

Regulation of AI Simulation Software in Resolving Disputes Through ADR: A Focus on Outer Space Commerce Law

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The increasing commercialization of space, coupled with the increasing number of private parties, cross-border commercial agreements, and complex technical disputes, has created a need for effective dispute resolution mechanisms. Alternative Dispute Resolution (ADR), particularly arbitration and mediation, is attracting attention from space investors due to its confidentiality, technical expertise, and procedural flexibility. At the same time, advances in artificial intelligence (AI), particularly simulation and creative systems, are being integrated into ADR workflows, from document review and case simulation to scoring systems, predictive analytics, and resolution recommendations. This article examines the regulatory challenges associated with the use of AI-based simulation software in ADR for disputes arising from or related to space trade. It summarises the relevant international legal framework (space treaties and international arbitration instruments), identifies gaps and risks (jurisdiction, liability, transparency, due process, probative value of simulation results, State liability and insurance) and proposes a multi-layered regulatory and administrative framework that combines international soft law, rules of arbitration institutions, contract drafting, technical standards and national enforcement measures. The central argument is that the legal framework for space activities and established arbitration structures together provide a framework for regulating the use of AI in ADR in space commerce. However, proactive and coordinated intervention by COPUOS/UNOOSA, UNCITRAL, arbitration institutions, and national law is needed to ensure fairness, accountability, and enforcement.

Keywords: Regulation of AI, AI in Dispute Settlement, AI Simulation Software, Alternative Dispute Resolution (ADR).

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Introduction

Space commerce, which mainly includes spacecraft production and launch, space activities, in-orbit maintenance, and contracts for satellite maintenance, has been growing rapidly (Sturdevant). Disputes in this area typically involve specialized technical issues (orbital dynamics, collision risk, telemetry data interpretation, damage to space components) and often involve international actors and national interests (Moltz, 2024). Alternative dispute resolution (in particular arbitration and mediation) has become the preferred dispute resolution method for many space actors due to its advantages such as party autonomy, technical expertise (appointment of professional arbitrators), confidentiality, and relative speed. At the same time, artificial intelligence simulation software has permeated litigation and ADR, from computational physics simulators and machine learning models trained on telemetry and operational data to generative models that generate proposed solutions (Moltz, 2024). Artificial intelligence can process large amounts of telemetry data, simulate in-orbit interactions and collision probabilities, estimate the costs of satellite service disruptions and suggest possible solutions based on past performance. However, AI is not neutral; it involves assumptions, biased training data, model simplifications, and uncertain decision-making. When AI output is used to inform negotiations, arbitrators, or mediators, questions arise about acceptability, net worth, fairness, interpretation, accountability, and enforcement (Klein, 2024: 49).

Aim of Research and Methodological Framework

This research aims to examine the ways in which the law should govern deployment of AI simulation software in ADR for outer space commercial disputes. Further, it also determines the adaptations or new regulatory instruments that are required to be enacted and enforced at different governance layers, including technical, contractual, institutional, and international. Further, the analysis proceeds by mapping existing legal frameworks, identifying challenges, and proposing a multi-track regulatory response. Besides, in this research article, the doctrinal synthesis and normative legal reasoning both are used as a methodological framework to analyse the existing legal principles along with the application of such principles by the States.

Legal and Institutional Context

International Space Law – Relevant Instruments and Institutions

International space law provides the basic legal framework for the conduct of space exploration. The 1967 *Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space* (the Outer Space Treaty, 'OST'), established fundamental principles such as freedom of exploration, the prohibition of alienation of celestial bodies, and the responsibility of States for activities in outer space. States bear international responsibility for the activities of their nationals in outer space and are obliged to recognize and monitor non-governmental organizations (Treaty, 1967). Article 3 of the Outer Space Treaty states that international law, including the Charter of the United Nations, applies in outer space (Jasentuliyana, 2023). International space law should therefore be seen as part of general international law and should be considered in conjunction with other relevant areas of international law (Convention, 1975). Thus, the legal assessment involves a body of legal rules that cannot be separated from the international legal order but must be integrated with other areas of international law. The relationship between international space law and other areas of law can be examined from different perspectives. Article VI of the Outer Space Treaty covers

a number of legal rules. The distinction between primary and secondary norms can therefore be used as a tool to identify the legal rules governing international responsibility for activities in outer space.¹ Although this distinction is not normatively unambiguous, it is a useful tool to highlight the main aspects of international responsibility. The law of international responsibility is generally considered to consist of secondary norms that indicate the legal assessment of primary norms. The conference also examined the relationship between international space law and principles of general law. A number of well-known general legal principles were identified, and their relevance for international space law was highlighted. These principles include “*Pacta sunt servanda*,” the principle of good faith, the principle of supreme law, the “*lex posterior derogat priori*,”² and the principle of *lex specialis* (Zorzetto, 2024). The analysis showed that the principles of *pacta sunt servanda*, good faith, and silence play a key role in international space law. The principle of *lex specialis* is also important in assessing the relationship between international space law and international law. Finally, international space law has emerged as part of international law in a fragmented context of international law. This analysis is based on the work of the International Law Commission. Since special or autonomous regimes are considered in this context as derogations from the norms of international law, they are never truly independent or self-sufficient (Cirkovic, 2021: 147). Although the terms “special regime” and “autonomous regime” are used interchangeably in this study, this does not mean that individual areas of international law can exist in isolation, without any connection to any other area of international law. While special regimes have specific rules that apply only to their own areas, they rely on general international law to formulate general principles and regulate issues that are not covered by their (special) rules (Graham et al., 2023).

Although different schools of law have attributed different characteristics to this principle, the perspective of this article is based on the assumption that its application does not require a conflict of norms. Two contradictory legal norms may “point in the same direction” rather than being contradictory. The principle of *lex specialis* is defined as applicable at the normative level and leads to a specific legal assessment of legal norms or rules, rather than to the interpretation of the entire field of law. Based on the study of the fragmented structure of the International Law Commission, it can be concluded that international space law constitutes a special field of international law due to its specific rules of international responsibility (Freeland & Ireland-Piper, 2022).

The study also shows that different areas of law are not mutually exclusive; provisions from these areas can be used simultaneously to establish legal rules on specific issues. It is clear that provisions of international space law, the law of contracts, and the law of international tort can be used in the context of international liability for space activities. This general conclusion can also be applied to specific issues covered by international law that go beyond international liability for space activities (Schmalenbach, 2022: 523). The study, therefore, has wider implications, such as the definition of norms and the treatment of international law as a branch of law.

Although the Outer Space Treaty (Treaty, 1967) was adopted in 1967 and the articles on State responsibility in 2001, the study concludes that the basic concepts of international space law and international tort law are consistent. The articles on State responsibility are based on decades of international case law and govern a number of existing legal rules. The adoption of the articles on State responsibility represents a significant advance in this area of law. Based

¹ Committee on the Peaceful Uses of Outer Space (COPUOS), UNOOSA, online materials and COPUOS session reports.

² The principle of *lex posterior derogat priori* is also known as ‘later law repeals the earlier law’.

on existing legal interpretations and principles, it significantly clarified the legal principles and application of the international law on State responsibility; this development was confirmed by subsequent practice. The drafters of Article VI of the Outer Space Treaty³ therefore referred to the concept of international responsibility during the negotiations, and this concept is reflected in the articles on State responsibility (Stavros, 2021: 31).

This legal interpretation of the international responsibility of space activities focuses on the first and third sentences of Article VI of the Outer Space Treaty (Treaty, 1967), while examining other provisions relating to international responsibility in international space law. These provisions therefore repeat or confirm the previously adopted Article VI of the Outer Space Treaty (Treaty, 1967). This legal interpretation of the first and third sentences of Article VI shows that the essential difference between the law of tort and liability under international space law lies in the attribution of conduct to States and international organizations (Treaty, 1967). Under the law of international responsibility, in addition to attribution of conduct to State organizations, the conduct of non-governmental organizations can also be attributed only to a State with which they have a sufficiently close relationship (acting on behalf of that State) (Jasentuliyana, 2023: 11).

In contrast, under international space law, the scope of attribution is broader and includes the conduct of any non-governmental organization that meets the criteria of a State. As regards the international responsibility of international organisations under Article VI, it is no longer claimed that they are responsible for the acts of “States,” but rather for the “acts” of international organisations and their Member States (Lawrence et al., 428). The broad perspective of the international responsibility of space activities can be explained by the extremely dangerous nature of these activities, which include the activities of any non-governmental organisation (State) engaged in space activities, may also fall under the responsibility of the State to which it is a party or of the international organisation carrying out the activities. The relationship between international responsibility and the law applicable to space activities is discussed below. The applicable law essentially consists of an article of international space law which sets out the principles of this area of law (Article VI of the Outer Space Treaty) and a body of law which develops from the codification of that law and may be relevant to its application (the law of international responsibility) (Boley & Byers, 2021). A consistent legal interpretation of Article VI therefore requires the use of the general framework for assessing international responsibility set out in the articles on the responsibility of States and the application of the methodology of that framework (Boley & Byers, 2021).

The draft articles on State responsibility apply international responsibility to internationally wrongful acts and are directly related to both the acts and omissions of subjects of international law (in this case, States). This is consistent with the second reference to international responsibility in article 6: to ensure the conformity of the actions of States with the provisions of the Convention, thereby establishing a mechanism for the enforcement of international responsibility as international law. This second reference to international responsibility for space activities is, therefore, a defining element of Article 6 and constitutes the legal basis for assessing international responsibility for any space activity. Article 6 must be read in conjunction with Article 3 of the Outer Space Treaty, which provides that space activities are subject to international law, including the Charter of the United Nations. An internationally wrongful act may therefore be based on a breach of a provision of a space treaty or of other provisions of international law, including the Charter of the United Nations. In applying the law of international responsibility to the interpretation of Article 6 of the Outer Space Treaty,

³ Art. IV of *Outer Space Treaty*

particular attention should be paid to the concept of international responsibility in these two areas of international law (O'Donnell, 2023).

According to the current understanding of international liability law, based on the articles on State responsibility and the responsibility of international organisations, the two situations in which liability under Article 6 is examined must be assessed separately (Levchenko et al., 2021: 73). The concept of “authorised States Parties” in Article VI of the Outer Space Treaty often overlaps with the concept of launching State, creating a harmonious link between the two articles. There are fundamental differences between the two concepts including the concept of “acts of a State” in Article VI emphasises the process of action, while the designation of the launching State is a factual assessment that freezes the moment at which an object is launched into space and is therefore more stable (Levchenko et al., 2021: 73). The article deals with the situation where ownership of an object is transferred from the (original) launching State to a State that is not considered to be the launching State. While international liability and registration of the object can be dealt with and redistributed bilaterally (or multilaterally) between the States concerned, this does not affect their effect under international space law. Under such a treaty, the acquiring State (non-launching State) may assume a contractual obligation to fulfil the resulting international liability obligations and thus assume the compensation obligations under the bilateral (or multilateral) treaties. Even after the sale of the bilateral (or multilateral) treaty, the original launching State cannot waive its obligation to pay such compensation under international space law (Wulandari et al., 2023: 139). Therefore, the adage “once a launching State, always a launching State” still applies, and States (or States Parties) that are parties to the space treaty and/or its successor treaties (the Liability Treaty and the Registration Treaty) may legitimately turn to one or more of the original launching States to present their claims if they believe that they have a better chance of obtaining compensation (Wulandari et al., 2023: 139).

The analysis shows that the concept of responsibility in international space law is closely linked to the law of international liability. It should be clarified that spacefaring States, as in other areas of international law, can be held internationally responsible for failure to fulfil their international obligations under space law (Abdelhamid & Wang, 2024). Clarification of the basic provisions of international space law would help to ensure compliance with these obligations. This provision is ambiguous in several respects. First, as with many other provisions of space treaties, there is no treaty that clarifies the concept of “principle.” Furthermore, there are no non-binding instruments, such as COPUOS, that clarify the basic concepts of Article VI of the treaty. Furthermore, no legal dispute or controversy has arisen at the international level to date in which one or more States have invoked this provision in court proceedings or other dispute settlement proceedings (Abdelhamid & Wang, 2024). It is important to note that, although Article VI is the subject of significant academic debate, some of the existing literature has only superficially examined the legal assessment of international liability for space activities. However, the scope of the debate in this area is relatively limited compared to other areas of space law. It can be argued that Article VI, or international liability for space activities, has never been addressed in detail. Given the evolving nature of space activities, the lack of a common understanding of Article VI of the Outer Space Treaty is a major concern (Stotler, 2025). The field of space is currently undergoing significant developments and changes, and the impact of these developments on the liability regime of international space law needs to be examined. Many of these developments can be summarized as the “modern space age,” which generally refers to the increase in space activities and the privatization and commercialization of space (Stotler, 2025).

The 1972 Convention on International Liability for Damage Caused by Space Objects (Convention, 1972) provides for strict liability procedures and requirements in certain circumstances. The Convention on Registration of Objects Launched into Outer Space ('Registration Convention') and related instruments provide for reporting and notification requirements. Under the centralized coordination of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) and the United Nations Office for Outer Space Affairs (UNOOSA), States are increasingly using national space laws to implement treaty obligations and regulate private sector actors (Li, 2023). These documents do not specify legal procedures for dispute resolution, nor do they address the role of AI in arbitration or alternative dispute resolution. However, they do establish important legal constraints which are the responsibility and obligations of States, the requirements for State control over private sector actors, the obligations of timely notification and assistance, and the importance of international cooperation mechanisms (Erhart & Boutovitskai, 2021: 20). Therefore, any regulatory approach to AI in alternative dispute resolution in space must be consistent with these treaty obligations and take into account its policy foundations which include security, peaceful uses, state control and accountability (Erhart & Boutovitskai, 2021: 20).

ADR and International Arbitration Framework

International arbitration is governed by model laws, such as the Convention on the Recognition and Enforcement of Foreign Arbitral Awards 1958 (New York Convention) and the UNCITRAL Model Law on International Commercial Arbitration (Convention 6 1958). The New York Convention replaced the Geneva Convention and its Protocols. It is the most important modern instrument in international commercial arbitration (Awada, 2023). Its comprehensive provisions serve as a universal charter for international arbitration practice, helping national courts and tribunals to establish a consistent and effective system for the enforcement of international arbitration agreements and awards. The Convention is the basis for most existing domestic laws governing international arbitration, including the UNCITRAL Model Law, which explains and implements the basic concepts and legal framework of the Convention. The New York Convention was drafted by the United Nations in 1969, before the establishment of UNCITRAL (Awada, 2023).

Notwithstanding, the main objective of the Commission's work programme is to improve the New York Convention. The New York Convention and the UNCITRAL Model Law are the most important instruments on international commercial arbitration. The main provisions of the Convention are as follows: "(a) Each Contracting State agrees in writing to submit to arbitration any dispute which has arisen or may arise between them in respect of any matter which is subject to arbitration under any legal relationship (contractual or otherwise); (b) Each Contracting State shall recognise the arbitral award as binding and enforce it in accordance with the procedural rules of the place where the award was made;" and (c) the recognition and enforcement of foreign arbitral awards may be refused only in certain circumstances (Uluç, 2023). The provisions of the Convention significantly change the global legal framework for international commercial arbitration by integrating the various aspects of the Geneva Protocol and the Geneva Convention into a single text. It creates a legal framework that governs international arbitration proceedings from the beginning (arbitration agreement) to the end (recognition of the award) (Zhang, 2025). The Convention provides a comprehensive framework for international arbitration agreements, arbitral proceedings, and arbitral awards. Arbitration awards continue to be attractive to space industry participants because they are widely applicable under the New York Convention and because the procedures can

be adapted to technical disputes (expert testimony, composition of the arbitration panel, confidentiality). However, arbitration rules and national laws often predate the emergence of AI simulation technology and do not directly regulate its use. Recent institutional guidelines and interpretations (and expert surveys) show interest in rules or guidelines on the permissible use of AI in arbitration proceedings, disclosure obligations, reliance on expert models and data protection (Proposal, 2021).

AI Simulation in ADR: Functions and Promise

AI simulation software can perform several functions in the context of alternative dispute resolution in the space industry (Ahmad, 2024: 273):

- **Forensic and Reconstruction:** reconstruction of collision trajectories, simulation of debris impact effects, or simulation of telemetry system failures. These simulations can also use physical machines to estimate probabilities with incomplete data, in addition to machine learning components.
- **Loss Prediction and Assessment:** Estimating revenue loss due to service outages, satellite wear, and replacement costs.
- **Evidence Classification and Discovery:** Processing large telemetry and technical data to identify timelines and gaps that are relevant to the parties to a dispute.
- **Predictive Analytics and Decision Support:** Generating probability estimates of outcomes for different cases based on precedents, expert opinions, and fieldwork datasets; generating solution scenarios to support negotiations or mediation (Chandra & Sanjaya, 2024: 21).
- **Decision Support for Arbitrators or Mediators:** Presenting scenarios, performing sensitivity analyses, and recommending decisions based on model results (Chandra & Sanjaya, 2024: 21).

These capabilities can significantly reduce costs, speed up dispute resolution, and increase technical accuracy, which is particularly important for disputes in time-sensitive and data-intensive sectors (Hodge Jr., 2024: 91). However, they also raise new legal and regulatory issues related to reliability, explanation, and procedural fairness (Rauch, 2024). Recent expert surveys show that almost everyone expects AI to soon be used in research and analysis methods in arbitration proceedings, but far fewer experts are willing to rely on AI to make a final decision (2025 International, 2025).

Key Regulatory Problems and Risks

Evidence and Admissibility: Probative Value of Simulations

AI simulations may appear scientific and convincing. However, the results of the models depend on the assumptions (initial conditions, model parameters, noise treatment), the quality of the training data and the choice of methodology (Grimm et al., 2023). Without proper documentation and explanation, the simulations risk being perceived as black-box disputes. Parties, courts, and arbitrators must determine the rules governing the admissibility of AI results (is the simulation expert evidence? Is the model itself discoverable?), the standard of proof they meet, and whether courts can rely on simulations without corroboration from human experts. The treatment of expert opinions in the common law tradition (eg, the Dubert-style standard in some jurisdictions that focuses on methodological soundness) creates a similar situation for the admissibility of AI models (Seng & Mason, 2021: 241). Arbitral

tribunals and national courts enforcing or reviewing judgments may require verifiable verification and documentation (Vassiliades et al., 2021). Some commentators have argued that models should be accompanied by verification reports, datasets, disclosure of source code (or independent replication tests), and expert interpretation (Petry & Gassmann, 2025).

Transparency, Explainability, and Due Process

The results of AI simulations can affect the adversarial process. If one party uses a proprietary simulation to justify damages or causation, the other party cannot substantively challenge the model on the grounds of trade secrets or technical uncertainty. This undermines equality of resources. In the case of ADR, important principles for ensuring due process include the obligation of disclosure (which must be provided), the right to independent expert review, and minimum standards for interpreting AI results in arbitration or mediation. Institutional rules should require parties to provide model documents or allow for the appointment of independent technical assessors (Chukwuebuka, 2025).

Liability, Responsibility, and State Oversight

Outer space treaties hold states accountable for their activities in outer space and often provide for strict liability for specific damages. If AI simulation software influences the outcome of a dispute (for example, if an arbitration tribunal later awards damages based on a proprietary simulation of the at-fault party), the question arises, who should be liable for damages suffered by the claimant due to model errors, the model developer, the party using the model, the experts relying on the model, or the arbitration tribunal? National professional liability laws (eg, attorney or expert negligence) can fill these gaps, but the involvement of states in cross-border enforcement and private liability makes the situation even more complex. States that license or regulate entities operating in space may be under pressure to meet minimum standards for the accuracy, verification, and auditing of AI tools used in regulated activities (Von der Dunk, 2015).

Confidentiality, Data Protection, and Export Control

Space activities involve sensitive data (telemetry data with potential military applications, proprietary technology data). AI simulations often require large datasets; Sharing these datasets as part of an ADR audit may violate confidentiality agreements, national security considerations, and data protection laws (Brown, 2022: 11). In addition, some jurisdictions impose export control or technology transfer restrictions on certain AI models and related datasets. Therefore, regulators must align ADR audit disclosure obligations with privacy protection and export control regimes; this is an important technical and legal consideration (Khan, 2024: 14).

Enforcement and Recognition of AI-Informed Awards

Under the New York Convention, judicial review of arbitral awards is generally limited. However, if the award is based on an unsound AI model (eg, withholding information and denial of the right to a hearing) and shows procedural deficiencies, courts may refuse enforcement on grounds of public policy. The risk of differences in application across jurisdictions encourages courts and parties to engage in potential judicial review, ensuring transparency in the process (Born, 2020: 1).

Regulatory Approaches: A Layered Model

Since the use of AI simulations in ADR involves several areas (technical standards, evidentiary law, arbitration, national licensing, and international obligations), a layered regulatory approach is preferable. This section proposes a range of administrative options aimed at striking a balance between innovation and fairness.

International Soft Law and Standard-Setting (UNOOSA/COPUOS)

UNOOSA/COPUOS is a natural multilateral forum for discussing guidelines for dispute resolution in AI and space. COPUOS already plays a role in developing best practices, standards, and non-binding transparency measures for space activities. COPUOS/UNOOSA guidelines (or a 'soft law' framework) could:

- Encourage States to include provisions for dispute resolution in space activities (eg, disclosure obligations, right to independent verification).
- Recommend that States monitor the use of AI models by private companies for safety-critical activities and encourage national licensing authorities to include validated simulation standards for safety-critical activities.
- Recommend the establishment of a registry of technical standards managed by UNOOSA containing validated simulation standards, test datasets and validation protocols for common use cases (collision hazard modelling, service disruption assessment, waste modelling).

Soft law is politically feasible and helps to harmonise national practices without conflicting with treaty obligations (Colombo et al., 2025). The COPUOS mandate and existing capacity-building, guidelines for responsible conduct in space, and workflows in national legal databases provide a suitable platform for such work (Anderson, 2022).

Model Rules from UNCITRAL and Arbitral Institutions

UNCITRAL has a long history of developing model laws and rules to harmonise practical expectations across jurisdictions (Quiroga, 2024). UNCITRAL Model Rules on the Use of Artificial Intelligence in International Commercial Arbitration/Online Dispute Resolution (or a link to the Model Rules) could harmonise key requirements: disclosure of AI tools used to provide evidence, standards for model validation, the right to appoint independent technical reviewers, confidentiality safeguards and minimal restrictions on human oversight of automated decision-making tools (Pratidina et al., 2024). The institutions (ICC, LCIA, SIAC, ICSID, and ICDR) should also develop specific procedural rules and guidelines that require parties to disclose the use of AI simulations and guide arbitral tribunals on their admissibility and weight. Many institutions and commentators have stressed the urgency of developing rules in this area (Chojcecki & Nappert, 2021).

Arbitral Practice: Model Clauses and Contractual Governance

Parties to commercial transactions should be encouraged (and sometimes required) to include dispute resolution clauses that specifically address the use of AI. Model clauses:

- Require prior notification and submission of model documentation (scope, inputs, assumptions, versions, validation results).
- Provide for the appointment of independent technical experts (or joint experts) when the dispute involves a simulation.

- Allocate the costs of model validation and establish rules for confidentiality and handling of sensitive information.
- Clarify the extent to which parties agree to classify AI or use simulation results as conclusive evidence. Standard model clauses are available in the UNCITRAL and UNOOSA database and can be used by broadcasters, operators and major insurers (Abbott & Elliott, 2022).

Institutional Accreditation, Technical Standards, and Certification

International Organization for Standardization (ISO) and other industry organizations, including the Institute of Electrical and Electronics Engineers (IEEE) and the International Electrotechnical Commission (IEC), should develop industry-specific standards for the validation of space simulation models, such as data source, metadata requirements, uncertainty quantification, repeatability protocols, and stress tests (Ashraf & Mustafa, 2025). An “ADR-level” simulation software certification system (similar to aviation safety certification) would help arbitration tribunals and parties assess the reliability of the model. While certification does not eliminate disputes over model assumptions, it would increase the underlying trust and reduce the likelihood that the public will accept simulation results as evidence (Sankaran, 2025).

National Regulation and Supervisory Frameworks

States should consider integrating the management of AI simulations into national space licensing systems. Where States authorize space flights and operations, licensing conditions could require the use of validated simulation tools for safety-critical analyses to support forensic analysis in future disputes (Langston & Brickhouse, 2024). National professional liability regimes should be updated to clarify the obligations of practitioners when using or presenting the results of AI simulations in alternative dispute resolution. In addition, data protection and export control laws may require specific exemptions or protocols for sharing sensitive data sets in ADR (Gritsenko, 2024).

Practical Procedures for Tribunals and Mediators

To put the principles into practice, practitioners should take practical steps:

1. Early disclosure: Parties should disclose the use of AI simulations at the pre-trial hearing and provide a summary of the model and its role. This will help the court determine the scope of disclosure and scrutiny early on.
2. Model documentation package (“model manual”): Parties using the simulations should develop a model manual that includes a description of the model, data sources, pre- and post-validation reports, sensitivity analyses, a description of the methodology (to the extent permitted by intellectual property rights) and a clear explanation of the assumptions.
3. Independent Reproducibility Review: If the model is a central issue, the court should consider conducting a reproducibility review by an independent technical panel or qualified experts. If reproducibility is limited due to proprietary restrictions, the court may take mitigating measures (eg, a closed hearing under a protective order).
4. Procedural Hearings: In technical disputes, arbitrators may hold preliminary hearings that focus solely on procedural and admissibility issues to avoid the contested model issues dominating the case.

5. Transparency of Methodological Limitations: Arbitrators and mediators should require parties to disclose known limitations and margins of error; AI decisions should be presented as uncertainty bounds and sensitivity analyses, not as definitive facts.
6. Human oversight rules: Parties should ensure that AI-based solution proposals that are the basis for a binding decision are reviewed and approved by competent human decision-makers. This ensures both human accountability and judicial review of decisions.

These measures enable the effective use of AI while being consistent with the principles of fairness and equity (Hussein, 2025). These measures can be implemented through company rules or court orders (Sherborne, 2022).

Insurance, Evidence Preservation, and Costs

Space actors often rely on insurance (both on-site and off-site). Insurers play a key role; they determine the acceptability of data collection and certain simulations in the assessment and valuation of losses (Raizner, 2022). Insurance companies may be required to use approved models or have the right to independent verification. Parties should anticipate these requirements and preserve raw telemetry data and chain of custody records to ensure the integrity of evidence. The costs of expert reconstruction tests and model inspections should be allocated in advance in a contract or court order to avoid a “winner-takes-all” imbalance (Raizner, 2022).

Case Studies of AI Simulation Tools used in Different Sectors

There have been several case studies where the AI simulation tools are used in different sectors, including aviation, satellite operations, and other analogous sectors. One of the prime examples of the aviation sector is Delta Air Lines (Reed, 2023). There were important challenges faced by Delta Air Lines to optimize the flight operations and enhance the experience of the passengers amid the global air travel’s complexities. Some of the key problems were preventing and predicting maintenance issues for reducing the delays in flights and improving safety. For resolving this issue, Delta employed the AI algorithms for analysing the data from maintenance records and aircraft sensors. This helped it in predicting the key problems before leading to the operational disruptions.

Besides the aviation sector, the organizations working within the satellite operations sector, mainly including NASA and SpaceX, have used the AI simulation tools to ensure that there are more efficient results obtained from their operations. For example, in the case of Starlink of SpaceX⁴, intelligent algorithms are used by the constellation for autonomously optimizing and managing the satellite movements, avoiding collisions and allocating bandwidth dynamically. This helps the network adapt to the demands in real-time and ensures the effective operation of thousands of satellites.

Recent Policy Developments in Global AI Governance

Considering the changes in the contemporary era involving technologies, there have been notable recent policy developments in the global AI governance that mainly include the implementation of the EU AI Act (2024), the U.S. Executive Order on Safe, Secure,

⁴ See <https://starlink.com/technology>

and Trustworthy AI (2023), UNESCO's global AI ethics framework, and the ongoing UN discussions on AI regulation. The EU AI Act is deemed as one of the most comprehensive regulations that has been enforced to regularize the use of AI. There are three main categories of risks that are assigned under this very law. Firstly, systems and applications that lead to the formation of unacceptable risks, such as the government-run social scoring system used in China, are banned under the EU AI Act. Secondly, the applications with high risk are deemed to be subject to particular legal requirements, which mainly include a CV-scanning tool that provides a specific rank for the job applicants. Lastly, the EU AI Act covers the category involving the applications that are implicitly listed or banned as containing high risk and not regulated.

Similarly, there was another major policy development noticed when President Joe Biden signed the U.S. Executive Order 14110 on Safe, Secure, and Trustworthy AI (2023). This was seen as a comprehensive effort from the United States for managing the risks and advantages of AI, specifically across the federal government and society as a whole. With these very developments in the AI policy, there was a national policy established for the governance of AI that directed the agencies working with the federal government of the United States to implement the particular actions stated in the Executive Order.

Following the recent developments at the global level on AI, UNESCO also contributed to the efforts of ensuring that the developments in science and technology are done with core ethical guardrails. Thus, UNESCO was the first organization to introduce the global standards on AI ethics, namely, the "Recommendation on the Ethics of Artificial Intelligence." This very policy initiative was focused on the widespread policy action areas that gave permission to the policymakers for translating the core principles and values into action with regard to social well-being and health, research and education, gender, ecosystems and environment, and data governance.

A Policy Roadmap: Recommendations (Summary)

1. International Guidance via COPUOS/UNOOSA: Development of a non-binding instrument on the use of AI simulations in space activities and alternative dispute resolution mechanisms (including model contract clauses, best practices for the provision of information, and standards for technical verification).
2. UNCITRAL Model Procedural Rules or Notes: Development of model rules on the use of AI and evidence in international commercial arbitration (UNCITRAL, 1985) and online dispute resolution to harmonize expectations regarding the provision of information and technical verification.
3. Institutional Rule-Making: Leading arbitral institutions should include clauses on the provision of information and AI expertise in their rules and procedural values.
4. Technical Standardization and Certification: Encourage the International Organization for Standardization/Institute of Electrical and Electronics Engineers (ISO/IEEE) and industry associations to develop industry-specific verification standards and accreditation processes for space simulation tools.
5. Contractual Safeguards: Parties to commercial space agreements should adopt standard rules on AI (including disclosure, independent verification, confidentiality agreements, and cost-sharing).

6. National Licensing and Supervisory Measures: States should include simulation verification requirements in their national space licensing systems and clarify the rules on professional liability for AI-enabled expert testimony.
7. Capacity Building: Develop the capacity of developing countries to understand and evaluate AI simulations through training and open, verifiable datasets provided by the UNOOSA.

Conclusion

AI simulation software has significant potential to make ADR in space trade faster, more technologically advanced, and more accessible. However, technological uncertainty, data sensitivity, and the potential for unequal access require a careful and multi-layered regulatory approach. The rise and development of the private sector in space activities from the 1980s to the present day, including the modern space age, have been directly influenced by the interpretation of this article. However, there is currently a lack of a comprehensive understanding of all the elements of this article, its possible interpretations, and, most importantly, Article VI of the Outer Space Treaty in international space law. This is a well-structured assessment, a systematic and comprehensive approach that clarifies the relationship between Article VI of the Outer Space Treaty and other provisions of both international law and the Outer Space Treaty.

International space law provides a basic framework for State responsibility; arbitration and alternative dispute resolution mechanisms provide practical tools and party autonomy. Coordinated action is now needed, and the recommended actions must be taken as follows. UNOOSA/COPUOS should lead the initial harmonization of multilateral policies; UNCITRAL and leading arbitration bodies should develop procedural rules; technical standards organizations should develop verification and accreditation protocols; and parties should implement treaty-based safeguards. This multi-layered approach – such as soft law, procedural rules, technical standards, and national licensing requirements – allows the international community to fully exploit the benefits of AI while supporting justice, accountability, and the rule of law in disputes arising from their context.

References

- 2025 International Arbitration Survey: The Evolution of International Arbitration (2025) Queen Mary University of London & White & Case. Available online: <https://www.qmul.ac.uk/arbitration/research/2025-international-arbitration-survey/>
- Abbott, Ryan, and Brinson S. Elliott (2022) Putting the artificial intelligence in alternative dispute resolution: how AI rules will become ADR rules. *Amicus Curiae*. Vol. 4 No. 3. <https://doi.org/10.14296/ac.v4i3.5627>
- Abdelhamid, Mohamed, and Guoyu Wang (2022) Addressing the Liability Regime in the Space Convention: A Legal Reformation of the Concept of Damage and Its Application to Private Entities. *US-China L. Rev.* 21 (2). <https://doi.org/10.17265/1548-6605/2024.02.001>
- Ahmad, Nadia (2024) Smart Resolutions: Exploring the Role of Artificial Intelligence in Alternative Dispute Resolution. *Clev. St. L. Rev.* 73: 273.
- Anderson, Dorcas Quek (2022) Interculturality in Online Dispute Resolution (ODR) 1. In *The Routledge Handbook of Intercultural Mediation*. Routledge: 67-76.

- Ashraf, Zahid Ali, and Nadeem Mustafa (2025) AI Standards and Regulations. In book: *Intersection of Human Rights and AI in Healthcare*: 325-352. <https://doi.org/10.4018/979-8-3693-7051-3.ch014>
- Awada, Ghada M. (2023) Alternative Dispute Resolution (ADR) for International Commerce Disputes through UNCITRAL. *Russian Law Journal*. Vol. 11, No. 5: 2993-3008.
- Boley, Aaron C., and Michael Byers (2021) Satellite mega-constellations create risks in Low Earth Orbit, the atmosphere and on Earth. *Scientific Reports*. Vol. 11 (1): 10642.
- Born, Gary B. (2020) International commercial arbitration. *Kluwer Law International*.
- Brown, David (2022) *Artificial Intelligence for Accelerating Nuclear Applications, Science, and Technology*. No. BNL-223196-2022-INRE. Brookhaven National Laboratory (BNL), Upton, NY (United States).
- Chandra, Rushil, and Karun Sanjaya (2024) *Artificial Intelligence and Law*. Academic Guru Publishing House.
- Chojecki, Sarah, and Sophie Nappert (2021) Evidence in International Arbitration through the Looking-Glass of the Digital Economy. *BCDR International Arbitration Review*. Volume 8, Issue 1. <https://doi.org/10.54648/bcdr2021032>
- Chukwuebuka MKPO, David (2025) Is Truth and Integrity of Justice on Trial in the Age of Artificial Intelligence (AI)? Re-Assessing Digital Evidence in the Context of AI-Generated Evidence such as DEEPFAKES. *International Review of Law and Jurisprudence (IRLJ)*. Vol. 7 No. 1. <https://www.nigerianjournalonline.org/index.php/IRLJ/article/view/1710/1604>
- Cirkovic, Elena (2021) The next generation of international law: Space, ice, and the cosmolegal proposal. *German Law Journal*. No 22 (2): 147-167.
- Colombo, Camilla, Peter Martinez, Francesca Letizia, Benedetta Cattani, Emmanuelle David, Diego Escobar, Satomi Kawamoto, Robert Rovetto, and Ivan Sumelzo (2025) Space capacity management and its interaction with space traffic management. *Acta Astronautica*. No 1.
- Convention on International Liability for Damage Caused by Space Objects (1972) United Nations Office for Outer Space Affairs. Available online: <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introliability-convention.html>
- Convention on Registration of Objects Launched into Outer Space (1975) United Nations Office for Outer Space Affairs. Available online: <https://www.unoosa.org/oosa/sk/ourwork/spacelaw/treaties/introregistration-convention.html>
- Convention on the Recognition and Enforcement of Foreign Arbitral Awards (1958) United Nations Office for Outer Space Affairs. Available online: <https://uncitral.un.org/sites/uncitral.un.org/files/media-documents/uncitral/en/new-york-convention-e.pdf>
- Erhart, Luca, and Maria Boutovitskai (2021) Transforming article VI of the outer space treaty into an effective mechanism of space debris mitigation. *Proc. 8th European Conference on Space Debris (virtual)*, Darmstadt, Germany.
- Freeland, Steven, and Danielle Ireland-Piper (2022) Space law, human rights and corporate accountability. *UCLA Journal of International Law and Foreign Affairs*. Volume 26, Issue 1.
- Graham, Thomas, Kathiravan Thangavel, and Anne-Sophie Martin (2023) New challenges for international space law: artificial intelligence and liability. In *Proceedings of the 17th International Conference on Space Operations, Dubai*. United Arab Emirates.
- Grimm, Paul W., Maura R. Grossman, and Gordon V. Cormack (2021) Artificial intelligence as evidence. *Northwestern Journal of Technology and Intellectual Property*. Vol. 19. Iss. 1.

- Gritsenko, Kat (2024) Arbitration as a Dispute Resolution Mechanism for Cross-Border Intellectual Property Disputes. *CYBARIS*. Vol. 15. Iss. 3.
- Hodge Jr, Samuel D. (2024) Is the Use of Artificial Intelligence in Alternative Dispute Resolution a Viable Option or Wishful Thinking? *Dispute Resolution and Arbitration Commons*. Vol. 24. Iss. 1: 91.
- Hussein, Emad (2025) AI Meets Mediation: Shaping the Future of Dispute Resolution in a Digital World. *Arbitration: The International Journal of Arbitration, Mediation and Dispute Management*. Volume 91, Issue 2.
- Jasentuliyana, Nandasiri (2023) *International space law and the United Nations*. Brill: 17-68.
- Khan, Ms Zaiba (2024) *Introduction To Artificial Intelligence and Human-centric Computing*. OrangeBooks Publication.
- Klein, John J. (2024) *Space warfare: Strategy, principles and policy*. Routledge. Pp. 23-53.
- Langston, Sara, and Anthony Brickhouse (2024) Charting the Course: Considerations and Frameworks for Investigating and Regulating Commercial Spaceflight Safety. *New Space*. No 12 (1): 54-66.
- Lawrence, Andy, Meredith L. Rawls, Moriba Jah, Aaron Boley, Federico Di Vruno, Simon Garrington, Michael Kramer et al. (2022) The Case for Space Environmentalism. *Nature Astronomy*. No 6 (4): 428-435.
- Levchenko, Igor, Shuyan Xu, Stéphane Mazouffre, Michael Keidar, and Kateryna Bazaka (2021) Mars colonization: beyond getting there. Available online: https://www.researchgate.net/publication/336179113_Mars_Colonization_Beyond_Getting_There
- Li, Du (2023) Cyber-attacks on space activities: Revisiting the responsibility regime of article vi of the outer space treaty. *Space Policy*. No 63: 101522.
- Moltz, James Clay (2024) *Crowded orbits: Conflict and cooperation in space*. Columbia University Press.
- O'Donnell, Scarlet Sarah (2023) *International Responsibility for Activities in Outer Space in the Modern Space Age: Article VI of the Outer Space Treaty in the context of international space law and public international law*. Lund University. Vol. 1.
- Petry, Jens and Tom Gassmann (2025) Artificial intelligence in dispute resolution: developments, challenges and perspectives for legal practice. Reuters. Available online: <https://www.reuters.com/legal/legalindustry/artificial-intelligence-dispute-resolution-developments-challenges-perspectives-2025-07-11/>
- Pratidina, Safira, Atip Latipulhayat, and Irawati Handayani (2024) Arbitration as the Dispute Settlement Method to Address Harmful Interference in the Age of Mega-Constellations of Satellites. *Padjadjaran Journal of International Law*. No 8 (1): 1-18.
- Proposal for a Regulation laying down harmonised rules on artificial intelligence (Artificial Intelligence Act) (2021) 206 final. European Commission.
- Quiroga, Marta Gonzalo (2024) The Use of Emerging Technologies in Out of Court Dispute Management Procedures: International Legal Approach and Regulatory Challenges. *Review of International and European Economic Law*. No 3 (6).
- Raizner, Josh (2022) Covered? Insurance Viability in the New Space Age. *Geo. J. Legal Ethics*. No 35: 1057.
- Rauch, Terry (2024) AI in IA: To What Extent and Capacity Can Artificial Intelligence Assist in International Arbitration Procedures and Proceedings? Available at SSRN 5100706.
- Reed, Ted (2023) How Delta Air Lines Uses AI. Forbes. Available online: <https://www.forbes.com/sites/tedreed/2023/12/07/how-delta-air-lines-uses-ai-yet-avoids-hallucinations-on-steroids/>

- Sankaran, Sridharan (2025) Enhancing Trust Through Standards: A Comparative Risk-Impact Framework for Aligning ISO AI Standards with Global Ethical and Regulatory Contexts. <https://doi.org/10.48550/arXiv.2504.16139>
- Schmalenbach, Kirsten (2022) Convention on international liability for damage caused by space objects. In *Corporate liability for transboundary environmental harm: An international and transnational perspective*. Springer International Publishing.
- Seng, Daniel, and Stephen Mason (2021) Artificial Intelligence and Evidence. *Singapore Academy of Law Journal*. No 33: 241-279.
- Sherborne, Andreas KE. (2022) The Commercialisation of Space: An Overview of Legal Risks and Considerations. *Risk Management in Outer Space Activities: An Australian and New Zealand Perspective*: 19-46.
- Stavros, Stephanos (2021) *The guarantees for accused persons under Article 6 of the European Convention on Human Rights: An analysis of the application of the Convention and a comparison with other instruments*. Brill. Vol. 24: 31-89.
- Stotler, Charles (2025) Interpretation as Creation: Article VI of the Outer Space Treaty. 26 *Chi. J. Int'l L.* 99.
- Sturdevant, Rick W. (2024) The Evolution of Commercial Space and Its Integration with US Military Space. In *The Rise of the Commercial Space Industry: Early Space Age to the Present*. Cham: Springer International Publishing: 253-290.
- Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space* (1967) United Nations Office for Outer Space Affairs. Available online: <https://www.unoosa.org/oosa/en/ourwork/spacelaw/treaties/introouterspacetreaty.html>
- Uluç, İnan (2023) Binding Arbitration of Disputes Arising from Space Accidents. *Law and Justice Review*. No 25: 51-88.
- UNCITRAL (1985) Model Law on International Commercial Arbitration, with amendments as adopted in 2006. UN. Available online: https://uncitral.un.org/en/texts/arbitration/modellaw/commercial_arbitration
- Vassiliades, Alexandros, Nick Bassiliades, and Theodore Patkos (2021) Argumentation and explainable artificial intelligence: a survey. *The Knowledge Engineering Review*. No 36.
- Von der Dunk, Frans (2015) International space law. In *Handbook of space law*, pp. 29-126. Edward Elgar Publishing.
- Wulandari, Sinar Aju, Izzah Khalif Raihan Abidin, Zainal Abidin Achmad, and Muhammad Ardy Prakoso (2023) The Obligations and Rights to Obtain Compensation as a Result of the Space Objects Discovery. *Jurnal Sosial Humaniora (JSH)*. No 16 (2): 139-151.
- Zhang, Luping (2025) The Modernization of Interstate Space Dispute Settlement Mechanisms. *Advances in Space Research*. No 1.
- Zorzetto, Silvia (2024) The Principle Lex Specialis: A Critical Explanation. 46 *Rev. Derecho Privado* 15.