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Navigating the Convergence of Artificial Intelligence and Space Law: Challenges and Opportunities

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Abstract

The space industry is one of the most technologically advanced industries that aims for scientific explorations that benefit humanity on multiple fronts. Further, Artificial Intelligence (AI) technologies comprise game-changing tools that could be utilized to facilitate space exploration aims. The emergence of AI in the space industry would evolve how both industries look. Since many challenges in the current space industry could be addressed by implementing artificial intelligence, space objects will create *"Intelligent Space Objects"*. Different studies were conducted to explore the implementation of AI technologies in space activities and their legal implications. The scope of this paper goes beyond the existing work. It will investigate the main AI applications in space and then explore their legal challenges, including issues related to regulations, liability, and policy questions. Accordingly, it will discuss the need for developing a novel legal framework to address these challenges, creating a strategic opportunity for international collaboration between states and organizations that will contribute to advancing space law. This study will review, evaluate, and analyze the current situation and recommend ways to establish a novel international space organization.

Keywords: Artificial Intelligence; Space Law; Convergence; Challenges; Opportunities.

1. Introduction

Artificial Intelligence (hereinafter referred to as "AI") was first coined in 1956 by Stanford Professor John McCarthy, who described it as "the science and engineering of making intelligent machines, especially intelligent computer programs. It relates to using computers to understand human intelligence, but AI does not have to confine itself to biologically observable methods." Other subject matter experts also attempted to define AI, and all of the definitions illustrate in simple words that AI is how a computer mimics human intelligence without involving biological methods [1]. Since 1956, AI has evolved to intersect with all aspects of our lives, especially with the technology humans use daily. The past two decades marked the rapid development of AI, which is renovating how life looks as it emerges in the public and private sectors, civil society, and academia [2]. AI is a comprehensible term to be interpreted very simply; it could be illustrated as Machine Learning (hereinafter referred to as "ML"), which Woolf describes as "a system's ability to acquire and integrate knowledge through large-scale observations and to improve and extend itself by learning new knowledge rather than by being programmed with that knowledge" [3]. Expressly, ML is training a computer under the supervision of humans, where the system is fed with training data to automate the process of solving specific tasks.

On the other hand, computers that are trained without human supervision and utilize Artificial Neural Networks in complex architectures to perform their functions are trained in a process called Deep Learning (hereinafter referred to as "DL"). IBM described DL as "a subset of machine learning, which is essentially a neural network with three or more

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layers. These neural networks attempt to simulate the behaviour of the human brain, allowing it to "learn" from large amounts of data. While a neural network with a single layer can still make approximate predictions, additional hidden layers can help to optimize and refine for accuracy" [4].

Training the computer with or without supervision depends on the user's application. Users usually employ different methods, such as support vector machines, decision trees, and K-nearest neighbours, for shallow ML to achieve their purposes. At the same time, DL is traditionally utilized for high-dimensional data and large domains, as could be illustrated in the Convolutional Neural Networks and Recurrent Neural Networks models that were compared by IBM as "commonly used for natural language processing and speech recognition, whereas convolutional neural networks (ConvNets or CNNs) are more often utilized for classification and computer vision tasks. Before CNNs, manual, time-consuming feature extraction methods were used to identify objects in images" [5].

AI's capabilities are deemed necessary with the large amount of data being harnessed from space missions. It is being recognized by many space agencies and private actors to promote and enhance the performance of space activities. Moreover, the success of space missions intersects with the perfect performance of the algorithms, communications architectures between the space and ground segments, and the computer models developed to aid the mission, as represented by authors in Sudmanns et al. [6], James & Roper [7], and Samal [8]. In all these areas, AI could be exploited to improve the operation of space missions toward its success. AI in space applications is well known in data and image processing for remote sensing, such as CO_2 emissions concentration monitoring or detecting environmental changes.

Also, it is proposed to integrate AI into satellites for air and maritime traffic control [9]. Further, it is suggested that cloud computing use satellites instead of ground-based systems. It is also essential to mention the large satellite constellations that are being developed nowadays in the space industry and that will revolutionize its nature due to the high number of satellites being launched by space actors and that will double fold the mass of the lower earth orbit. The end-to-end communication in the constellations will be dependent on AI systems to synchronize the transmission of data and control of satellites while in orbit [10].

This research aims to review the main studies examining the admissibility of governing AI technologies in international space law. It will highlight its importance by presenting the legal challenges of emerging AI technologies in the space industry. This research will contribute in the following ways:

- Presenting current AI applications in space;
- Assess the current legal regime governing AI in space;
- Compare other relevant legal frameworks to govern AI in space;
- Address the international community toward the future of AI impacts on space activities.

The research will have its central focus on the following questions:

- How is AI being implemented in the space sector?
- What are the main applications of AI in space?
- How will AI benefit space exploration?
- What are the legal challenges of AI implementation in space?
- How is AI important to the international space community?

The rapid advancement of AI in space technologies is encouraging more success in the space industry; however, it poses legal challenges concerning space activities and AI in space due to the lack of jurisdiction in space law, drafted in the 1960s [11]. Hence, this paper is divided into the following sections: Section 2 presents the research methodology; Section 3 reviews the present and future of AI in space; and Section 4 explores AI technologies in space legal challenges, including challenges related to liability and regulations. Section 5 will recommend developing a legal framework to govern AI applications in space. Section 6 offers the conclusion.

2. Research Methodology

This research paper was written on the basis illustrated in Figure 1. First, relevant studies and literature were reviewed to determine the status and gaps in recent research. Second, the central research questions were formulated according to the obtained information. Third, the analysis of the selected literature and data presented to relate important research topic variables. Fourth, involves proposing recommendations based on the study findings. Fifth, the researchers assessed the legal framework to govern AI in space. The research paper aims to show how AI technologies would evolve the international space community's legal regime to create opportunities from the challenges posed by implementing such technologies.

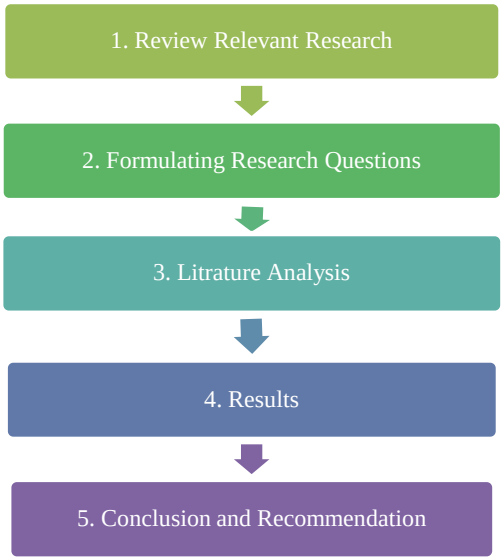

Figure 1. Research Methodology

3. AI Applications in Space Activities

In this section, different AI applications that are currently implemented will be discussed to explore the potential of their advancement. Also, the future of AI applications will be discussed to formulate an idea of what legal challenges could escalate from the future of AI in space.

3.1. Current AI Applications in Space

SpaceX announced in 2021 that its Starlink satellite constellation is equipped with a collision avoidance system powered by AI. The announcement came after an incident involving the close approach of 190 feet-miss of collision between SpaceX and OneWeb satellites [12]. The AI collision avoidance system, in general, continuously monitors the position of the constellation's satellites relative to its surroundings. It makes decisions about maneuvering when necessary, either with or without human supervision. However, with such systems, at least the satellites could communicate with the operators to alert them of possible collisions. Moreover, if the system is entirely independent of the operator, takes a particular decision, and explains its action, it depends on the AI system's maturity. If it is capable of contextual adaptation or abstraction, then it will justify; if it is just a simple AI system, it will only operate to achieve its high-level objectives [13].

Moreover, the data obtained from satellites brings different kinds of benefits to humankind. One of these benefits is earth imaging. Earth observation is one of the most popular missions space actors invest in due to the high demand from major companies worldwide. Many oil companies require satellite images to monitor their oil plants and operations to detect pipeline leaks [14]. Other manufacturing companies also inspect the impact of harmful gas emissions from their premises and determine if any concentrations are being formulated. Methane and CO_2 concentrations could have negative consequences leading to the escalation of climate change driving factors, such as the increment in the global temperature or forest fires, which subsequently cost governments billions of dollars in health care and reconstruction. Thus, the satellite imaging industry is highly demanded, similar to the image processing market.

Google and Maxar are two industry giants that provide high-resolution earth images [15], while companies such as Satelytics [16] process those images using AI-driven algorithms to provide the oil industry and other manufacturers with images and data related to their activities, as illustrated previously. AI is currently being implemented to automate the process of image processing rather than the traditional image processing methods; it is also adding more reliability due to its capability of making predictions and could also be utilized in urban planning and national security.

Those examples illustrate the current applications of AI in space. It also reveals the necessity of creating a solid bridge between space operators and AI developers to accelerate the development of both sectors toward more fruitful outcomes that will be represented in the next section.

3.2. Future AI Applications in Space

As discussed, the current AI applications represent a constructive influence on outer space activities. The advancement of AI technologies and the partnership between AI developers and space actors may shape the future of space missions as many space agencies plan to launch satellite constellations into Lower Earth Orbit (LEO). This phenomenon is wider than governmental bodies because private space actors are increasingly active players due to the

high demand for the services constellations could provide in LEO. These include providing high-speed internet with reduced latency to unserved communities and establishing the Internet of Things (IoT), defined as "*a dynamic global network infrastructure with self-configuration and interoperable communication. IoT means the ability to make everything around us, starting from machines, mobile phones, cars, cities, and roads, connected to the internet with intelligent behaviour and taking into account the kind of autonomy and privacy*" [17].

These technologies' return on investment for private space actors such as SpaceX will be beneficial; however, it will result in the congestion of LEO. Thus, Space Traffic Management (hereinafter referred to as "STM") [18] is needed to govern such activities, which could be achieved using mature AI technologies to be implemented in the space segments of these constellations for collision avoidance. It could also enhance how satellites operate entirely autonomously and interact with each other to adjust their attitude and settings to aid the traffic in orbit.

Further, AI could facilitate the space robotics concept [19]; for example, a rover capable of making its own decision to detect and classify objects or to repair itself and adjust during the mission in a completely autonomous way. These robots will enhance deep space missions to other planets to achieve more in space sciences, exploration, and exploitation [20]. For this to be achieved, the adoption of laws and policies that shed light on these technological advancements is required to govern such activities due to their complexity and to ensure the responsible and peaceful use of outer space. Indeed, space mission integration with AI is beneficial, but only when used to the advantage of all; however, these technologies could be used differently. Hence, it is imperative that AI applications in space need to be addressed in specific laws and policies to govern them.

4. AI Technology in Space Legal Challenges

AI technologies could be considered another loophole in international space law, as they could cause many concerns as long as legal space instruments do not cover them. One of the main challenges with AI technologies in space is the liability issues that will be discussed after reviewing the situation of AI applications in international space law.

4.1. AI Technologies in International Space Law

The United Nations (UN) space treaties, namely, the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies (Outer Space Treaty), the Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue Agreement), the Convention on International Liability for Damage Caused by Space Objects (Liability Convention), the Convention on Registration of Objects Launched into Outer Space (Registration Convention), and the Agreement Governing the Activities of States on the Moon and Other Celestial bodies (Moon Agreement) were drafted between the 1960s and 1970s to illustrate the international space law. Since then, the technologies have developed with time; however, the treaties have remained untouched.

The current international space law governs the fundamental activities in outer space, such as claims of sovereignty in outer space or any celestial body are not valid; the exploration and exploitation of outer space and other celestial bodies should be maintained to the benefit of all humans and countries without discrimination; cooperation is the fundamental principle of space activities to benefit all other states; space activities should be performed in compliance with international law, etc., as demonstrated in the Outer Space Treaty [21]. As AI advances to reach outer space activities, it is not mentioned in any treaties, which could threaten the international space community in many aspects. Recently, the UN Committee on the Peaceful Use of Outer Space discussed the issue related to the utilization of AI in space.

In 2018, its annual report raised the issue of using AI in satellite imagery processing and how the rapid advancement of technologies could foster and, vice versa, affect space exploration. Space powers and international organizations deemed it necessary to regulate the usage of AI in outer space, and different legal initiatives were adopted as "soft laws" to achieve that purpose. For instance, the United States proposes creating a federal agency to regulate AI [22]. Further, the Russian Government released an order in 2019: "*On approval of the concept for the development of regulation of relations in the field of artificial intelligence and robotics technologies for the period up to 2024*" [23].

This could be extended to cover the area previously mentioned regarding space robotics. Thus, the international space law community needs to take measures to regulate AI technologies in space due to the issues that may arise from their utilization. The Liability Convention does not highlight any issue related to the use of AI in space activities, which raises a significant concern due to the fact that states responsible for these intelligent space objects will not be able to justify the decision of their assets in space due to their automation while taking decisions [24].

4.2. Liability Issues related to AI Technologies in Space

The autonomy of intelligent space objects is the main worry in the liability context. As mentioned, the UN space treaties do not cover any of the AI technologies in space; however, the outer space treaty established the responsibility of states in articles VI and VII by stating:

Article VI:

States Parties to the Treaty shall bear international responsibility for national activities in outer space, including the moon and other celestial bodies, whether such activities are carried on by governmental agencies or by nongovernmental entities, and for assuring that national activities are carried out in conformity with the provisions outlined in the present Treaty. The activities of nongovernmental entities….

Article VII:

Each State Party to the Treaty that launches or procures the launching of an object into outer space, including the moon and other celestial bodies, and each State Party from whose territory or facility an object is launched, is internationally liable for damage to another State Party to the Treaty or its natural or juridical persons by such objects or its parts on the earth, in air space or outer space, including the moon and other celestial bodies [21]*".*

Article VI generally describes wrongful acts in space as states' responsibilities, as it implies by affirming *"International responsibility"*. Also, it put forward that the satellites operated by nongovernmental entities should be licensed by the state authorizing them and under its supervision. In this context, satellites that will implement any AI technologies need to be approved by the state they are registered in; this relates to the fact that states will have to bear the responsibility of the AI incorporated in those satellites to ensure their security, especially since those satellites will have high levels of automation. However, Article VII introduced the liability of states toward their assets in outer space and further illustrated this matter in the Liability Convention through Articles II and III, as stated:

Article II:

A launching State shall be liable to pay compensation for damage caused by its space object on the earth's surface or to aircraft flight.

Article III:

In the event of damage being caused elsewhere than on the surface of the earth to a space object of one launching state or 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 [25]*".*

As the liability convention was drafted to elaborate the seventh article of the Outer Space Treaty, the articles stipulated provide the fundamentals of imposing liability on states for their assets' activity in outer space. The convention defines the launching states as "(i) A state which launches or procures the launching of a space object; (ii) A state from whose territory or facility a space object is launched" [24] from the perspective of the convention, states in case of any damage caused by their satellites, will have to bear the liability. However, when AI is involved, how will the Liability Convention govern its obligations in such a context? The main issue will arise from who is liable due to a problem caused by a fully automated space object. An explanation is necessary for the party that sustained the damage in such an event. Further, the Outer Space Treaty and the liability convention established the regime of responsibility and liability for states, but neither appropriately defined those terms, which will cause ambiguity when dealing with intelligent space objects.

AI is foreseen as a tool that could support the exploration of outer space and enhance its safety and security; however, it could also be used to threaten these aspects if it were misused [26]. Furthermore, the implementation of AI in space objects is imposing a mounting global risk due to its high capabilities for automation, which could be used to invade privacy and data. Thus, there is an essential need to establish a legal regime for using AI in space, stipulating all aspects of the risks that it may cause to assure its safe and secure use in space and guarantee that its implementation is being used responsibly by states.

5. Recommendations for the Development of a Legal Framework Governing Ai in Space

The UN is the current international body governing states' space activities through its committees and treaties; however, these legal instruments should align with the recent technological advancements in the space sector. One of the proposed solutions is to expand the ability of the UN committees through the establishment of an international specialized agency, like the International Civil Aviation Organization (ICAO), which governs every aspect of civil aviation, and the International Maritime Organization (IMO), which regulates maritime activities by assuring their safety, security, and prevention of pollution of our planet.

5.1. The International Civil Aviation Organization

ICAO was established under one of the oldest legal instruments ever drafted, known as the Convention on International Civil Aviation, or the Chicago Convention, referring to where it was signed. It came into force by 1947 after 52 states signed it internationally on Dec 7, 1944 [26]. Currently, the ICAO consists of 193 member states. The civil aviation industry is one of the world's most advanced and regulated industries due to its high maintenance of safety

and security. This was only possible with the role that the ICAO plays; even though the Chicago convention came into force around 75 years ago, the ICAO maintains it through its annexes, which keep updating towards the best practices in the aviation industry. The 19 annexes comprise documents hosting the Standards and Recommended Practices (SARPS), Guidance Manuals (GMs), etc., covering the most important topics to keep the industry in line with technological advancements. Of course, aircraft back in the 1940s were not the latest Airbus or Boeing aircraft we see today; however, both were governed by the same legal instrument. Thus, the success of the ICAO in regulating the civil aviation industry is important to be taken as an example of regulating technical concerns relating to space activities.

5.2. The International Maritime Organization

IMO was established in 1948 under the International Convention for the Safety of Life at Sea (SOLAS) and came into force by 1958, and the first task assigned to it was amending SOLAS. The organization's primary purpose was to keep the conventions up to date and promote safety. As its mission statement states, "The mission of the International Maritime Organization (IMO) as United Nations Specialized agency is to promote safe, secure, environmentally sound, efficient, and sustainable shipping through cooperation. This will be accomplished by adopting the highest practicable standards of maritime safety and security, the efficiency of navigation, and prevention and control of pollution from ships, as well as through consideration of the related legal matters and effective implementation of IMO's instruments with a view to their universal and uniform application" [27, 28].

Since 1960, IMO has shed light on international maritime traffic and other essential aspects of the marine industry and amended the SOLAS six times between 1965 and 1973. Currently, the organization comprises 175 member states maintaining the industry's highest standards of technological advancement through its legal power. Further, the organization adopted protocols and conventions, such as the International Convention for the Prevention of Pollution from ships, drafted due to oil spillage while transported. In 1967, Torrey Canyon marked the disaster by spilling 120,000 tons of oil. Also, two other treaties were adopted in 1969 and 1972, the International Convention on Civil Liability for Oil Pollution Damage and the Convention relating to Civil Liability in the Field of Maritime Carriage of Nuclear Material, respectively [2]. These conventions were adopted to establish a system that would support the compensation to parties that suffer from pollution caused by maritime activities. IMO's role in the marine industry is crucial in maintaining the highest standards of safety and security and assuring the reliability of the systems being implemented in the industry.

5.3. Questions Related to the Development of AI Policy

A uniform legal framework to regulate AI applications in any field has yet to be created [29]. Thus, the policies governing AI applications in space raise will raise many concerning questions that could be represented by the following:

- Do governments have the intention to acquire the benefits of AI?
- Is investment deemed necessary to promote the research and development of AI systems?
- Is strategy on national levels necessary to address AI technologies' implications?
- What are the implications of intelligence in space on the operators? Who is responsible for the acts of intelligent space objects in cases of decision-making that result in a collision in space?

The emergence of AI technologies in space will automate satellites' operations in orbit. The impact on the industry will be major in terms of posing responsibility and liability on operators, which could even escalate further when involving the insurance of assets in outer space. The responsibility and liability ideology in the space industry plays a crucial role since it is posed on states in the first place, which requires states' oversight of the nongovernmental space operators. Hence, the emergence of AI technologies will require international policies to guide states in addressing the above questions.

5.4. The Establishment of an International Space Organization

A specialized agency governing space-related activities is necessary for the international community to maintain outer space's safety, security, and sustainability. In sections 4.1 and 4.2, two of the functionally specialized agencies of the UN were discussed to highlight the importance of having an updated scope of work represented with regulations to govern an activity. One interesting point of view is that both agencies were established under well-defined legal instruments; however, these instruments were adopted after finding a serious issue that needed to be regulated. The difference between those industries and the space industry is that the current technological advancement, such as the emergence of AI technologies [30, 31], could severely impact the international community if not addressed by a legal instrument. Thus, the previous lessons from other industries should be considered to address the issue related to space activity, not wait for a catastrophe to regulate its impact. Space safety and security should not be risked nor compromised due to their high importance and benefits. Hence, adopting new conventions superseding the current set of outdated international space laws that address the fundamentals of space activity is of utmost importance.

The challenges relating to the use of AI technologies in space could be an opportunity to create a positive impact through the enhancement of the space industry by creating a space-specialized agency of the UN to govern the current activities through the adoption of new treaties. Such treaties may oversee the activities of large satellite constellations [31] through an adequately developed STM that includes the different aspects related to governments, agencies, and private stakeholders. This will result in a dramatic change in the industry towards a safer, more secure, and more sustainable environment for space actors, consequently creating a more reliable and stable situation. Further, the newly formed agency would contribute to developing AI usage regulations from many aspects, particularly the liability of intelligent space objects, which was discussed as a challenge in the previous sections. This issue could cause severe chaos in the space environment due to its implications for the space debris issue. Currently, the regulation that addresses this issue does not exist, and space debris [32, 33] needs to be defined in the current legal framework of international space law. Moreover, the implementation of intelligent space objects could extend to issues related to privacy protection. To ensure the ethical and responsible use of AI technologies in space, the newly established organization could implement similar mechanisms as ICAO and IMO in updating legal instruments through annexes or protocols to keep technological advancement and the legal framework parallel.

ICAO will differ from the space organization due to the different technologies in use and the harsh environment of space. However, an organization like the ICAO is a feasible solution to address the issues relating to STM, as space standards could be set by an international space commission, which would have to keep the standards monitored and updated [34]. Implementing such measures would be harder for space applications since space is unrestricted by boundaries. However, the uniformity in ATMs is appealing, as the ICAO is putting distinguished efforts into maintaining the industry at the highest level of conformity and safety. Further, the SARPs are soft law instruments that could also be used to address the issues related to intelligent space objects' technical guidance is necessary to regulate AI activities in space, particularly if it is used in a manner to address the technical and regulatory regimes of such implementations.

Like the mixture of hard and soft laws that harmonize ATM and MTM, it is necessary to develop rules to govern STM. As a minimum standard to initiate the STM regime, it might be useful to adopt soft laws that will pave the way toward an internationally uniform and standardized regime of STM. Space AI technologies constitute one of the issues that should be regulated and harmonized to ensure the uninterruptible provision of services and benefits of space technologies. Consequently, there is a need to amend the existing hard laws governing space activities.

The value of the global space market reached 424 billion US dollars in 2022 and is expected to grow to 737 billion US dollars in the next decade, which makes it very attractive for other sectors to invest in Vanleynseele [35]. As discussed, the AI industry is directly related to the advancement of the space sector. The establishment of an international space organization will not only enhance the usage of AI technologies in space but also drive the stakeholders of the AI industry to develop a more reliable system due to the high level of competition in the market and increase the return on investments for the stakeholders. This creates an opportunity that can have significant implications for the advancement of both the AI and space sectors from a technological, economic, and legal point of view. Thus, it is recommended that a novel International Space Organization be established under a convention that would bring states to the same understanding of the importance of space activities' sustainability. In addition, establishing such a novel organization will contribute directly to advancing a mutual legal framework that will bring other relevant international organizations and stakeholders towards more success and advancement in parallel with developing laws and policies governing space activities.

6. Conclusion

The use of AI technologies in space became one of the main focuses in both industries. The convergence of both would resolve many challenges emerging from deep space exploration, exploitation, and the utilization of its benefits. Many governmental and private space actors invest in such technologies to advance and explore outer space. For that to be achieved, intelligent space objects could be widely used to automate the activities in outer space, which would not only cut the cost for space actors but also save time toward the utilization of human resources in doubling the efforts in outer space. A brighter future of space exploration could be foreseen with the emerging AI technologies; however, such technologies may raise legal issues related to liability and data protection that could delay enhancements and contradict transparency when dealing with others. Such cases should be considered, but not in a manner that would stop the progress in both fields; it is undoubtedly true that AI technologies will aid automation, robotics, and STM.

Therefore, this article emphasizes facilitating the emergence of AI challenges in space as an opportunity for the international space community to reconsider the UN treaties by utilizing the efforts to establish an International Space Organization to help the space actors achieve their goals and objectives in space by governing their activities through standardization and harmonization of the regulations, just like how it works in the aviation and maritime industries. This will contribute to the novel legal regime of outer space, particularly in addressing the issues discussed in the article. Further, it should be noted that the recommendation of this article, if considered by the international space community, could be used to alter and fit many issues related to outer space since the proposed international space organization could have a broader scope that covers the governing body of all space activities.

Space sustainability plays a crucial role in characterizing the space environment, and we should not wait for a catastrophe to happen before acting and resolving the issue. However, the current international space system needs to catch up to technological advancement and requires efforts to unite them on a single page. Hence, further research in this field is required, and the current observations in this aspect, along with other observations from other elements such as space traffic management, could be taken into consideration to formulate preliminary solutions to address these concerns and push the wheel forward towards sustainable, peaceful use of outer space. It is also important to note that the space industry scholars and subject matter experts should work in an actionable manner to promote establishing such an organization that will aid space sustainability, a core pillar of safe operations in the earth's orbit.

7. Declarations

7.1. Author Contributions

Conceptualization, I.A., and M.F.; methodology, I.A.; validation, I.A., and M.F.; formal analysis, I.A., and M.F.; investigation, M.F.; resources, I.A.; data curation, I.A., and M.F..; writing—original draft preparation, I.A.; writing—review and editing, I.A. and M.F.; visualization, I.A.; supervision, M.F.; project administration, M.F.; funding acquisition, I.A. All authors have read and agreed to the published version of the manuscript.

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7.5. Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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