Whose Fault Is It? Artificial Intelligence and Liability in International Space Law

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Abstract

Artificial intelligence (AI) is increasingly used in space activities. AI employs machine learning techniques, which enable the system to automatically improve its performance by exposure to large amounts of data. Such technological developments entail that space activities will be conducted with increased system autonomy. However, this makes its behavior largely unpredictable, Thus, questions arise on how AI impacts the current system of liability under international space law.

This paper submits that cases that require 'fault' of the launching State will become (even) more difficult to handle, in view of the challenges in defining 'fault' and in establishing causal connection between the fault and the damage. Fault may be indicated by non-compliance with established international rules or codes of conduct, by insufficient regard of other States' interests under Art. IX OST, or by unreasonable behavior. These parameters are examined in relation to AI, alongside additional AI-specific factors, e.g. training data. If AI is used to support human decisions through recommendations, then human factors should also be considered, such as appropriate warnings and user-friendly system design. Moreover, explainability of AI decisions is highly desirable, but also hard to materialize owing to the complexity of AI systems. In any case, comparing AI behavior with human behavior should not be excluded, but extreme caution is required.

The paper concludes that it is necessary to establish international regulations on space activities, even in non-binding form, and international, performance-based safety standards. Any gaps in victim protection will have to be filled by national legislation and insurance.

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1. AI and Its Use in Space Operations

1.1. AI and Machine Learning

There is not any generally accepted, uniform definition of Artificial Intelligence (AI). However, it has been suggested that artificial intelligence refers to systems that display intelligent behavior by analyzing their environment and taking autonomously actions to achieve specific goals.[1]

Machine learning is a type of AI, which works by identifying patterns in available data and then applying the knowledge to new data.[2] As a result, the system can automatically improve its performance by exposure to large amounts of data. However, this makes its behavior largely unpredictable, even if all initial programming parameters are known.

1.2. Use of AI in Space Systems and Operations

AI is increasingly being used in many kinds of space operations, while its use is very likely to become standard in the future. AI is already used or going to be used in unmanned operations to assist in manufacturing of satellites and spacecraft,[3] for in-orbit assembly, satellite servicing and refueling,[4] for event detection and mission replanning,[5] for collision avoidance,[6] to distinguish and process useful satellite data form unnecessary data[7] etc. There are also plans to use AI to support manned missions to the Moon and Mars in various

1 European Commission, COM (2018) 237 final, p.1.
2 *Id.*, p.10.
3 See e.g. R. Eite and L. Finucan, AI in Space: Trends and Applications, 30 Oct. 2019, https://www.accesspartnership.com/trends-and-applications-of-ai-in-space/ (accessed 1 Oct. 2020); R. Schmelzer, How Is AI Helping To Commercialize Space?, 21 March 2020, https://www.forbes.com/sites/cognitiveworld/2020/03/21/how-is-ai-helping-to-commercialize-space/#76b0eaa47c9f (accessed 1 Oct. 2020).
4 See e.g. NASA, Satellite Servicing TDM Project Overview, https://www.nasa.gov/mission_pages/tdm/satellite-servicing.html (accessed 1 Oct. 2020).
5 See e.g. ESA, AIKO: Artificial Intelligence for Autonomous Space Missions, 14 Sept. 2018, https://www.esa.int/Applications/Telecommunications_Integrated_Applications/Technology_Transfer/AIKO_Artificial_Intelligence_for_Autonomous_Space_Missions (accessed 1 Oct. 2020).
6 See e.g. ESA, Automating collision avoidance, 22 Oct. 2019, https://www.esa.int/Safety_Security/Space_Debris/Automating_collision_avoidance (accessed 1 Oct. 2020); M. Harris, SpaceX Preps Self-Driving Starlink Satellites for Launch, 22 May 2019, https://spectrum.ieee.org/tech-talk/aerospace/satellites/spacex-preps-selfdriving-satellites-for-launch (accessed 1 Oct. 2020).
7 See e.g. ESA, Working towards AI and Earth observation, 11 March 2019, https://www.esa.int/Applications/Observing_the_Earth/Working_towards_AI_and_Earth_observation (accessed 1 Oct. 2020).

ways, e.g. spacecraft and habitat operations, maintenance of operations, support of in-space tasks etc.[8]

Such extensive uses of AI and machine learning entail that space activities will be conducted with increased system autonomy. Therefore, the question to be examined is how the use of AI systems affects liability under international space law.

2. Provisions on liability in international space law

2.1. Liability and Responsibility

Liability in international space law is regulated in Art. VII Outer Space Treaty (OST)[9] and in the Liability Convention (LC).[10] The ILC considers that responsibility arises through an unlawful act, while liability is connected to legitimate activities of States.[11]

2.2. Exemptions From The Scope of the LC

The LC does not apply to damage caused to nationals of the launching State, as well as to damage caused to foreign nationals who are participating in the operation of the space object.[12]

Hence, the LC will be inapplicable, should an AI system malfunctions and causes damage or injury to the persons involved in its operation, e.g. malfunction of an "intelligent" automated docking system or life support system.

2.3 Art. VII OST and LC

Art. VII OST provides that each State that launches or procures the launching of an object into outer space, including the moon and other celestial bodies, and each State from whose territory or facility an object is launched, is internationally liable for damage to another State or to its natural or juridical

8 See e.g. NASA, Trusted Autonomy for the Moon and Mars, 11 Oct. 2019, https://www.nasa.gov/offices/oct/feature/Trusted_Autonomy_for_the_Moon_and_Mars/ (accessed 1 Oct. 2020).

9 Treaty on principles governing the activities of States in the exploration and use of outer space, including the moon and other celestial bodies, signed at Washington, Moscow and London on 27 Jan. 1967, in force since 10 Oct. 1967, 610 UNTS 205.

10 Convention on International Liability for Damage Caused by Space Objects, signed at Washington, Moscow and London on 29 March 1972, in force since 1 Sept. 1972, 961 UNTS 187.

11 See Boyle, Liability for Injurious Consequences of Acts Not Prohibited by International Law, in: J. Crawford et al. (Eds), The law of international responsibility, OUP, Oxford 2010, p.95.

12 Art. VII LC.

persons by such object or its component parts on the Earth, in air or in outer space, including the moon and other celestial bodies.
These provisions have been further clarified in Arts II and III of the LC.
According to Art. II LC, a launching State is absolutely liable for damage caused by its space object on the surface of the Earth or to an aircraft in flight.
Art. III LC provides that in the event of damage being caused elsewhere than on the surface of the Earth to a space object of one launching State or to persons or property on board such a space object by a space object of another launching State, the latter shall be liable only if the damage is due to its fault or the fault of persons for whom it is responsible. Hence, for damage caused to other space objects, liability is depended on 'fault' of the launching State, which is a key concept.
As a result, the elements of liability under international space law are: a 'space object' of a 'launching State', which 'causes' 'damage'; 'fault' of the launching State is also required in the cases of Art. III LC. The elements that may present particularities when AI is used are the 'space object', the 'fault' and the requirement for causation.

3. Space Object

Art. I(d) LC clarifies that the term 'space object' includes component parts of a space object as well as its launch vehicle and parts thereof. AI capabilities are part of the software used in the operation of a space object. Since the software is a component of the space object, the use of AI does not affect the notion of 'space object'.

4. Fault

Fault is not defined either in the LC or in any other Space Treaty.

4.1. Interpretation

To define 'fault', the interpretational criteria of Art. 31 of the Vienna Convention (VC) on the Law of Treaties[13] are applicable, i.e. examination of the treaty's ordinary meaning, purpose, context and any subsequent agreements and practice.

13 United Nations Convention on the Law of Treaties, Signed at Vienna 23 May 1969, in force since 27 January 1980, 1155 UNTS 331.

4.1.1. Ordinary Meaning and Ratio

The ordinary meaning of 'fault' is *mistake*, *error*.[14] In a legal context, 'fault' is defined as:

1. An error or defect of judgment or of conduct; any deviation from prudence or duty resulting from inattention, incapacity, perversity, bad faith, or mismanagement.
2. The intentional or negligent failure to maintain some standard of conduct when that failure results in harm to another person.[15]

Thus, 'fault' means that the launching State has acted in an inappropriate manner. Fault denotes negligence, in the sense of failure to use due care in a given situation.[16] It may also denote a choice made between two possible courses of conduct, when the choice made resulted in damage, while the other choice would have not.[17]

The purpose of the LC is to provide compensation to victims of damage caused by space objects, which is indicated in its preamble too.[18] Given that space activities are considered ultra-hazardous, the States conducting them should be strictly liable to those not engaged in the space activity. But, when an accident happens involving two States that are both engaged in such activities, then liability should be borne by the State that acted in a wrong, inappropriate way. In such cases, both States have undertaken similar risks, parties are in a position of equality, and fault liability is the most reasonable solution.[19]

Hence, fault exists where the launching State has not demonstrated a behavior reasonable and appropriate to prevent the damage occurred, given the circumstances of the particular case.

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14 See Cambridge dictionary https://dictionary.cambridge.org/dictionary/english/fault (accessed 1 Oct. 2020); British dictionary https://www.dictionary.com/browse/fault?s=t (accessed 1 Oct. 2020).

15 Bryan A. Garner (ed.), Black's Law Dictionary, 9th ed., Thomson Reuters 2009.

16 M. Mejia-Kaiser, Collision Course: The 2009 Iridium-Cosmos Crash, in: C. Jorgenson (Ed.), Proceedings of the International Institute of Space Law, 52nd Colloquium on the Law of Outer Space 2009, American Institute of Aeronautics and Astronautics, Washington DC 2010, p. 274 (277).

17 Frans van der Dunk, Too-Close Encounters of the Third-Party Kind: Will the Liability Convention Stand the Test of the Cosmos 2251-Iridium 33 Collision?, in: C. Jorgenson (Ed.), Proceedings of the International Institute of Space Law, 52nd Colloquium on the Law of Outer Space 2009, American Institute of Aeronautics and Astronautics, Washington DC 2010, p.199 (203).

18 Smith and Kerrest, *Preamble LIAB*, para. 26, in: Hobe/Schmidt-Tedd/Schrogl (eds.) Cologne Commentary on Space Law, Volume II, Heymanns, Cologne 2013.

19 M. Lachs, The law of outer space, re-issued, Martinus Nijhoff, Leiden Boston, 2010, p.117; I.H.Ph. Diederiks-Verschoor and V. Kopal, An introduction to space law, third ed., Wolters Kluwer, The Netherlands, 2008, p.38.

The appropriate behavior can be determined taking into account various factors as *context* of the provision.

4.1.2. Context

4.1.2.1 *Art. IX OST*

The LC builds upon the OST, which is also mentioned specifically in the preamble of the LC. Thus, the provisions of the OST can be used to interpret provisions of the LC.

Art. IX, first sentence, OST provides that in the exploration and use of outer space, States shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space with due regard to the corresponding interests of all other States. This means that States must ensure that the exercise of their rights and freedoms in outer space does not affect the safety of space operations of other States.[20] The requirements of 'due regard' under Art. IX OST refer to the exercise of a standard of care, attention or observance during the performance of space operations: States have to prove that they undertook everything possible to prevent the harmful act from occurring in the light of the circumstances of the particular case.[21]

4.1.2.2. *Art. III OST and General International Law*

By virtue of Art. III OST, general international law is applicable complementary to the special rules of international space law.

Regarding international liability for space activities, especially important are the Articles of the International Law Commission (ILC) on the Responsibility of States for Internationally Wrongful Acts, which have been approved by the UN General Assembly and reflect largely customary international law.[22] Under Art. 2 ILC Arts, an international wrongful act is an act or omission attributable to the State, which constitutes a breach of an international obligation of that State. Therefore, fault in the ordinary meaning of the word is not part of international State responsibility under general international law. Instead, fault is used to denote the breach of an international obligation.[23] In addition to any special rules, such obligation includes Art. IX OST to exercise due regard.

Very similar to due regard is the duty of due diligence, which is a general principle of international law.[24] It is central in the work of the ILC on liability for injurious consequences arising out of acts not prohibited by

20 S. Marchisio, *Art. IX OST*, para.22, in: S. Hobe, B. Schmidt-Tedd, K.U.Schrogl (Eds), Cologne Commentary on Space Law, Vol. I, Heymanns, Cologne 2009.

21 S. Marchisio, *ibid*., para. 25.

22 Annex to General Assembly resolution 56/83 of 12 December 2001.

23 G. Palmisano, Fault, in: Max Planck Encyclopedia of Public International Law, September 2007, Oxford Public International Law (http://opil.ouplaw.com), para. 17.

24 T. Koivurova, Due diligence, in: Max Planck Encyclopedia of Public International Law, February 2010, Oxford Public International Law (http://opil.ouplaw.com), para. 2.

international law.[25] In this context emphasis is laid on the adoption of measures to manage risks and prevent foreseeable harm from arising.[26] Nevertheless, there is no duty of the State to totally prevent damage, but to exercise its best possible efforts to minimize the risks.[27] This means that States have to adopt and enforce specific legal rules and regulations to prevent and mitigate harm.[28] The standard of diligence depends on the degree of risk in the particular case and may change as technology progresses.[29] Efficient prevention could require technological upgrades and allocation of sufficient financial and human resources.[30]

4.1.2.3. ***Special Agreements of the Parties Involved***

In international space endeavors, it is very common that the States involved reach special agreements on the exact standards to be met, including liability issues among them. Such rules often define the respective responsibilities of each partner State,[31] a breach of which could bring about its international responsibility, or even directly regulate liability issues.[32] In such cases, the special agreements will supersede the general provisions of the LC as to the *inter-partes* relations.

Of course, by virtue of Art. 34 VC[33] such agreements will not affect the relations of these States with other States parties to the LC, to which the provisions of the LC will be applicable. Nonetheless, they might serve as indicators of reasonably expected behavior in some instances.

4.1.2.4. ***Soft law, State and Industry Practice***

Soft law instruments can provide useful guidance as to the appropriate behavior expected by States.

Such instruments could be codes of conduct adopted by space agencies or supported by international bodies, e.g. the UN Interagency Space Debris

25 See General Commentary on Prevention of Transboundary Harm from Hazardous Activities, ILC Yearbook 2001, p.148, paras (2)-(3).

26 *Ibid.*

27 See Art. 3 of the ILC draft articles on prevention of transboundary harm from hazardous activities and commentary thereon, para. (7), ILC Yearbook 2001, Vol. II, Part Two, pp.153-154.

28 *Id.*, p.154, para (10).

29 *Id.*, p.154, para (11).

30 *Id.*, p.155, para (14).

31 See e.g. the Memoranda of Understanding signed between NASA and the space agencies of the other States participating in the International Space Station.

32 E.g. Arts 16-17 of the Intergovernmental Agreement on the International Space Station. See the text of the agreement at https://aerospace.org/sites/default/files/policy_archives/Space%20Station%20Intergovernmental%20Agreement%20Jan98.pdf (accessed 1 Oct. 2020).

33 Art. 34 VC bears the title *General rule regarding third States* and provides that "a treaty does not create either obligations or rights for a third State without its consent."

Coordination Committee.[34] These contain technical rules, which are not binding, yet they serve as reference to reasonable courses of action.
State practice, especially of space-faring States, as indicated in national space legislation could too serve as guidance.[35] It includes, among others, policy instruments and certification standards.[36]
Internationally recognized private standards developed by specialized organizations[37] can also be useful.[38] However, it is important that these organizations apply safeguards to maintain their objectivity and neutrality.
Industry practice in certain fields may be helpful as well,[39] provided that such practice is reasonable under the circumstances. The underlying thought is that private entities, notwithstanding any duties incurred under the applicable national legislation, will adopt rational behavior to protect their interests and other parties involved. Caution is required though, given the highly competitive nature of modern economy, which might lead to suboptimal behavior in terms of safety.
Combining any common elements of the above-mentioned sources could give a good idea of what is reasonable under the particular circumstances.

4.1.2.5. ***Human Behavior***

Reasonable human behavior might also indicate what could be appropriate in a given case.
Since a space object employing AI is able to reach its own decisions and act autonomously, without human input, the inquiry on fault could focus on its behavior as compared to human behavior under similar circumstances. Again, caution is required.
First of all, there has to be a task, which could have been undertaken by a human. AI is often used to solve problems that exceed human abilities. In such cases, this test would make no sense.

34 Smith and Kerrest, *supra* note 18, *Art. III LIAB*, para. 131.
35 See also J. Dennerley, State Liability for Space Object Collisions: The Proper Interpretation of 'Fault' for the Purposes of International Space Law, European Journal of International Law 29 (2018), 281 (299-300).
36 E.g. NASA Human-Rating Requirements for Space Systems, NPR 8705.2C, available at https://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPR&c=8705&s=2C (accessed 1 Oct. 2020).
37 E.g. International Association for the Advancement of Space Safety, Commercial Human-Rated System Certification, IAASS-SSI-1700, http://iaass.space-safety.org/wp-content/uploads/sites/24/2020/08/IAASS-SSI-1700-MASTER-RELEASE-JULY-2018-mod-13.pdf (accessed 1 Oct.Sept. 2020); ISO standards on safety of space systems, such as ISO 14620-2:2019, https://www.iso.org/standard/74116.html (accessed 1 Oct. 2020).
38 See also Dennerley, *supra* note 35, 297.
39 See Mejia-Kaiser, *supra* note 16, 277, who observes that standards of care may be established by practice among members of a community that exercise a similar activity.

Second, to compare the behavior of a machine with the appropriate behavior expected by a human might be unsuitable, since AI works very differently than the human mind.[40] In many instances it has capabilities superior to those of humans – in such cases, comparison with human behavior would set the fault requirements too low. Besides, it may be quite challenging to train a machine to pay 'due regard' to other outer space users, in the absence of uniform, internationally accepted rules of conduct.

Nevertheless, taking into account the victim-oriented character of the LC, we could use human behavior as the minimum required by an AI system. This means that there will be a 'fault', if an AI system causes damage that would most likely have been avoided if a reasonable human had been operating a conventional space object. To the rest, we should examine whether the operator had received all reasonable measures to avoid and/ or mitigate a foreseeable damage.[41]

4.1.3. Conclusion as to the Notion of 'Fault'

The above analysis makes clear that fault indicates erroneous, suboptimal behavior. In the absence of specific agreements among the parties, the optimal behavior is determined by reference to binding rules of international law, especially the duty of due regard and due diligence. What is 'due' can be extrapolated by combining elements of soft law instruments, national and international standards, State and industry practice and even human behavior in some instances. However, what exactly constitutes fault depends on the circumstances of the particular case.

In the next section, we will examine certain domains and circumstances, in which fault can occur.

4.2. Domains of Fault in AI Cases

Fault related to the use of AI may concern a variety of domains. Although detailed requirements depend on the nature, the function, the risks connected to a malfunction, and many other parameters, an indicative list would include the following:

- Quality and quantity of the data used to train the algorithm.[42]

40 See D. Watson, The Rhetoric and Reality of Anthropomorphism in Artificial Intelligence, Minds and Machines 29 (2019), 417.

41 See in this regard also K. Chagal-Fefercorn, How can I tell if my algorithm was reasonable? 27 Mich. Tech. L. Rev. (forthcoming), available at https://ssrn.com/abstract=3578399 (accessed 1 Oct. 2020), pp.41-45.

42 E.g. in cases of algorithms used for avoidance of space collisions, it has been observed that a single source of orbital data is not good enough to automate critical decisions about safety – see *Harris*, *supra* note 6.

- Sufficient testing of the system, including interaction with other system components.
- Performance of necessary system updates to fix potential flaws and improve performance.[43]
- Clear instructions and warnings on the use and limitations of the systems, including system troubleshooting.
- Possibility of human intervention.
- Resilience in contingencies.
- If AI is used to substitute for human decisions or support them through recommendations, then human factors should also be considered.[44]
- Explainability of AI decisions is desirable, yet hard to materialize owing to the complexity of AI systems.[45]

The next question is whose behavior can be attributed to the launching State.

4.3. Attribution of Fault

According to Art. III LC, there must be a fault of the launching State itself or of persons for whom it is responsible. The persons for whom it is responsible refers to Art. VI OST,[46] which provides that States bear international responsibility for national activities in outer space, whether such activities are carried on by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the OST.

In the context of AI in space operations, a State will be liable, among other instances, for damage due to a space object operated by a legal entity under its jurisdiction. Hence, fault will refer to acts or omissions of human actors regarding the launch and operation of the space object. The ability of a space object to act autonomously and reach decisions on its course of action independently of any human input does not affect ultimate attribution of its

43 See e.g. P. Tucker, The NSA Is Studying Satellite Hacking, 20 Sept. 2019, https://www.defenseone.com/technology/2019/09/nsa-studying-satellite-hacking/160009/ (accessed 1 Oct. 2020).

44 Compare the MCAS system that Boeing had installed in its 737 max aircraft, which has been found to provide inadequate time to pilots to react – see US House of Representatives Committee on Transportation and Infrastructure, The design, development and certification of Boeing 737 max, Final Report, September 2020, pp.111-116 https://transportation.house.gov/imo/media/doc/2020.09.15%20FINAL%20737%20MAX%20Report%20for%20Public%20Release.pdf (accessed 1 Oct. 2020).

45 See The Royal Society, Explainable AI: the basics, November 2019, https://royalsociety.org/-/media/policy/projects/explainable-ai/AI-and-interpretability-policy-briefing.pdf (accessed 1 Oct. 2020).

46 Smith and Kerrest, *supra* note 18, *Art. III LIAB*, paras 137-139.

behavior to a State:[47] the space object belongs and is operated by an entity that is subject to the jurisdiction of a State. In such cases, the 'person' under Art. III LC is not the space object itself, but the entity responsible for its operation.

A conceivable alternative would be to refer to the behavior of the space object itself. Such solution might be envisaged, especially if national law recognizes AI as a separate legal entity.[48] The reference to Art. III LC to 'persons' includes legal entities of all kinds, since internationally liable is in any case the launching State, to whom the behavior of other persons is attributed.

Consequently, fault refers to the behavior of persons or legal entities, whose behavior is attributed to the State. The use of AI does not change anything in this regard.

5. Causation

Another important element is causation. In cases of strict liability, there must be a causal link between the injurious activity and the damage. In cases of fault liability, there must be a causal chain connecting the fault, the injurious activity and the damage.

Despite the various terms that have been used to describe the elements of causation, it appears that there must be (a) factual causation and (b) legally significant causation. The former exists where the injurious behavior forms part of a causal chain of events leading to the damage (*causa sine qua non*). The latter requires that the damage occurred must be a foreseeable/ proximate/ not too remote consequence of the injurious behavior; in other words, the causal chain of events between the behavior and the damage must not be too long.[49]

Under Art. II LC, i.e. strict liability of the launching State, it makes no difference whether the space object uses AI technology or not. Important is the link between the behavior of the space object and the damage.

47 See also G.A. Long, Artificial Intelligence and State Responsibility Under the Outer Space Treaty, in: P.J. Blount, T. Masson-Zwaan, R. Moro-Aguilar, and K-U Schrogl (Eds), IISL Proceedings 2018, Eleven Publishing, The Hague, 2019, p.709 (716-717), who thinks that a decision by an intelligent space object will not be the 'fault of persons for whom it is responsible', but there will be responsibility of a State under Art. VI OST for damage caused by such object.

48 See in this regard A. Bertollini, Artificial Intelligence and Civil Liability, Study commissioned by the Committee on Legal Affairs of the European Parliament, July 2020, pp.33-47, https://www.europarl.europa.eu/RegData/etudes/STUD/2020/621926/IPOL_STU(2020)621926_EN.pdf (accessed 1 Oct. 2020).

49 See Smith and Kerrest, *supra* note 8, *Art. II LIAB*, para. 107; ILC Yearbook 2001, Vol. II, Part Two, pp.92-93, Art. 31, para. 10.

Things become more complicated for fault liability under Art. III LC. In such cases, there must be a causal chain linking the fault of the launching State with the injurious behavior and the damage. However, AI systems may decide on their own what course of action to follow, based entirely on their algorithms. The launching State, or the persons for whom it is responsible, may not be always able to foresee, and thus determine, the result of the complex computations of the AI system. AI systems are usually programmed to learn on their own and behave autonomously. In such cases, it is likely that the requirement of foreseeability and proximity of damage are not satisfied.[50]
Thus, establishing a causal link between the fault of the launching State and the damage will be an additional challenge for claimants.

6. The Way Forward

Consequently, the liability system of the OST and the LC applies also to cases of AI. However, establishing liability of the launching State under Art. III LC is challenging in view of definitional and evidentiary difficulties surrounding the notion of 'fault', and the challenges in establishing a causal link between fault and damage.
Imposing strict liability on the launching State by e.g. abolishing Art. III LC and extending the strict liability regime of Art. II to all damage caused by space objects would not solve any problems. Art. II LC in essence distinguishes between States engaged in space operations and States not involved therein. The former bear strict liability towards the latter. But when all States involved in an accident are engaged in space activities, this distinction ceases to exist. In addition, amending the Space Treaties by establishing new binding rules is an unrealistic option in practice, in view of the extreme reluctance of States to even discuss any binding multilateral rules.
Therefore, international rules of conduct need to be established, which would provide guidance, despite their non-binding nature. First of all, there is a great need for international rules and standards on space traffic management. Second, the development of international, technical standards on space safety and certification should be encouraged and expanded. Such standards should be performance based, to ensure flexibility as to compliance and thus greater acceptability. Third, special agreements among the States participating in a space endeavor could regulate necessary details and technical due-regard duties. Prior consultation of all actors involved would be more time-consuming, yet necessary to maximize adherence to the standards.

50 In the same vein, Long, *supra* note 47, p.717, with further references.

To the rest and until such standards and rules are developed, the gaps in protection will be filled on the one hand by insurance cover, especially first-party insurance; on the other hand, by national liability rules on space activities.[51]

Conclusion

AI technologies are expected to be used extensively in many kinds of space operations.

From the standpoint of liability under international space law, the use of AI raises significant challenges regarding the interpretation of Art. III LC, namely the determination of 'fault' and the establishment of a causal chain between the fault and the damage.

'Fault' refers to compliance with international rules, especially the principle of due regard under Art. IX OST. This principle can be concretized by reference to special agreements among the States involved, national legislation, and soft-law instruments, such as codes of conduct and international technical standards. Important is not only the behavior of the launching State itself, but also the behavior of the persons and entities under its jurisdiction as per Art. VI OST. In some instances, comparing the behavior of the 'intelligent' space object to the behavior of a reasonable human might be cautiously used to provide guidance. The use of AI technology does not affect attribution to the launching State, since in any case the space object is owned and operated by humans.

In this respect, the challenges of defining 'fault' in cases of AI underline the need for international regulation of space activities, even in a non-binding form, which exists already for conventional space objects. Furthermore, widely accepted, international performance-based safety standards contribute to legal certainty.

The challenges in causation arise in view of the algorithm's self-learning abilities and evolving behavior.

As a result, there will be cases in which no liability can be established under Art. III LC. In such cases, national legislation or ad hoc arrangements among the parties involved may provide a remedy to victims. In practice, the role of insurance will be paramount.

51 Smith and Kerrest, *supra* note 18, *Art. III LIAB*, para. 132, who observe that if there has been no fault on the part of the launching State, then domestic law might be able to provide a remedy, as implied by Art. XI (2) LC.