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General Introduction

Benefits generated by GNSS have penetrated to every corner of the earth. National security, economic growth, and transportation safety as well as efficiency are severely dependent on positioning information, navigation capabilities, and time dissemination provided by GNSS. Nevertheless, that is only one side of the coin. Without exception, GNSS is not risk-free, even though, often, new technologies present opportunities for increased safety, security and efficiency. The more humanity depends on GNSS; the more risks it has to face. A defect in, or loss of GNSS signals occurring due to unintentional or intentional causes may not only endanger hundreds of lives onboard an aircraft which is based on a GNSS landing system, but it may also cause substantial economic loss to critical civilian infrastructure for banking, electricity and other purposes.

Who is it that shall be responsible or liable in the event that real damage is unfortunately caused by GNSS to its users or any third parties, and how shall such be responsible or liable? In the case where GNSS signals are provided free of charge, is it fair to force a GNSS provider to bear the burden of compensation? Could a GNSS provider release its civil liability by the doctrine of State Immunity if that provider is a public authority? The international community has contributed decades of effort into searching for answers for those questions, yet thus far, no consensus has been reached. Some believe that there are no matters that exist in a legal vacuum, and that the current international law regime could deal with the issue of GNSS civil liability; others confirm serious doubts on the fitness of 'old' laws to such 'new' technologies, the reasoning being that, when stakeholders were fighting intensely for the adoption of relevant conventions, they may not have even anticipated the essential role and, in particular, the risks of GNSS.

Against this backdrop, the aim of this research is to explore whether current international law is adequate to deal with the issue of civil liability in the context of GNSS. In other words, the aim is to explore whether present international law can ensure that parties suffering damage get fair, prompt and adequate compensation while balancing the interests of the GNSS industry in order for it to maintain its sustainable development. If so, how does international law apply in a case related to GNSS civil liability? If it does not apply, where is the legal gap and how should we move forward? For those answers, the author examines published papers and recent developments of authors, analyses, travaux préparatoires and current texts of treaties as well as national legislation, and addresses conference documents released by international organisations. To make the analysis easily under-

standable, the author designed a hypothetical case where damage is caused by GNSS due to different reasons, and illustrated each legal relationship and causal link in various figures.

The research divides its contents into four parts. All chapters start from an introduction and close with concise concluding remarks. Part I (Chapter 1) shifts its focus from GNSS technical matters to legal issues in general, and then gradually to civil liability in particular. Part II (Chapter 2) concerns a conceptual analysis of GNSS civil liability, serving as a basis for any further study. Part III (Chapters 3 and 4) checks the application and adequacy of current international air and space laws to the case where damage is caused by GNSS. Part IV tries to find a roadmap for the issue of GNSS civil liability to move forward in a feasible way.

Chapter 1 is an overview of GNSS from technical, financial, institutional and legal perspectives. It begins with technical know-how of GNSS to understand what is GNSS and how GNSS benefits humanity. GNSS performance parameters are described to clarify the standard on examining the defection of GNSS signals. The global nature of GNSS is presented to serve as the technical basis for the need for the international law to deal with GNSS civil liability. Risks faced by the international GNSS community is analysed to lay the foundation of triggers of GNSS civil liability. Against those risks, that chapter proposes, among others, a uniform governance structure composed of an institutional framework and a legal system for GNSS.

Chapter 2 defines the term of civil liability in the context of GNSS from a more legal perspective. It examines which parts of the value-chain of GNSS could be qualified as the origin of damage in this research. The terms 'liability' and 'responsibility' were distinguished with specific regard to GNSS. The concept of 'GNSS liability' is discussed separately based on criminal, administrative and civil laws. The structure of 'GNSS civil liability' is further divided into three pillars: GNSS contractual liability, GNSS general tort liability, and GNSS product liability. Four elements, that are the parties, unreasonable acts, damage, and their causality, are analysed to see how GNSS civil liability is established. Considering the aforementioned global nature of GNSS from a technical perspective, the chapter continues to discuss how that factor influences the concept of GNSS civil liability in a legal sense.

Chapter 3 checks whether and how international space law applies to the issue of GNSS civil liability. It establishes a link between GNSS and international space law by reasoning that GNSS is a space system, and relevant activities belong to space activities. After presenting various sources of international space law, the chapter examines the possibility of applying both Article VII of the Outer Space Treaty, and the Liability Convention to

GNSS civil liability by answering the following questions: (i) does a GNSS signal qualify as a 'space object'? (ii) is damage caused by GNSS covered by outer space treaties as an 'indirect damage'? and (iii) where is the causal link, if at all, between damage and GNSS? By producing answers to those questions, the chapter proceeds to assess practical challenges in claims for compensation under international space law for damage caused by GNSS.

Chapter 4 checks whether and how international air law applies to the issue of GNSS civil liability. The chapter establishes a link between GNSS and international air law by reasoning that GNSS is one of the critical infrastructures during the operation of an aircraft. The chapter divides its contents into three parts to discuss the application of legal documents of international air law to the issue of GNSS civil liability. First, the legal effect of regulatory materials and guidance documents generated on the platform of ICAO is examined to see whether they can be of any help to deal with the issue of GNSS civil liability. Second, the possibility to resolve the issue of GNSS civil liability under the international legal framework of ATC civil liability is checked. Third, the applicability of international treaties, concluded from Warsaw to Montreal via Rome, regarding air carriers' civil liability for damage caused by GNSS malfunction or defective PNT signals through the operation of aircraft is reviewed.

Chapter 5 intends to present a highly practical solution for the issue of GNSS civil liability through a series of proposals. A fairness test on GNSS civil liability is scrutinised in conjunction with a free-charge policy for GNSS open signals. The question of whether a disclaimer of civil liability justifies GNSS providers not assuming civil liability is also addressed. The chapter further strives for a clear roadmap to make solutions for the issue of GNSS civil liability feasible: first, a legal and an institutional solution is presented against the doctrine of Sovereignty Immunity; second, various solutions for GNSS civil liability are assessed based on their respective feasibility; and third, several international organizations are listed to see how shall they work together to achieve the way forward for the issue of GNSS civil liability.

The final point of this research is to promote public safety by restraining the negligent activities and omissions of GNSS signal providers, and urging them to improve the stability of the satellite navigation systems, and these by establishing a clear regime of GNSS civil liability. The author acknowledges that, although for the time being a catastrophic crash due to a malfunction of GNSS is quite unlikely, this cannot be ruled out in the future when, for example, GNSS safety-of-life signals constitute essential elements for each autonomous aircraft, ship and car. It is irresponsible to wait for an accident to happen merely to justify the need for an appropriate GNSS civil liability regime. This research, accordingly, deserves certain significance and attention.

