

Planetary Protection Obligations in Space Exploration Law and Ethics Regarding the Biological Contamination of Outer Space

Caitlyn A. K. Singam*

Abstract

The issue of biological contamination in space exploration has highlighted the relevance of addressing the ethical and legal responsibilities entailed in exploring previously undisturbed regions of space, especially those which have the potential to harbor life. While the scientific importance of space exploration means that the introduction of spacecraft into otherwise undisturbed environments is a necessity, the extent to which environmental disruption can be considered a responsible use of a shared space, has not been consistently identified in the scientific or legal literature. This paper discusses some of the key legal and ethical issues concerning the responsible use of space from an astrobiological and planetary protection perspective, as well as proffering recommendations as to how international space law can create more effective ethical responsibility and liability standards regarding the biological integrity of space-based environments.

1. Introduction

Despite the exponential increase in space launches seen over the last decade, the international body of law governing *corpus juris* governing space activity has not expanded accordingly. Notably, there has not been any new legally binding international treaties or conventions governing state behavior in outer space since the Moon Agreement's adoption in 1979, and none which have been signed by, and rendered legally binding on, a majority of spacefaring nations since the Registration Convention of 1974.¹ Nonetheless, recent increases in space activity have emphasized the need for clear, enforceable obligations in the use and exploration of space, a need which has been exacerbated by the variegated, and often conflicting, priorities of the

* University of Maryland.

1 United Nations Office for Outer Space Affairs, *International Space Law: United Nations Instruments* (United Nations, 2017).

newly expanded cast of spacefaring actors. Existing international space law has generally fallen short in providing clear guidance on handling balancing priorities, with legal commentaries frequently remarking on the broad language and vague terminology used across much of the corpus juris of space, and the lack of formal legal precedent or supplemental documentation to otherwise guide the interpretation of such language.²

The ramifications of this state of affairs have become particularly evident with regards to planetary protection, i.e., the protection of the biological environment of space and the avoidance of interplanetary contamination. There has already been substantial debate as to how scientific and environmental interests in retaining the natural environment of space in its current state can and should be balanced with the desire to engage in developmental and commercial activities that might cause irreversible environmental damage.³ Although it is generally accepted that at least some level of environmental protection is necessary in order to keep the usage of space sustainable into the future, the legal obligation for spacefaring parties to actually implement environmental measures remains ambiguous. Implementation of planetary protection measures (i.e., a combination of technical and strategic approaches to measurably reduce the quantity of biological contaminants introduced into the space environment) has thus largely been an secondary consideration tied to scientific interests, rather than a legal obligation. However, with increasing economic and strategic impetuses to prioritize space usage over space protection, there is no guarantee that current de facto practices will continue to be implemented into the future, nor that they will be employed by all spacefaring parties. There are thus open questions as to (1) what the nature of ethical imperative is with regards to planetary protection, (2) the degree to which planetary protection measures can be made legally enforceable under existing space law, and (3) how space law should be adapted in the future in order to better ensure ethical and environmentally responsible usage of space.

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- 2 H. Keefe, 'Making the Final Frontier Feasible: A Critical Look at the Current Body of Outer Space Law' (1995) 11 *Santa Clara Computer and High-Technology Law Journal* 345; E. W. I. Paxson, 'Sharing the Benefits of Outer Space Exploration: Space Law and Economic Development' (1992) 14 *Michigan Journal of International Law* 487.
 - 3 J. S. J. Schwartz, 'Prioritizing scientific exploration: A comparison of the ethical justifications for space development and for space science' (2014) 30 *Space Policy* 202–8; J. D. Rummel, M. S. Race, G. Horneck, and the Princeton Workshop participants, 'Ethical Considerations for Planetary Protection in Space Exploration: A Workshop' (2012) 12 *Astrobiology* 1017–23; J. S. Koch, 'Institutional Framework for the Province of all Mankind: Lessons from the International Seabed Authority for the Governance of Commercial Space Mining' (2018) 16 *Astropolitics* 1–27.

2. Ethical Considerations in Planetary Protection

Fundamentally, this author argues that planetary protection represents a form of ethical trolley problem. In this view, the choice to implement, or not to implement, planetary protection measures is the metaphorical ‘trolley switch’, and evaluating the ethics of planetary protection can be distilled into a matter of the relative cost associated with either choosing or failing to take planetary protection measures.

The primary cost of choosing to implement planetary protection is the incurrance of financial and logistical costs by spacefarers, which run counter to spacefaring parties’ interests in keeping the overall cost and burden of spacefaring endeavors to a self-defined minimum. Planetary protection implementation costs are generally understood to comprise only a few percent of the total program cost for each space mission, though some have argued that indirect costs mean that it comprises as much as 10% of total cost.⁴ Nonetheless, these expenditures are relatively short-term in nature, in that planetary protection spending is largely limited to the pre-launch phases of any individual space mission (due to resource intensive procedures such as spacecraft sanitization having to occur before launch), and can be argued as having a limited long-term impact on overall spacefaring interests when considered in respect of the overall cost of spacefaring endeavors in general. Furthermore, the minimum necessary cost for the implementation of planetary protection measures may not be as high as generally assumed; mission architects for prior spacefaring endeavors have made note of the fact that a substantial portion of the expenditures previously seen in association with planetary protection implementation are, in fact, avoidable products of a lack of systematic application of *de facto* planetary protection requirements.⁵

In contrast, the primary cost of inaction on planetary protection is the potential for biological contamination. The current scientific understanding is that biological contamination is a considerable threat to space, and can cause immense and irreparable harm to planetary environments.⁶ Unlike harm to financial interests, harm stemming from biological contamination tends to be much more expansive in scope and duration, and consequently have the potential to cause adverse effects well after the spacefaring activity which

4 A. Debus, ‘Planetary protection: Elements for cost minimization’ (2006) 59 *Acta Astronautica* 1093–1100; National Academies of Sciences, Engineering, and Medicine, *Review and Assessment of Planetary Protection Policy Development Processes* (The National Academies Press, 2018).

5 L. Hamlin, A. Belz, M. Evans, J. Kastner, C. Satter, and A. Spry, ‘Design Tools for Cost-Effective Implementation of Planetary Protection Requirements’ (2006).

6 C.-J. Clemenson, ‘Sterilization of Lunar and Planetary Space Vehicles (A Review)’ in N. Boneff, I. Hersey (eds.), XIIIth International Astronautical Congress Varna 1962, (Vienna: Springer, 1964), pp. 292–313.

instigated such harm has ended. Scientific literature has noted that biological contamination poses a significant long-term risk to the space environment.⁷ Unlike general space debris, which can arguably be removed without much issue, the ability of biological contaminants to potentially adapt, spread, and replicate in number means that they can cause catastrophic and irreversible damage to planetary environments and cannot be easily mitigated.⁸

Given that the ubiquity of microorganisms on Earth means that contamination is a near-inevitable consequence of introducing any sort of Earth-originating artifact into space, it is clear that inaction on planetary protection jeopardizes the long-term safety of the biological environment of space and the interests of any parties which may have a stake in the continued integrity of the space environment.⁹ The key question of ethical relevance is thus the extent to which planetary protection procedures can be said to be justified when juxtaposed with competing interests to forgo such procedures in favor of reducing costs.

As aforementioned, the cost of inaction on planetary protection places a substantial risk of significant and permanent harm to environmental and scientific interests, which would have a deleterious effect on spacefarers being able to pursue their long-term goals. In contrast, the cost associated with implementing planetary protection measures poses relatively little material threat to any long-term spacefaring interests, and is – more importantly – a smaller cost which is can be recovered from (via the acquisition of new funds to replace pecuniary losses) in a manner in which permanent harm cannot. From this perspective, even with the financial cost to spacefarers, the ethical choice is thus to pull the metaphorical trolley switch and enact planetary protection measures.

There is also further argument that acting in favor of planetary protection is the appropriate ethical option given shared and future interests. It is well understood that much of the value which space currently offers humanity will be lost if the environment of space sustains significant irreparable harm; to that end, there is a shared interest in the protection of space from such harm. Individual parties' future use of the space environment, after all, is inherently contingent on there still being an environment in existence that can be of practical use. Space can thus be considered to a sort of *res communis* which is held in trust both by and for present and future generations, and which spacefaring parties have an affirmative obligation to sustainably protect. Under this “common heritage” principle, requiring all individual spacefaring entities to employ planetary protection practices, in lieu of permitting

7 National Academy of Sciences, *Addendum to Minutes of the Meeting of the Council of the National Academy of Sciences on February 8, 1958* (1958).

8 Clemedson, 'Sterilization of Lunar and Planetary Space Vehicles (A Review)'.

9 J. V. Lopez, R. S. Peixoto, and A. S. Rosado, 'Inevitable future: space colonization beyond Earth with microbes first' (2019) 95 *FEMS Microbiology Ecology* fiz127.

unrestricted spacefaring, is arguably the most ethical means of allowing spacefaring endeavors to continue while still ensuring maintenance of intergenerational equity.

3. The Current State of International Space Law

Based on this reasoning, it can be concluded that there is an ethical obligation to ensure that planetary protection measures are being appropriately employed by spacefaring actors. However, there is currently limited legal enforcement of such obligations. Across the six treaties which form the basis of international space law, the only direct, legally binding provision for protecting the space environment exists in Article IX of the Outer Space Treaty, which mandates that states avoid the “harmful contamination” of space and “adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter”, furthermore stipulating that states must “where necessary...adopt appropriate measures” to ensure such contamination and adverse effects are avoided.¹⁰ (The Moon Treaty contains a near-identical reiteration of these provisions, but is not legally binding on most nations). This provision provides grounds for making the implementation of planetary protection procedures a legal requirement for spacefaring parties, conditional on general acceptance that (a) biological contamination meets the standard of being “harmful” and (b) that planetary protection is an “appropriate” measure for combating and/or mitigating the risk of harm being caused. However, the actual language of the Outer Space Treaty does not provide any direct indication of how the concepts of harm and contamination should be defined, nor what should be considered “appropriate” in the prevention of harmful contamination. Even artificial space debris, which is a known cause of significant, observable physical damage to spacecraft and other property stationed in space, is not clearly covered under the “harmful contamination” standard; the United Nations and other organizations have developed non-binding resolutions and guidelines to clarify expectations about preventing and minimizing space debris, but have not conclusively asserted a legal obligation to follow those expectations.¹¹

There is additional ambiguity as to how parties should be kept accountable for any “harmful contamination” they may cause. Article IX of the Outer Space Treaty stipulates that any state that is party to the treaty must engage

10 United Nations Office for Outer Space Affairs, *International Space Law: United Nations Instruments*; United Nations Office for Outer Space Affairs, *International Space Law: United Nations Instruments*.

11 L. D. Roberts, ‘Addressing the Problem of Orbital Space Debris: Combining International Regulatory and Liability Regimes’ (1992) 15 *Boston College International and Comparative Law Review* 51.

in “international consultations” when there is a potential for “harmful interference with activities of other States Parties in the peaceful exploration and use of outer space”.¹² Other states are also permitted to request consultations from a given spacefaring state based on the belief that such interference may occur as a result of the spacefarer’s activities, though there does not appear to be an obligation on the part of the spacefaring state to actually honor consultation requests. Regardless, the Article IX provisions – despite introducing some level of accountability for spacefaring-associated damage – are only relevant to activities which threaten the interests of spacefaring parties, and do not necessarily extend to environmental concerns or to cultural interests of non-spacefaring nations in the preservation of space unless a case can be made for those concerns being tied to “interference with activities in the use of outer space”.

Similarly, while the Registration Convention allows for a state to use the United Nations’ registry of space objects to identify a space object which caused “caused damage to [the state] or to any of its natural or juridical persons”, it is nebulous as to whether the law as written considers the environment of space to be party to international law (e.g. as a form of juridical person) in a manner that might allow damage to the space environment or to indigenous space biota to be of legal concern. Even if it did, it is also noted here that while the Registration Convention obligates other states to assist when requested “to the greatest extent possible... under equitable and reasonable conditions” in identifying the party/parties responsible for a space object that causes damage, there do not appear to be any consequences for failing to do so; thus, even if the environment of space were to be effectively considered a party to the treaty, it is unlikely to have any meaningful effect unless another party were to act on the environment’s behalf.¹³

It is thus unclear as to whether there is any meaningful accountability under the law for damage or potential damage caused by biological contamination, especially because the law does not take a stance on whether biological contamination can be said to pose “interference with activities in the use of outer space”. It is also nebulous as to whether the law as written has any intent towards protecting the interests of the space environment or to indigenous biota that may exist in space, given that the aforementioned accountability provisions in international space law only encompass damage to states and “natural or juridical persons”.

Furthermore, ambiguities in defining parties’ legal responsibilities towards the prevention of biological contamination and the degree to which parties

12 United Nations Office for Outer Space Affairs, *International Space Law: United Nations Instruments*.

13 United Nations Office for Outer Space Affairs, *International Space Law: United Nations Instruments*.

can be held accountable for contaminating space have also made it challenging to ascribe liability to parties for damage caused by biological contamination. As it stands, the question of whether spacefaring parties are liable for environmental damage is not directly addressed in international space law.

A *prima facie* reading of Article VII of the Outer Space Treaty and the Liability Convention would suggest that parties are not, in fact, liable for environmental damage if that damage is to the space environment and not the environment of Earth. As written, the implication appears to be that states cannot be held liable for damage to the space environment since the environment is not a party to any international space law treaties in its own right, and must be held in indemnity for such damage unless the space environment, or parts thereof, is considered to be the property of a state or its any natural or juridical persons.

With regards to the possibility that the space might qualify as property, it must be noted that space cannot be directly considered to be the property of any one state – or indeed, any natural or juridical person, depending on one’s reading of the law – due to Articles II and VI of the Outer Space Treaty. Article II states that “outer space, including the moon and other celestial bodies, is not subject to national appropriation by claim of sovereignty, by means of use or occupation, or by any other means”; Article VI, which ascribes to states “responsibility for national activities in outer space”, would imply that attempts to claim property by persons under a nation’s jurisdiction would be considered forms of “national appropriation”.¹⁴ However, though there is arguably no permissible assertion of individual property over the space environment itself, there does not appear to be a direct prohibition against either (a) the space environment being declared *res communis* and consequently the property of all of humanity as a collective whole, regardless of nationality, or (b) states and/or persons claiming property interest in tangible or intangible items *derived from* resources in the space environment (including, one could argue, items such as data collected from astrobiology missions), rather than ownership over the space environment itself. Either option would open the possibility for some level of international liability for damage to the space environment by rendering such damage either a direct or indirect threat to such property.

The Moon Treaty attempted to build on the *res communis* concept of environmental liability to some extent, by aiming to create a legally binding declaration of humanity’s collective international ownership of space under the “common heritage” principle. This concept was largely rejected by industrialized nations due to arguments that universal shared ownership of space would pose an insurmountable obstacle to the success of commercial

14 United Nations Office for Outer Space Affairs, *International Space Law: United Nations Instruments*.

space endeavors, and consequently was a notable contributing factor to the lack of signatories on the Moon Treaty. However, the concept of derived ownership essentially remains untested in international space law, and could provide a means by which existing space law could be leveraged to generate a clear obligation of liability for environmental damage to the space environment.

National and regional laws also tend to share the same problems as international law, in that they are either nebulous à la the “harmful contamination” standard (some nations in fact echo the same language in their national laws without elaboration), or otherwise do not specify a minimum standard of care with regards to avoiding environmental damage.

In the absence of any clear *de jure* obligations towards planetary protection, most of the enforcement of planetary protection ethical needs has occurred via *de facto* agreements and practices. Much of the impetus for practical enforcement of planetary protection measures has come from the scientific community, and in turn from government space agencies that directly facilitate or fund space science research. These scientifically-oriented parties have, for the most part, a shared and concerted interest in planetary protection as a means of ensuring that biological contamination does not interfere with current or imminent astrobiological experimental and exploratory objectives, even if only to the extent of maximizing the scientific value of their efforts and their return on investment. Awareness that other parties’ failures to properly implement planetary protection could jeopardize their own interests has further spurred attempts to engage in international collaboration on the matter, rather than simply developing individualized planetary protection initiatives in isolation.

Nonetheless, as more parties gain spacefaring capabilities, there is no guarantee that widespread *de facto* implementation of planetary protection requirements will continue. A strong driver of international consistency in planetary protection implementation has previously been the consistency of spacefaring parties’ interests; as these interests branch out from merely being research-oriented into pursuing other uses for space, there will inevitably be cases where spacefaring parties will perceive planetary protection requirements as being at odds with their priorities and choose to not to implement planetary protection as part of their endeavors. Without legal obligations that set affirmative obligations for planetary protection, or provisions which render parties accountable and liable for breaches of such obligations, there are no meaningful obstacles to dissuade parties from doing so.

4. Improving International Space Law

It is thus apparent that international space law is in need of an update with regards to planetary protection consideration. Especially as spacefaring activity continues to increase and more actors become involved in spacefaring endeavors, it will be increasingly necessary to ensure that there is a clear, robust, and enforceable body of laws to ensure that the environment of space is used responsibly and sustainably.

4.1. Recommended Extensions to International Space Law

As argued by philosophers such as Plato, the law is most effective when it relies primarily on persuasion, rather than compulsion.¹⁵ Even in instances where the mandated obligation stems primarily from the need to protect another party's interest, rather than the interests of the party undertaking the obligation, it is sensible to presume that a law which nonetheless is presented in relation to the interests of its subject will be less of a burden to implement than one which does not. To that end, it is prudent for any attempt to include planetary protection in the *lex ferenda* to present planetary protection obligations as a means of supporting parties' individual interests rather than as purely environmental concerns.

Environmental protection in space law has faced particular difficulty in handling the fact that the environment is not, in and of itself, a legal entity, and as such is not one of the parties whose direct interests are typically considered under conventional law. The concept of making the space environment a juridical person presents a possible solution to this dilemma, but is impractical given the need for parties to assert legal guardianship over the environment (given the environment's inherent inability to represent itself or its interests in a court of law), the likelihood that such guardianship could be used as grounds to further national appropriate and/or misuse of the environment in support of individual interests, and the possibility that any designated legal guardians of the environment could technically be held liable for damage caused *by the environment* (e.g. due to natural disaster) to other parties.

Instead, a potential approach is to utilize the concept of damage to individual property – which is already addressed under the provisions of the Liability Convention – and extend it in a manner that, at minimum, explicitly allows for damage to scientific interests to be considered a form of property damage. The legal discussions which occurred during the development of the Moon Treaty have already highlighted how spacefaring nations prioritize the protection of property interests in spacefaring; consequently, while nations are typically loath to sign on to any treaty which significantly curtails their right to commercial enterprise in space, they are more likely to be amenable to the idea of planetary protection if it is highlighted as a means of protecting property.

15 Plato, *Laws* (Dover Publications, 2006).

Specifically, utilizing the Lockean concept of private property, wherein private property is created by a person mixing their labor with the raw materials of nature, this author argues that the fruits of scientific exploration (e.g. accurate scientific data) can well be considered a type of property that is produced by mixing the efforts of scientists and engineers with the natural environment they are attempting to study.¹⁶ Continuing with that line of logic, irreversible damage to exploratory efforts in the form of the loss of scientific data, etc. is effectively an infringement upon the right to property, and thus something for which parties can be held liable. It is proposed herein that this idea be implemented by explicitly defining “property” to include scientific data and scientific outcomes of exploratory missions, and subsequently extending the Liability Convention’s stipulations of liability for “damage to property” to encompass damage caused to scientific interests due to contamination. If implemented, this provision would afford some degree of protection for space which, while not necessarily comprehensive, is in accordance with scientific priorities.

As addressed earlier in this paper, the alignment between scientific and environmental interests is already the primary impetus behind the adoption of planetary protection on a *de facto* basis. Introducing the idea of rooting *de jure* planetary protection on the mutual overlap of scientific and environmental is thus likely to have greater traction with the international community than any attempts to legislate environmental protection obligations based on pure ethics. Tying the immense financial investment involved in scientific research endeavors in space to the continued preservation of the space environment also provides a direct and material motivation for parties to keep each other accountable for environmental protection obligations.

Another reason for defining environment protection provisions in terms of their impact on individual property interests, rather than on the independent interests of the environment as a *de facto* legal entity, is to simplify the implementation of liability clauses. There is already ample existing international law on the matter of liability for environmental contamination on Earth, including the Trail Smelter Arbitration (which articulated that a state may be held responsible under international law for the damage it causes to another state) and the Corfu Channel/*United Kingdom v. Albania* case (establishing the idea that each state has a mandatory responsibility to not knowingly allow its territory to be used to commit acts against the rights of any other state).¹⁷ More recently, the *Certain Activities/Costa Rica v.*

16 J. Locke, *Locke: Two Treatises of Government* (Cambridge University Press, 1988).

17 A. P. Rubin, ‘Pollution by Analogy: The Trail Smelter Arbitration’ (1970) 50 *Oregon Law Review* 259; M. Fitzmaurice, ‘The International Court of Justice and International Environmental Law’ in C. J. Tams, J. Sloan (eds.), *The Development of International Law by the International Court of Justice*, (Oxford University Press, 2013), p. 0.

Nicaragua case (directly addressing the determination of compensation for international environmental damage) as well as *Cáceres v. Paraguay* (explaining how the rights of individuals protected under non-environmental treaties, such as the International Covenant on Civil and Political Rights, can be used to enforce environmental protection) have elaborated on the manner and extent to which liability should be handled relative to environmental concerns.¹⁸

The existing foundation set by the Liability Convention in space law can thus be expanded in a similar fashion, with the following modifications:

- (1) extending absolute liability to damage which occurs in the space environment, rather than limiting liability to damage that occurs terrestrially or in Earth airspace;
- (2) changing the definition of ‘damage’ to explicitly include non-physical damage;
- (3) extending the definition of ‘damage’ to include damage to “parties or entities, to components thereof, or to parties’ property interests”;
- (4) explicitly extending the definition of “property” and “property interest” to include data from scientific investigations and “other types of property whose existence may be directly or indirectly contingent on the integrity of a particular environment”;
- (5) explicitly extending liability for space damage to include consequential as well as direct damage;
- (6) establishing a fault-based, non-absolute standard regarding liability for consequential damages,
- (7) explicitly extending planetary protection obligations to include natural and juridical persons in addition to states, in cases where such persons operate their own spacefaring endeavors; and
- (8) rendering states liable for negligence or willful ignorance of obligations, including in promulgating planetary protection obligations to persons under their jurisdiction.

Collectively, these provisions serve to ensure that the legal definition of liability in space more explicitly and comprehensively includes the protection of scientific interests, and that there are fewer ambiguities regarding the parties which have the legal obligation to accept liability for spacefaring-associated damages.

The author of this paper also suggests that the Rio Declaration and Kyoto Protocol, as international agreements governing pollution, can also be used as precedent for establishing more affirmative obligations with regards to planetary protection, such as requiring all states to engage in cooperation in

18 J. Harrison, ‘Significant International Environmental Law Cases: 2017–18’ (2018) 30 *Journal of Environmental Law* 527–41.

scientific study and technological development related to improving human understanding of the (space) environment and the interventions required to protect it.¹⁹ In a similar vein, it would also be meaningful to obligate spacefaring parties to:

- (1) ensure that spacefaring activities under their control do not cause damage to other parties;
- (2) develop individual/national planetary protection policies for reducing the risk of material harm caused by contamination; and
- (3) minimize the risk of material harm to the environment to the greatest extent possible, including, at minimum, sanitizing space objects to the greatest extent reasonably feasible.

5. Conclusions

The recommended extensions suggested in this paper are, of course, only the foundational components for fully integrating planetary protection considerations into enforceable space law. Nonetheless, integrating these provisions into the formal body of space law (such as via a new international treaty, a proposed text for which has been previously published by this author²⁰), can ensure that international space law will be able to grapple with the emerging challenges of the next generation of space exploration.

¹⁹ United Nations, *Rio Declaration on Environment and Development* (1992); United Nations, *Kyoto Protocol to the United Nations Framework Convention on Climate Change* (2005).

²⁰ C. A. K. Singam, 'Ethical and Legal Considerations in Preventing the Contamination of Space', *International Astronautical Congress* (Paris, France, 2022).