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Apprehensions with Regard to Commercial Space Flight: Outlook on Space Law

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The advent of "space tourism" has induced outer space law to respond and adapt to this dramatic growth because of the principled contribution of private entities in these activities. This article discusses the main legal aspects of licensing, supervision, liability, registration, and health side effects, and how these reveal the influence of space tourism. Because of the moral participation of private individuals in these activities, "space tourism" demands that outer space law be modified and adaptable. Although many issues of ship, crew, and passenger certification have not been defined in international law, these would be evaluated to show that domestic legislative interests may drive the law before it reaches international law. Air and adventure tourism laws are also evaluated. Space are not likely to remain limited to professionally trained individuals and wealthy astronauts. The potential for public access to space raises complex legal, health-related, and ethical questions on the inadequacy of the current international legal instruments addressing the utilization and exploration of outer space. Furthermore, this study is designed to evaluate the role of human presence in spaceflights, accidents that occurred to participants of space missions, and other risks spaceflights may induce on humans. In addition, this study focuses on analyzing existing legal regulations related to astronauts' health and life protection during spaceflight and how states can address emerging challenges to astronauts' safety. The existing global legal framework regulating aviation and space operations is unsuitable for the widespread commercial entry into space. This is because it was designed when drafters did not envisage such endeavors to this extent. The insufficient legal clarity should be addressed rapidly to set applicable standards to promote such activities. To conclude, this article compares national space regulations and elaborates on the drawbacks of the current international space regulations.

Keywords: space tourism, risk to space flights, consequences of space environment on human health, international legal space regime

1. INTRODUCTION

Laws and policies have governed the world for as long as humanity can remember. The Code of Hammurabi is one of the earliest written codes officially announced by Babylonian King Hammurabi during his reign from 1792 to 1750 B.C. (Horne 1915) Codifying laws and regulations highlights the importance of governing relevant activities and knowing one's rights and responsibilities. However, as the world moved toward the 1900s, not knowing the unknown placed the world at curiosity. What is space, where does it start, what is considered a space activity, and what are our rights and responsibilities for such activities? All of these required clarity and uniformity, specifically toward the launch of the Soviet Union Sputnik 1 in 1957 (Siddiqi 2017). What is space law? Space Law is a branch of international law that is regarded as the body of norms that govern states' international relationships (Jasentuliyana 2023). It is also the "broadest of principles that govern how states act in outer space." (Lyall & Larsen 2017). Uniformity is an important term and aspect of codifying space regulations, considering that sovereignty does not apply in outer space but rather to a state's sovereignty over its territory. Therefore, states cooperate and collaborate

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on all spatial activities. The function of the United Nations (UN) here plays a significant role. The UN Charter binds its member states to their international relationships and highlights their "sovereign equality" (UN 1945). This resulted in the adoption of UN instruments. The UN General Assembly (UNGA) has established the "Committee on the Peaceful Uses of Outer Space (COPUOS)" (Jessup & Taubenfeld 1959) for the better satisfaction of humanity. It governs space activities and all its attached functions and requirements. It has adopted five international treaties that specify provisions for relevant space activities (Space Law Treaties and Principles UNOOSA 2017).

Many nations have established their own space-related laws. However, they have not consistently included provisions concerning "space tourism". Given this article's restricted focus, we confine our discussion to a brief overview of how private human spaceflight is regulated at the national level.

The main space powers are the parties to the UN space treaties excluding the Moon Agreement 1979 (UN 1979). The first treaty, the outer space treaty (OST), was the most ratified, with 112 state members. The remaining four, with equal importance, address different aspects of space activities. However, a few of them are less ratified (UN 2024). Space-faring nations have shown significant interest in space activities and have expressed their interest in space by establishing Space Agencies and adopting legislation specific to space. The 21st century has been filled with significant developments, with countries racing to be the world's first to introduce exclusive services such as commercial space transportation. The spotlight on space activities is heavier than ever.

With all these newly emerging space activities, how do the UN Instruments and National Space Legislation (NSL) regulate space transportation effectively and efficiently while considering its commercial and legal aspects? These commercial and legal factors include boosting the economy while maintaining a level of passenger safety identical to that of commercial space flights (CSFs), and establishing the liability of space transportation operators.

2. SCOPE OF COMMERCIAL SPACE TRAVEL

Tourism is currently the largest industry in the world. Russians may be able to revive their space programs by utilizing this potential. Although the National Aeronautics and Space Administration (NASA) has performed outstandingly in leading the US space program thus far, it is valid to investigate its economic and scientific prospects, as well as space exploration. The potential value of assisting patients with balance problems on Earth is excellent.

In the absence of specific international laws governing space activities such as space tourism or space resources, individual countries have taken them upon themselves to regulate these issues at the national level. Some nations have enacted legislation that promotes the commercialization of space, including space tourism. For instance, Australia's 1998 Act provides protection for private space sector activities. The US, a major player in space, introduced legislation in 1984 and amended it in 1988 to grant certain powers to the private sector. Additionally, countries such as Luxembourg, Japan, and the United Arab Emirates (UAE) have established regulations concerning space resources and mining.

Countries such as Great Britain, Ukraine, Finland, Portugal, and New Zealand regulated their space activities through separate acts or bills. In the commercialization process, beyond ensuring safety and proper operational procedures, the economic factors (i.e., profitability) are also important. Government authorities should issue commercial spaceports and operating licenses only after assessing operators' ability to ensure public safety, protect property, and safeguard the environment. A spaceport is any location where spacecraft is launched, taken off, or landed. However, it is not specifically defined by US national or international law. Each spaceport must have appropriate facilities and equipment, and all operations must be insured. In the US, spaceports were initially used solely for military purposes. Eventually, these transitioned to private ownership. Government spaceports engaging in commercial activities and commercial spaceports must comply with registration and licensing requirements, although government ports performing only governmental functions are exempt from these regulations. Spaceports are classified into terrestrial and offshore. The safe return of crew members, passengers, and cargo using reusable launch vehicles (RLVs) is crucial in space tourism. The system must be operational and quality-checked while delivering economic benefits. To operate such a business, various procedures are required. In particular, these are related to transportation and include ship equipment, route types, insurance for crew and passengers, emergency procedures, and space port infrastructure. Space travel is no longer a mere concept in science fiction. It has become an almost everyday experience for people (Denis 2020).

2.1 The United States of America

Owing to the lack of international guidelines on space tourism, the US government had to deal with various issues

during the emergence of various US-based tourist spacecraft projects. In the US, the intention is to register SpaceShipTwo as a spacecraft although it will operate as a glider and perform other activities. This approach is very different from those of other countries where the same idea is being pursued. At the national level, certification is a down-to-earth process. Although there is little harmonization in aviation, all the procedures and requirements for certification are left to the national authorities of the country. This is beneficial for the entire aviation industry and Europe as a whole. Virgin Galactic was asked to seek Part 25 certification for its SpaceShipTwo spacecraft without an obligation to do so. This is essentially without any obligation to do so.

The Crew Act refers to individuals who perform activities related to the launch, re-entry, or any other operation of a launch vehicle or re-entry vehicle that carries human beings. The people onboard Virgin Galactic's SpaceShipTwo are referred to as flight participants. However, the company's CEO stated that the medical risks would most likely be the highest among passengers. This raises concerns regarding the liability of passengers in air transportation. Currently, this issue is addressed primarily because of the requirement to clearly inform passengers about the dangers of a flight. This effectively excludes him from claiming liability under the Act. Essentially, this regime involves a licensing obligation applicable to launches conducted in the US or by US persons or legal entities overseas. This obligation is usually accompanied by a financial responsibility requirement equivalent to the lowest of the three requirements.

2.2 The Russian Federation

Another company planning to offer space trips is Rocket Plane. In this case, an aircraft would be used as the launch vehicle for the mission. This concept is legal in Russia and carries certain risks and requirements that affect aircraft registration and certification. This characteristic also qualifies Russia as a launching state under the provisions of the European Union's Liability Convention. In 2010, Russia enacted national space law requiring all entities involved in space activities to obtain licensing obligations. The most convenient solution for Russia is through a Clause in the Law of the Federation on Space Activities. It states that Russia's jurisdiction pertains to Russian space objects. This implies that aircraft carriers used for launching space objects should be registered in Russia. It is not yet clear whether the Russian authorities have the necessary legal tools to address this issue. Consequently, it is possible that the licensee would be held liable for any third-party claims made against them.

2.3 The United Kingdom

So far, only the US has drafted legislation on space tourism. However, other states have not yet decided on their legal frameworks to address this issue. As Virgin Galactic is a UK-based company, it is not considered a US entity. Its operations will be conducted in the state of New Mexico. Virgin Galactic flights, if they occur, would likely trigger UK responsibility under the OST. This could also be argued as allowing flights to bring about the state's obligation to launch. This could mean that the UK is liable for the actions of entities incorporated in the United to carry out the launch of a space object or operate it in the UK. This is in accordance with the UK's national space law. Under certain circumstances such as those wherein arrangements have been made between a country and the UK regarding the operation of space tourism, a license is not required. The UK Secretary of State can also waive the license obligation if the applicant satisfies the requirements to secure a license. It is not necessary to ensure that the UK's international obligations are met.

2.4 United Arab Emirates

Other states such as the UAE are not far behind in terms of space tourism plans. Space Adventures (a US-based company) is subject to the same legislation as the other entities involved in the spaceport industry. As such, it would be liable for the liabilities applicable to the UAE. The UAE has ventured into the commercial space sector and developed a regulatory structure to supervise diverse space-related undertakings. The UAE Space Agency (UAESA) is responsible for overseeing the nation's commercial space activities including the industries such as space tourism. Companies intending to conduct suborbital spaceflights in the UAE would probably need to apply for licenses and permits from the agency, similarly as how the FAA operates in the US (UAESA).

Under national space law, commercial space travel is subject to licensing and regulation by the UAESA (UAE 2023). Private companies that wish to engage in commercial space travel must obtain a license from the agency and comply with the safety and security requirements. The law also addresses liability issues related to commercial space travel. It establishes a framework for determining the liability in the event of accidents or damage caused by commercial space activities, and requires companies to carry insurance to cover potential liabilities (UAE 2022).

Overall, the UAE Space Law provides a supportive regulatory environment for commercial space travel. The country is positioned as a leader in the emerging space tourism industry. With its strategic location, modern infrastructure, and ambitious space goals, the UAE is well positioned to capitalize on the growing demand for commercial space travel in the years to come.

Commercial space transportation (CST) is a scheduled commercial flight operated by CSF operators that allows humans to experience space tourism. According to the Commercial Spaceflight Federation (USA), the main aim of CST is to develop and succeed in commercial spaceflights while achieving the required level of safety and providing members of the Commercial Spaceflight Federation with best practices toward achieving their aim (Chaddha 2010).

The UAE Space Law has defined the "Specified Area" to which the activities are targeted to be considered space activities. The definition of "Specified Area" per the UAE space Law is "any area that is at least eighty kilometers above the average sea level." So far, there have been two instances of national space legislation, the Australian Space Activities Act and Danish Outer Space Act. These have shown a tendency towards a spatial-centric perspective and defined the boundary using the Karman Line situated 100 km above sea level. Furthermore, it is an additional milestone that the UAE National Law has undertaken while identifying the space area to be 80 km or beyond, and to include any discovery or impact that results from the exploration or use of outer space (Dembling & Arons 1967).

3. APPLICATION OF INTERNATIONAL SPACE LAWS TO SPACE TOURISM

Since spaceflights purely for pleasure purposes were never envisaged in treaties governing space, this chapter briefly describes the concept of space travel as an area of international concern. Injecting pleasure into space was never considered an essential part of treaties governing space activities.

3.1 The Outer Space Treaty

The OST was created to allow the peaceful use of space, as well as the exploration and development of space technology. The concept of space tourism is considered a part of the OST. If the conditions are not restrictive, space tourism can operate as long as it is permitted as a point of departure. Article V of the Astronauts Charter also addresses the concept of envoys. This article was drafted to ensure that astronauts are treated in conformity with the standards of their profession. No diplomatic immunity has been granted to astronauts stranded in foreign countries. He is not entitled to immunity from the local jurisdiction. For instance, imagine an astronaut who must travel to a foreign country because of an emergency. Because there is a chance that an astronaut's actions could be violated while in space, their actions could be regarded as illegal. Therefore, the provisions of the Human Space Act were drafted to ensure that participating astronauts were fully aware of their responsibilities. Space tourists have always been considered non-astronauts. Their non-professional nature has raised the question whether they should be treated as such.

3.2 The Liability Convention

The main issue in space tourism operations is the uncertainty surrounding which liability standards should be applied. Article II of the Convention mentions absolute liability, whereas Article III refers to fault-based liability owing to negligence. It is also unclear whether the compensation for the damage caused by space tourism should have a maximum limit or remain unlimited. (Harrington 2017). These uncertainties are particularly important for insurance companies and make it difficult to determine appropriate coverage amounts. The liability convention for space tourist damage is an example of an OST law that is applicable to the present situation. It makes no distinction between the launch state and ultimate cause of damage. With regard to space tourism, the state has a duty to ensure that its activities are carried out in a manner consistent with its international obligations. As space tourism becomes more prevalent, this issue becomes a national (as well as any applicable) law enforcement process. However, it remains unclear which space-related commercial ventures are permitted to operate. Currently, there is no definite space delimitation. This means that Virgin Galactics' SpaceShipTwo can be considered a space object after it is completed and returns to Earth. This could potentially trigger the application of the liability convention in case of damage.

3.3 The Registration Convention

The liability convention applies to the OST and Registration Convention. This implies that the launching state retains jurisdiction over the space object and its personnel in space. If a person carrying tourists into space would like to register their space object, their jurisdiction would apply to the provisions of the OST. This difference is not relevant to the

aircraft or subject of the discussion. Generally, if a vehicle is defined as an aircraft, it is subject to the same jurisdiction as any other vehicle type. Additionally, with respect to space objects, the registration of such objects requires the establishment of a national registry. The obligations of such a registry are also implied by conventions.

The current legal uncertainty related to the classification of aeronautical vehicles creates a dilemma regarding the appropriate legal framework for their registration. Whether these vehicles should be registered as aircraft or space objects remains debatable. Under space law, the launching state is obligated to register the space object in its national registry and with the UN in accordance with Article II of the Registration Convention 1974 (UN 1974). Conversely, aviation law mandates that aircraft be registered and bear the nationality of the state of registry as per Article 17 of the Chicago Convention. A literal interpretation of Article II of the Registration Convention suggests that it should apply only to trips "to Earth's orbit or beyond." This implies that suborbital tourism, in which flights reach only suborbital altitudes, does not fall under its purview. Consequently, suborbital tourist activities are not subject to the requirements of Article II (Hobe 2004). The most practical solution to this registration issue is to amend the convention to require spacecraft registration only for the initial launch, with any subsequent launches reported to the appropriate state of registry.

3.4 The Rescue Agreement

The Rescue Agreement provides for the safe and proper evacuation of persons from spacecraft. It also refers to the rights of the people on a spacecraft to be assisted and evacuated safely. This is an important aspect of the OST. Although space tourists are widely believed to not have the same rights as other humans, this issue has been raised several times. This is a fallacy, as humanitarian duties applicable to humanitarian situations do not depend on the Articles of the UN Charter. These are derived from the principles and ethical considerations of international law. Are space tourists allowed to return safely without any conditions?

The main reason people enter space is to perform jobs. In other words, they do so for the same reasons as humans who have already entered space. From a legal perspective, it makes sense to treat space tourist vehicles as spacecraft, and not just individuals on board. This is because the Rescue Agreement provides for the rights of the spacecraft crew members.

When it comes to international space law, it is generally insufficient to focus only on the technical aspects of an issue and move on to other national legal actions. The concepts of jurisdiction and national law for space activities are based on the following three key parameters. These include the obligation of a state to oversee and authorize private entities' activities in space. The international liability for damage caused by space objects also applies to states if they decide to launch a rocket themselves because of the actions of private actors. This provides them with a strong incentive to exercise jurisdiction over those who suffer damages. As stated in the OST, a space object can be registered as one under certain conditions.

In addition, the question of whether the Space-Ship-Two-mode (the vehicle used for space tourism) is an aircraft or a space object has always been an issue that international law must consider. In terms of passengers and crew, this section addresses the various international laws applicable to both the parties. For crafts, this issue is more complex and involves more national laws.

3.5 Outer Space Treaty and Rescue Agreement: Astronauts vs. Personnel of Spacecraft

According to Article V of the OST, an astronaut should be regarded as an envoy for humankind [OST (Outer Space Treaty) 1967; UN 1966]. In contrast, the Astronaut Rescue and Return Agreement (ARRA) refers to astronauts as spacecraft personnel [RRA (Rescue and Return of Astronaut)1968; UN 1968]. The term "astronaut" does not have a legal definition. Therefore, we resort to the ordinary. According to NASA, an astronaut is a member of the crew onboard a NASA spacecraft launched into orbit. Therefore, an astronaut can be the captain of the spaceship, a pilot (captain understudy), or mission specialists such as scientists and engineers.

However, the exact meaning of this term remains debated. Therefore, it requires clarification regarding what legal protections modern international space treaties afford to space tourists, specifically regarding their status as "astronauts" or "personnel of a spacecraft" and their legal standing in relation to these protections (McCauley 2019).

We note the different qualifications and responsibilities of an "astronaut" and the fact that we do not have a legal definition of an astronaut per the UN Instruments. Considering the thorough qualification training and the timeframe required to become an astronaut, a CSF operator shall ensure the utmost safety of their CST. Therefore, the operator of the CSF shall ensure that sufficient training is conducted to qualify the passengers on board of a CSF for their commercial space journey and thereby, become eligible for the commercial spaceflight operation. This is assumed to

be undertaken by the UAE according to the UAE National Law based on its above-stated definition of "person."

International space law, in its broadest sense, governs state action in outer space. However, the space activities of each nation are governed by national space laws. According to the OST, nongovernmental organizations that engage in space activities must first obtain approval.

The relevant state party will supervise the said activities notwithstanding Article VI [OST (Outer Space Treaty) 1967; UN 1966] (Can Space Tourism be considered a Space Activity?) including other UN instruments did not explicitly identify the type of activities in outer space. We can assume that space tourism can be a part of space exploration, which provides comfort to private actors' activities in the form of commercial space transportation that will be authorized and monitored to allow for its safe operation and compliance with the provisions of the OST. However, to avoid uncertainty, national state legislation for participating in commercial space transportation should include space tourism as part of its national space activity. According to Article VI of the OST, a state party is held accountable internationally for operations carried out in space by domestic entities. This duty ensures that all space activities comply with UN resolutions. However, to apply Article VI of the OST within the framework of the Convention on International Liability for Damage Caused by Space Objects, it is essential to define the precise limit of outer space. This is because the applicability of international space law frequently rests on this demarcation.

The Federal Aviation Administration (FAA) is responsible for regulating and licensing commercial space transportation for private actors in the United States of America (Davidian 2017). Accordingly, the FAA authorized Virgin Galactic's commercial space transportation by updating its license to allow the space line to onboard and fly tourists to space (Madan & Halkias 2020), followed by Blue Origins. The FAA indirectly accepted and acknowledged that CST are considered a space activity by this authorization. In accordance with Article VIII of the OST, a state party that registers and launches a space object into outer space maintains both jurisdiction and control over that object, as well as any associated personnel. Therefore, based on the existing regulations, the CSF shall bear the state's nationality in which it has been registered. Accordingly, the state shall have jurisdiction and control over the CSF and its personnel that it launches into outer space.

3.6 Search and Rescue of Commercial Spaceflights

Article 3 of the ARRA states that if a state party receives information or discovers that the personnel of a spacecraft have landed on the high seas or any other location not under the jurisdiction of any state, certain procedures and obligations may come into play. These are typically related to the prompt rescue and return of those personnel to their home country or the country responsible for the space mission. The specifics of these procedures can vary depending on the terms and provisions of the ARRA [RRA (Rescue and Return of Astronaut)1968; UN 1968]. Therefore, other state parties' support can extend to areas that do not fall under state jurisdiction, such as space. However, the question remains as to whether a CSF has suffered an accident or incident that necessitated support. Can a state party, if possible, extend its support to CSFs?

Based on the lack of legal definitions for the terms "astronaut" and "personnel of aircraft" and on the acknowledgment accorded by the FAA to Virgin Galactic and Blue Origin by including space line to onboard and fly tourists to space, we can assume that tourists are considered as astronauts and/or personnel of spacecraft. Therefore, we can assume that state parties may render search-and-rescue missions following Article 3 of the ARRA to commercial space transportation based on their need for such support. Nevertheless, according to UN Instruments, the clear statement is that the activities performed by astronauts are subject to space law. On that basis, legal grounds and arguments may still arise on whether a state party is legally obligated (when possible) to render rescue and support missions to CSFs, and whether the relevant state party may be subjected to liability if it chooses not to render the relevant rescue and support.

The UN Instruments on the state party's legal obligation and responsibility toward providing rescue and support to the CST and personnel onboard commercial spacecraft is ambiguous. A clear and explicit responsibility of state parties to UN Instruments is mandatory to eliminate such ambiguity regarding a state party's responsibilities in rendering rescue and support missions in this regard. Such an explicit addition is recommended to include the CST as a part of space activity, in addition to identifying personnel onboard the spacecraft (regardless of their profession or purpose for onboarding the commercial spacecraft) as personnel of a commercial spacecraft who are eligible (in accordance with Article 3 of the RRA) for rescue and support missions.

3.7 Damage Corresponding to International Space Law

The LC adopted an approach different from that of the OST and RRA. The LC introduced supportive definitions to eliminate ambiguity and added clarity to its provisions. For

the functional scope and from the title of the LC (Convention on International Liability for Damage Caused by Space Objects), we observe that the governed activities are the damages that result from a launching state. However, the LC did not express that space activity causes the said damage or define space activity. According to Article 1(a) of the Liability Convention (LC 1972; UN 1971), the uncertainty in LC revolves around whether the CSF will be liable to damages caused to the persons on board the CSF due to the direct or indirect fault of the CSF or the personnel thereon, including human or technical error. This is because the LC addresses only the damage caused by a space object of a launching state to another launching state's space object or personnel thereon. The term "damage" was defined to include loss of life and personal injury in addition to the loss of or damage to property. We further note the necessity of identifying the explicit responsibility and liability of CSF operators and personnel thereon for this article. This is considering that the legal ground of the CSF is valid toward their liability based on the current regulations per the UN Instruments, regardless of the treaties per UN Instruments that the relevant state party has ratified and accordingly the CSF operator shall comply with.

Under international law, international responsibility is established upon breach of an international obligation. Private actors have established international responsibilities based on the relevant national space legislation. This is an indirect application of the Treaty to private actors. The appropriate state is internationally responsible for the acts of private actors' and can claim violations. Accordingly, through national space legislation, a state can ensure that private actors conform to the provisions of International Space Law, specifically to the ratified treaties [OST (Outer Space Treaty) 1967; UN 1966].

According to Article VI of the OST, the state party under which space organizations, whether governmental or non-governmental, hold international responsibility for their actions in space. This obligation also applies to activities on heavenly bodies such as the moon. In this example, the state party, the US, is internationally liable for the actions of these operators in the context of the FAA licensing of two space line operators for commercial space transportation. Therefore, it is the responsibility of the US to ensure that these operators abide by both national space laws such as the FAA regulations for commercial space transportation, and international space laws such as the OST. This demonstrates the importance of the state.

Article VII of the OST establishes that the launching state bears international liability for any damage caused to another state party to the treaty or to its natural or juridical persons as a result of a space object or its components impacting the earth, airspace, or outer space. This provision emphasizes the responsibility of the state that conducts the launch to compensate for any harm caused by its space activities. Ensuring accountability and protection for all the parties involved in space exploration and use is an essential element of international space law. When applying the provisions of Article VII to the CSF, ambiguity remains in identifying whether the term "damage" includes death or personal injury, the nature of liability, and whether the CSF operator will be internationally responsible for the personnel on board the CSF when suffering loss of life or personal injury caused by other factors such as a celestial body; a space object of another state party; or even the negligence of the commercial space operator or the captain, personnel, or crew thereon.

4. ILLEGAL ACTIONS ON BOARD A COMMERCIAL SPACEFLIGHT

Crimes are activities committed against letter or spirit of the law. People found guilty in a court of law are subject to punishment, especially if the punishment is harsh (such as imprisonment). It is crucial to emphasize that any violation of international law is subject to international accountability. The proper forum for examining and resolving legal disputes between nations in line with international law, as well as for providing advisory opinions, is the International Court of Justice. However, the above statement does not explicitly reflect the responsibility of the competent authority to look into criminal activities committed in space or onboard spacecraft, and clearly identify if multiple states are at stake. The most recent example of criminal activity comprises the acts of a NASA astronaut while undergoing divorce proceedings in the USA. The astronaut accessed her spouse's bank account through online banking without authorization by using the same, unchanged, bank account password, and availed confidential information of her spouse. This case may have been more complicated if this cybercrime or other criminal activity had taken place on a commercial spacecraft of State X. However, its outcome took place in State Y. Therefore, an update to the existing regulation must undergo an extensive study to include regulations that meet this century's various criminal activities and applicable jurisdiction(s).

4.1. Ensuring the Safety of Space Tourists on Board

It is a general principle of the International Civil Aviation

Authority (ICAO) that air consumer rights are established by each airline and airport. Here, the ICAO has provided non-binding general guidelines and principles on air consumer protection that the member states shall abide by upon establishing their own set of consumer protection rules based on their domestic and regional law (Abeyratne 2015). There is no unified practice for CST. Considering the literature and legal aspects of commercial space activities, UN Instruments lack similar guidelines that commercial spaceflight operators may enforce at the national level. The current assumption is that spaceflight personnel must resort to onboarding commercial spaceflights and bear complete responsibility for any damage, personal injury, or even death. It is also known that exemption from liability for death is illegal.

Therefore, unless the national space legislation includes an obligation for its private actors to bear responsibility and liability for damage, personal injury, and death, commercial spaceflight operators may have legal grounds to argue on the validity of the relevant claims. This will extend the proceedings and result in resorting to the judge's diligence in their ruling. This would then become a leading base for any future claims until the UN amends the existing UN Instruments or even introduces a new treaty to explicitly govern commercial space activity and its legal issues. Meanwhile, commercial spaceflight operators are recommended to follow a practice similar to that of the ICAO. Herein, CSF operators should establish a set of rules reflecting the rights and responsibilities of the operator and personnel onboard the CSF to ensure the safety of the personnel thereon, including property damage in all its forms, personal injury, and death.

4.2 Worth of the Spaceflights and Astronautics

The space industry has become dynamic and the most developing sphere in the modern realm. It is oriented toward new space exploration while also expanding human input in such activities, thereby forming the foundation for future space tourism. When new borders of space become more accessible and attractive to science because of the successful and widespread use of AI, the role of astronauts in space flights should not be neglected or underestimated. Astronauts play a vital role in gathering information on the space industry and discovering new aspects of human space exploration. Therefore, it is important to explore how the space environment impacts the health, behavior, and nervous system of astronauts exposed to harsh conditions that are abnormal for normal human lives and perception. Although many scientific studies have attempted to determine the influence of spaceflights on astronauts' health, many health-related issues still need to be solved, especially from a legal perspective. Hence, because the protection of astronauts' lives and health plays a pivotal role in safely exploring space and holding different missions, it is essential to establish how the space environment influences astronauts' brain and behavior and how space law regulates these aspects.

The produced effects of the space environment negatively influences human health conditions, mainly the nervous system and mental and physical health. This has raised awareness within the international community for mitigating such problems for further safe space exploitation and organization of missions with human participation. These improvements are also relevant for future space tourism. The increased levels of radiation, microgravity exposure, and prolonged isolation in a space environment without access to regular human resources on Earth negatively affect human health, body, and brain functioning. The analysis shows that during the post-flight phase, astronauts suffer not only from prolonged physical disabilities, but also from mental health disruptions and internal health problems that are sometimes not visible to the public, such as depression, feelings of sadness, and loneliness. Thus, the development of legal mechanisms related to the health protection of astronauts and other space crew personnel before and after spaceflight has become an emerging issue in the context of ongoing space exploration. Although the space industry is developing rapidly, the analysis shows that current international space regulations lack clarity and unity in protecting astronauts' lives and health.

4.3 Human Existence in Space: First Space Flights and Accidents

Human presence in space activities has always been vital in expanding space frontiers while also receiving a reasonable scope of attention from the scientific community and enjoying further development. It remains indisputable that space missions and flights are life-threatening pursuits characterized by a high risk of adverse or even fatal consequences. This continuously puts astronauts' lives at significant risk during space travel. Since the beginning of space exploration with human input, history has documented several accidents that occurred during space missions. One of the earliest and most famous cases was a lethal accident that occurred to astronauts during the Apollo program launched by NASA. Two American astronauts [Edward White, the first American to perform an extravehicular activity (EVA), and Roger Chaffee, a Corvette captain] were sitting in the Apollo-1 capsule on top of the Saturn rocket in the launch area. After

several hours of successfully staying in the cabin, a fire broke out suddenly. Even though the special rescue team tried to save the astronauts quickly, the fire had already spread to the astronauts' equipment, and they died of asphyxiation in the burned cabin. This was the first accident to occur during a space mission with fatal consequences for its crew. However, because the accident occurred on the ground and not in space, the accident scenes were relatively accessible to the rescue team. Hence, such situations are prone to easier solutions because the inaccessibility factor is expressed to a lesser degree.

Compared with accidents on the ground, more logistics problems arise when such occasions occur in space and are not manageable easily. For instance, the first lethal accident in space occurred to Vladimir Komarov during his flight aboard Soyuz-1 owing to the abnormal rotation of the spacecraft and later, the malfunction of the parachute. In this case, the ground team could not provide practical assistance to the astronaut immediately or fix the technical problems that he struggled with onboard. This left him with inevitable life-threatening conditions. Hence, this episode illustrates that the state failed to take all the necessary precautionary measures to protect the astronaut's life on the spaceboard, which was far from Earth. Nonetheless, officials did not face any liability consequences because the law did not provide any life-protective mechanisms. Accordingly, when the first space flights were unsuccessful and resulted in crew causalities, such negative experiences also stimulated states to develop protective mechanisms for astronauts' safety to avoid fatalities in the future.

4.4 Aftermaths of Space severe Environment on the Human Health

The space environment has a tremendous impact on the health, brain activity, and nervous systems of spaceflight participants. Research has shown that most adverse effects are caused by radiation exposure, particularly trapped radiation, galactic cosmic radiation, energetic solar particle events, and ionizing radiation. These can cause cancer or induce nausea, vomiting, and depilation (Clément et al. 2020). Another factor that significantly influences the health of astronauts is the duration of their space missions. Prolonged space missions harm astronauts' bodies and mental health because they are placed in abnormally harsh space conditions for a long time. In this regard, prolonged space flights and exploration of space by humans could not only harm the physical health of astronauts, but also dramatically affect their mental health and moral state. Because of their great exposure to radiation and microgravity, only a small number of astronauts manage to undertake long-distance and prolonged space travel, and perform such space-related missions (Cucinotta et al. 2014).

Notably, space missions with long durations, such as the Mars mission transportation vehicle, increase feelings of sadness and loneliness, cause sleeping problems, and even produce appetite disturbances. In addition to the specified syndrome list, space flights can also lead to adaptation disorders caused by a profoundly new environment that is not typical of normal human habitat. Therefore, space-related regulations should predefine the organization of control and monitoring systems before assigning a particular person to space flights. Hence, only self-controlled, sustainable, and well-prepared astronauts should perform dangerous, long-distance space missions. To safeguard a stable moral state of space flight participants, it is also vital to provide continuous in-flight psychological support measures that imply both remote monitoring of crew members' mental and emotional states and measures aimed at countering feelings of monotony and social isolation, such as upholding communication ties with other crew members. Evidently, space flights must be well organized and consider all surrounding factors that could influence astronauts' health conditions.

It is vital to consider the influence of spaceflight on the functioning of the human brain. The human brain undergoes several changes during a space mission. These may include small changes in the structure of the gray matter and profound behavioral and cognitive performance alterations. Notably, the human brain is more vulnerable to such impacts during far-distance space flights or for prolonged periods. The impact on the human brain occurs both before spaceflight and after or during the completion of space missions (Krittanawong et al. 2022). Hence, even the spaceflight preparation phase can affect astronauts' health.

In general, the scientific literature categorizes the factors that have an impact into three main stages: pre-flight, in-flight, and post-flight. During the pre-flight stage astronauts undergo stressors related to flight preparation and various trainings that usually last several years. This puts astronauts in "expected flight" conditions. During the in-flight stage, the brain is subjected to numerous stressful factors such as isolation, lack of communication, heavy workload, and decreased cardiovascular reactivity. In addition, the brain is negatively influenced by radiation exposure, microgravity, headward fluid shifts, and internal irritants such as emotional stress and lack of sleep. These have adverse effects on the central nervous system.

Finally, during the post-flight stage, people often suffer

from depression, a lack of appetite, and emotional distress caused by radical environmental changes. Accordingly, these findings confirm that the human brain is vulnerable to the space environment and affiliated mental and biological factors such as emotional stress and radiation exposure. The space environment also affects human behavioral performance during the post-flight stage. The observed difficulties with spaceflight mostly have negative consequences for people's ability to differentiate between the masses of two different things. These also change how they perceive their own movements. Additionally, space travel may affect the brain's adaptive processing of visual, vestibular, and proprioceptive information as well as spatial disorientation, vertigo, and other physical symptoms. Such findings confirm that space flights can cause tremendous post-flight effects that astronauts would experience even after returning to normal Earth life. Due to the prolonged stay in harsh space conditions, astronauts are getting used to a microgravity environment. This could lead to adverse outcomes for everyday human existence and performance of basic cognitive functions and daily activities.

Consequently, after astronauts return to Earth and normal gravity, the post-flight period may require sufficient time for readaptation and reintegration into social life through daily routine activities. This typically takes weeks after the landing date. In summary, space environment factors affect not only astronauts' health conditions during spaceflight, but also have an impact even after their return to life on Earth (Demontis et al. 2017).

4.5 Legislations for Spaceflight: Astronauts' Health and Safety

An analysis of the impact of spaceflight on human health should emphasize the legal issues that could arise, especially regarding the guarantee of the fundamental human rights of spacecraft personnel. International space law comprises various legal documents and treaties with embedded fundamental provisions and principles that regulate space missions and exploration. In addition, such legal acts provide a special regime with a specific scope of protection for astronauts as envoys of humankind in outer space. Upon reviewing the existing global space law regulations, it is possible to identify five main documents. However, only the OST, RRA, and MA address the legal issues related to spacecraft personnel.

To be precise, Article V of OST mandates that state parties must provide "all possible assistance in the event of accident, distress, or emergency landing on the territory of another state party or on the high seas." Accordingly, the article imposes obligations on the state to provide assistance in case of emergencies and accidents. At the same time, there is no clear indication regarding health protection measures that should be taken prior to spaceflights or in the post-flight period. However, over time and with the rapid development of the space industry, these provisions are no longer interpreted narrowly. This means that even when the OST does not provide a precise provision for astronauts' health and life protection, the scope of "all possible assistance" indirectly entails the obligations upon health protection. Moreover, unlike the listed space treaties, international human rights treaties guarantee the right to life. This also remains applicable to accidents inflicted on persons during spaceflight.

To illustrate, Article 6 of the International Covenant on Civil and Political Rights guarantees every person the right to life, whereas states hold positive obligations to protect this right in all possible ways, thus not excluding human participation in space mission performance. Thus, states must provide the exact scope of guarantees for protecting astronauts' right to life during spaceflight as provided within the state territory. International human rights laws do not recognize the right to health as a distinct human right. However, as per Article 12 of the International Covenant on Economic, Social, and Cultural Rights, all states that have ratified the covenant uphold the right of every person to enjoy the utmost achievable standard of physical and mental health (Casla 2023). The duties of states to preserve public health are based on this. This means that even when space law treaties do not cover the protection of astronauts' health and life, they do not relieve them of other obligations imposed under other international treaties. Therefore, it can be concluded that even though space treaties do not explicitly embody the right to life and provisions on health protection, the broad approach to legal interpretation and application of human rights treaties expands the scope of law applicable to states' exploration and protection of humans during space missions.

When international space law contains vague and limited provisions on health and life protection regulations, the situation is diametrically different from national legal policies and developed standards. For instance, NASA, as a governmental space agency, operates its internal regulations. It has developed special safety and health standards for spacecraft personnel, which are codified in the NASA Space Flight Human-System Standard Volumes 1 and 2. These standards provide a wide scope of regulations regarding the required countermeasures related to body and psychological conditions.

Another example is the set of standards "Space systems—Human-life activity support systems and equipment integration

in space flight." It lists the main policies for safeguarding physiological and behavioral needs of crewmembers. However, existing local acts are diverse and not unified universally. Thus, there is no binding force for other state parties participating in space missions and activities. Furthermore, such acts apply only within a territorial jurisdiction and do not expand their force to other state parties. Accordingly, separate space agencies and national systems have more detailed and precise regulations at the local level, whereas international space treaties provide basic, nonconcrete provisions that sometimes lead to ambiguity. The final issue concerns the territorial scope of state obligations related to the protection of astronauts and spacecraft personnel.

Article V of the OST mandates that a state must provide any practical support in case of an accident, an emergency landing, or a distress situation occurring in the territory of another state party or in international waters. When astronauts encounter such a situation, they should be expeditiously and safely repatriated to a state that has registered their spacecraft, as outlined in the provisions of Article V of the OST. However, the wording does not clearly specify how a state can provide assistance to astronauts on the territory of another state, especially considering territorial jurisdiction issues and the principle of sovereignty of the state. Moreover, this article provides a narrow scope of state obligations that are mainly limited to lifesaving assistance rather than the maintenance of health and well-being.

Thus, states take only post-flight actions instead of acting proactively and preventively. The current regulations do not address the existing challenges and are unable to solve problems that arise upon the performance of space missions with the crew onboard, especially in the recourse of new scientific projects and exploration activities. Therefore, existing international rules and acts require modification with the primary orientation in modern space reality and an emphasis on human safety and health.

5. CONCLUSION

Considering the origins and development of space law as a distinct branch of international law, many governmental and non-governmental organizations have participated in similar activities. Therefore, it is crucial that each state develops and adopts its national space legislation, especially since many aspects of UN Instruments are kept broad for states to interpret through national legislation. Different states have adopted national space legislation that sets provisions for space activities in conformity with UN Instruments. It remains undeniable that human presence in spaceflight plays a predominant role in space exploration, allowing the expansion of space frontiers from Earth to Moon.

However, the study showed that spaceflight effects could induce changes in the structure and function of the human brain, and even affect behavioral performance. The adverse effects that spaceflights could produce on human health pertain not only to the physical state of astronauts but could also lead to internal psychological problems. These mainly affect the mental health of spaceflight participants. Therefore, most of them require an adaptation period after returning to Earth, which is associated with a change in gravity conditions and may occur after prolonged radiation exposure. In addition, there are records of fatal accidents involving astronauts during space missions. This has encouraged states to develop special laws regulating astronauts' protection from accidents and distress. However, international space regulations provide basic and outdated rules that do not consider the new space reality and challenges. This creates legal gaps in regulating the life and health-related issues of astronauts in space. Simultaneously, national legal systems and private space agencies have developed internal health-related regulations for safe spaceflight. However, it is non-binding on other states and jurisdictions that exclude its universal application.

Accordingly, the absence of a unified legal framework for space activities among different states undermines the safety and health of astronauts during space missions. This research has presented many areas where the existing UN Instruments, the FAA, and powerful space agencies minimally address such activities and the regulations they set to ensure safe operations of commercial space transportation. In addition, to better safeguard the health and life of astronauts during space missions, it is necessary to develop universally accepted health-oriented principles that would facilitate sustaining the physiological and mental health of astronauts during the pre-, in-, and post-flight phases. The limited regulations on the operator's explicit liability and responsibility toward such operations against safety, claims, and jurisdictions are applicable to any legal issues that may arise from commercial space transportation.

Therefore, it is highly recommended to amend the existing treaties or establish a new treaty specific to activities for commercializing space. There is a dire need to define space tourists and classify CST as a part of space activities at international and national levels. International space regulations provided basic and outdated rules that did not consider the new space reality and challenges. To develop universally accepted health-oriented principles that would facilitate the sustaining of the physiological and mental health of astronauts during the pre-, in-, and post-

flight phases considering ICAO standards and to regulate the rescue and return of CSFs and space tourists' Eligibility Training Programs, national legal systems and private space agencies should develop internal health-related regulations for safe spaceflights.

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