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Planetary Protection in the New Space Era: Science and Governance

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Committee of Space Research's Planetary Protection Policy is a triumph of technocratic governance in the global sphere. The Policy is produced by a group of scientific experts and subsequently enjoys high regard among the scientific and space community. However, as Committee of Space Research is an independent organization without any legal mandate the Planetary Protection Policy is an example of so-called "soft law" or a non-binding international instrument, in short, no one is under any legal obligation to comply with them. The policy is linked to Article IX of the Outer Space Treaty and its provision calling for the avoidance of "harmful contamination" of the Moon and other celestial bodies. While space activities beyond Earth orbit have been the exclusive preserve of government scientific space agencies this has posed little problem. However as private and "non-science" space activities proliferate and begin to spread their reach beyond Earth orbit, the Planetary Protection Policy is being tested. This paper will examine the challenges of developing and maintaining an effective planetary protection regime in this "New Space" era. This will involve looking at the existing policies, as well as the governance framework they sit within. However, it is also necessary to consider and understand the scientific basis not just for the specifics of the policy itself but the necessity of it. Finally, this paper will consider whether a broader "environmental" framework is needed as space activities diversity in type and location.

Keywords: COSPAR, planetary protection, space law, space governance, enforcement, environment, astrobiology

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INTRODUCTION

The Committee of Space Research's (COSPAR) Planetary Protection Policy (PPP) (COSPAR 2020a) has sought to protect the space environment from "harmful contamination" which would endanger the integrity of the scientific exploration of outer space including the search for life. The PPP predates the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (Outer Space Treaty/OST) (OST 1967). The PPP's non-binding status has allowed a flexible and organic development enabling the Policy to be updated as scientific understanding has developed. Yet, as the geopolitical order shifts, new challenges to the governance of space emerge. This discussion will examine the threat to the consensus that has developed in respect of planetary protection caused by a shift in space exploration. The traditional science-led approach to the exploration of celestial bodies is now being augmented by non-governmental, non-scientific actors looking to pursue commercial activities in outer space. These

new actors, some of whom have already expressed skepticism about the current arrangements, will test the way in which planetary protection is enshrined in future missions to other planets.

Summer 2020 has seen the launch of several Mars bound scientific missions, including the first effort from the UAE and China's first independent mission.[1] Further, the United States has unveiled further details for its Artemis program which intends to return humans to the Moon during the 2020s and involves a commercial lunar payload service in order to open opportunities for private sector activities on the Moon (NASA 2020b). Elon Musk, Jeff Bezos and others continue to advance their plans for non-governmental activities in outer space. Space governance, and planetary protection, is evolving to deal with these developments, the United States has proposed the Artemis Accords (NASA 2020b), NASA has updated their planetary protection policy (NASA 2020c, NASA 2020d), COSPAR also updated the international planetary protection policy in June 2020 (COSPAR 2020a). Planetary protection is perhaps more important as ever as the number of actors and the diversity of their activities increase. Private and non-governmental space activities present a particular challenge given the status of the COSPAR Planetary Protection Policy in international law and the motivations and intentions of some of these new actors. Non-binding guidelines rely on parties caring about their objectives, however, States have an ability, and a responsibility, to ensure responsible conduct by their nationals and non-governmental entities, in outer space and that includes ensuring adherence to the principles of planetary protection. However, as issues such as space debris demonstrate, it is also necessary to consider whether a broader environmental perspective is needed, whether it is necessary to protect the outer space as an environment, to ensure future use for a range of activities.

This article will start by critiquing the extant planetary protection principles, why they are necessary and their position within international space governance. The discussion will then explore the issues of enforcement in international law, particularly of "non-binding" norms (the so-called 'soft law' provisions), before discussing whether there is a need for a refocusing of international efforts to protect the space environment.

The COSPAR Planetary Protection Policy

The requirement to protect natural celestial bodies has been recognized by both the scientific and legal communities since the early days of space exploration, but this has led to divergence in approach (Tennen 2004). The concept of planetary protection, while recognized by both communities, is emphasized by the legal community to be concerned with prevention of harmful contamination of celestial bodies. For the scientific community, it refers to the need to ensure that pristine celestial bodies are not contaminated by terrestrial biological (or organic) contamination (forward contamination), specifically in order to avoid compromising the search for extraterrestrial life in the Solar System (Coustenis et al., 2019). It also concerns protection of the Earth's biosphere from the return of (potential) biological extraterrestrial materials (backward contamination). These principles underpin agreed international practices which have evolved as our understanding of the boundaries of life on Earth and elsewhere in the Solar System has progressed (Rummel and Billings, 2004) and as there has been an increase in commercial activity and exploration, including life detection and sample return missions.

Internationally, technical aspects of planetary protection are developed though deliberations between the space agencies and international scientific organizations, and recommendations are made COSPAR (Rettberg et al., 2016). The COPSAR Planetary Protection Policy (PPP) (COSPAR 2020a) defines the specific technical guidelines (COSPAR 2020b). The policy is based on two rationales: 1) to ensure that the conduct of scientific investigation of possible extra-terrestrial life forms, precursors, and remnants is not be jeopardized; and 2) the Earth must be protected from the potential hazard posed by extraterrestrial matter carried by a spacecraft returning from an interplanetary mission (Coustenis et al., 2019).

To date, the COSPAR PPP has identified five categories for planetary protection requirements depending on the type of mission, the target body, and the type of scientific investigations involved. For Category I mission, no PP measures are needed, but from II to V, the PP regulations become increasing stringent depending on the scientific focus of the particular mission on the astrobiological relevance of their individual mission target, as shown in **Table 1**. These missions include flybys, orbiters and landers to Venus, the Moon, Mars, and the icy moons of the outer Solar System, among other locations as indicated by **Table 1**. Examples of such missions are the Mars 2020, ExoMars and Mars Sample Return missions. Based on the return of the Apollo samples, samples returned from the moon are not deemed a threat, and as a result the Moon is Category II with unrestricted Earth-return.

Category IV, however, recognizes that some missions are to bodies where extinct and extant life may exist, e.g., the Martian sub-surface or the sub-surface oceans of icy moons. Indeed, the significance of this is recognized by specific subdivisions of Category IV for Mars (IVa, IVb, and IVc), a prime target for astrobiology investigations. These sub-divisions are dependent on the mission aims and specific target location: Category IVa missions do not have objectives relating to the search for life; Category IVb missions are those investigating the existence of extant life; Category IVc is for missions that target "special regions" (e.g., features such as gullies, subsurface cavities, below 5 m, and Recurring Slope Lineae (RSLs)) (Rummel 2009) even if the objective is not related to the search for life. "Martian Special Regions" were created in the 2002 COSPAR PPP for Mars, to recognize regions where terrestrial or native Martian life might flourish. One obvious determinant for these regions is the presence of liquid water. For Category IVc missions, additional restrictions are placed on spacecraft bioburden (terrestrial contamination) and the feasibility of the target site to support the replication of terrestrial microbial life is also taken

[1]Previous attempt was done in cooperation with Russia.

TABLE 1 | Categories of missions and target as stated in (new 2020 ref).

Category	Mission type	Target bodies
I	Flyby, orbiter, lander	Undifferentiated, metamorphosed asteroids; Io
II	Flyby, orbiter, lander	Venus; Moon; Comets; Carbonaceous Chondrite Asteroids; Jupiter; Saturn; Uranus; Neptune; Ganymede[a]; Callisto; Titan[a]; Triton[a]; Pluto/Charon[a]; Ceres; Kuiper-Belt Objects >½ the size of Pluto[a]; Kuiper-Belt Objects <½ the size of Pluto; others
III	Flyby, Orbiters	Mars; Europa; Enceladus
IV	Lander Missions	Mars; Europa; Enceladus
V	Any Earth-return mission	—

[a]*Must be supported by an analysis of the "remote" potential for contamination of the liquid-water environments that may exist beneath their surfaces.*

into consideration. As further information is obtained about proposed targets, the Categories are re-evaluated.

The development of the "Mars Special Regions" highlights the flexibility of the COPSAR PPP and its evolutionary approach, which is essential because we are increasing our understanding of the boundaries within which life can grow on Earth and increasing our awareness of potential habitability elsewhere in the Solar System. Planetary protection is critical for enabling scientists to study the natural environments of celestial bodies without interfering with possible life forms that may have developed there. Most importantly, it also helps to preserve the terrestrial biosphere from possible contamination by extraterrestrial material. The United Nations Committee of the Peaceful Uses of Outer Space (UNCOPUOS), in 2017, noted the long-term standing role of COSPAR in maintaining a Planetary Protection Policy as a reference standard for spacefaring nations and in guiding compliance with Article IX of the Outer Space Treaty (United Nation 2017: 42).

International Space Law

The space governance regime, of which the COSPAR Planetary Protection Policy is part, is comprised of treaties, such as the foundational Outer Space Treaty, customary international law, and non-binding "soft law" such as UN General Assembly Resolutions and the COSPRAR Planetary Protection Policy. As international law the regime directly addresses States. However, private and non-governmental activities are addressed by space law because, while private activities are governed directly by national law these national regimes sit within the framework of international law, specifically the "special regime" (*lex specialis*) of international space law. Space law was first developed through customary international law dating from at least the first instance of state practice, the launch of Sputnik, and strengthened by the Declaration of Legal Principles in 1963 (United Nations General Assembly. Resolution A/RES/1962 (XVIII), 1962) but the Outer Space Treaty of 1967 is a milestone as a formally binding or "hard law" instrument which serves as the legal foundation for the space governance regime. The Outer Space Treaty, as its full name implies is a framework treaty laying out key principles. It has been built upon by subsequent treaties focusing on specific aspects, such as elaborating liability and registration provisions. The Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Agreement) (Moon Agreement 1979) was an attempt to develop a more detailed and specific regime for activities on the Moon and other celestial bodies but despite receiving sufficient ratifications to become an active treaty it has been rejected by the majority of the international community. It is therefore regarded as a "failed" treaty and is of limited relevance. The decades after the Moon Agreement have seen a dearth of "hard law" instruments in space governance. What development there have been has come in the form of customary international law and non-binding instruments or so-called "soft law." The COSPAR Planetary Protection Policy (PPP) is one of the leading examples of "soft law" within space governance.

The key aspects of the Outer Space Treaty (OST 1967) for planetary protection are found in Articles I, II, III, VI, VIII, and IX. Article I declares that all States are free to explore and use outer space, including the Moon and other celestial bodies. Such exploration and use should be "carried out for the benefit and in the interest of all countries" and States should "facilitate and encourage international cooperation" in scientific investigation. Article II prohibits the exercise of territorial sovereignty in outer space or on the Moon and other celestial bodies. It also means that the use or occupation of outer space, the Moon and other celestial bodies, gives rise to no sovereign rights over those areas. Article III stipulates that space law is part of international law, and therefore where space law "runs out" international law can be used to "fill the gaps." This is particularly important for enforcement, as it means, among other things, while there is not specific "dispute resolution" mechanism in the Outer Space Treaty states can make use of the International Court of Justice (ICJ) and other such measures. Article VI is vital for modern international space law as it makes States responsible for the activities of their nationals and private corporations in outer space and requires that they "authorize" and "continually supervise" those activities. Similarly, Article VIII establishes that the State on whose registry a space object is carried "retains jurisdiction and control" over the space object and its personnel. Therefore the "state of registry" is able to exercise legal authority over a space object (and its personnel should it have any) despite Article II OST. Article IX is the most directly relevant for this discussion and will therefore be subject to a more detailed examination.

Article IX stipulates that States shall conduct their activities "with due regard to the corresponding interests of all other" parties. They conduct their activities so as to avoid the "harmful contamination" of the Moon and other celestial bodies, as well as

changes to the Earth's environment by the introduction of "extraterrestrial matter". Further, states are encouraged to engage in "appropriate international consultations" to avoid "harmful interference" with the activities of other States. As is the case with most of the provisions of the space treaties, "harmful contamination" and "harmful interference" are not defined by the Outer Space Treaty itself. While their 'ordinary meaning (using the Vienna Convention on the Law of Treaties (VCLT) (VCLT, 1969) approach) seems reasonably clear, particularly based on the dictionary definitions (OED 2011: 308, 651), it remains unclear as to what needs to be subject to the harm in question? Environmental law is particularly focused upon harm to "life" whether directly or indirectly. Based on the subsequent practice of the conduct of the various mission to the Moon, and other celestial bodies, the interpretation that can be drawn from State practice is that "harmful contamination" is about biological contamination of celestial bodies particularly where and when there is "potential" for life or related indicators. Therefore, it would be a stretch to interpret "harmful contamination" as being the "contamination" of the celestial body itself *per se*. This also leads to a conclusion that different approaches are in order for different celestial bodies given the different "environmental" conditions on those bodies (the presence of an atmosphere makes Mars different from the Moon for example) (Newman 2015: 35–36). However, what standards are necessary to meet the requirements of Article IX are an open question. It seems logical to adopt an "evolutionary approach" to the interpretation of Article IX given the technical nature of the issue. To use, say "planetary protection" standards applied to the Viking landers in 1975 would ignore the developments in both sterilization and the understanding of the outer space environment(s) in the intervening 45 years.

There are planetary protection polices, in addition to the COSPAR PPP, which have been implemented, and can be viewed as 'subsequent practice' and therefore help to define the meaning of the terms of the Outer Space Treaty. NASA, the European Space Agency and the Japanese Space Agency (JAXA) all have their own internal policies. These only apply to those agencies and their associated missions, so commercial missions are not necessarily subject to those policies. As mentioned, States are responsible for the activities of their nationals in outer space and required to authorize and supervise those activities. Therefore, non-governmental missions are required to "avoid harmful contamination" as per Article IX OST. The practice of the various space agencies should be viewed as "subsequent practice" and therefore form a baseline of what should be expected of states to require of non-governmental actors in order to secure the necessary authorisations to conduct a space activity. However, unless those States choose to do so there is no obligation to implement COSPAR's PPP. Yet it is important to note the broad acceptance and general adherence to the principles, and indeed, the COSPAR PPP is a respected technically driven international set of guidelines.

As the relevant space agencies operate their own policies and no State has opted to incorporate COSPAR's PPP into their national laws their value as customary international law is limited. However, "soft-law" is a growing part of the space governance infrastructure, and particularly in technical arenas such as "planetary protection" can be a useful approach especially for emerging governance issues. Indeed, Setsuko Aoki argues that soft law, such as the COSPAR PPP, is often best suited for technical guidelines, it reduces the need for compromise, and can be more easily updated than hard law options (Aoki 2012: 72–73). COPSAR's PPP is an exemplary example of such technically driven guidelines and should serve as a model for such "soft law" instruments.

New Space and the Problem of Enforcement

Up until the middle years of the 2010s, it was inconceivable that a private company would become seriously engaged in the exploration of celestial bodies other than the Moon within the foreseeable future. The proliferation of private companies seeking to "Mine the Skies" (Lewis 1997) and unlock a prospective trillion-dollar space-resource was greeted with a hopeful but realistic recognition of the difficulties. The size of the investment required coupled with the vast infrastructure needs of space mining meant such ventures would be difficult to bring to fruition, and the troubles experienced by companies like Planetary Resources did little to dampen those doubts (Foust 2019).

So, while the exploitation of celestial bodies has been in the zeitgeist of the space community, the aforementioned financial *realpolitik* meant that journeys to celestial bodies remained the province of the scientific and academic actors. The natural corollary of this was that the COSPAR PPP became firmly embedded as the international standard by which contamination of celestial bodies would be avoided. In the United States, for example, no NASA probe will be launched into space without receiving prior approval from the NASA Planetary Protection Officer (Butler 2006: p. 1357). Therefore, while COSPAR PPP is entirely voluntary in nature, and it is not enshrined within the OST regime, there has been broad compliance it by both regulators and mission planners eager not to contaminate a potentially pristine extraterrestrial environment.

This scientific hegemony in respect of planetary protection is not guaranteed to continue in perpetuity, however. The first signs of a serious attempt by the private sector to engage in missions that would require adherence to the principles of planetary protection came at the 2016 International Astronomical Congress, where Elon Musk outlined his plan to colonize Mars using rockets built by his company SpaceX (Newman and Williamson, 2018). Unlike some of the other ventures, Musk has the financial resources and SpaceX has evidenced significant technological prowess to make the space community pay serious attention to Musk's proposals. Given that Musk has previously made it clear that he has no great attachment to the planetary protection protocols, believing there is no life on Mars (Berger, 2015), there a distinct possibility that those looking to explore other celestial bodies for commercial reasons will eschew the restrictive requirements

of the COSPAR PPP in favor of a more relaxed approach to planetary protection.

It is not only Musk from the private sector who seeks to challenge the COSPAR regime. In February 2019, the Arch Mission Foundation, a non-profit, independent organization created a "Lunar Library" archive for Israel and secured a launch berth on the Beresheet mission. This was the first attempt at a lunar lander from Israel and was the result of funding from a range of philanthropic organizations and private investment. The mission itself was a failure, with the spacecraft crashing into the lunar surface (Foust 2019b). However, in August 2019, Nova Spivack, the founder of the Arch Mission Foundation, announced that among the payload (which was, as proposed to the regulator–in this case the UnitedStates' FAA–a DVD-sized archive containing 30 million pages of information and DNA) was a number of tardigrades, the small microscopic lifeforms that are highly resilient to all manner of conditions in space that would normally be considered inimical to most life forms (Oberhaus 2019). In a later interview, Spivack further declared that the other launch partners, or the space agencies were unaware of the presence of tardigrades. He claimed that he wanted to take the risk to see how life behaved and would "ask for forgiveness rather than permission" (Taylor 2019).

The lack of disclosure of the existence of the tardigrades casts doubt upon the compliance of the Beresheet mission to the planetary protection guidelines. Missions to the Moon are classed as Category II under the COSPAR PPP (**Table 1**). This requires the creation of a planetary protection plan and "a series of reports both pre-launch report, post-launch report, post-encounter report, and an end-of mission report" (Johnson et al., 2019). While the actions of Spivack and the Arch Mission Foundation were clearly aimed at sidestepping the COSPAR guidelines, the reaction of the international community to the seeding of the Moon with tardigrades was a mixture of curiosity and outrage, but little in the way of substantive action.

Recent developments beg the question as to how secure the principles of planetary protection will be if challenged by adventurous entrepreneurs, unfettered by the constraints of the scientific community. The recent NASA Planetary Protection Independent Review Board (NASA 2019) has led to the announcement of a reframing of the COSPAR guidelines for the Artemis program (NASA 2020a), but even these revivified proposals may be too cautious for those who are prepared to risk some contamination in exchange for commercial developments. While guidelines provide a suitable mechanism for establishing approved behavior within a specific community of practice, they are ultimately non-binding and not designed to be enforced when actors refuse to adhere to the norms of a group to which they themselves do not belong. In essence, guidelines rely on "carrots" rather than "sticks" (Goh, 2008).

Johnson et al. (2019) highlight that although the COSPAR PPP is not binding on any State, that does not mean they cannot be voluntarily adopted by States and then implemented through national legislation or licensing requirements. This is where the legal status of the COSPAR PPP becomes somewhat opaque. Internationally, they do not have the binding force of a treaty, but once a nation decides to incorporate the principles within their licensing regime, it could be unlawful for either an individual or a company to act in a way which is not in accordance with a license (see, for example, United Kingdom Outer Space Act 1986, s3).

Licensing is an inherent requirement of international space law. As stated previously, the five UN space treaties seek to regulate the behavior of States, establishing the obligations and positive rights of States in the peaceful uses and exploration of outer space (Marboe 2017: p 131). Indeed, this is one of the three core principles around which the OST is located; freedom of exploration, the requirement that exploration and use is undertaken for peaceful purposes and that states are responsible for national space activities (Masson-Zwann 2017: p 2). It is therefore fundamental to the overarching international regime that State parties to the OST agree to take on responsibility not only for state-sponsored missions, but also non-governmental entities. The provisions of Article VI of the Treaty ensure that the principles of the OST are embedded within all space activity, be it public or private in nature:

> "State parties to the Treaty shall bear international responsibility for national space activities in outer space, including the Moon and other celestial bodies, whether such activities are carried out by governmental agencies or by non-governmental entities, and for assuring that national activities are carried out in conformity with the provisions set forth in the present Treaty."

As with much of the OST, this provision represented a compromise between the two dominant powers of the time of drafting: the United States and the Soviet Union (USSR). The USSR at the time believed that only a nation state, "conscious of its intention responsibility should carry on space activities." (Hobe et al., 2009: p 106). This is particularly germane when considering notions of planetary exploration as for much of the life of the OST, it was believed that it is only nation states that would either be capable or interested in exploring the Moon or other celestial bodies.

As Johnson et al. (2019) point out, the "attribution to the State is direct and automatic. Article VI of the OST makes States internationally responsible for the actions of. . .private actors such as corporations, non-profit foundations or others not acting in a governmental capacity". It is the second sentence of Article VI that creates the need for a licensing and regulatory framework within the domestic legislation of State Parties to the OST. It states that "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". As can be seen, therefore, Article VI creates a positive obligation upon the State to make sure that all non-governmental activities are monitored to ensure compliance with the terms of the OST.

The fact that the principles of planetary protection are not contained within a binding international treaty is, therefore, not fatal to the prospects of ensuring compliance. Indeed, the

fluid nature of scientific opinion means that a non-treaty agreement can incorporate changes, such as those proposed by the Stern review (NASA, 2019), as scientific opinion changes and develops without the need to open a treaty up for renegotiation. As Goh (2008) highlights, there is a danger that a poorly constructed and overly restrictive treaty could be prone to premature failure, leaving a significant gap in normative guidance. Non-treaty agreements and guidelines constitute a versatile pre-droit regime that can capture and galvanize developments in the field.

By having States as the guarantors of compliance with the treaty, national regulators have to bear in mind scientific best practice when thinking about the authorization of space missions (Lyall and Larsen 2018). The COSPAR PPP is recognized across the world, and - perhaps more importantly–throughout the scientific community as being the best way to capture developments in scientific understanding. This, in turn, will equip national regulators, who have a duty to authorize and oversee all aspects of any mission by their nationals or companies, with the guidance to deal with each mission on a granular level. It is surely logical for nations to incorporate COSPAR guidelines within the extant licensing mechanisms (as the FAA do with their payload reviews and the United Kingdom Space Agency do by virtue of s5 (2) (e) (i) Outer Space Act 1986). Doing this and discharging the supervisory duty under Article VI of the OST, means that approval of missions remains within the competency of States.

What then of the tardigrades and the threat posed to planetary protection by hyper-wealthy entrepreneurs? According to Article VI of the OST, the Beresheet mission was part of a payload launched from the United States (it is important to distinguish the responsibility for the mission from liability under Article VII, however in this case, the FAA in the United States would consider the launch a national space activity and therefore would provide authorization under Article VI as well as being a launching state under Article VII). As the mission involved the activity of an Israeli not-for-profit foundation, both Israel and the United States would be internationally responsible under Article VI of the OST (Johnson et al., 2019). It is, therefore, for their regulators to decide what action should be taken against the Beresheet mission for the presence of unauthorized tardigrades.

Article VI imposes the positive obligation upon States to license non-governmental actors (of whatever kind) for any area of a space mission. The OST requires consideration to be paid to scientific information, especially regarding the contamination of outer space (Lyall and Larsen, 2018). That the COSPAR PPP are not binding upon States and merely persuasive is something of a red herring. Any regulator wishing to be seen as responsible ignores the findings of COSPAR at their peril. In the current geopolitical environment, having planetary protection as part of consideration of the granting of a launch license is as close to enforcement as can be realistically hoped for. The burden now passes to individual States to ensure that its nationals and its companies do not engage in exploration that endangers the scientific value of celestial bodies.

Environmental Framework for Outer Space?

In light of the increasing interest in the Moon and other celestial bodies by non-governmental actors, for activities other than scientific investigation, it is worth considering whether there should be a broader "environmental" consideration embodied in the conceptualization of planetary protection, i.e. widen its remit. Increased lunar activities could replicate Earth's "space debris problem" around the Moon (and later Mars); lunar dust, kicked up by activities on the surface could be a significant environmental issue (Grush, 2019); not to mention the "damage" mining operations will cause to hereto pristine environments. Positioning "planetary protection" as more than just a question of protecting scientific integrity but part of a broader "environmental protection" regime for outer space will strengthen the case for such measures. It will broaden the stakeholders and help guard against an ambivalence toward the objectives of astrobiology.

There has been a clear lack of recognition of the nature of outer space as an environment, doing so provides a framework for understanding and protecting outer space as an arena for human activity. The "Stern Report" (NASA 2019) draws the boundaries between scientific and commercial space endeavors. There is a recognition of the multi-purpose nature of space activities (commercial, scientific, prestige etc.) but there has not been a sufficiently persuasive argument for the protection of the space environment itself.

While outer space in undoubtedly a unique environment, it is, as discussed, within the scope of international law and therefore under the auspices of the "international community". Central to this international order are the principles set out in the UN Charter of a duty to cooperate, conduct peaceful international relations and a commitment to the rule of law in global governance. The Outer Space Treaty repeatedly reaffirms these principles, particularly the duty to cooperate in the exploration and use of outer space. Article III OST firmly cements space law within the wider general international legal regime with the UN Charter as its foundation. Therefore, it is quite reasonable to draw upon principles in other fields of international law as models for addressing environmental problems in space law.

The United Nations Convention on the Law of the Sea (UNCLOS) (UNCLOS 1982) is frequently used as an analogue regime for outer space. There are numerous similarities between the law of the sea (particularly as it pertains to the high seas) and the law of outer space. Both the high seas and outer space are "areas beyond territorial jurisdiction" and generally regarded as *res communis* or part of the global commons. A key example of the similarities can be seen between the right of peaceful passage in UNCLOS and Article I of the Outer Space Treaty which provides for a right of free access to all areas of outer space, the Moon and other celestial bodies for all States. A link can even be made to the need to tackle the space debris issue if conceived of as a "hazard to navigation" that potentially impedes the "free access" to outer space.

International environmental law is a useful source for a model or analogue for the development of a more "environmentally"

minded space law regime. Similar to outer space, international environmental law has a set of core treaties which have been advanced and developed by non-binding "soft law" instruments, with a limited role for customary international law. While international environmental law is not directly applicable to outer space, it can serve as a model for space law, and the core principles can be transliterated to the space law regime. Further, if these principles of environmental law become further established as customary international law within general international law then they may become applicable to space law.

As it currently stands, with the exception of the "failed" Moon Agreement, Article IX OST is the central pillar of 'space environmental law' and it offers little help. However, it does introduce a requirement of principle of "appropriate international consultation", and "due regard", but given the paucity of details within Article IX OST there needs to be further elaboration of what is meant these terms. As discussed above, States can take a proactive role in this, particularly with respect to non-governmental actors such as commercial entities; they can require "environmental impact assessments" or similar measures as part of their national licencing process.

Further, UN guidelines are critical in providing this elaboration and are "a prudent and necessary step toward preserving the outer space environment for future generations" (United Nations Committee on the Peaceful Uses of Outer Space, 2007). These guidelines should draw on the principles of wider international law, and international environmental law more specifically. Positive action taken at the UN and by the international space community would have the additional advantage of demonstrating intent to "import" or "transliterate" principles that are not necessarily firmly established in customary international law. This would serve the objective of creating an environmental framework to protect space for the future, maintain the viability of scientific endeavors, limit harm to all States and to equally and adequately allow growth of space activity sustainably and economically. This would serve not just to protect the scientific value of outer space as intended by the planetary protection principles espoused by COSPAR and others but would also ensure the sustainability of all outer space activities.

Space is a fragile environment; it lacks many of the "naturally restorative" processes that exist in terrestrial environment and therefore needs extra care. It is therefore important to place the maintenance and protection of the space environment at the forefront of the space governance regime. Outer space is already an important part of the global economy and will only become more important. Therefore, it is imperative to ensure that the use of space is undertaken on a sustainable footing, to ensure its continued availability. However, the concept sustainability is a debated one, and there are many differing visions of what "sustainable" means. Inherent to the concept of "sustainable," at least in international environmental law, is that use or exploitation of natural resources can continue however, the needs of future generations and the broader environment must be taken into account (Dupuy and Vinuales 2018: 91–92). Moreover, sustainability, by definition, includes an ecological, economic, and social component, which seems widely accepted.

As has been explored, even with the provisions of Article IX OST, space law is limited in terms of specific measures to protect the space environment. Space is an environment; a fragile environment in need of greater protection. However, general international law, the Law of the Sea, and international environmental law all provide principles and models for how the space environment can be afforded greater protection. Any international governance measure is only as strong as those that support it, and therefore it is important to build broad support for any measure. That need, combined with a need to allow measures to develop and adapt over time based on new science and technology, lends support for any space environmental instrument to be rooted in "soft law." The COSPAR PPP demonstrate the potential of such measures. States should recall that outer space is a unique and fragile resource. It is imperative that its continued use and development be undertaken in a sustainable manner.

CONCLUSION

The discovery of extraterrestrial life, in whatever form, will undoubtedly be one of, if not the, most seminal scientific discovery in human history, it is therefore imperative that the integrity of that finding is as unimpeachable as is possible. COSPAR's PPP and allied efforts are central to that. Paradoxically, the inherent responsiveness that is its greatest strength is also potentially its fatal weakness. That COSPAR is an expert driven process which generates technical guidelines that are adaptive to circumstances and scientific development and that both makes them an exemplary example of 'soft law' and has furnished them with high regard within the scientific community. As non-binding guidelines they are followed because space exploration agencies and mission planners recognize their value as "good practice" for scientists. The Achilles heel in this is that actors who see themselves as outside of this community and who do not care about protecting the scientific integrity of outer space, will not feel obliged to adhere to the guidelines. This situation is not terminal, however, as States have the ability, and the responsibility to ensure respect for the guidelines through Article VI of the OST and the resultant licencing process. Furthermore, as can be seen from the above discussion, States would benefit from promoting the COSPAR PPP as a model. This expert led, adaptive process is a model for other areas of space governance to follow particularly as outer space becoming increasingly commercial and non-governmental. It is also sensible, as this transition occurs, to consider a broader "environmental" framework for outer space to ensure that there is not a repeat of the space debris problem around other celestial bodies, among other issues. The incentive for States to act is clear: there will be significant national prestige for the mission that discovers the existence of extraterrestrial life. The many missions to other worlds have shown that adhering to the COSPAR PPP does not prevent activity but it may be vital to establishing the provenance of any discovery of extraterrestrial life.

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