

Cover Page



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General Conclusion

GNSS benefits all walks of life. Major space powers are in various stages of deploying their own GNSSs for the interests of national security and economic growth. Nevertheless, GNSSs are now facing technical, financial, institutional and legal challenges which may raise various risks on system malfunction or the loss or defection of signals. An integrated governance system consisting of a clear, efficient organizational structure and a comprehensive legal system for GNSS constitutes necessary institutional guarantees and legal safeguards for all innovative solutions to mitigate those risks and related accidents.

Among others, legal certainty on the issue of GNSS civil liability has been an earnest desire of international user community, including both sovereign States and private entities, for decades. But, how does the issue of GNSS civil liability matter? For the answer, the term civil liability has to be understood in the context of GNSS. GNSS is a generic term of core navigation satellite systems and its augmented systems, with global coverage. In the provision of GNSS signals, providers have to follow specific performance parameters, i.e., accuracy, integrity, continuity and availability, degrading of which damage may be thus caused and the issue of civil liability would arise.

Following a general theory of civil liability, the author defines the term 'GNSS civil liability' 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'. GNSS contractual liability, GNSS general tort liability and GNSS product liability constitute three pillars of the GNSS civil liability regime, which are mostly discussed in legal researches. To generally establish GNSS civil liability, claimants have to prove the existence of four elements, that are the parties, the trigger, the damage and a causal link.

GNSS civil liability is inherently labelled by its international characteristics in most situations because of transnational litigant parties, cross-border triggers and damage in multiple jurisdictions which are generated by the global coverage and worldwide deployment of GNSS. To deal with such an international civil liability, the domestic approach would cause conflicts of jurisdictions and a series of legal uncertainties. The most critical issue

would be the obstacles imposed by the doctrine of Sovereignty Immunity, particularly because most of GNSS providers are public agencies. It seems that only an international legal framework could better ensure the equitable and uniform compensation for all persons affected irrespective of the State to which they belong.

How does the said international legal framework look like? The international community has been searching for the answer for decades, but, without a consensus. GNSS providers States believes that this international legal framework refers to the present system of international law as there is no indication has been found it cannot cope with GNSS; while GNSS user States insist that a new international framework has to be developed because no existing international laws may cover the issue of GNSS civil liability. The author concludes the core of this controversy as the question that whether the current system of international law is adequate to deal with the issue of GNSS civil liability? To find out the answer, the applicability of international air and space law to the issue of GNSS civil liability deserves the first try.

International space law regulates the issue of civil liability for damage caused by space objects. Although the development and operation of GNSS qualify as space activities, it is too reluctant to interpret GNSS signals as space objects and hence apply Article VII of the Outer Space Treaty and the Liability Convention. To make civil liability regime under the Outer Space Treaty and the Liability Convention applicable to the issue of GNSS civil liability, some literatures wrongly entangled in the questions of (i) whether indirect damage is covered by Article VII of the Outer Space Treaty and the Liability Convention, and (ii) whether GNSS damage qualifies as indirect damage. The author holds that what really matters lies in the establishment of causation between *damage* and *GNSS satellites*, which qualify the requirement of '*damage caused by space objects*'. This causation has to be identified on a case-by-case basis, with the criterion of '*directness*', '*foreseeability*' and '*proximity*' under the sense of general international law.

Nevertheless, the current international space law provides neither an adequate nor a fair mechanism for GNSS civil liability. Firstly, the Liability Convention does not support juridical proceedings between a private party suffered damage and liable party under private law, but merely allow the individual to petition his/her government start traditional diplomatic negotiations with the government of the wrongdoer. This State-vs-State liability system involves too many political wrangling. Secondly, what the current international space law is focusing is civil liability arisen from launching activities, rather than the application of satellites. Thirdly, legal uncertainty may result from different understandings of the matter of causation by different judges and arbitrators, particularly in the case where external factors contribute to the occurrence of damage caused by GNSS.

International air law regulates the issue of civil liability occurred in the course of a flight. Damage caused by the use of GNSS for the purpose of air navigation, as well as automated flight control, falls within the application scope of international air law, ranging from public to private international legal instruments. Because of the inherent connection with the safety of civil aviation, the issue of GNSS civil liability has been a primary focus and concerns of the international civil aviation community.

To establish a legal framework of GNSS, ICAO has released a series of public statements and reports of the Council and its Legal Committee, Assembly Resolutions, SARPs, exchange of letters with States and other documents including manuals, global air navigation plans and procedures. But, the purpose of those regulatory and guidance materials is mostly for public governance or technical assurance for the implementation of GNSS in the sense of public law; none of those materials addresses legal rules of civil liability directly, even though some of them could be used as reference materials in court to justify the accountability of States providing either GNSS signals or ANS based on GNSS.

GNSS is in essence no more than another navigation aid, but there are many challenges to apply the present regime of ATC civil liability for damage caused by GNSS. Firstly, Article 28 of the Chicago Convention neither enforces any legal obligation on States about the introduction of GNSS for the time being nor serves as the legal basis of ATC or GNSS civil liability under the private law. Secondly, the national regime of ATC civil liability is reluctant to fit an international civil liability caused by GNSS due to the failure of practice on the proposal for a convention. Thirdly, under the fault-based system of ATC civil liability, victims run the risk of inadequate compensation or no compensation at all in a given case where damage was caused by defective GNSS signals if no negligence can be attributed to the ATC service provider. Fourthly, under the no-fault system of ATC civil liability, it is unfair to make an ATC service provider responsible and liable for damage caused by GNSS which is entirely out of its control.

The system of air carrier civil liability is composed of a series of international legal instruments concluded from Warsaw to Montreal via Rome. But none of them provides a legal basis for a direct claim raised by victims against the GNSS provider in the case on GNSS civil liability. If the air carrier is brought in front, a series of recourse actions have to be raised to channel the burden of civil liability to the GNSS provider who is the real wrongdoer. There is no case law giving evidence of the feasibility of such recourse actions. Even in the case ignoring the interest of air carrier but merely focusing on passengers or third parties suffering damage, international air law still cannot ensure those victims receiving full compensation for damage caused by defective GNSS signals in most cases because the majority of conventions regulate a limited civil liability.

In spite of substantial efforts in identifying possible solutions for the issue of GNSS civil liability under international air and space law, neither of them presents much success on the adequacy of victims' compensation and the fairness in the allocation and channel of civil liability. Continuing efforts, coordination and international cooperation are thus needed to search for alternative solutions for the issue of GNSS civil liability. Although the resistance exists from the side of GNSS providers due to the problem of open signals with a free-of-charge policy, and from the protection of the doctrine of Sovereignty Immunity, the fairness of GNSS civil liability to be borne by those providers is not questionable. Also, the provision of GNSS safety-of-life signals for safety-critical industries deserves much more attention than that of GNSS open signals for the public use in the roadmap to achieve an international solution for GNSS civil liability.

Against this background, the author proposes that efforts have to be made by relevant organisations from different sides working in parallel, particularly in the matters of:

(i) promoting the commercialisation and corporatisation of GNSS through a policy on charges or a cost-sharing mechanism which may force GNSS providers to assume a higher degree of duty of care for safety-critical applications.

(ii) establishing an authorisation mechanism on GNSS safety-of-life signals for a legally binding service guarantee containing a stable performance standard meeting the requirement of users such as civil aviation.

(iii) setting a standard clause for the disclaimer of civil liability for damage caused by defective safety-of-life signals. The disclaimer of civil liability made by the ESSP SAS for the provision of EGNOS SoL signals merits consideration as a model.

(iv) adopting a contractual chain on GNSS civil liability with a focus on the provision of safety-of-life signals through a series of contracts that include provisions on GNSS civil liability, and a governmental framework which contains certain mandatory common elements such as a clause on waiving sovereign immunity.