Artificial Intelligence, Space Liability and Regulation for the Future: A Transcontinental Analysis of National Space Laws

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Abstract

The private sector is leading the deployment of emerging technologies such as artificial intelligence (AI), which is used for various applications including satellite collision avoidance and spacecraft operations management. However, these technological advancements may pose a number of challenges for traditional space law. This paper will focus the concept of liability for damage caused by space objects that incorporate AI through the lens of national space legislation, examining examples from various countries including the Netherlands, Indonesia, Australia, South Korea, and the United Arab Emirates. Based on this analysis, recommendations will be provided for regulating AI in the context of space activities, taking into account the European approach to AI governance and liability.

1. Introduction: welcoming artificial intelligence from Earth to space

Artificial intelligence (AI) has increasingly become part of our digital lives on Earth in a variety of domains such as healthcare, transport, finance and personnel recruitment.[1] In space related activities, examples of the use of AI, incorporating various levels of autonomy, include autonomous mission

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1 Executive Agency for Small and Medium sized Enterprises, *Advanced Technologies for Industry, Sectoral Watch: Technological Trends in Creative Industries* (European Commission 2021) 4.

planning,[2] deep-space exploration,[3] autonomous satellite collision avoidance,[4] astronaut assistance,[5] and Moon exploration.[6]

The utilization of the emerging AI technology does not come without legal challenges. One such challenge currently on the agenda of both legal and technical professionals relates to defining the term "artificial intelligence". At a policy level, various international and regional initiatives have proposed a series of definitions. For example, in Europe, the proposal of the European Commission for the harmonized rules on AI systems (the "AI Act")[7] provides a quite comprehensive definition. The term encompasses a broad spectrum of technology from basic systems, including symbolic expert and more advanced systems, reaching high automation levels and operating based on sophisticated learning approaches, such as machine learning.[8]

This proposed definition has raised considerable debate. Some authors claim that the definition is not clear enough, leading to uncertainty in the legal domain. This is mainly because some systems are not covered by the proposed definition even though they might (potentially) have a negative impact on specific fundamental human rights.[9]

2 European Space Agency, 'AIKO: Artificial Intelligence for Autonomous Space Missions', <https://www.esa.int/Applications/Technology_Transfer/AIKO_Artificial_Intelligence_for_Autonomous_Space_Missions> accessed 16 July 2022.

3 European Space Agency, 'Robots in Space', <https://www.esa.int/Enabling_Support/Preparing_for_the_Future/Discovery_and_Preparation/Robots_in_space2> accessed 16 July 2022.

4 Ron Schmelzer, "How is AI helping to commercialize space?", Forbes, 2020, <https://www.forbes.com/sites/cognitiveworld/2020/03/21/how-is-ai-helping-to-commercialize-space/> accessed 12 February 2021.

5 "Astronaut Assistant CIMON-2 Is on its way to the International Space Station", <https://www.airbus.com/newsroom/press-releases/en/2019/12/astronaut-assistant-cimon2-is-on-its-way-to-the-international-space-station.html> accessed 12 February 2021.

6 Rick Chen, 'VIPER' (*NASA*, 9 January 2020), <http://www.nasa.gov/viper> accessed 5 November 2021.

7 European Commission, 'Proposal for a Regulation of the European Parliament and of the Council Laying down Harmonised Rules on Artificial Intelligence (Artificial Intelligence Act) and Amending Certain Union Legislative Acts' (2021) COM(2021) 206 final.

8 Article 3 of the AI Act: "AI system means software that is developed with one or more of the techniques and approaches listed in Annex I and can, for a given set of human-defined objectives, generate outputs such as content, predictions, recommendations, or decisions influencing the environments they interact with".

9 Nathalie A Smuha and others, 'How the EU Can Achieve Legally Trustworthy AI: A Response to the European Commission's Proposal for an Artificial Intelligence Act' (2021) SSRN Scholarly Paper ID 3899991 3, <https://papers.ssrn.com/abstract=3899991> accessed 18 March 2022.

Irrespective of the academic deliberations, the increasing level of autonomy represents a priority for developers of AI systems utilized in space related activities.[10] AI systems are now designed for functioning without human intervention.[11] A point of concern is that the absence of human control in the operation of advanced AI systems may challenge existing theories of liability that are traditionally centered on the concept of foreseeability.[12] AI systems with a high level of autonomy may behave unpredictably - their actions or lack of action (omissions) might not always be foreseeable.[13] An AI system capable of learning from external data such as the surrounding environment may behave in ways that its designers might not have anticipated.[14] This is especially the case for AI systems operating based on machine learning or deep learning techniques, allowing them to modify their functions after being deployed in a specific environment.[15]
In this context, the need for clear governance structures becomes a priority, especially in what concerns the potential rules applicable to liability for damage caused by actions or omissions of AI systems.

2. The European approach to the synergy of "AI - Space"

In Europe, over the last decade a series of non-binding initiatives have been formulated by European legislative bodies seeking to identify optimal solutions for the potential risks posed by AI systems. The work of European legislators culminated in 2021, with the proposal for the AI Act[16] and in 2022 with the AI liability package composed of the AI Liability Directive[17] and a revised Product Liability Directive.[18]

10 Jet Propulsion Laborator, 'Strategic Technologies | Science and Technology' (2019), <https://scienceandtechnology.jpl.nasa.gov/research/strategic-technologies> accessed 14 February 2021.
11 European Space Agency (n 2).
12 Leon Green, 'Foreseeability in Negligence Law' (1961) 61 Columbia Law Review 1401, 1401.
13 Peter Asaro, 'The Liability Problem for Autonomous Artificial Agents', *AAAI Spring Symposia* (2016) 2.
14 Weston Kowert, 'The Foreseeability of Human - Artificial Intelligence Interactions Note' (2017) 96 Texas Law Review 1, 182.
15 Miriam C Buiten, 'Towards Intelligent Regulation of Artificial Intelligence Symposium on Regulating the Risk of Disruptive Technology' (2019) 10 European Journal of Risk Regulation (EJRR) 41, 56.
16 European Commission (n 7).
17 'Proposal for a Directive of the European Parliament and of the Council on Adapting Non-Contractual Civil Liability Rules to Artificial Intelligence (AI Liability Directive)' (European Commission 2022) COM(2022) 496 final.
18 European Commission, 'Proposal of the European Commission for a Directive of the European Parliament and of the Council on Liability for Defective Products' (European Commission 2022) COM(2022) 495 final.

The AI Act adopts a risk-based approach for governing various types of AI systems, as follows: AI systems posing unacceptable risks are prohibited while high-risk systems must comply with a series of requirements; systems not presenting high risks will need to comply with fewer, or (in some cases) no requirements. For a detailed presentation of various types of AI systems, please refer to Annex 1 (the European Regulatory Pyramid), attached to this paper.

The AI Act and the proposals for the new Directives do not include any references to AI systems used in space related activities. Exception makes the revised Product Liability Directive that especially acknowledges the important role of navigation systems in enabling AI.[19] Rather unexpectedly, some general references to the synergy of "AI - space" were included in Regulation 696/2021 approving the EU Space Programme, which underlines the necessity of exploiting such synergies to foster the use of new technologies.[20]

3. Legal basis for enacting national space laws

The incorporation of AI in space-related activities necessitates a comprehensive examination of the legal frameworks currently in place. The existing international space law, represented by the Outer Space Treaty[21] and the Liability Convention,[22] were not designed with such technological advancements in mind. As a result, the legal status of AI in space activities is uncertain, particularly in cases of damage caused by a space object equipped with AI capabilities.

In light of this, national space legislation plays a crucial role in providing legal certainty for such activities. Article VI of the Outer Space Treaty imposes international responsibility on States for their "national activities in outer space", requiring them to authorize and continuously supervise the activities of non-governmental entities.[23] Additionally, the Outer Space Treaty and the Liability Convention provide for obligations that require

19 Explanatory Memorandum of the revised Product Liability Directive, p. 5.

20 Preamble (4) Regulation (EU) 696/2021 of the European Parliament and of the Council of 28 April 2021 establishing the Union Space Programme and the European Union Agency for the Space Programme and repealing Regulations (EU) No 912/2010, (EU) No 1285/2013 and (EU) No 377/2014 and Decision No 541/2014/EU 2021 (OJ L).

21 'Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies', done 27 January 1967, entered into force 10 October 1967; 610 UNTS 205.

22 Convention on International Liability for Damage Caused by Space Objects done 29 March 1972, entered into force 1 September 1972; 961 UNTS 187.

23 Irmgard Marboe, 'National Space Law', *Handbook of Space Law (eds. Frans von der Dunk and Fabio Tronchetti)* (Edward Elgar Publishing 2015) 131.

relevant national space law for their implementation, such as international liability for damage caused by space objects.

The Liability Convention establishes two distinct liability regimes for such damage, depending on the location of the damage. Damage caused on the surface of the Earth or to aircraft in flight triggers absolute liability, while damage caused elsewhere gives rise to fault-based liability. However, the Liability Convention does not provide for any limitation of liability,[24] making it imperative for States to take necessary steps to minimize risk and ensure compliance with safety standards through their national space legislation.

In conclusion, the increasing autonomy of AI-deployed space objects necessitates a review of the existing legal frameworks and the role of national legislation in providing appropriate safeguards for the general public while promoting technological innovations. A transcontinental analysis of national space laws from different countries, could provide insights into potential solutions for regulating AI liability in the context of space activities.

4. Liability under national space laws: selected jurisdictions

We now briefly[25] analyze the liability provisions from national space laws of the following countries: The Netherlands, Indonesia, Australia, South Korea and UAE. These jurisdictions may differ in terms of their history in space related activities or their financial resources, but they, like other States, each share a common ambition of further develop their national space capabilities.

4.1. The Netherlands

The Netherlands embraces a pragmatic approach when it comes to space activities, bearing in mind its relative size and scale of activities compared to larger spacefaring nations.[26] The Dutch government often collaborates with other States when undertaking space activities, as opposed to acting independently.[27] That said, some private space activities have emerged over recent years. In 2021, for example, the first Dutch military nanosatellite was

24 Rather, the quantum of compensation for such damage is to be "determined in accordance with international law and the principles of justice and equity" and based on the notion of *restitutio in integrum* wherever possible; see Article XII of the Liability Convention.

25 Given the constraints in terms of the length of this paper, we have only highlighted certain aspects of relevance from the national legislation of each of the countries we look at. The discussion below is in no way intended to be a comprehensive analysis of all of the relevant provisions contained in those laws.

26 Frans von der Dunk, 'Regulation of Space Activities in The Netherlands: From Hugo Grotius to the High Ground of Outer Space', in Ram S. Jakhu (ed.) *National Regulation of Space Activities* (2010) 225.

27 *Ibid.*

launched by Virgin Orbit,[28] and a Dutch space tourist joined Blue Origin's first group of customers.[29]

The main legal instrument dealing with Dutch private space activities is the Law Incorporating Rules Concerning Space Activities and the Establishment of a Registry of Space Objects, 24 January 2007 ("Dutch Space Activities Act").[30] The legislation establishes a flexible licensing system for private space operators, including requirements like insurance for liability. It contains a series of conditions to be complied with by operators, relating to the safety of persons and property, environmental protection, public order and security, and financial security, as well as compliance with the international obligations of the State.[31]

The Dutch Space Activities Act provides under Chapter 4 (Redress) that, if the State is obliged to pay compensation pursuant to Article VII of the Outer Space Treaty and/or the Liability Convention, it is entitled to recover the amount, in full or in part, from the party whose space activity caused the damage. The liability of a license holder, granted in accordance with the provisions of the legislation, is limited to the sum insured. A liability insurance policy is mandatory and represents a pre-condition for the granting of the relevant license.[32]

4.2. Indonesia

Indonesia's island geography offers a natural advantage for the development of space launch capabilities.[33] Investments in space activities are growing at an unprecedented pace and the potential construction of a spaceport is

28 Ministerie van Defensie, 'First Dutch Military Nanosatellite Launched Successfully - News Item - Defensie.Nl' (2 July 2021), <https://english.defensie.nl/latest/news/2021/07/02/first-dutch-military-nanosatellite-launched-successfully> accessed 28 June 2022.

29 'Dutch Teen to Become Youngest-Ever Astronaut as Blue Origin's First Customer' (*NL Times*), <https://nltimes.nl/2021/07/15/dutch-teen-become-youngest-ever-astronaut-blue-origins-first-customer> accessed 28 June 2022.

30 Law Incorporating Rules Concerning Space Activities and the Establishment of a Registry of Space Objects, 24 January 2007, entered into force 1 January 2008. See Netherlands at 'Space Law: National Space Law Database', <https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html> accessed 23 June 2022.

31 Von der Dunk (n 34) 236.

32 Article I, A.1 of Order by the Minister of Economic Affairs of 26 June 2015, no. WJZ/15055654, amending the Space Activities Licence Application and Registration Order, in connection with changes to the application form, available on <https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html> accessed 23 June 2022.

33 Kumar Abhijeet, 'Introduction' in Kumar Abhijeet (ed.), *National Space Legislation for India: Proposal for a Draft Framework* (Springer 2020) 5, <https://doi.org/10.1007/978-981-15-2675-6_1> accessed 24 June 2022.

encouraging the development of the private sector.[34] The spaceport construction is made possible by the provisions of Chapter IV of Law no. 21 of 2013 ("Indonesian Space Law"),[35] subject to obtaining all necessary legal approvals, including an environmental impact assessment.[36] Further details on procedures and operation of the spaceport are to be included in a separate (future) governmental regulation.[37]

Provisions relevant to liability issues are set out in Chapter X of the Indonesian Space Law, including procedures for recovering damage and obtaining compensation,[38] and transfer of liability from one operator to another following a space asset transfer of ownership.[39] Article 77 transposes the provisions of Articles II and III of the Liability Convention, differentiating between absolute and fault-based liability. Moreover, private operators will be obliged to take out insurance for potential liability for damage caused to third parties.[40]

Article 40 of the Indonesian Space Law provides for a Master Plan for Space Activities 2016–2040 to be enacted via the Presidential Regulation no. 45 of 2017.[41] The aim of the Master Plan is to promote commercial space activities with the help of the national industry, by implementing a series of short, mid, and long terms strategic roadmaps.[42]

4.3. Australia

Australia has a long history in space related activities facilitated by its geographic location as well as its strategic partnerships with various

34 See Dera Menra Sijabat, Richard C Paddock and Ulet Ifansasti, 'Will an Island in Indonesia Become a New Frontier in the Space Race?' *The New York Times* (16 November 2021), <https://www.nytimes.com/2021/11/16/business/indonesia-spaceport-elon-musk.html> accessed 24 June 2022; The Jakarta Post, 'Indonesia at a Crossroads in Pursuing Spaceport Dream' (*The Jakarta Post*), <https://www.thejakartapost.com/opinion/2022/04/06/indonesia-at-a-crossroads-in-pursuing-spaceport-dream.html> accessed 24 June 2022.

35 Law of the Republic of Indonesia no. 21 of 2013 on space activities, <https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html> accessed 23 June 2022.

36 Article 48 Indonesian Space Law.

37 Article 50 Indonesian Space Law.

38 Article 79 - 83 Indonesian Space Law.

39 Article 78 Indonesian Space Law.

40 Article 84 Indonesian Space Law.

41 See Indonesia at 'Space Law: National Space Law Database', <https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html> accessed 23 June 2022.

42 Ida Bagus Rahmadi Supancana, 'Indonesian Space Policy, Regulations and Programs: Past Achievements and Future Prospects', in Quentin Verspieren and others (eds.), *ASEAN Space Programs: History and Way Forward* (Springer Nature 2022) 34-35, <https://doi.org/10.1007/978-981-16-7326-9_2> accessed 24 June 2022.

spacefaring countries.[43] It is increasingly investing in its space capabilities, establishing a national Space Agency in 2018 and, in 2022, announcing the creation of a new space defense agency as a response to China's and Russia's space ambitions.[44]

The main legal framework regulating Australian space activities is now the Space (Launches and Returns) Act 2018 ("Australian Space Act"), which was promulgated following a review of its earlier legislation, the Space Activities Act 1998.[45] The Australian Space Act is focused on a series of space activities requiring approval, such as launching, registering and returning space objects, operating a launch facility and launching a high-power rocket from Australia.[46] It also includes detailed provisions about liability for damage caused by space objects or high-power rockets. Liability for damage caused to third parties is differentiated using the classical geographical dichotomy included in the Liability Convention: damage caused (i) on Earth or in air; and (ii) in space.[47] The compensation is limited to the amount of $3 billion, representing the amount in excess of the insured amount for the Australian launch permit or overseas payload permit.[48] Liability is also addressed in the context of "returns conducted by overseas nationals".[49] In addition, Article 71 provides that compensation will be paid for any damage caused by the space object to a third party, in the context of such return.

4.4. South Korea

South Korea has been active in space related activities with a variety of partners since the 1990s. Recently, South Korea's space ambitions have reached a new milestone when, in June 2022, it successfully launched its first domestically built rocket.[50] The Nuri rocket places South Korea among only

43 Steven Freeland, Val Sim and Kirsty Hutchison, 'How Technology Drives Space Law Down Under: The Australian and New Zealand Experience' (2018) 43 Air and Space Law 133, <http://kluwerlawonline.com/journalarticle/Air+and+Space+Law/43.2/AILA2018010> accessed 28 June 2022.

44 'Defence Space Command | Royal Australian Air Force' (*airforce.gov.au*), <https://www.airforce.gov.au/our-mission/defence-space-command> accessed 17 July 2022.

45 See Australia at 'Space Law: National Space Law Database' (n 49).

46 Science Department of Industry, 'Regulating Australian space activities' (*www.industry.gov.au*, 2 January 2018), <https://www.industry.gov.au/regulations-and-standards/regulating-australian-space-activities> accessed 28 June 2022.

47 Articles 67 – 68 Australian Space Act.

48 Articles 69 (4) (b) Australian Space Act.

49 Subdivision B Australian Space Act.

50 'South Korea Launches First Satellite with Homegrown Rocket' (*NBC News*, 22.06.2022), <https://www.nbcnews.com/news/world/south-korea-launches-first-satellite-homegrown-rocket-rcna34679> accessed 25 June 2022.

seven nations that have successfully launched rockets carrying more than a 1-ton satellite onboard into space.[51]

South Korea is also one of the few countries[52] addressing liability for damage due to space activities in a specific legal instrument, Law no. 8852 of 21.12.2017 ("Space Liability Act").[53] The purpose of this instrument is to complement the liability provisions already included in Law no. 7538 of 31.05.2005 ("Space Development Promotion Act").[54] The Space Liability Act aims to protect victims of accidents resulting from space activities and to contribute to the development of space activities by establishing compensation rules, as well limitations of liability, as the case may be.[55]

Although it generally reiterates the key liability principles of international space law,[56] the Space Liability Act imposes a limitation of two hundred billion won (approximately 150 million EUR)[57] on compensation payable in case of damage, as opposed to the uncapped regime in the Liability Convention. A waiver of liability included in Article 4 is also more detailed than the exonerations specified in Article VI of the Liability Convention: "in case of space damage caused by armed conflict, hostile activity, civil war or rebellion or caused in outer space, the launching party shall be liable only if the damage is due to his willful misconduct or negligence". Article 4 also provides that product liability rules are not applicable to space damage.[58]

4.5 The United Arab Emirates

The United Arab Emirates ("UAE") is one of the six spacefaring nations currently proposing missions to the Moon in 2023, alongside Japan, South

51 Deutsche Welle (www.dw.com), 'South Korea's Space Ambitions Grow with First Homegrown Rocket Launch | DW | 21.06.2022' (*DW.COM*, 22.06.2022), <https://www.dw.com/en/south-korea-successful-satellite-launch/a-62202173> accessed 25 June 2022.

52 According to the National Data Base of UNOOSA, only South Korea and Italy (via Law No. 23, 25 January 1983 approving Norms for the implementation of the Convention on International Liability for Damage Caused by Space Objects) have implemented dedicated national space legislation specifically dealing with liability for damage caused by space objects.

53 Republic of Korea at 'Space Law: National Space Law Database' (n 49).

54 Articles 14-15 generally refer to the obligation of a launch permit holder to contract for liability insurance for space related activities. Article 16 provides that a Space Accident Inquiry Committee is to be formed to investigate specific space accidents that are separately defined by Presidential Decree.

55 Article 1 Space Liability Act.

56 Youngshin Ahn, 'Recent Developments in the Republic of Korea's Space Policy: An Overview of Space Activities and National Laws' (2019) 44 Air and Space Law 181, <http://kluwerlawonline.com/journalarticle/Air+and+Space+Law/44.2/AILA2019012> accessed 7 June 2022.

57 Article 5 Space Liability Act.

58 Article 4.3 Space Liability Act.

Korea, Russia, India, and the United States.[59] This will be its first lunar mission,[60] representing part of a long-term plan concerning Moon exploration announced in 2021.[61] Investments in national space activities are also growing at an unprecedented pace, reaching in excess of AED 22 billion (approximately 5.9 billion EUR) in 2021.[62]

The UAE's space activities are governed by Federal Law No. 12 of 2019 ("UAE Space Law"), which aims, among other things, to encourage investments and the private sector and ensure safety, security of, and the implementation of certain environmental measures for space activities.[63] According to the UAE Space Law, the State is responsible for all space related activities taking place on its territory or at the State's establishments outside its territory, for registered objects, and for nationals and companies headquartered in the State.[64] All space activities will be subject to a "permit", which must be obtained and maintained in force any operator.[65]

The UAE Space Law includes seven articles focusing on liability and differentiating between contractual liability and "liability towards others" (third party liability).[66] Liability is not limited by the provisions of the law, but a decision issued by the Council of Ministers is required to enforce a limit of compensation.[67]

5. Challenges posed by the synergy of "AI - space"

Although the legal aspects concerning the use of AI in space related activities are becoming highly significant, thus far only a few authors have identified

59 John Pickrell, 'These Six Countries Are about to Go to the Moon - Here's Why' (*Nature.com*, 11 May 2022), <http://www.nature.com/articles/d41586-022-01252-7> accessed 26 June 2022.

60 Elizabeth Gibney, 'UAE Ramps up Space Ambitions with Arab World's First Moon Mission' (2020) 587 Nature 186.

61 Sarwat Nasir, 'UAE Reveals Long-Term Moon Exploration Plan at Global Space Conference' (*The National News*, 17 June 2021), <https://www.thenationalnews.com/uae/science/uae-reveals-long-term-moon-exploration-plan-at-global-space-conference-1.1242597> accessed 26 June 2022.

62 'Investments in Space Industries Witness Renewed Momentum with Announcement of the UAE's New Space Project' (*wam*, 26 October 2021), <https://wam.ae/en/details/1395302980835> accessed 26 June 2022.

63 Federal Law No. 12 of 2019 issued on 19/12/2019 corresponding to 22 Rabi' Al-Akhar 1441H, on the Regulation of the Space Sector available at 'Space Science and Technology - The Official Portal of the UAE Government', <https://u.ae/en/about-the-uae/science-and-technology/key-sectors-in-science-and-technology/space-science-and-technology> accessed 26 June 2022.

64 Article 3 UAE Space Law.

65 Article 14–17 UAE Space Law.

66 Article 20-21 UAE Space Law.

67 Article 24 UAE Space Law.

potential challenges triggered by this emerging technology.[68] These authors have mainly focused on the absence of human judgment from the equation, questioning the attribution of liability in case of damage,[69] as well as on the potential difficulties associated with the absence of definitions for key liability terms.[70]

The Liability Convention refers to fault-based liability attributable to a State or to the "persons for whom it is responsible". Neither the Liability Convention, nor international space law in general, provide a definition of, or clear assessment criteria as to what might constitute fault for the purposes of the Liability Convention. The notion of "persons" is also not defined, although it is generally assumed that this term refers to an entity which is subject to legal rights and duties, such as a natural or juridical person.[71]

In the absence of definitions, challenges may arise within the context of a decision made by an advanced AI system, without any human intervention. In such a case, this decision might no longer be interpreted as being the "fault of persons", leading to difficulties in attributing liability based on the fault-based regime under the Liability Convention and, thus, highlights a potential "liability gap".[72]

A similar challenge may appear in the context of the exonerations under Article VI of the Liability Convention: "exoneration from absolute liability shall be granted to the extent that a launching State establishes that the damage has resulted either wholly or partially from gross negligence or from an act or omission done with intent to cause damage on the part of a claimant State or of natural or juridical persons it represents". The term "gross-negligence" is not defined, but negligence is generally thought to be

68 Anne-Sophie Martin and Steven Freeland, 'The Advent of Artificial Intelligence in Space Activities: New Legal Challenges' (2021) 55 Space Policy 101408; Ioana Bratu, Arno R Lodder and Tina van der Linden, 'Autonomous Space Objects and International Space Law: Navigating the Liability Gap' (2021) 18 Indonesian Journal of International Law 423; George Anthony Gal and others, 'Artificial Intelligence in Space' [2020] arXiv:2006.12362 [cs], <http://arxiv.org/abs/2006.12362> accessed 28 January 2021; Michael Chatzipanagiotis, 'Whose Fault Is It? Artificial Intelligence and Liability in International Space Law' (2020) 63 International Institute of Space Law 429; George Anthony Long, 'Artificial Intelligence and State Responsibility under the Outer Space Treaty' (2018) 61 International Institute of Space Law 709; Ioana Bratu, 'Blaming Galileo: Liability for Damage Caused by GNSS Enabled Autonomous Systems', *Proceedings of the 72nd International Astronautical Congress (IAC), Dubai, United Arab Emirates* (2021); Ioana Bratu, 'Artificial Intelligence for Future Lunar Societies: A Critical Analysis of the Liability Problem', *5th Global Moon Village Workshop & Symposium*.

69 Martin and Freeland (n 76) 6.

70 Bratu, Lodder and van der Linden (n 76) 435–436.

71 *Ibid* 436.

72 *Ibid* 137.

"associated to an action or omission part of a human activity,"[73] therefore, making it difficult to apply in relation to an advanced AI system operating without any human intervention.

In the light of such challenges, the role of national legislation may play an important role in addressing potential liability gaps. Nevertheless, our analysis illustrates that none of the selected jurisdictions have included any specific provisions addressing the use of AI in their national space activities, as well as any provisions directly concerning liability for damage caused by a space object equipped with AI capabilities. In such a context, the following question arises: what legal solutions are necessary to deal with future situations in which damage is caused by advanced AI systems operating without human intervention?

6. Regulation for the future: proposals *de lege ferenda*

The regulation for the future addressing the synergy of "AI - space" requires a holistic integrated approach, combining multiple regulatory levels, as follows:

6.1. International Level

i. Supplementing the Liability Convention

Although a complex endeavour from a political perspective, the supplementation of the Liability Convention – perhaps by way of a binding "Protocol" to the treaty – might prove necessary, given that the technological developments have radically changed the circumstances from the time that the Liability Convention entered into force. Notions such as "space object", "fault" and "gross-negligence" might necessitate a fresh approach in the light of the rapid integration of AI in space related activities.[74]

ii. A non-binding "rules of the road" approach

Adopting a cooperative approach for space activities fosters responsibility and promotes international consultations, public awareness of space activities, and alerts for potential dangers to astronauts. Encouraging states to implement these "best practices" or "acceptable and responsible rules of conduct" into their legislative frameworks is in their national interest, despite their non-binding nature. [75]

73 *Ibid* 434.

74 For a proposed definition of the term 'space object', in the light of technological advancements, please refer to Bratu, 'Blaming Galileo: Liability for Damage Caused by GNSS Enabled Autonomous Systems' (n 75) 7.

75 Martin and Freeland (n 76) 7.

6.2. National Level

An alternative solution at the national level would be integrating special provisions in national space laws to address potential liability gaps. Such provisions would relate to the risks involved by the incorporation of AI within the specific national space activities, as well as mitigating actions. For example, these provisions may *inter alia* refer to enhanced liability provisions, corresponding insurance, and compensation for damage caused by, or in relation to a space activity involving the use of AI systems.

6.3. Regulatory synchronization between the AI Act, AI liability Directives and national space laws

The integration into national space laws of any provisions related to AI systems should be properly synchronized with the provisions included in the policy documents focused on AI governance and liability. Specifically, the AI Act and the proposed AI liability Directives should clearly provide whether their provisions are applicable to AI systems used in space related activities, together with a clear description of their place in the "regulatory pyramid", as described in Annex 1.

7. Concluding Observations

The integration of AI in space-related activities requires a critical examination of existing legal frameworks, particularly in Europe where several regulatory initiatives aim to govern the use of AI in different sectors. However, these initiatives do not currently include AI systems used in space-related activities. Furthermore, the international treaties that form the foundation of space law, such as the Liability Convention, were drafted before the advent of AI and therefore do not address the legal implications of such technologies.

The legal status of AI technologies used in space activities is particularly relevant in the event of damage caused by a space object equipped with AI capabilities. Given the increasing autonomy of these technologies, traditional notions of "space liability" such as "fault" and "gross-negligence" may be insufficient.

In this regard, national space legislation can provide a degree of legal certainty. Our analysis of the liability provisions in five national space laws (the Netherlands, Indonesia, Australia, South Korea, and UAE) revealed a lack of specific legal solutions related to damage caused by AI in national space activities. To avoid legal gaps, it is recommended that regulatory initiatives be considered at both an international and national level, to ensure comprehensive and complete legal solutions.

Annex 1
The European Regulatory Pyramid