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Human Spaceflight: Regulations, Legal and Geopolitical Application Throughout the International Community and Commercial Actors

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Abstract: Human spaceflight without change to International Space Law will remain very much the same. The Outer Space Treaty, the Liability Convention and Rescue Agreement remain an essential element to all space activities. Luckily, the application of these treaties was considered to allow some form of the evolutionary process in their interpretation. This paper will discuss the use of these treaties to the question of human spaceflight; what obstacles may be produced; and how humanity at an international level can adhere to the law, while forming a mutually cooperative approach to space governance. As the United Nations has stood the test of time, this paper will assume that the UN elements of space governance will remain. This paper will argue that with the delegation of activities to an international body, such as UNOOSA, spaceflight and sustainable living on celestial bodies may be possible. The approach of this paper will be to focus on the national and multinational agencies such as NASA and ESA, which are proactive and holding their weight in space governances. This paper will, therefore, examine the international view, with a more focused approach on corporations and multinational agencies. Space colonization is the forefront of visionaries such as Elon Musk, who view Mars as their destination. At today's rate, the likelihood of closer platforms such as the Moon and larger habitable stations such as the ISS may be afforded as more reasonable as a first stage colonization experiment before Mars. This paper will consider the positive approach to living in closer proximity to Earth and what is needed to fuel such a drive to live in a sustainable environment on the Moon and in orbit. The future element of Mars will be hypothesis-based humanity being able to agree and focus on these 'forward stations' in the first attempt of colonization. It is therefore proposed that this paper will consider all the above with a focus on space governance, technology advancement and nearby space colonization with the forward concept of widespread expansion for the betterment of humanity.

Keywords: Spaceflight, International Law, Space Law

1. Introduction

Human spaceflight at this stage is a dream among star dwellers and in all of the industries of space. The consideration of whether spaceflight will enhance space law or the creation of space governance through soft law, based on a generic global governance perspective is a significant consideration of this article. Whether current space laws can support the progressive nature of spaceflight must be a significant view and holds a direct correlation to the UN Charter on cooperation [59] which is a critical factor to current hard and soft laws. The article will consider the constraints currently presented in spaceflight and how International Law can provide redress for such a task.

Space agencies will also play a pivotal part in spaceflight. The application of funded and non-funded agencies presents a unique and diverse system to which this article will discuss. The consideration of these agencies presents an industry specialism and collaboration between industry, legal, finance and science. Moreover, the article will finally touch upon private actors, colonization and planetary protection issues. The application of such a powerful presence in the space sector, such as SpaceX has provided a potentially new, innovative way to access space and thus must be analysed as

an evolving presence. Undercutting budgets and making a profit are the two main developments of the private sectors and SpaceX has not only provided a sustainable way to access space but done so at a marginal cost. This article critiques current progress in spaceflight crewed missions.

The questions include: as space agencies are working towards sending humans back to the Moon, what will humanity be doing in 50 years? Will we have settlers living on the Moon or even Mars? And how will international and space law work in such a scenario? Or will it be through international endeavours; efforts by single governments, or even by private actors, to which the state remains in control under the Outer Space Treaty [58] and develops their understanding on how a space governance mechanism may look.

These uncertainties are accounted for by the following seven assumptions, which are key to space colonization, spaceflight/travel, space governance and astrobiology.

1. Future space missions would involve partnerships between private companies and national space agencies such as SpaceX and Blue Origin, ESA and NASA.
2. The commercialization of space research and missions would facilitate upscaling and capital-intensive research and development.
3. The current interest to explore outer space would be sustained by capital funds, which would accrue from space mining in the final frontier.
4. UN Space Treaties and UNOOSA treaties, which govern extraterrestrial missions, would remain relevant.
5. The regulation of space exploration would be delegated to a non-partisan international agency.
6. NASA and ESA would continue to provide global leadership in space exploration, and the future of space exploration can be benchmarked on existing long-term plans.
7. The colonization of Mars would be dependent on whether global space agencies would adopt an international space station-type collaboration and focus on the development of 'forward stations' on the lunar surface in the first attempt of colonization.

The perils and promises to inform the questions of future space research is key to the fact of the future of humanity and the development of technology. On the one hand, space provides limitless resources and a potential second home for humanity in the event of a catastrophic phenomenon. Beyond the sustenance of the human species, the milestones achieved by NASA and others provide humanity with a collective sense of pride [8]. In brief, the benefits drawn from space exploration are multifaceted and should help define the future of human spaceflight. The risks associated with crewed spaceflight limits the scope of future missions and has somewhat limited the forward movement of such an industry in certain areas as such as Europe, who are focused on the science and technological factors. The stakes are however twofold - loss of human life and contamination (forwards and backwards contamination) which will be discussed later. There is also a question of practicality and feasibility. Without a legal scope on how these could be implemented, international law and the allowance by article III of the Outer Space Treaty, 1967 (OST) plays as an active foundation to which spaceflight is based on. Yet relying upon such a comprehensive article and leading principle requires cooperation, mutual acceptance and a clear vision.

The current concerns about safety are legally justified based on the fatalities in crewed space flight, including the Colombia mission [44]. Other national space agencies have recorded similar fatalities while undertaking similar missions. The explosion and depressurization of the Soyuz 1 and 11 capsules killed three Russian astronauts in the 1960s and 1970s [2]. Beyond the immediate risk of death, multiple indirect health risks have been associated with spaceflight. With the Liability Convention (LC) mainstreaming the OST to which the state retains ultimate liability, the question remains that to what definition tourists are classified while undertaken spaceflight activities. The researcher postulates that a tourist cannot be an astronaut unless trained, and therefore the Rescue Agreement (RA) and employment laws fail to protect them adequately. These elements will be considered later on.

Additionally, the costs of space R&D are a concern considering that NASA are contending with budget deficits and increasing legislative oversight by Congress [41], and it is entirely possible in the future other space agencies will suffer a lack of central funding. The presence of a unique partnership to which closer collaborations may provide commercial and scientific funding may be the main avenue in future space endeavors. The commercial benefits that the private sector brings to space are unqualified and working on a national and international level carries an element of cooperation and commercial interest for all. These partnerships are not uncommon, and as always have been a driving force within the space sector. However, a consideration on whether a space focused public-private partnership is applicable for the future is a lasting question in all new industries, to as to whether the risks associated with future spaceflight outweigh the benefits.

Beyond the legitimate concerns listed above, this article explores the utility and relevance of COSPAR's categorization of space explorations (I-V), the legality of existing space laws, especially the Outer Space Treaty (OST) adopted by UN member states under Resolution 2222 (XXI) [61] in 1967. Other treaties and laws which are of interest include the RA under UNGA Resolution 2345 (XXII) [61] and the LC, which provides a limited legal framework for resolving issues relating to damage in space [31]. Considering the lack of a legal mechanism of enforcement through international space law, the researcher reverts to article III of the OST to provide redress to some extent. It is accepted that the OST and other space treaties provide no direct legal mechanism to which a state could resist international involvement which forms from non-compliance and disregards ethical provisions in space research, which is a fundamental concern of UNCOPUS. Reliance on existing legal regimes developed in the 20th century poses new

challenges –article VI of the OST shows that:

'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 non-governmental entities, and for assuring those national activities are carried out in conformity with the provisions outlined in the present Treaty. The activities of non-governmental entities in outer space, including the Moon and other celestial bodies, shall require authorization and continuing supervision by the appropriate State Party to the Treaty. When activities are carried on in outer space, including the Moon and other celestial bodies, by an international organisation, responsibility for compliance with this Treaty shall be borne both by the international organisation and by the States Parties to the Treaty participating in such organisation". [58].

A review and amendment of the UN General Assembly resolution 3235 is overdue given the non-compliance of states and space agencies. Space law provides the foundations, and such are invaluable. In comparison, disagreements around the environment and climate change spurs further questions to the ethical need to indulge in an activity, not of necessity. The cost benefits of the existing legal regimes are reviewed considering the dynamics of the new space race, which is driven by complex factors beyond the nuclear confrontation and the Cold War.

Moreover, the discussion also focuses on private space agencies such as SpaceX, Lockheed Martin, Boeing and Northrop Grumman [17], which are critical to the future of space exploration. In particular, the discussion plays a favored focus towards SpaceX because the researcher believes that due to the recent Dragon flight and the landing of the rockets, the company is at the forefront of space ability and masks CEO Elon Musk's dream of colonization. Based on recent events, the role of private entities cannot be disregarded given budgetary constraints in national space agencies [41]. With the cost of space declining and state interest primarily focusing on infrastructure before exploration, the private sector must either fund the ventures, enter competitions that incentivize the industry [41], create shares or market "one offs" as venture capital [55], or rely upon the state or space agencies for funding by "piggybacking" and supplying the likes of a satellite into orbit.

2. Future of Space Exploration

The future of space exploration will be dependent on the realization of private and space agencies, without the will of the state and devoid of politics. Chapter 2.0 seeks to address some fundamental questions such as will humans develop adequate space technologies to live on the Moon? What laws will govern space colonies? Will the new space territories be governed by governments or private actors? The legal concerns are informed by the economic and geopolitical benefits that would accrue from spaceflight for tourism and space mining expeditions. The present discussion assumes that the NASA-ESA-CSA-JAXA alliance would remain the global leader in spaceflight with Roscosmos and CNSA (China National Space Agency) being a potential competitor. Another critical proposition is human spaceflight would be limited to the Moon and or possibly Martian tourism (interplanetary) and habitation, suborbital tourism and Earth orbital tourism [67].

2.1. History of Spaceflight and ESA/NASA's Long-Term Plans

The stop start application by states is not only apparent but has created and allowed the commercialization of space. The OST did not only lay the foundations for activities in space, but it laid the preamble to all that has followed. In the subsequent years, NASA, ESA, Roscosmos and JAXA have successfully launched flyby and landing missions destined for the Moon, Jupiter, Saturn, Mars and other celestial bodies. Beyond the historical milestones in space exploration, the long-term plans by the leading national space agencies offer insights into the progress that will be achieved in the next half a century.

Even though the actualization of the plans would represent a giant leap for humankind, it is prudent to dissociate plans on paper and technologies available for large-scale/commercial deployment and the role of private space entities whose potential has not been unlocked [69]. By considering the likes of science fiction, early space travel and motion picture was limited. This analogy is perfect as it shows only those fictional programs remain limited by the future, and its technology. This article will not consider space technology as to a legal specification or artificial intelligence; the researcher considers this as a future article.

The issues come when international and most domestic laws are reactive as opposed to proactive. Spaceflight will create a legal burden to which the state under international law is responsible. Still, international law fails to create a set of rules beyond that. The application of space governance must therefore pick up the mantle and create or adopt a principle to which spaceflight operators can develop or adopt. Delays in actualizing space goals inform the cautious projection of future milestones. For example, the planned crewed mission to the Moon in 2020 [36] has been rescheduled to 2024 [37]. In addition to the delays, the actualization of the space missions is dependent on the rate of technological developments and innovations in science, technology, engineering and mathematics (STEM), budgetary factors and strategic interests. If we consider the Viking Rover landscape as agreed planetary protection minimal standard, in addition to many failed flybys launches, it would be impracticable to use the same technology in new missions. The consideration comes as to how much human involvement is needed in space missions and can a computer remove human error? Like most International law, space law fails to introduce such a concept on science and technology and will only react to a situation when needed.

The researcher postulates that private space companies are

motivated by the need to research for the benefit of humankind and their bottom line is a synergistic approach. Without profit or a subsidy from the state, most space entities could not yet develop a viable business without having billions to self-support; nevertheless, this may be different. The prospect of mining, spaceflight and other commercial activities present a way for commercial companies to develop while making a profit. Sustainable rockets allow for less debris and pollution, which would save a commercial entity large sum of money in the future. The commercial approach to space exploration helps to explain why SpaceX has launched multiple rockets into space and pioneered the Dragon capsule, which has transported two US astronauts to the ISS [1]. SpaceX has also concentrated on the establishment of a human colony on Mars, the transport systems and the landing capsule for the Artemis program. Beyond the commercial interests of private space companies such as SpaceX, the pace of developing technologies for crewed missions to space is a primary concern. Cost-effectiveness and safety are a primary concern. Secondary concerns are how can safety and costs be reduced, and how can this be done with current technology.

The researcher postulates that the future of human spaceflight might not be markedly different from now if national space agencies continue to assume ownership of space exploration. Similarly, Russia has achieved marginal progress in actualizing radical space innovations. In particular, Russia attained tremendous success in its space program between 1956 and 2000 compared to the post-2000 era as evidenced by the number of successful launches of robots and missions to space (Sputnik 1 to 5; Luna 1 and 2; Vostok 1-6, the launch of the first space station in 1971) [46]. However, tangible progress could be achieved through public-private partnerships such as between NASA, SpaceX and Blue Origin. On the downside, the benefits that accrue from private sector involvement could be limited to the US and the EU, given state monopolization of space exploration in Russia, China, and India [54].

From another perspective, the involvement of private actors might not be a panacea to structural challenges in space exploration; this is because private space companies have limited resources and are often dependent on national space agencies for support. NASA spent around $3.1 billion on the Demo 2 program in partnership with SpaceX. A similar contract was awarded to Boeing at the cost of $4.8 billion [33]. However, Boeing's spacecraft did not satisfy the requirement during testing [41]. Following the appraisal of the long-term plans adopted by NASA, ESA and other space agencies, there are multiple uncertainties relating to future space exploration. However, the exploration of outer space is informed by resource considerations, human populations, global power and the possibility of conflict in the final frontier. The researcher argues that a shift in the status quo would have a significant effect on the future of space research and thus spaceflight. The consideration between spaceflight and space travel will be considered as a single topic for this article. In time both will be considered as travel, both are under the auspice of spaceflight for this article. The possible scenarios, which may emerge, are considered throughout.

2.2. Public Sentiments Concerning Space Travel and Political Support

The commitment of states which will shape the future of space exploration by advocating for commercial travel to the ISS [32] has now been progressed through the extent of technology, science and private ventures. In particular, the Obama administration cancelled the Constellation program and increased R&D funding by $200 million [32]. There are no guarantees that future administrations would support space exploration, given the politics that have traditionally defined the funding for NASA [51]. The lack of a guarantee is grounded on the fact that public sentiments and political intentions influence government policy and space policy. Private sector interests partly shape the political intentions - the transition to the commercial crewed program was opposed by private companies that benefited from the traditional NASA-led launches to the ISS [11]; this shows that private sector interests in the space program are often divergent. As with the global pandemic and the easing on business, the researcher would consider that programs will be pushed back, and state resources will be removed from certain space activities. A more research based subjective STEM may be retained for the advancement of technologies here on Earth. The researcher hypothesizes that the space sector will be hit by the global pandemic (COVID-19) in future years. Funding that has already been agreed may be awarded, but future contracts will depend on the economy and whether a second wave occurs. If the economy shrinks back to previous recessions, the researcher considers that only infrastructure space-based operations will be a primary funding state venture. This would mean that science, industry and space agencies would have to consider additional mergers, angel investor funding and even additional collaborations with all space and non-faring nations.

Survey data suggest that public sentiments were not the primary drivers for the space program in the 1960s. At the time, only 50-53% of the population believed that extraterrestrial exploration was a priority [70]. However, the need for accountability has led to mixed public sentiments on space exploration - there is an equal level of support and opposition. A study conducted by the PEW research center noted that the majority of Americans supported NASA's exploration of outer space but were not content with the cost of space exploration - 30% supported funding cuts [10]. The observations made by Hsu [70] and Wormald [65] concerning mixed public sentiments and support for space exploration are in line with Steinberg [3] who observed that public opinion was less influenced by "short-term programmatic and related media effects" of space programs; the most pressing concern was the cost and impact on the national budget. In place of government support for space exploration, the public proposed that the funds should be channeled towards other priority sectors of the economy such

as education, health and alternative energy [70]. The findings drawn from the survey validate the need for a privatizing of space exploration because future government spending would be subjected to public scrutiny [9] and might be overshadowed by other socioeconomic issues. Considering that the crewed spaceflight to the ISS has recorded a victory with SpaceX's demo 2, private sector-led interplanetary spaceflight would be fundamentally influenced by NASA's Commercial Lunar Payload Services (CLPS) program [4], which is expected to precede the commercial landing of humans on the lunar surface. Even with the success of spacecraft technologies, public concerns regarding space resources utilization must be addressed. Commercial spaceflight to GEO seems accepted, but public venture to carry people seems to be outside of the public scope.

The motive of space law and governance for spaceflight is as such that should the public, and the top 1% class of shareholders or venture capitalists, who are not interested in spaceflight or a potential long-term profit-based venture then the future of spaceflight will be based on the owners, collaborations and attraction sponsorship. The researcher considers that without the public, willingness and acceptance of such an expenditure, it unlikely that state interest will be as high as political will. The focus on public sentiments towards spaceflight is critical because scientific expeditions alone cannot sustain human spaceflight. Moreover, government funding for public-led space programs remains uncertain based on public opposition. Based on these constraints, spaceflight and commercial activities would be an integral component of human spaceflight. Plat, Jason, and Sullivan [12] noted that the general public was skeptical of the feasibility of SpaceX Mars mission. The public's skepticism was informed by the costs, safety concerns, lack of appropriate technology and individual variations in the perception of risk. There was also a question of what if space colonization goes wrong or ultimately fails to either perform or create a lasting structure [12]. Such a failure would have disastrous consequences for future space exploration based on the resources spent and financial losses. While bringing it back to the OST, red flags are raised as to article II and the non-appropriation principle. Colonization must be concerned under such a consideration and therefore, a significant hurdle. Although this is beyond this article, this concept should be a thorough consideration as to current international space law and the need for space governance.

The safety concerns are particularly validated by the fatal crash of Virgin's SpaceShipTwo in the Mojave Desert [71]. The focus on isolated accidents by private space companies is a valid approach for safety assessment given there are different benchmarks and presumptions for safety in crewed missions. The main benchmarks for safety include the track record for successful launches, organizational experience, ability to meet the technical requirements and pro-government or pro-commercial mindset [11]. However, even these benchmarks should not be applied to private space companies because they cannot match the industry experience of NASA or ESA. In brief, the public should adopt a new safety paradigm, to which space governance can consider international space laws which evolves into a space governance proactive approach as a foundational principle.

Considering the significant opposition from the general public, space exploration to the Moon and other planets could only appeal to a smaller population until the fundamental issues of concern are addressed. The claims made by Plat, Jason, and Sullivan [12] are in line with Chang [67]. They observed that there was a correlation between R&D in innovative space tourism technology and consumer attitudes towards space tourism and travel. If consumer sentiments are negative, there is minimal impetus for companies to develop advance space technologies. However, the challenge could be overcome by focusing on the hedonic and cognitive, social and functional factors that inform consumer decision making.

Apart from addressing the concerns raised by the public, private space companies must create a compelling narrative of why space exploration is necessary. Presently, there are two compelling reasons advanced by private space companies. First, private space companies argue that space tourism would offer a unique experience. Second, private space companies argue that the colonization of space is necessary to prevent the extinction of human species in the event of an apocalyptic event. Such concerns are partly informed by anthropogenic contamination of the environment and climate change. The extraterrestrial worldview of human existence is shared by leading scholars, including former Cambridge University professor Stephen Hawking who suggested that humans must leave Earth at a certain point in the future [15]. On the downside, Hawking's theory and propositions about the need to leave Earth are not grounded on any theory. Presently, there is no immediate known event that may threaten the existence of humankind. It is accepted that climate change, rising populations and other issues remain high on such an agenda but there is no compelling reason to leave Earth now. Humanity is at the stage of discussing and attempting to consider such a view on mitigation and adaption. As the law is retroactive, it is challenging to consider a strong enough reason; why to create hard law for spaceflight at this time. Even after the event of SpaceShipOne, there was not enough need. It became a standard that laws are considered when a significant event occurs. The law is created, after such event as well cited in Anti-Terror Laws. This being acknowledged it would be perfectly applicable for soft law to take up the mantle and be considered as such a void builder. By the creation of non-binding agreements might the consideration of spaceflight become a legally binding and legally recognized activity under an umbrella agreement which could be accepted as customary law in the future spaceflight.

Additionally, there is no appropriate legal framework to guide space tourism and crewed suborbital flights [57]. The researcher suggests that the notional view of international law would have to be considered to fill the gap. With laws, the operating system would fall to domestic law, yet without domestic law, examples of similarities would gain cause within a judicial setting. With a lack of guidance from

international space law, the issue would seamlessly revert to the guidance from the state on the classification around tourist or traveler, the waiver or agreement between the parties satisfying both international human rights laws and national laws while complying with adequate insurance and liability under the OST and LC. In the absence of a common framework, it would be unfeasible to commercialize space tourism. The national framework is therefore left to consolidate the gaps and consider international law while developing elements within their borders for spaceflight and travel. A possible move to space governance would be that a state contracts special powers to their national space agency that holds a minimal autonomy while overseeing their duties under the OST and domestic law.

Consumer Acceptance of Space Flight and Space Travel

Beyond the legal issues and consumer acceptance of spaceflight / travel as a viable form of tourism, the economics of space tourism has not been resolved. Private companies are willing to develop commercial space travel systems due to consumer factors, and so far, interest has been taken up. According to the initial cost estimates made in 1985, spaceflight would be realized in three phases, namely the pioneer, exclusive and mature. In the first and final phase, a ticket would cost $1 million and $10,000, respectively [67]. Since cost and safety are primary concerns - there is a proposal for spaceflight to be initially limited to about 120 km from Earth [28]. On the downside, there is no industry consensus to support the 120 km demarcation line.

The findings reported by Chang [67] contrasts with Pelton's [47] conceptualization of space 2.0. Drawing upon the progress made by Virgin Galactic, Lynx Mark I, Dreamchaser [67] in developing commercial space planes, Pelton argues that future spaceflight would be a preserve of royalty, sports personalities, celebrities and movie stars [47] due to cost factors. However, space flights continue to persevere. In the eyes of concerns, the likes of SpaceX can now fly to the ISS, which in consideration is harder than suborbital spaceflight. The model of safety versus cost is a consideration in any theme park, adventure business or any company where the risks are high. These businesses are often as safe as "possible" and have extensive insurance policies should they need them. Under the licensing of space venture, the state would make it mandatory for new space companies that launch to take out an indemnity. The only issue that may arise is what can be accepted as risk and what is considered to acceptable risk at the time of flight. This factor was not a consideration in any international treaties. Therefore, once again, the mantle of common law, domestic law and soft law must come to a coherent form of conjunction to better set out the future of spaceflight.

Consumer acceptance of near-Earth spaceflight could be impacted by emerging psychological evidence, which indicates that the cognitive wellbeing of humans would be diminished by extended spaceflight of the back of SpaceShipOne [43]. However, with the successful launch of the Dragon capsule and the safe re-entry of the rocket and landing, the future consideration of spaceflight may look different from what is currently being considered. Therefore, critical legal questions should be centered around, can the risk be mitigated? Are space companies liable for physical harm to their occupants? Would insurance companies provide policy covers for tourists? The issue of space insurance is not well defined compared to aerospace, marine and automotive insurance on Earth. Most readers may wish to compare these insurance issues with the likes of skydiving, paragliding and those activities to which a degree of high risk is clear. And they would be correct in making such a link. However, the classification of the vehicle, administration and observation by the state places a distinct duty of care on those operators directly. The difference of maintaining a parachute to a reasonably high operating standard cannot be compared to whether the operator of a multimillion-dollar vehicle has reasonably been cared for and is safe with a realm to which standards have not been legally created.

High risk insurance relies upon others to provide minimal assistance for a reason. Spaceflight and travel rely upon highly skilled professionals to do their jobs and allow the people on board to have an experience while being safe. Astronauts who train in zero gravity follow on from the weightless wonder. The experience is only brief, but this is something that can and is being considered for the classification of what term is used for someone who undertakes spaceflight. To maximize the experience of spaceflight, the experience needs to be a prolonged version of this, and that offers views of space and Earth. Although the risk of failure is high, is the experience worth it? These questions are addressed in section 2.3 and 2.4.

2.3. Regulatory Landscape for Human Spaceflight

Even though the EU and the US have collaborated in space exploration, they have adopted different frameworks in space exploration. Several legal arguments exist in favor of accommodating crewed suborbital flights within the ambit of the current air law regime: (1) Vehicles spend most of the time in the airspace, crossing only very briefly through outer space. One can say that the fact that the flight may transit briefly through the lowest part of outer space is incidental to the larger part of the activity that takes place in the airspace [7]. (2) Un-crewed suborbital devices are usually not subjected to space law, and this practice could develop into customary law. Furthermore, at least one country, Sweden, has expressly taken the position of excluding the applicability of its national space law to sounding rockets [56]. (3) Suborbital vehicles could be registered as aircraft (whereas under the Registration Convention they cannot be registered as spacecraft, because they do not reach orbit). Hence, registering them as aircraft would help to avoid a legal gap [57] and bring them in line with air law.

The difficulty within international law lies in its enforcement methods or the lack thereof. Space treaties fail to offer jurisdiction to a court or tribunal and govern through principles, without redress. One could argue that the International Courts of Justice or the Permanent Court of Arbitration may be a consideration to such tasks. Firstly, the

ICJ would have no jurisdiction unless the member state agrees, and the OST is the fall back to why the PCA could not be considered. Legal mechanisms, unless written into treaties, can only be advisory and even when an advisory opinion occurs, the enforceability is nonexistent. Spaceplanes are a new class of vehicle that is not formally defined [27]. The International Civil Aviation Organization (ICAO) defines an aircraft as 'any machine that can derive support in the atmosphere from the reactions of the air other than the reactions of the air against the Earth's surface' (ICAO Annex 1 or Annex 6 Part I) [25]. It is hard to argue that suborbital flights cannot be classed under aviation law. However, this considers the challenge to both space and aviation law into what laws need to be followed. The state would legislate for such an event, and it would be entirely conceivable that different states may have different laws. The researcher does favor that a mixture of aviation law and space law should be applied but argues that one size fails to fit all. By allowing spaceflight to fall under an already established law would be easy, but what is being undertaken is not easy. The researcher argues that the creations of a hybrid policy between space agencies and adopted by states as a non-binding agreement should be considered. Gone are the days that the law waits for an event to act; a proactive legal action should be followed. With such well-regarded expertise in the UK, the EU and so on these agreements can be created in such areas and considered by the state. The researcher would consider that a delegation of power should be offered to progress such a nature of space and amplify these innovative areas. This allowance would allow for spaceflight to not only be created but to be trialed and tested before such a time through governance and flexible regime.

2.4. Laws That Will Govern Space Colonies on the Moon and Mars and Human Spaceflight

The future of spaceflight, travel and colonization is the pioneering event that will either shape the future of the law or will restrict it. Planetary protection (PP), cooperation, space resources and a goal for science, technology, and law may all form a charter. Such a moment will forever be held in human history, and such a moment deserves to be memorialized. The laws that will be required to govern will have to consider technology and how the advances may cause difficulty for the law, how extraterrestrial bodies are to be protected and how the law must respect the foundations of international geopolitics. By the creation of a mutual agreement through spaceflight, a flexible procedure may be put into place to where growth and an accepted standard be considered.

Legal Issues in Human Spaceflight

As noted in the preceding sections, human spaceflight would assume either of the three forms, interplanetary tourism and habitation, orbital Earth tourism, and suborbital tourism [67], there is also an element of exploration, research and political strength that comes with success, yet this is beyond this article. Each of the three forms of space tourism raises distinct legal issues. Orbital space tourism would require the development of reusable spaceships that can conduct multiple trips around Earth and maneuvers through the Earth's atmosphere and space. The temporary re-entry into the atmosphere might necessitate the application of national air laws that apply to commercial and private aviation. The questions of how to define sub-orbital flights seem to be a legal problem. Several academic contributions focus on the element of height (altitude) to determine whether or not an object is to be considered sub-orbital, overlooking the fact that an orbit is not reached as a function of altitude but of velocity [19].

Forganni [6] postulates that sub-orbital space flight would pose a new legal dilemma because the spaceship relies on both commercial aviation and space hybrid technologies to maneuvers through space. The legal concerns are valid because the sub-orbital spacecraft needs to draw lift and thrust from the Earth's atmosphere. Considering that re-entry to the atmosphere may violate national airspace laws, prior consent may be required; it is not clear whether laws that apply to commercial aviation or outer space travel would apply considering there is a minimal framework for reconciling the two, with the likes of the Commercial Space Launch Amendments Act of 2004, which is only applicable in the US [6] and the UK Space Industry Act 2018 [52]. However, this would be fundamentally dependent on the willingness of the host state to adopt a flexible authorization mechanism until the global community adopts a uniform legal regime [6]. The implications on the qualification of tourists would not be covered under the RA unless the tourists are trained to be an astronaut. The waivers that currently covers spaceflight operators can only be successful in some jurisdictions. For example, UK contract law states that death, injury or personal injury cannot be contracted out of. Therefore, depending on the different applicable laws in different states, it is clear that not all states can be uniformed in their agreements and use of their laws in such a subject. If the OST is the last line of defense for the tourist, then a claim in any occurrence would be made against the state and not the operator. In the UK, for this example, the operation would be under international law which follows the OST. They would cover the extended space insurance and follow the UK government’s guidance. If an event occurs, they will attempt to rely upon the wavier, which was signed by the occupant of travel. As discussed, this would fail within the UK, and thus a claim against the UK and the operator would be made for breach of contract or under the health and safety act. Although the researcher at this stage cannot predict the outcome, a future article would consider the application of UK space operations and spaceflight with the consideration of common law. Such an interesting scenario could go multiple ways, and yet it is beyond this article to consider the UK space industry and common law. To conclude this chapter, without a unified acceptance of spaceflight and travel in an industry or group of states, must jump over this hurdle to define and build a basic understanding. Any lawyer in a domestic or international court that is willing to hear the case would use article III of the OST to introduce other

international laws and domestic laws to make a case for such an incident. Moreover, the example given would place a reasonable precedent on the state to create laws.

3. Planetary Protection and Human Spaceflight

Human spaceflight may assume either of the three forms: sub-orbital flight, orbital spaceflight and interplanetary spaceflight [5]. The transition from a suborbital flight that is championed by private companies such as Virgin Galactic to inter-planetary spaceflight [67], which is a defining aspect of SpaceX's Mars mission [53], would be dependent on the rate of new technological innovations. Presently, existing technologies are incapable of sustaining inter-planetary spaceflight. For instance, current technologies would take at least eight months for humans to reach Mars, and it is not yet clear on how humans would survive in deep space for such an extended period given the metabolic requirements and psychological implications of isolation.

Beyond the technical aspects, potential consumers have expressed their reservations towards space tourism owing to the inherent risks and the costs [12]. For example, SpaceShipTwo crashed in 2014 [14]. Practical evidence suggests that human spaceflight might be unfeasible over the short-term or even long-term considering that minimal progress has been made in the past 60 years [14]. Although to be judged by the past must be a consideration. Humanity has not created such innovations and an ability to extend beyond the Moon in such a way, is a technical and scientific endeavor that has only been abled through uncrewed missions An alternative school of thought argues that commendable progress may be realized in the short-term considering the progress realized by Lynx, Spaceplane, Dreamchaser and other private sector companies, which are developing reusable suborbital launch vehicles. The race towards crewed spaceflight to deep space has significant planetary protection and space governance implications as discussed in the next section.

Space governance, space law and planetary protection are critical to the protection of extraterrestrial planets from forward and backwards contamination in crewed spaceflight. However, the success of space governance, space law and planetary protection would be contingent on global consensus. Presently, the global legal consensus is limited. For example, there is no unified definition of space among COSPAR member states; this is a limiting factor because an upper limit of sovereignty should inform the enforcement of a space governance framework. Many states in the US are content with the status quo because the lack of a unified definition of space had no impact on governance or space exploration. Based on this school of thought, we are delineating an upper limit of space as non-value adding.

States such as New Mexico had adopted contradictory definitions of space, which are incompatible with the Karman line (the boundary between air and space). The Karman demarcation line is 100 km above Earth [29]. The New Mexico legal system states that space starts 62,000 feet above the ground [29]. Such radical definitions are not unique to the US; Colombia and Denmark have adopted definitions of space also. For example, the Columbian constitution argues that Columbia's space territory/airspace extends from the ground up to the GEO - about 35,786 kilometers [29]. The lack of a unified definition of what constitutes space impedes the establishment of cooperative space governance, space law and planetary protection framework. Considering that COSPAR and UNOOSA have no jurisdiction in the development of local space laws, states have the latitude to develop domestic laws in line with their desires and plans in space. However, the laws should not be incompatible with international law.

The lack of consensus on space Earth demarcation illustrates that the lack of domestic jurisdiction is a barrier to global collaboration in space exploration. Another fundamental issue of concern is who has the power to enforce space laws considering the influence of space politics, and geopolitical influences [13]. Steer [13] argues that space power is vested upon the countries with advanced space capabilities such as Russia and the US, private space companies such as Space X and OneWeb, and global military organizations. However, this should not be the case because the OST was informed by the *Ubuntu* worldview, which places greater emphasis on equality, shared identity, compassion and justice. This helps to explain why space was considered a province of humanity.

Moreover, the OST envisaged that it would only be used for peaceful purposes [61] in a unified acceptance of space with the ability to form and respond to new space ventures. The demarcation line is a prime example of the issues faced in current spaceflight. Without a limit or an accepted limit, aviation law would be assumed for spaceflight in certain states, while space law in others. The discrepancy among states holds that issues of launches, landings and flyovers may hold more significant political say then many lawyers give credit for.

Even though the accumulation of space power in a small group of nations has not had any adverse effects on space governance, planetary protection and space law, it might have disastrous consequences if public and private interest's clash. One of the hypothetical scenarios is the entry of private service providers, such as SpaceX which may challenge the traditional collaborative relationship between NASA and Roscosmos. The observation is grounded on the fact that such relationships are only sustained when all the interests of the stakeholders are met. The economic interests of Russia may not be adequately met with the entry of SpaceX spacecraft because it eliminates its 9-year Soyuz monopoly in the transportation of astronauts to the ISS. Russia would suffer from direct economic threats. Moreover, SpaceX and other private players pose a threat to planetary protection and space governance due to the scale of their operations, such as the envisaged 42,000-star link constellation. In general, the future of space governance, space law and planetary

protection remain uncertain from economic and legal points of view.

The risk of forward contamination linked to human spaceflight is dependent on the distance from Earth - orbital, sub-orbital and interplanetary spaceflight and the habitability of the target planet/moon. In contrast to robotic missions such as Europa Clipper and JUICE, human spaceflight and colonization of the solar system would magnify the risk of interplanetary contamination. The assertions are reinforced by the waste that was deposited on the lunar surface during the Apollo mission [22, 48]. Moreover, the risk of contamination linked to human presence would be proportional to the length of the missions. However, existing space technologies are incapable of sustaining extended lunar and Martian missions.

Presently, NASA does not have the capabilities to transport humans to the Moon - the Artemis landers and rockets are still under development in collaboration with the private sector [38]. After considering the technical constraints, the ability of humans to become a spacefaring generation in the next 50 to 100 years can be questioned. However, the scenario may change with private sector investments, which are fueled by the monetary gains that would accrue from space mining and tourism. Sameh notes that SpaceShipOne demonstrated the feasibility of sub-orbital flight systems [50]. However, failure of SpaceShipTwo [64] test flights in the Mojave Desert shows that safety concerns must be addressed before the commercialization of Virgin Galactic, Lynx, Spaceplane and Dreamchaser space tourism models. Beyond safety, other concerns also contributed to the delayed launch of commercial sub-orbital flights, which were initially scheduled to commence in 2008 [14]. In the European market, private sector investments in commercial spaceflight/tourism have dissipated given the projected low return on investment over the short-term [47].

The state of sub-orbital and orbital spaceflight suggests that the possibility of forward contamination emanating from orbital and sub-orbital spaceflight is marginal owing to the challenge of commercializing space tourism - cost models show that it would be a preserve of the ultra-rich and not the general public [64]. Moreover, public sentiments concerning human spaceflight suggest that there is no compelling justification [6]. Apart from the economic factors, Dempsey and Manoli [42] note that there is no legal framework to guide the delimitation of air space and outer space and safeguard airspace sovereignty, spatial and functionalism. Therefore, forward contamination risks would primarily emanate from inter-planetary spaceflight and colonization of Mars and the Moon.

The estimation of the risk of forward contamination after human colonization/settlements in space is based on models provided by SpaceX, NASA and ESA. However, the reliability of these models remains unknown, considering that the requirements change over time while other missions are scrapped. For example, ESA's plan to build lunar colonies using 3D printing techniques and lunar regolith were cancelled [18]. According to Space.com, SpaceX Martian mission would be capable of launching at least 100 spaceships after 26 months [34]; this will help to ensure a constant supply of necessities and human transport to space - each spaceship has a crew capacity of 100. Considering that the current model of SpaceX's Starship is only capable of transporting 100 tons of payload to Earth orbit [34], further modifications are necessary before the Martian mission. Another concern is the absence of feasibility studies on the crew capacity for the Mars mission and the life support systems that would help to sustain the seven-month cruise to Mars. The lack of data limits the estimation of the probability of interplanetary contamination during cruise, landing and the colonization phases. The risks are more significant since the missions would be one-way [45]. In the absence of accurate data on the scale of lunar and Martian colonization, life support systems and cruise rockets, current estimates are modelled on the Apollo and other lunar missions. It is therefore difficult to see how spaceflight could be feasible from a technological view. The researcher considers that if the technology were available, the legal and ethical equation would still be missing from a reasonable person view. The consideration of what laws possibly transcend Earth to be enacted on Mars presents a large proportion of spaceflight, security, safety and legal uncertainty. Although this is such a broad consideration, spaceflight presents a continued reliance on the foundations of international law and agreements which may differ between states. Such a challenge presents risk presents risks of a pick and choose approach for space which can be a dangerous precedent both scientifically and legally.

As noted, the Apollo mission was a giant leap for humankind but also a gigantic leap for Earth-based microbes. A significant population of microbes was deposited on the lunar surface in the form of human waste and other materials such as golf balls left by US astronauts [22]. Other objects include the Saturn spacecraft rocket stages, USSR's Luna probes and defunct spacecraft launched by India, China, Japan, ESA and Israel. Cumulatively, about 500,000 pounds of waste was deposited on the lunar surface since the Apollo missions [63]. Other studies estimate the quantity of organic waste and spacecraft junk to be about 200 tons [24]. Even though the quantity of waste is significant in current standards, it would be incomparable to the quantity of waste that would be generated by lunar or Martian outposts that would continuously be inhabited by hundreds or thousands of humans. Moreover, NASA's crewed missions to the Moon would involve the cultivation of crops to sustain humans - any form of farming would lead to forward contamination because plants and manure are foreign objects that would irrevocably contaminate the lunar surface.

The researcher argues that the risk of contamination would not be mitigated by recycling systems such as the Vortical Oxidative Reactor Technology Experiment (VORTEX) [49]. The direct allocation of spaceflight would only add to irrefutable damage to other celestial bodies. Readers may consider that the Moon has no atmosphere and therefore, the risk of planetary protection is below minimal. The researcher argues that the creation of space debris was born from this.

By setting a clean example from an early stage, humanity can learn from the mistakes of the past. The researcher agrees that waste on the Moon is unlikely to grow, spread microbes or cause harm. Still, if nothing is found on Mars, then this precedent migrates to an irresponsible path of destruction throughout the solar systems to which spaceflight and tourism, due to the willingness of humanity and technological advances, primarily has caused.

A novel mechanism of limiting the bioburden of human colonies in space is necessary, considering that an average human on Earth generates about 4.4 pounds of waste per day [62]. If space colonies host 100 persons, this will translate to 160,600 pounds of waste per year, which is significant considering the technological limitations in space recycling. The process of handling waste during flight remains a challenge because astronauts aboard the ISS collect organic waste in trash bags, which are shipped back to Earth for disposal or burned up during re-entry [69]. Liquid organic waste drawn from human sweat and urine is recycled to provide potable water as demonstrated by the Environmental Control and Life Support System (ECLSS) [40]. The ECLSS system can be effective in human spaceflight, lunar and Martian colonization. However, advanced techniques are necessary, considering that there is no mechanism of extracting solid waste from deep space.

4. Regulations and Models to Optimize the Balance Between Human Exploration and Planetary Protection

This chapter explores the development of a new regulatory framework and model to facilitate a balance between planetary protection and human exploration given the limitations of existing planetary protection hard laws such as the equivalent Rescue Agreement, Moon Agreement, OST and the Liability Convention. Modelling is not a new phenomenon in legal scholarship and practice; it has been employed to mitigate uncertainties based on probable outcomes such as Brexit (the process that culminated in the withdrawal of the UK from the EU). The legal models were integral in the forecast of probable Brexit scenarios and the alternative models of relationships. Considering that the scale of space exploration is incomparable to Brexit and there are no appropriate benchmarks for space law modelling, a fundamental question is whether the five models of legal science namely normativist legal science, realistic legal science, argumentative legal dogmatics, realistic-technological legal dogmatics or critical legal dogmatics would be useful in modelling the future space legal regimes.

Laws and regulatory models for future space exploration and planetary protection should be based on facts in the public domain; this approach is supported by the history of space exploration starting from the launch of the Sputnik satellite in 1957 to 2020. The progress made has been characterized by giant leaps into the unknown, rapid technological development, failure, violation of existing codes of conduct, accumulation of waste in space and international collaboration between national and private entities. The rate of progress in the last five decades could offer insights on legal models for a crewed mission to Mars and beyond. Additionally, the models would reduce conflict in the extraction of minerals from extraterrestrial bodies.

The modelling of optimal regulatory regimes remains a challenge considering the incompatibility between previous space missions and the planned missions. Following the review of NASA and ESA's long-term plans, previous missions such as crewed lunar landing, exploration of life on Mars using robots and planetary flybys are minuscule compared to the grand projects planned for the 21st century. However, the suitability and achievability of the projects are dependent on current forecasting of future technological capabilities. NASA's "space 2100" team has so far tried to imagine the future of space exploration in the year 2100 and beyond. Accurate forecasting is a crucial building block for futuristic legal and regulatory models. Given that some form of spaceflight would occur in this model, the question would be whether it is industrial, scientific, commercial or all three. The researcher would suggest that depending on who was carrying out the missions; a tripartite system could occur to minimize costs, factor in cooperation and form a share of burden-based costs.

From a scholarly point of view, forecasts could be inaccurate considering the absence of precise information on how the world would be in 2100; available and space-proven technologies in 2100; the intensity of new challenges that the world would be contending with; and the future of NASA given the rise of private space agencies. The NASA and ESA's aborted missions show that prediction of future events in the space domains remains a challenge.

The grandiosity of plans, coupled with the ethical concerns about the integrity of the technologies, underscores the need to model governance solutions, which would address the needs of various stakeholders with direct and indirect interests in the space industry (such as governments, national space agencies, private space companies, independent and non-partisan agencies such as UNOOSA and COSPAR and legislators) with the flexibility to explore planets other than Earth, while at the same time ensuring that private companies seeking to mine celestial bodies do not sidestep voluntary guidelines.

On the downside, the researcher postulated that the role of NASA would be further degraded to mere guidance and oversight. The realization of the 2100 plans is dependent on technological progress and innovations in the four thematic areas namely Earth technologies (robotics, AI, IT, medical diagnostics, manufacturing and energy); Earth social (security, privacy, social networks, water, climate and related issues). The grandeur of NASA and ESA space missions to 2100 demonstrates the limits of existing legal frameworks.

The construction of human dwellings/forward stations on the lunar surface would violate the OST because construction of residential facilities amounts to appropriation of lunar resources. Similarly, the planned replication of Noah's ark in

space - the transfer of essential species to space would violate planetary protection guidance on forward and backwards contamination. However, it is imperative to question the ability of NASA and ESA to actualize each of the long-term goals. From the researcher's point of view, future space projects have uneven probabilities of success; it would be prudent to focus on developing new legal and regulatory models for high-priority missions, whose implementation is guaranteed. ESA records show that the agency conceptualized long term lunar outposts seven years ago.

Considering that over time projects were not implemented, and NASA's Artemis mission would only focus on short-term stays on the Moon, the future of space commercialization from a legal point seems to be based on technical and scientific factors without legal consideration. Based on the inconsistencies between planning and reality, should national space agency long-term goals inform legislative changes? Should a proactive approach to legislation and regulation be adopted? Or should the regulatory/legal framework be reactive? Such questions are legitimate because the development of new regulations specific to the Moon mission would be non-value adding.

5. Conclusion

The review was structured to resolve the following fundamental questions: what will the global space community be doing in 50 years? Will there be colonies on the Moon or even on Mars? Will space exploration be defined by international collaboration, unilateral decisions by governments or the private sector? The history of spaceflight from Sputnik to Apollo and SpaceX's Crew Dragon, offered new insights and helped to address the questions. Moreover, the review of the merits and drawbacks of crewed missions vis-à-vis robotic missions, space travel and tourism (inter-planetary, orbital and sub-orbital systems), consumer acceptance and sentiments, regulatory landscape, commercial property rights and antecedents for space colonization showed that the state of human spaceflight remains uncertain. However, past and current events may offer insights into the future.

The following hypothetical scenarios are viable. One, human spaceflight would entail inter-planetary crewed travel for space mining and scientific expeditions and orbital and sub-orbital space flight [21]. The progress made by SpaceX informs the assumption crewed space programs by NASA and ESA's commitment to Mars and lunar colonization. Moreover, there are significant economic rents that would accrue from space colonization. The nexus between commercial interests (space mining and space tourism) and scientific inquiry would be the driving force for advanced spaceflight.

Two, human spaceflight may be limited to the progress achieved since the first human landing on the Moon (temporary colonization of LEO via the ISS). Based on this point of view, human spaceflight would not transcend the Moon and short-term orbital and sub-orbital space flight. The drawbacks inform the pessimistic worldwide view. A primary concern is the absence of suitable technologies for human spaceflight; it would take at least seven months for humans to travel to Mars using existing technologies. Secondary concerns include health, cost and death [43]. The prolonged human spaceflight may compromise organ function (heart, lungs, bones, and muscles and nervous system) and cognitive wellbeing due to isolation and exposure to inhabitable conditions in space.

Moreover, there is a considerable risk of death attributed to spacecraft accidents during launch, cruise or landing. Multiple robotic and crewed missions to space have failed, leading to the death of US and Russian astronauts. The costs of space travel are critical barriers to mass transport - a one-way ticket to Mars would cost $200,000.

In brief, the pace of technology development and adoption would influence the rate of new scientific breakthroughs, including the discovery of exo-planets and colonization of Mars and the Moon. However, the technological progress is dependent on a wide array of factors including research budget, federal funding, global economic trends, unforeseen events, national regulatory regime and consumption of the technology products (public sentiments and consumer acceptance) and ROI in space mining or tourism. The viability of space travel would be dependent on short-term ROI because the maximization of shareholder wealth is a crucial driver for private enterprise; this is evident from SpaceX’s distinct approach to space exploration.

The consideration of space investment seems to come in levels. Satellites and telecommunication present the first significant and for the foreseeable future, the primary source of investment. Space offers that make things work on Earth will always be the primary source of funding. Through these actions, technology and science can obtain funding and increase their capability for the likes of the Mars Rover and Clipper missions. Moreover, such advancements come as all industries trial and error. The global pandemic, followed by an unstable market, geopolitical events and recessions have always hindered industry, and it would be interesting to see whether the likes of SpaceX can weather such a storm. Suborbital flight operators must consider a legal framework to which their interests are protected as do the states. The risks associated and different classifications of tourists, pioneers or temporary astronauts must be clarified to enable the development of a targeted contract between operators to help develop legal protection for the operators and the people enjoying this experience.

Moreover, UNCOPUS, UNOOSA and COSPAR must consider such actions as mentioned above. The current landscape of the COSPAR categories does not reach to such a venture making them incompatible for such use. Making COSPAR an active partner in spaceflight and using a collaborative method between science, technology, and law seems a viable option to increase public perception as to risk and cost for the venture and beyond. Without space governance or a legal regime, states will play a key stakeholder in the development and failures of spaceflight in the future. Will states administrate and oversee space venture

while private industry surpasses the needs of states? Will the law allow for protection if spaceflight fails and injures people or land? These are just some of the main legal questions that remain, until an event occurs to which the state or international community needs to react. The researcher hopes that international law and governance are proactive instead of being reactive. The development of technology regardless of an economic recession will continue to advance, and the researcher believes that spaceflight can be managed under a space governance regime with elements of space law to lay the foundations. This would be based on soft law, and hard law would be for domestic use through a web of cooperation and the foundations of state responsibility.

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