64] In these words, 'third party' is based on the other two parties having a relationship, which is usually, but not limited to a contractual relationship. In terms of liability arrangement, there is also no contractual relationship under the name of a third party.[65] This directs us to the simple understanding that, when there are no first and second parties there is no third party, and therefore there is no third-party liability. In the context of GNSS, the first and second parties are GNSS providers, either basic signal providers or augmented signal providers, and the user; the third party is the group of victims in the accident caused by GNSS, which can be illustrated by the two following examples with regard to EU GNSS included in the EU document:

– with regard to the Open Service: a car accident, where the driver is the user of the GNSS, and the pedestrians walking by are the third parties;
– with regard to the Safety-of-life Service: two aircrafts colliding over a populated area, where the user is the aviation company, and the third parties are the passengers on board – though covered by a particular international Convention – and the victims on the ground.[66]

63 See Unidroit, *An instrument on third party liability for Global Navigation Satellite System (GNSS) services: a preliminary study*, UNIDROIT 2010, Study LXXIX – Preliminary Study, March 2010; EC, *supra note* 29; ESPI, *Policy Aspects of Third-party liability in Satellite Navigation: Preparing a Roadmap for Europe*, Report 19, P42-C20490-04, July 2009.

64 Walker, *supra note* 27, at 1216.

65 Joseph N. Pelton & Ram Jakhu, *Space Safety Regulations and Standards* (Elsevier, 2010), at 208.

66 EC, *supra note* 29.

Combining the definition of third-party liability in general, that is the civil liability towards a third party, we can read from the above examples that the GNSS third-party liability regime does not apply to the damage caused by GNSS providers to the users. This is similar to the case where the third-party liability insurance does not cover the damage to the insurance contractors at issue.

Does this however mean that the civil disputes between the two parties other than the third – constituting, in the two examples above, civil liability of GNSS providers to the driver and aviation company for their loss of property and bodily injuries of employees – have to resort to the GNSS contractual liability regime? The answer is clearly in the negative for the following three reasons.

First, the question whether there is an 'implied contract' between GNSS open service/signal providers and relevant users remains open (see 5.2.3.2). If the contractual relationship between the above two parties is not recognised, which is the most common case, the open signal user/the driver that suffered damage has to claim for compensation based on *general tort law*, rather than the law on third-party liability.

Second, to say the least, given that the contractual relationship is accepted in open service by the court, or is established in the commercial service, under the regime of *anspruchskonkurrenz* in German law[67] as well as Chinese law[68] or the concept of *contort*, i.e., contract plus tort, in English law,[69] the user that suffered damage is allowed to claim for compensation against the GNSS provider based on *general tort liability*, not third-party liability, even though that user is entitled to claim contractual liability at the same time.[70]

Third, unlike the term GNSS product liability, which usually applies strict liability (see below), GNSS third-party liability does not have its own featured regime and has to depend on the general theory of tort liability, even though legislators or researchers use an independent term simply because

67 Apostolos Georgiades, Die Anspruchskonkurrenz im Zivilrecht und Zivilprozeßrecht (Beck, 1968), at 167.

68 Article 122 of China's Contract Law reads as follows:
"Where the breach of contract by one party infringes upon the other party's personal or property rights, the aggrieved party is entitled to choose to claim the assumption by the violating and infringing party of liabilities for breach of contract according to this Law, or to claim the assumption by the violating and infringing party of liabilities for infringement according to other laws."

69 See Garner, *supra note* 14, at 365; *Brown -v- Boorman, Boorman, and Wild*, [1844] EngR 65, (1844) 11 Cl & Fin 1, (1844) 8 ER 1003.

70 If some torts are also breach of contract, the party suffering damage may sue either in tort or for breach of contract, or both. See Jonathan Law, *A Dictionary of Law* (Oxford University Press, 2015), at 623.

it is the collective concept of civil liability to/for a third party. Therefore, it can be concluded that, regardless of how the term is used in international law or national legislation, third-party liability is just a specific category of tort liability,[71] which is supplemented by general tort liability in the context of GNSS. The term GNSS third-party liability appears only in those cases where there are second parties, these being the GNSS providers and the users, and therefore there are third parties, these being the victims suffering damage caused by GNSS.

(iii) Is the term product liability unique enough to be qualified as one of independent pillars of GNSS civil liability?

Although unpopular, some academic researchers,[72] rather than rule-making bodies, do address GNSS civil liability from the perspective of product liability. The author is not going to discuss how and to what extent product liability can be applied to GNSS signals/services or whether it is necessary to create a specific system named *GNSS product liability*; what the author is going to do is determine the position of the term product liability in the whole definition framework of GNSS civil liability.

Compared with legal concepts such as contract and negligence, product liability is defined more empirically as the liability of manufacturer and other persons for defective products.[73] Regardless of 'non-strict' theories of product liability in US law, where negligence, tortious misrepresentation and breach of warranty may be used as ground for a claim,[74] the term product liability is indeed more closely connected to *strict liability*, which is different from the general theory of tort liability based on fault. Considering the special rules of product liability, besides academic research such as the 'American Restatement (Third) of Tort Law: Products Liability', many national laws codify this division of civil liability independently, for example, Title IV bis 'Of Liability for Defective Product' of the French Civil Code. In addition, many states in the US have enacted comprehensive product liability statutes, and a Model Uniform Products Liability Act (MUPLA) was promulgated to make up for the lack of Federal products liability law.[75]

---

71 See Claire McIvor, *Third-party liability in Tort* (Bloomsbury Publishing, 2006), at 1.

72 See, e.g., Andreas Loukakis, *Product liability ramifications for erroneous GNSS signals: an alternative approach is Possible?*, 56 Proceedings of the International Institute of Space Law 2013, at 320-324; Frans von der Dunk, *GNSS applications-Legal implications*, presented to UN Office for Outer Space Affairs, 06-10-2010, at 61-67; GAO Qi, *Civil Liability of GNSS Service Provider: From the Perspective of American Law and Practice*, 29 (2) Journal of Beijing University of Aeronautics and Astronautics (Social Science Edition) 2016, in Chinese, at 30-31.

73 Jonathan Law, *supra note* 69, at 484.

74 See Michael Krauss, *Principles of Products Liability* (West Academic, 2014), at 55.

75 *Products liability*, Legal Information Institute, Cornell Universality Law School, https://www.law.cornell.edu/wex/products_liability, last accessed May 15 2016.

More convincingly, a specific directive on defective product liability has been effective since as early as 1985.[76]

In the context of GNSS, the distinctiveness of product liability seems more obvious considering two possible ways of understanding the term GNSS product liability under the regime of GNSS civil liability:

– a GNSS satellite or its components, user equipment having a defect, and the defective software, system design, or workflow in the circulation of GNSS operation may trigger product liability in a more usual way if damage is thus caused;
– whether a GNSS signal with wrong PNT data or information which lead to damage may be considered as a defective product and then apply the product liability regime, with the reference to such analogies as electricity or defective aeronautical charts.[77]

More importantly, GNSS product liability may direct victims to seek compensation from the manufacturer or relevant civilian bodies bearing the responsibility for guaranteeing safety in the circulation of products, and this is without the difficulty, in most cases, of having to prove fault thereof under the umbrella of strict liability. This makes the liable party far more identifiable than under the general tort liability regime. In addition, next to the term GNSS product liability, *service liability*, which is usually fault-based liability, is viewed by at least one author as a more suitable concept for GNSS;[78] at the current time this question is indeed confusing since neither has the legal nature of space signals been settled, nor has it been settled whether GNSS provides only signals, whether it could be qualified as one kind of *service*, or whether it varies on a case-by-case basis.

Based on the distinctiveness of product liability and its *value* to victims as well as complexity in the context of GNSS, it will be nice to characterise GNSS product liability as an independent pillar of GNSS civil liability besides GNSS contractual liability and GNSS tort liability. The following clarification has to be however clear on the subordination of respective terms in the definition of GNSS civil liability:

76 Council Directive 85/374/EEC of 25 July 1985 on the approximation of the laws, regulations and administrative provisions of the Member States concerning liability for defective products.
77 Loukakis, *supra note* 72.
78 Atsuyo Ito, *Legal Aspects of Satellite Remote Sensing* (Martinus Nijhoff Publishers, 2011), at 282.

First, GNSS product liability falls under the category of GNSS tort liability as a subset. Although the application of product liability ramification does not exclude the parties with a contractual relationship, and regardless of how GNSS product liability is interpreted, the term is still a concept under the framework of tort liability since its legal basis is not on the contract in question but the law, including both case law, and statutory law namely tort law. The law requires that providers, including the system constructors, equipment manufacturers, operators and other actors involved in the circulation of GNSS products, guarantee that what they offer to the consumer or someone to whom the product was transferred is of such a level of safety as persons are generally entitled to expect. Otherwise, if not, they are obligated to make fair remedy to the party suffering damage. The difference between tort liability and product liability in the context of GNSS is not *fundamental* but *subordinate*. In addition, even the researcher who addresses the significance of the *threefold distinction between tort, contractual and product liability* has to respect the fact that *product liability can be defined as a specific type of tort liability* in the context of GNSS.[79]

Second, the scopes of *GNSS product liability* and *GNSS third-party liability* sometimes overlap and hence they are not in a relationship of *either A or non-A* under the framework of GNSS tort liability. The definition of product liability focuses only on whether the liability is caused by a defective product and does not consider whether or not victims are a third party. For example, in an autopilot aircraft accident caused by the malfunctioning of the GNSS Landing System (GLS) due to incorrect PNT signals, the passengers, as third parties who are outside the transaction of the PNT signals, could also claim compensation against the signal *producer* in question, if GNSS signals are recognised as the subject of product liability law.[80]

Based on the analysis above, it is clear that contractual liability and non-contractual liability constitute the complete picture of civil liability in the context of GNSS. Although it is not the entire picture, GNSS tort liability represents the major percentage of GNSS non-contractual liability. Both GNSS third-party liability and GNSS product liability are two subordinate concepts under the same 'guiding' GNSS tort liability, and although not complementary, as different criteria of classification they do occasionally overlap. The pattern above could be illustrated as follows:

79 Loukakis, *supra note* 69.

80 In this case, the question that whether the GLS constructor, the airport or the GNSS provider, or all of them, are the *producer* of incorrect PNT signals remains open at the current stage.

	Non-contractual Liability	
Contractual Liability	⁞	…
	Tort Liability	
	Third-party Liability and/or *Product Liability* and/or other types of Tort Liability	

Table 2-4 Structure of GNSS Civil liability (Author)[81]

2.4 Elements in establishing GNSS civil liability

2.4.1 Four elements of GNSS civil liability

The discussion above hopefully clarifies the respective relationships of different concepts under the framework of GNSS civil liability. Nevertheless, in order to establish GNSS civil liability and be able to benefit from it in court, certain elements must be proven. Although the content of those elements depends on the national legislation applied to the case of GNSS damage and on the basis of civil liability relied on by the claimant, it is still possible to extract the basic formula. Compared to the history of legal theory on civil liability from as far back as Roman law, GNSS civil liability is obviously a new area, meaning that it has to be rooted in a general theory of civil liability. By recalling the definition of civil liability and making reference to case law, regardless of the nature of the claim in a civil case, two parties – claimant and defendant – must be qualified, and two facts must be established: the defendant did something which violated either legal or contractual rules, and the health and/or economic interests of the claimant are *therefore* damaged or under significant threat. This also holds true for GNSS civil liability. Hence, the following section discusses the elements,

81 The three concepts in italic in the table will be discussed as three pillars of the GNSS civil liability regime, namely:
GNSS contractual liability, triggered by the breach of contract of the provision of GNSS signals or services.
GNSS tort liability (without product liability), hereinafter referred as *GNSS general tort liability*, triggered by an unlawful act of the GNSS provider, excluding the defects of the GNSS product defined below.
GNSS product liability, triggered by a defective GNSS product, including space satellite, ground stations and their components for the provision of GNSS signals or services, and GNSS signals themselves but whose qualification as a product remains to be discussed further.

in the context of GNSS, of: *the parties*; *unreasonable acts*; *damage*; and their *causality*.

2.4.2 The parties: GNSS providers vs GNSS users or/and third parties

Without considering the complexity of the GNSS technical constitution and legal relationships, the roles of the parties in court are usually obvious: the victim suffering the damage caused by GNSS and/or its family acting as the potential claimant, and the potentially liable party providing GNSS signals/services and, if any, its insurer summoned to appear in court as the defendant.[82] Figure 1-3 above shows how intricate the various lines, representative of relationships, between all actors are, and this means that we need to reasonably *translate* those technical participants into legal subjects, especially the liable party (compensator) and potential victims (claimer). Throughout the entire process of making PNT signals finally meet up with the user, two technical groups represent those two parties in the supply and demand chain of GNSS respectively, these being *GNSS providers* vs *GNSS users*. Outside that chain, a *third party* could also be involved as either compensator or claimer depending on an individual case.

(i) GNSS providers. Aside from the *direct provider* to transmit PNT signals to the users, there are various actors from the supply side in the value chain of GNSS, including but not limited to the *owner*, *system constructor* and *operator*. A GNSS provider is the party most probable to be the main defendant in court. Under the current pattern of the GNSS industry, most GNSS providers are the *State* or a public authority in nature, that is, the regulator and legislator at the same time. This gives rise to the applicability of the principle of State immunity (see 5.3.2.2).[83] In addition, as few States can afford their own GNSS, they have to subcontract the responsibility of GNSS provision to foreigners.

---

82 The insurer can also be the direct defendant, but only as the party who pays compensation to the victims, rather than the liable party. See Sergio M. Carbone & Maria Elena De Maestri, *The Rationale for an International Convention on Third-party liability for Satellite Navigation Signals*, 14(1-2) Uniform Law Review 2009, at 54.

83 Here the big difference between 'public authority' and 'public company' should be noted: the former enjoys immunity under the umbrella of State immunity, while the latter has the same liability and tax issues as a private company. EC, *Proposal for a Regulation of the European Parliament and of the Council on further implementation of the European satellite navigation programmes (2014-2020)*, SEC (2011) 1446 final, Brussels, 30. 11. 2011.

Although some actors from the supply side in the value chain of GNSS are the same single body, it is not always the case.[84] The operations of space satellites and ground facilities may be granted to different bodies, while GNSS providers can be more than one entity, all of which focus on specific areas such as aviation or maritime, and/or specific types of GNSS activity respectively. Currently, most actors from the supply side in the value chain of GNSS are public in nature, while some private contractors or suppliers may be directly involved into court proceedings particularly in the case of product liability. Furthermore, if a GNSS signal is recognised as 'product' in court proceedings, those parties in each link of the chain would be held liable as either manufacturer or seller.[85]

The plurality of possible defendants offers more sources of compensation but decreases the *identifiability* of the liable party at the same time. Therefore, *channelling of liability* and *joint liability* are much needed in the context of GNSS to guarantee, to the claimant, the easy identifiability of the liable party. Also, that plurality increases the possibility of *vicarious* liability, and this will lead to certain recourse actions where the defendant in one case could be the claimant in another case against the actual liable party.

(ii) GNSS users. According to what a GNSS provider provides, a GNSS user could be categorized as either an 'open service user' or an 'authorised service user'. While the eligibility of the latter as a possible claimant is usually recognised on the basis of a contractual relationship, in the case of the former it is difficult to find the legal basis. It is self-evident that open service users do not establish the required contractual relationship with a GNSS provider, making it less possible to submit a claim on breach of contract (see

84 Regardless, the owner, constructor, operator and direct provider of GNSS signals/services are not always the same single public authority. Take one basic GNSS system and one augmentation system respectively as examples:
For the Galileo system as a GNSS, in the In-Orbit Validation phase, the ESA is the developer and system designer, European Commission (EC) is the co-funder; In the Full Operational Capability phase, the funder and owner would be the EC alone, and the ESA is the only agent of the EC for the role of design and procurement. See *The history of Galileo*, http://ec.europa.eu/growth/sectors/space/galileo/history/index_en.htm, last accessed 16 May 2016.
The GAGAN augmentation satellite, an India augmentation satellite system, is a joint venture enterprise between Indian Space Research Organization (ISRO) and the Airports Authority of India (AAI). While ISRO operates the satellite and the command and telemetry control, indeed as an operator, it is the AAI that will be the direct provider of the GPS/GAGAN signals for air navigation services. See Ranjana Kaul, *India-Liability in context to the air navigation service provider*, presented to the International Conference on Contemporary Issues in Air Transport, Air Law & Regulation, New Delhi, India, 23-25 April 2008.

85 Product liability is not linked to the direct manufacturer of components, and if that component is installed into another product, the producer of the whole product could also be sued through product liability. The case should be the same in the context of GNSS. See *MacPherson v. Buick Motor Co.*, 160 A.D. 55, 145 N.Y.S. 462, N.Y.A.D. 3 Dept. 1914.

5.2.3.2). Furthermore, it is very hard to establish a high-level duty of care to the public at large in a highly attenuated relationship[86] as the potential number of persons to whom an open service might become available is without limit (see 5.2.3.3).

In addition, the term GNSS users is a multi-level concept. In other words, before a GNSS signal is finally transmitted to its terminal user, each provider, compared with its downstream user, is also the signal user of its up-stream provider and they can be called as 'first user', 'second user' and so on all the way down to the 'final user'. The final point that needs to be addressed is that the international characteristics of GNSS users inevitably make a big difference in identifying the claimant and jurisdiction in the cases of GNSS civil liability (see 2.5).

(iii) Third parties. As mentioned, a third party is beyond any relationship or transaction between the other two parties. As the victim who suffered GNSS damage, a third party could be the subject of third-party liability; yet, as the source of frequency interference against GNSS signals, a third party could potentially be the liable party, regardless of intent (see Figure 1-3). Considering the pervasiveness and unpredictability of a third party, it would be a good solution to channel its civil liability to a more identifiable party such as GNSS providers.

In addition, unlike a GNSS provider, which is usually a public authority or sizeable corporation, a third party could be a five-year-old child or mental health patient who, in any case, would be the victim. To this end, if such a third party were the wrongdoer, the guardian thereof would have to assume the 'vicarious liability of guardians', this being a type of tort liability.[87]

2.4.3 Triggers: unreasonable acts

GNSSs are facing technical vulnerability, financial pressure and institutional challenges (see 1.3), but can all those elements be transferred to the triggers of civil liability? Not really. Two typical cases are:

(i) State of the art technology. No matter how advanced GNSS technology is declared to be, it will always have a gap between real and ideological condition. A technical defect which is beyond current practical technological feasibility is free of civil liability, even under the regime of strict liability, namely, product liability.[88]

---

86 *Rosenberg v. Harwood et al*, Utah District Court, Case No. 2:10-cv-00496.

87 Jaap Muscle & Francesco Donato Busnelli, *Unification of Tort Law: Liability for Damage Caused by Others* (Kluwer Law International, 2003), at 239.

88 E.g., Article 7 (e), Council Directive 85/374/EEC; § 107 (A) (D), the US Model Uniform Product Liability Act; Article 1386-11, French Civil Code.

(ii) Acts of God. GNSS signals pass from the near vacuum of space, and then through the various layers of the atmosphere to the earth at the speed of light.[89] In doing so, it is unlikely that it will avoid being influenced by uncontrolled space weather such as ionosphere and solar activity which would lead to inaccurate or total loss of PNT signals, and therefore cause damages.[90] Similar situations may also occur because of earthquakes, tsunamis and other natural disasters which may destroy the ground facilities of GNSS.[91] In the legal sense, no one body may be liable for events outside human control.[92]

The conditions above free the parties from civil liability regardless of contract law or tort law, civil law systems or common law systems. The legal causes of GNSS civil liability could be divided into the following three branches, which correspond to the three pillars of GNSS civil liability (see 2.3.3), because different rules will apply and diverse subjective requirements follow from this distinction.

(i) Wrongful act or omission. Generally speaking, civil liability will arise only upon the proven existence of the fault of the obligated person, which may be expressed by act or omission. In the context of GNSS, civil liability is triggered by the failure of GNSS signals, including the absence of signals, the error of signals, and/or the degradation of performance.[93] The causes giving rise to the failure of GNSS signals can be summarised as follows (see also 3.3.4):

– *system malfunction*, which could be caused by a navigation satellite crash just like the 2009 Iridium-Cosmos Collision, system shutdown or, more possibly, partial signal cut-off,[94] incorrect uploading of data,[95] organiza-

89 NovAtel Inc., *An Introduction to GNSS* (NovAtel Inc., 2010), at 20.

90 The errors caused by bad space weather thereof maybe very small, but keep in mind that in one nanosecond, light travels 30 centimeters, and this level of inaccuracy is enough to cause disasters. *Ibid*.

91 The distinction between 'acts of God' and 'force majeure': the former is limited to a natural disaster which is beyond human control; In addition to natural disasters, the latter also includes societal events impossible to be controlled or anticipated by a single party, including acts of war, acts of terrorism, etc. See Marsha L. Baum, *When Nature Strikes: Weather Disasters and the Law* (Greenwood Publishing Group, 2007), at 87.

92 As GNSS connects with acts of war and acts of terrorist much more than other non-safety-of-life system, whether the war or terrorist event could be cited as a defense in particular by a State, remains open.

93 Anna Masutti, *CSN/ATM Systems: framework and regulation on GNSS, experiences in Europe*, presented to the Conference on Contemporary Issues in Air Transport, Air Law and Regulation, April 21-25 in New Delhi, India.

94 This may happen during military or political conflicts and this is the exact reason why China developed its own BDS.

95 See *Satellite Outages Afflict GLONASS: The Russian system suffers two major disruptions in April*, http://www.insidegnss.com/node/4009, last accessed 24 May 2016.

tional problems and other malfunctions which can be attributed to the provider's intention or negligence;
– *harmful interference*, which refers to the radio frequency conflicts from jammers and spoofing devices, in particular the low-cost low-priced ones, which are usually wilfully or unintentionally used by third parties including privacy rights fighters, government authorised services providers, operating forces, criminals, or, even worse, terrorists, etc.[96]

In strict liability, where a victim suffers damage without anyone deserving blame for it,[97] the element of wrongful act or omission is still however required, otherwise it would be the case of 'acts of God' (see above). Nevertheless, if the subject of that wrongful act or omission cannot be attributed to the defendant, the actual claim against the defendant is assumed to be vicarious liability. For example, when certain civilian GNSS providers have no choice but to implement national policy, like the former Selective Availability did so secretly and suddenly for the sake of 'national interest', the behaviour of that government constitutes a wrongful act even though the civilian GNSS provider has to bear civil liability if damage happens because of that.[98]

(ii) Non-performance. This term here is limited to the sense of the failure to perform an agreed obligation in a reasonable manner, for example, breach of contract. To judge non-performance in the context of GNSS, the court

96 The threat of jamming and spoofing technology is not unreachable any more to the safety of common people's lives. For example, in August 2012, a US citizen operated unlawfully a $33 dollar GPS jamming device that caused harmful interference to the GBAS used for precision approach, departure procedures and terminal area operations in Newark Liberty International Airport (Federal Communications Commission (FCC), *Notice of Apparent Liability for Forfeiture*, FCC 13-106, August 1, 2013); In January 2007, as two navy ships were conducting test procedures when communications were lost by jamming radio signals, air traffic management systems, emergency systems, and cellphone communication, and ATMs in San Diego, California were unwittingly disabled for about two hours; In 2013, an academic group from the University of Texas demonstrated how a false GPS signal generator could override a luxury yacht's navigation computers as it travelled at sea; A study in 2011 on the problem at Taiwan's Kaohsiung International Airport found an average of 177 jamming and spoofing incidents a day; In 2011, Iran successfully hijacked the US UAV through GPS spoofing; etc. All the above news can be publicly accessed from the Internet.

97 Jaap Hage, et al. (Eds.), *Introduction to Law* (Springer International Publishing Switzerland, 2014), at 104.

98 The cut-throat competition may happen in the context of GNSS between space rivals. For example, Roscosmos (Russian Federal Space Agency, which has been transferred to the 'State Corporation for Space Activities') was threatening to restrict the use of certain GPS ground stations located in Russian territory because its attempts to build a base in the US were blocked by the US government. See Jeo Miller, *Russia to 'restrict' US-run GPS satellites*, http://www.bbc.com/news/technology-27662580, last accessed 22 September 2015; *Об исполнении поручения Правительства Российской Федерации*, http://www.federalspace.ru/20646/, last accessed 22 September 2015.

or expert witness would need to proceed from the four performance parameters: accuracy, integrity, continuity and availability (see 1.2.4). The detailed indicators or the general description of level of performance required is found in the contract terms or minimum standards by law. In general, if a GNSS provider itself fails to comply with required and promised performance parameters, the provider would be considered to undertake the contractual liability.

As to the requirement of subjective matter, the most striking rule of civil liability in contract law is no fault, compared with the fault rule in tort law, even though the special tort liability regime, such as product liability, blurs the line of demarcation.[99] Although certain authors researching for the 'Economics of Law' are trying to address fault in contract law,[100] national legislation rarely considers that factor in the case of contract liability.[101] In addition, bearing in mind the technical complexity of GNSS, the stricter the obligation, the easier it is for the promisee who complains of a breach to establish liability.[102] So far there is no revolutionary excuse to establish fault in GNSS contractual liability, which would be against the general theory of contract law. Hence fault, regardless of wilful or negligent breach of contract, is not a necessary element to establish GNSS contractual liability.

(iii) Defects in GNSS provision. As one form of typical strict liability, product liability seems never to take into account whether it is the manufacturer's or the seller's fault. The victim may claim for no-fault liability for the damage caused by the defective GNSS equipment or signals/services (see 2.3.3). However, whether that which a GNSS provides can be labelled as a 'service', 'product', 'data', 'information' or just 'signal' remains open.

2.4.4 Damage: safety-of-life dangers

Satellite navigation, satellite communication and satellite remote sensing are three critical applications of satellites with the same importance. Why, then, is civil liability a topical concern of satellite navigation, but seldom an issue

---

99 Omri Ben-Shahar & Ariel Porat, *Fault in American Contract Law*, 107 Michigan Law Review 2009, at 1344.

100 See e.g., Melvin Aron Eisenberg, *The Role of Fault in Contract Law: Unconscionability, Unexpected Circumstances, Interpretation, Mistake, and Nonperformance*, 107 Michigan Law Review 2009, at 1413; Richard A. Epstein, *The Many Faces of Fault in Contract Law: Or How to Do Economics Right, Without Really Trying*, 107 Michigan Law Review 2009, at 1461; George M. Cohen, *The Fault that Lies Within Our Contract Law*, 107 Michigan Law Review 2009, at 1445.

101 For example, China's Contract Law regulates contractual liability as one strict liability, i.e., no-fault liability. See ZHANG Guangxing and HAN Shiyuan, *General Principles of Contract Law* (Law Press China, 1999), in Chinese, at 86.

102 Solène Rowan, *Fault and Breach of Contract in France and England: Some Comparisons*, 22 (4) European Business Law Review 2011, at 467.

in either satellite communication or satellite remote sensing? The reason behind this phenomenon is the gaping differences on the extent of damage caused by each of them. Unlike satellite communication, the service based on GNSS is related much more to safety-of-life, especially in the transportation and search-and-rescue sectors, even though this can also connect terrorists by easy spoofing devices. Moreover, safety critical applications of GNSS usually need more real-time data than satellite communication, especially for high-speed mobile vehicles such as landing aircraft. Likewise, satellite remote sensing is actually a space-based monitoring system which is not capable of mitigating ongoing disasters. The reason why GNSS has more to do with dangers lies in the fact that it can play the role of the controller of autopiloted aircraft and other decision-making systems, whereas satellite communication and remote sensing are usually the assistant tools of the controller's decision.

As to the types of damage caused by GNSS, they range from inconvenience to catastrophe:[103]

- *personal injury*, which is always the key issue even in the context of GNSS; yet, whether mental injury is included should be decided by the national law selected by the court;
- *economic loss*, including the property damage and the delay of goods or passengers because of the GNSS malfunctioning, in particular in the civil aviation sector.
- *environmental damage*, which may happen, for example, if the GNSS causes the collision of vehicles transporting oil, nuclear or other dangerous materials, or damage to the nuclear vehicle itself;[104]
- *privacy leak*, caused by an unlawful GNSS data leak from a provider or because of system-related reasons, such as suffering a hacker attack, rather than the illegal use of GNSS equipment (see (v) of 1.4.3);
- *other* types of detrimental effect.

This notwithstanding, is 'damage' an essential element for establishing each type of GNSS civil liability? The answer is, beyond any doubt, yes. Unlike criminal law and regardless of tort liability or contractual liability, civil law does not impose civil liability for attempts. Even though numerous GNSS risks expose people's lives and property to danger (see 1.3), there is no civil liability for mere risk. In tort law, even though the extent of risk could affect the content of the civil liability regime, such as special rules for ultrahazardous activity where strict liability applies, if the defendant's wrongful acts or

103 John A. Lever, *Unintended Consequences of the Global Positioning System*, 7 Systems Engineering 2004, at 221.

104 The crash of a navigation satellite in orbit may also cause the damage to the outer space environment, but this is not the damage caused by GNSS discussed in this research.

omissions could not have caused the damage claimed and the situation will continue unchanged for a reasonable period, there is no ground for holding the defendant liable in torts.[105]

In contract law, although all civil liability arises from breach of contract, damage may not always exist. This is also true in the context of GNSS, as the following hypothetical case illustrates:

> Airport A and GNSS provider B concluded a contract that B is to provide 24/7 PNT service for aircrafts landing in that airport, and performance parameters are listed in the contract. Due to the negligence of B's employee, the PNT service malfunctioned for 30 seconds. During that period, flight C based on the GNSS landing system was to land at Airport A.

(i) If an *accident* occurred to flight C because of that GNSS malfunctioning, the damage is obvious: loss of life and property, decrease of reputation and other intangible loss;[106]

(ii) If an *incident* occurred to flight C for the same reason and caused negative effects to the flight, airport or airline, although the damage is still identifiable to some extent, only the intangible loss is left;[107]

(iii) If flight C happened to be cancelled or the pilots landed manually for other reasons, where would the damage be? Even though GNSS provider B did violate its contractual duty, should it be held liable in the case where no damage occurred?

Returning to the general theory of contract law, whereas damage arising from contractual breach is usually presented by 'expectation loss', if the party does not suffer any loss of expectation or it cannot be proven, that party could then make a claim for 'reliance loss'.[108] While the former refers to the benefits, expected by party A from the performance of party B's obligation, which were prevented by the breach of contract committed by party B, the latter refers to the expense incurred by party A to perform the contract which was however wasted because of non-performance of party B.[109] In the case of (iii) above, even if GNSS provider B performed its obligation accordingly, flight C would neither benefit from that performance,

---

105 Ariel Porat & Alex Stein, *Tort Liability Under Uncertainty* (Oxford University Press, 2001), at 102.

106 The term accident is defined as an occurrence in flight which caused casualties and loss of property. See Annex 13 to the Convention on International Civil Aviation.

107 The term incident is defined as an occurrence associated with the operation of an aircraft which affects or could affect the safety of operation. In other words, there is no actual damage that happened in the incident but just the symptom of *accident*. *Ibid.*

108 See *Anglia Television Ltd. v. Reed*, [1971] 3 All E.R. 690.

109 See Joseph Chitty & H. G. Beale, *Chitty on contracts* (Sweet & Maxwell, Limited, 2008), at 26.

nor would it increase its cost as it did not intend to use that GNSS signal or service during those 30 seconds. Therefore, neither expectation loss nor reliance loss were incurred in the case of (iii), meaning that no damage occurred there and that, in turn, no one should be held liable for that breach of contract, as it should be. Even though the pilots unwillingly landed the flight manually because they realised that the GNSS signal was lost, only 'nominal damages' would be considered by the court, provided the aircraft landed safely and calmly as usual.[110]

Therefore, to establish GNSS civil liability at least one type of damage listed above must be proven in court, regardless of whether the basis is tort law or contract law. Not all breaches of contract cause damage and are subject to contractual liability in the context of GNSS.

2.4.5 Causal link: a challenge to prove behand 'middle tools'

Can radio signals really *hurt* people *directly*? The answer is no. Unlike a tangible object, a radio signal is tasteless and colourless, the existence of which we are even unable to sense unless we use special devices. Technically speaking, satellite navigation signals are 'soft', and this is decisive in determining that those signals could never *hurt*, *hit* or *collide* with people and their properties.[111] That is why the causal link in the case of GNSS is usually not apparent. However, there is civil liability for the damage *caused* by those signals in the legal sense. The term 'caused' does not require direct physical contact or connection. Like damage caused by a wrong information service, such as defective software and aeronautical chart,[112] as long as the radio signal is one of the reasons for damage, we can say that a causal link exists. Another analogy could be that of a car accident caused by the failure of the brake system to work due to a defective design; this failure of the brake system links damage to the manufacturers, even though the *brakes* never *touched* the victims. Therefore, to be qualified as a causer of damage, the causal link between GNSS signals and defective information, brake failure and other issues has to be proven via the pathway of 'middle tools', such as vehicles in transportation, for example in the case of economic loss

110 *Nominal damages* are awarded as a sum of money that can be spoken of, but which sum has no existence of quantity, such as two cents, in cases, *inter alia*, where there are no damages in fact are or can be proven. William Benjamin Hale, *Handbook on the law of damages* (Рипол Классик, 1896), at 25.

111 The only possible way to make people feel threaten by a signal itself may be the danger of electromagnetic radiation to an individual's the health. Fortunately, radio signals routinely are usually within safety standards too minimal or insignificant to be an issue. See *Frequently asked questions about the safety of radiofrequency (RF) and microwave emissions from transmitters and facilities regulated by the FCC*, https://www.fcc.gov/engineering-technology/electromagnetic-compatibility-division/radio-frequency-safety/faq/rf-safety#Q6, last accessed 2 June 2016.

112 See *Saloomey v. Jeppesen & Co.*, 707 F.2d 671 (2nd Cir. 1983).

of banks caused by wrong GNSS timing data, computers. What GNSS civil liability addresses is the consequence of GNSS signal, rather than the signal or the middle tool itself (see also3.3.4).

However, the real challenge in the case of GNSS liability is to prove that the damage in question was actually *caused* by GNSS. On the one hand, as a member of a high technology family, GNSS is too technically complicated to be understood by most laypersons; on the other hand, GNSS signals update second by second and it is impossible to store them unless conduct monitoring is agreed in advance and records are kept. This technical nature determines the difficulty of proving that the failure of GNSS was the contributing factor or one thereof to the damage.[113] Furthermore, in an accident it is usually various accumulated factors coming together at one time, rather than just one element, which cause the accident, thus making it very hard to peel the failure of GNSS away from the other factors. The above is particularly true for a claim based on tort law, which has a substantial causality requirement, contrary to contract law wherein causality is seldom an issue.[114] This circumstance urges us to find a feasible way to re-balance the inequality in court between GNSS providers and victims. Although *causal link* is an essential element to establish GNSS civil liability, it does not mean that a link has to be proven by the claimants. The reversal of the burden of proof in GNSS tort law, *inter alia*, could be considered as a solution in cases concerning GNSS civil liability.[115] Also, taking into account the difficulty in proving the *specific* causal link in the case of multiple providers or multiple actors in one set of GNSS providers, it would be a good point if we address joint liability in the context of GNSS damage.

In addition, it is worthwhile repeating here that no direct causal link exists under GNSS civil liability if the damage is caused by wrong map data or navigation route provided, designed or computed by certain value-added service providers (see 2.2).[116]

113 See EC, *supra note* 29.

114 Omri Ben-Shahar & Ariel Porat, *Fault in American Contract Law* (Cambridge University Press, 2010), at xii.

115 Another challenge is to decide to what extent a GNSS factor contributes to the damage. For example, if GNSS data is only reference material for pilot, who is actually flying the aircraft, can we say the failure of GNSS makes the plane finally crash and not the pilot? The answers to questions like this are found in section 3.3.4.

116 For a recent case on damage caused by wrong map data rather than GNSS signals or services, see http://abcnews.go.com/International/woman-drives-car-canadian-bay-gps-wrong-directions/story?id=39115061, last accessed 1 June 2016.

2.5 International characteristics of GNSS civil liability

Through decades of development, GNSS now has become a truly global resource[117] determined by its global deployment, coverage, and application (see 1.2.5). The technical global nature of GNSS has been transferred to the international characteristics of *GNSS governance* and *GNSS law*. Added to this, criminal liability is in general a matter of national autonomy,[118] and administrative liability shares this similar feature because of its close connection with public powers originating from State sovereignty. Civil liability, however, can be engaged in both domestic law and governing rules of international law, especially for global systems such as GNSS and international air transportation.

(i) Transnational litigant parties. GNSS technology is relevant to all States regardless of their stages of economic or technological development.[119] This means that GNSS users and relevant third parties, who are potential claimants for compensation, are geographically distributed in every corner of the globe. At present, however, potential defendants, i.e., GNSS providers, can be counted on one's hand, therefore claimants do not have much choice but to aim at those few GNSS oligarchs for compensation. This would create a lot of transnational litigation with either foreign claimants or foreign defendants. Furthermore, current GNSS oligarchs enjoy and are more or less connected to State sovereignty (see 1.3, 1.4.3 & 5.3.2.2), and usually this doctrine cannot be excluded merely by regulations under *national* law.

(ii) Worldwide triggers of civil liability. GNSS is a global business with its provision of a World Public Good (open signals),[120] so the triggers of civil liability are ready to be activated in one jurisdiction or in multiple jurisdictions. Even though the places where contracts have been signed would be limited to provider States within a certain number, the places where contracts have been performed and breached would be quite complicated in the context of GNSS, in particular for the regularly mobile vehicles; the malfunctioning of GNSS would cause damage to many targets all over the world which would lead to unlimited *locus delicti* and *lex loci*. The same applies to the product liability regime, taking into account the global supplier of GNSS satellites, software, and the signals transmitted to all corners of the world. The above unstable places of contract and tort makes it is impossible to achieve the

117 Someswar, *supra note* 3.

118 Wang Hui, *Civil Liability for Marine Oil Pollution Damage: A Comparative and Economic Study of the International, US and the Chinese Compensation Regime* (Kluwer Law International, 2011), at 39.

119 Scott Madry, *Global Navigation Satellite Systems and Their Applications* (Springer, 2015), at 99.

120 See Serge Plattard, *Can Global Navigation Satellite Systems Signals Qualify to Become a World Public Good?*, 3 (3) NEW SPACE 2015, at 142.

same result of choice of law even in the case of the same accident brought before the same court.

(iii) Damage in multiple jurisdictions. Modern GNSS has the technical ability to be used by an unlimited number of multimodal users at sea, on the ground and in the air,[121] with the result being that a single malfunctioning of GNSS would possibily damage each user at the same time. When the mobile feature of aircraft, vessels and cars from one jurisdiction to another is taken into consideration, transboundary damage would be very common in case of accidents caused by GNSS.

Facing the challenges above, it is easy to imagine that the call for a global approach to GNSS civil liability has been the subject of extensive consultation in the international arena, including ICAO, Unidroit and IMO, for more than 20 years.[122] The lack of an international uniform instrument could cause many legal problems. First, transnational litigation would increase the difficulty and costs of identifying the liable party.[123] Second, the absence of a single criterion for private international law in the context of GNSS would expose the victims in the same event to the embarrassing situation of 'similar lives but with different values' due to the various indemnification standards of each State. Third, the cross-border damage means that jurisdiction-connecting factors related to GNSS accidents can range from the location of the damage to the location of the ground receiver stations, and this would inevitably cause conflict of jurisdictions and legal uncertainties.

Therefore, GNSS civil liability could to a significant extent be referred to as a type of international liability resulting from transboundary harm, in most situations because of its international characteristics. Like the legal regime of international air transportation,[124] a global approach has to be taken into consideration when discussing the establishment of a GNSS civil liability regime. It seems that only an international legal framework with mandatory effect could better ensure the equitable and uniform compensation for all affected persons, irrespective of the State to which they

121 There are two different modes of GNSS technology, one is active systems, and the other is passive systems. Depending on the different modes, systems have a limited capacity or they serve an unlimited number of users. Currently, GPS, GLONASS and Galileo are passive systems, and BDS keeps both active and passive methods. See Bernhard Hofmann-Wellenhof, et al., *GNSS – Global Navigation Satellite Systems* (Springer Science & Business Media, 2007), at 55 & 397.

122 Bollweg, *supra note* 38.

123 Manzini & Masutti, *supra note* 37.

124 GNSS civil liability seems to be more *international* than air carrier's civil liability: the international characteristic of air law is from the multi-national victims' perspective but the damage usually happens in the same State; the international feature of GNSS civil liability is derived from both the multi-national victims' perspective and the place of damages.

belong.[125] Being aware of the reluctance of States to reach a consensus on a new convention,[126] there is still a long way to go to find an acceptable global approach where alternative forms, such as unification of private international law rules, model law or guidelines, should also be on the list for consideration.

2.6 Concluding remarks

It is not easy to define civil liability in the context of GNSS since few pre-existing reference materials focus specifically on this term. Following the general theory of liability, GNSS could trigger civil liability and criminal liability, as well as administrative liability, even though GNSS civil liability would be the major concern in most cases. Nevertheless, in the regime of international law, the demarcation between responsibility and liability in the context of GNSS should not be vague due to their duality in different areas of law.

Bearing those points in mind, GNSS civil liability could be defined as 'the obligation to make reparation for any damage caused, especially in the form of monetary payment, by the inappropriate PNT signal provided by core GNSSs, augmentation systems and regional systems, but excluding GNSS value-added services and malfunctioning of the user equipment'. The complete picture of GNSS civil liability is composed of contractual liability and non-contractual liability, and the largest percentage of the latter is represented by GNSS tort liability, even though it is not the entire picture. Both GNSS third-party liability and GNSS product liability are two subsets of GNSS tort liability which sometimes overlap.

To establish civil liability, GNSS, using the four elements structure, needs to identify the parties, the trigger, the damage and the causal link. Considering the difficulty in determining the trigger and proving a causal link, specific legal arrangements such as the reversal of the burden of proof and joint liability must however be addressed more than they are in other sectors. More important, transnational litigant parties, cross-border triggers and damage in multiple jurisdictions determine the necessity of a truly global approach to deal with civil liability in the context of GNSS. Therefore, the following two chapters address whether current international aerospace (air & space) law could grapple with the overall situation of GNSS civil liability.

125 See Carbone & Maestri, *supra note* 82, at 41.

126 Francis P Schubert, *An International Convention on GNSS Liability: When Does Desirable Become Necessary?*, XXIV Annals of Air and Space Law 1999, at 267.