ARIZONA JOURNAL
OF
ENVIRONMENTAL LAW & POLICY

VOLUME 11 SPRING 2021 ISSUE 2

MOSS PIGS IN SPACE:
LEGAL LESSONS FROM TARDIGRADES ON THE MOON

Dov Greenbaum[*]

The international community's concern for the environmental impacts in outer space is predates the 1972 Stockholm Declaration and is often viewed as the first fundamental international statement on the protection of the environment. As Space Exploration continues to ramp up, with both private and public actors seeking to go boldly where few have gone before, there is a growing need to assess the protocols currently in place to both protect the space environments from earth-based contamination, as well as to protect the Earth from space contaminants. Recent crashes of probes on the lunar surface and intentional launches of microscopic life forms and other biological matter into outer space by public and private actors raise questions about the efficacy of the current regulatory scheme, which was designed before commercial space exploration was envisioned to the degree that it exists. This Article outlines planetary protection protocols, analyzes a case study of lunar contamination, the history of planetary protection regulations, and humanity's historic contamination of the moon, before pointing to effective models of terrestrial international environmental treaties and agreements that provide useful guidance for developing new planetary protection protocols.

[*] Director, Zvi Meitar Institute for Legal Implications of Emerging Technologies, IDC Herzliya; Professor of Law, Harry Radzyner School of Law, IDC Herzliya; Research Affiliate, Molecular Biophysics and Biochemistry, Yale University, New Haven CT; Research Fellow, Singapore Management University, Centre for AI and Data Governance.

I. Introduction

Last summer, on July 9, 2020, NASA promulgated interim directives related to its planetary protection policies, especially as they relate to our nearest neighbors Mars and the moon.[1] These revised guidelines, which came a bit too late for the three Mars-bound spacecraft that launched only weeks later,[2] followed a report by the Planetary Protection Independent Review Board, empaneled by NASA and released on October 17, 2019.[3] Generally, the report called for important revisions to the internal regulations promulgated by NASA's Office of Planetary Protection, [4] part of NASA's office of Safety and Mission Assurance (OSMA).[5]

More recently, the Biden White House began work toward implanting[6] the Trump Administration's National Strategy on Planetary Protection, which includes a wide ranging alphabet soup of federal agencies including the EPA, the FBI, the CDC and FEMA.[7] This new emerging set of strategies and proposals to develop planetary protection guidelines is set to include private actors as well as the new cohort of sample-return missions.[8] In fact, the White House hosted a day-long round table in June 2021 to include private actors in these discussions.[9]

NASA's Office of Planetary Protection's motto is indicative of the agency's goals : to protect "all of the planets, all of the time."[10] Part of their mission, among other objectives, is to avoid human-directed panspermia, or "the biological contamination of explored environments that may obscure our ability to find life elsewhere."[11] To this end, NASA and other space agencies have

---

[1] OFFICE OF SAFETY AND MISSION ASSURANCE, NAT'L AERONAUTICS AND SPACE ADMIN., NID 8715.128, PLANETARY PROTECTION CATEGORIZATION FOR ROBOTIC AND CREWED MISSIONS TO THE EARTH'S MOON (2020), https://nodis3.gsfc.nasa.gov/OPD_docs/NID_8715_128_.pdf.
[2] Ashley Strickland, *This summer, multiple spacecraft are launching to Mars. Here's why*, CNN (July 29, 2020), https://edition.cnn.com/2020/07/27/world/mars-mission-launches-summer-2020-scn/index.html.
[3] ALAN STERN ET AL., PLANETARY PROT. INDEP. REV. BD., REPORT TO NASA/SMD (2019), https://www.nasa.gov/sites/default/files/atoms/files/planetary_protection_board_report_20191018.pdf.
[4] *Planetary Protection*, NAT'L AERONAUTICS AND SPACE ADMIN., https://sma.nasa.gov/sma-disciplines/planetary-protection (last visited May 5, 2021).
[5] OSMA https://sma.nasa.gov/ (last visited July 25, 2021).
[6] Marcia Smith, BIDEN'S OSTP GETS COMMERCIAL INPUT ON PLANETARY PROTECTION, July 6, 2021 https://spacepolicyonline.com/news/bidens-ostp-gets-commercial-input-on-planetary-protection/ .
[7] Marcia Smith, WHITE HOUSE RELEASES IMPLEMENTING STRATEGY FOR PLANETARY PROTECTION December 30, 2020 https://spacepolicyonline.com/news/white-house-releases-implementing-strategy-for-planetary-protection/ (last visited July 25, 2021).
[8] The White House National Space Counsel, *National strategy for Planetary Protection*¸ December 2020 https://fas.org/spp/eprint/protection.pdf (last visited July 25, 2021).
[9] Readout of Planetary Protection Industry Day, June 30, 2021 https://www.whitehouse.gov/ostp/news-updates/2021/06/30/readout-of-planetary-protection-industry-day/ (last visited July 25, 2021).
[10] John Rummel, *Protecting All of the Planets, All of the Time*, PSW SCIENCE (November 30, 2001), https://pswscience.org/meeting/protecting-all-of-the-planets-all-of-the-time/.
[11] *Planetary protection officer: NASA will pay you six figures to keep planets pure*, ABC 30 (Aug. 2, 2017), https://abc30.com/nasa-planetary-protection-officer-science-mars/2267647/; For more on panspermia, *see, e.g.*, Paul S. Wesson, *Panspermia, Past and Present: Astrophysical and Biophysical Conditions for the Dissemination of Life in Space*, 156 SPACE SCI. REV. 239 (2010).

various approaches to implement the biological reduction of the microbial bioloads of spacefaring crafts, albeit each method with their own limitations.[12]

In some instances, NASA has gone to extreme efforts to preserve the space environment. For example, it plunged the spacecraft Cassini into Saturn's atmosphere to prevent contamination of the Cronian moons, [13] which may harbor life.[14] There have also been decades-long efforts to measure and validate the level of biological contamination on spacecraft prior to launch, as well as to limit said contamination as much as possible on future outgoing missions, even quarantining returning Apollo astronauts after returning from the moon. [15]

In addition to the ethical and moral obligations to avoid contaminating pristine and scientifically valuable environments, as well as protecting the Earth from extraterrestrial contamination from return missions, there is also legal substantiation for NASA's endeavors. Encoded in NASA's mandatory compliance policy directive 8020.7G is the requirement that "the conduct of scientific investigations of possible extraterrestrial life forms, precursors, and remnants must not be jeopardized."[16] NASA explicitly notes that its policy arises under US treaty obligations.[17] In particular, as per Article IX of the foundational 1967 Outer Space Treaty (OST), all State Parties are required to "pursue studies of outer space, including the moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination . . . ."[18] The international community's concern for the environmental impacts in outer space is particularly remarkable, dating as far back as 1967, as this Article predates the 1972 Stockholm Declaration, often viewed as the first fundamental international statement on the protection of the environment. [19]

The subsequent Moon Treaty, which was not ratified by most of the space-faring nations, attempted to explicate Art. 9: Viz., Art. 7.1 reads: "In exploring and using the moon, States Parties shall take measures to prevent the disruption of the existing balance of its environment . . . by its harmful contamination through the introduction of extra-environmental matter or otherwise."[20] The Moon Treaty, however arguably, doesn't even rise to the level of customary law.[21] As such, any specific obligations vis-à-vis the moon created by the Moon Treaty are legally non-binding. Nevertheless, NASA and other organizations seem to still endeavor to responsibly explore the moon and the rest of the universe through their own sets of regulations that seek to prevent harmful contamination.

---

[12] D. E. Betsy Pugel, J. D. Rummel, & Catherine Conley, *Brushing your spacecraft's teeth: A review of biological reduction processes for planetary protection missions*, IEEE AEROSPACE CONF.1 (2017).
[13] Scott G. Edgington & Linda J. Spilker, *Cassini's Grand Finale*, 9 NATURE GEOSCIENCE 472, 472 (2016).
[14] See Laura M., Barge, and Laura E. Rodriguez. *Life on Enceladus? It depends on its origin*. 1 NATURE ASTRONOMY 1 (2021).
[15] M.S. Favero, *Microbiologic assay of space hardware*, 1 ENVTL. BIOLOGY & MED. 27-36 (1971).
[16] NAT'L AERONAUTICS AND SPACE ADMIN., NPD 8020.7G, BIOLOGICAL CONTAMINATION CONTROL FOR OUTBOUND AND INBOUND PLANETARY SPACECRAFT, § 1 (1999), https://nodis3.gsfc.nasa.gov/displayDir.cfm?t=NPD&c=8020&s=7G.
[17] See, e.g., NASA Interim Directive NID 8715.129 Subject: Biological Planetary Protection for Human Missions to Mars, NASA 1, 2 (Jul. 9, 2020), https://nodis3.gsfc.nasa.gov/OPD_docs/NID_8715_129_.pdf.
[18] G.A. Res. 2222, art. IX (Jan. 27, 1967).
[19] S. Freeland & S. D. Lawler, *Whose Mess is It Anyway? Regulating the Environmental Consequences of Commercial Launch Activities*, 55 PROC. INT'L INST. SPACE L. 318-326 (2012).
[20] G. A. Res. 34/68, art. 7 (Dec. 18, 1979).
[21] *See, e.g.*, Exec. Order No. 13914, 85 Fed. Reg. 20381 (Apr. 6, 2020), https://www.whitehouse.gov/presidential-actions/executive-order-encouraging-international-support-recovery-use-space-resources/ ("Accordingly, the Secretary of State shall object to any attempt by any other state or international organization to treat the Moon Agreement as reflecting or otherwise expressing customary international law").

Most recently, the National Academies of Sciences, Engineering, and Medicine's (NASEM)standing Committee on Planetary Protection (CoPP) was created to serve as a "source of information and advice on those measures undertaken by robotic spacecraft and human exploration missions to protect the biological and environmental integrity of extraterrestrial bodies for future scientific studies and the means to preserve the integrity of Earth's biosphere when spacecraft return potentially hazardous extraterrestrial materials to Earth."[22] The committee just released a report on seeking to assess the impact of human activities on lunar volatiles like water, carbon dioxide, and methane, looking specifically at "organic and biological contamination of permanently shadowed regions."[23]

NASA's interim guidelines described above and which will be discussed herein, while ostensibly limited only to NASA, will ultimately have a broad impact on the way planetary protection is done; the guidelines also involve all of NASA's many public and private collaborators.[24] Even the Committee on Space Research (COSPAR) also modified their non-binding rules as a result of NASA's suggested guidelines.[25]

NASA's guidelines are especially timely, given the recently released Artemis Accord Principles, a set of guidelines publicized by NASA's administrator Jim Bridenstine, on May 15, 2020.[26] The principles are intended to govern the Artemis Accords, a set of eventual bilateral agreements that the United States has signed with twelve other space faring nations to date,[27] regarding moon exploration and exploitation.[28] Notably, this interest in developing binding agreements relating to the moon, especially in light of the aforementioned Moon Treaty, portends the likely significant increase in travel to and from the moon, and the desire to lay claim to lunar territory and even mine it.[29]

In addition to their interim guidelines relating to the moon, NASA also simultaneously released additional guidelines relating to Mars.[30] While there a number of Mars missions planned and in

---

[22] NASEM Comm. on Planetary Prot., Nat'l Acad. Science 1, 33 (2020),https://www.nationalacademies.org/our-work/committee-on-planetary-protection.

[23] Committee on Planetary Protection Space Studies Board Division on Engineering and Physical Sciences , REPORT SERIES: COMMITTEE ON PLANETARY PROTECTION: PLANETARY PROTECTION FOR THE STUDY OF LUNAR VOLATILES, The National Academies Press 2020 https://www.nap.edu/download/26029#.

[24] Off. OF SAFETY AND MISSION ASSURANCE, *supra* note 2, at 2. "Component Facilities and Technical and Service Support Centers . . . the Jet Propulsion Laboratory (JPL) (a Federally-Funded Research and Development Center), other contractors, grant recipients, or parties to agreements to the extent specified or referenced in the appropriate contracts, grants, or agreements . . . robotic and crewed spaceflight missions with NASA involvement . . . . NASA-controlled missions, commercial missions sponsored by NASA, joint missions in which NASA participates, and NASA support of non-NASA missions to the extent specified or referenced in the applicable contracts, grants, or agreements." *Id.*

[25] Jeff Foust, *NASA implements changes to planetary protection policies for moon and Mars missions*, SPACENEWS (July 11, 2020), https://spacenews.com/nasa-implements-changes-to-planetary-protection-policies-for-moon-and-mars-missions/.

[26] NAT'L AERONAUTICS AND SPACE ADMIN., THE ARTEMIS ACCORDS: PRINCIPLES FOR A SAFE, PEACEFUL AND PROSPEROUS FUTURE (2020), https://www.nasa.gov/specials/artemis-accords/img/Artemis-Accords_v7_print.pdf. Ostensibly named after the Artemis Program for lunar exploration. *See also Trump administration drafts pact for mining on the moon*, THE GUARDIAN (May 5, 2020), https://www.theguardian.com/science/2020/may/05/trump-mining-moon-us-artemis-accords.

[27] https://www.nasa.gov/specials/artemis-accords/index.html (last visited July 25, 2021).

[28] Leah Crane, *Lunar laws of the land*, 246 NEW SCIENTIST 14 (2020), https://www.sciencedirect.com/science/article/abs/pii/S0262407920309866.

[29] *Id.*

[30] OFFICE OF SAFETY AND MISSION ASSURANCE, SUPRA NOTE 18, AT 9 (2020), https://nodis3.gsfc.nasa.gov/OPD_docs/NID_8715_129_.pdf.

progress, including, most recently, one from the United Arab Emirates (UAE),[31] the discussion of Mars protocols is beyond the scope of this paper. However, one timely aspect relates to the implementation of guidelines to prevent the reverse contamination of Earth by Mars life forms.

The fear of novel deadly space contagions is a longstanding science-fiction trope, especially timely in light of the Coronavirus Pandemic. The 1960s New York Times best seller, *The Andromeda Strain* by Michael Crichton famously highlights this fear. In the book, and later the film by four-time Academy Award winner Robert Wise, a highly virulent extraterrestrial contagion infects and kills out an entire town.[32] Fiction may eventually become reality sooner than we think with the imminent return of space samples.[33] Research suggests that contamination from space is a real possibility,[34] hence, NASA's new guidelines.[35]

As Space Exploration continues to ramp up, with both private and public actors seeking to go boldly where few have gone before,[36] there is a growing need to assess the protocols currently in place to both protect the space environments from earth-based contamination, as well as to protect the Earth from space contaminants.

This issue is especially timely as we have recently seen probes crash into the moon potentially contaminating it. Similar tragedies could happen on other celestial bodies and it behooves us to consider the current state of affairs regarding interplanetary protection measures.

The second section of the paper will review a case study wherein hardy microorganisms were intentionally sent to the Moon, seemingly in contravention to the planetary protection guidelines developed by the United States and international non-governmental organizations on a private space mission. The third section of this paper looks to the history of planetary protection regulations, especially those developed by COSPAR and the most recent iteration published by NASA in the summer of 2020, and COSPAR in 2021. The fourth section questions the necessity of these rules as they relate to the moon especially in light of humanity's historical contamination of the moon, which seems to imply either that the moon cannot support life, or that we don't care about the moon's ability to support life. The fifth section sets up the possibility that regulatory bodies look to terrestrial treaties that protect Earth's environment to develop guiding principles for a new universal set of regulations to prevent the contamination of outer space. The sixth section then goes through a number of successful, unsuccessful, and not yet successful international treaties and agreements that may provide useful guidance for developing a new planetary

---

[31] Elizabeth Gibney, *How a Small Arab Nation Built a Mars Mission From Scratch in Six Years*, 583 NATURE 190 (2020); Emirates Mars Mission: Home, United Arab Emirates, https://www.emiratesmarsmission.ae/ (last visited July 27, 2021).

[32] See Michael Crichton, The Andromeda Strain (1969); Dov Greenbaum, *To Seek out New Life and New Deadly Viruses*, CTECH BY CALCALIST (Feb.14, 2020), https://www.calcalistech.com/ctech/articles/0,7340,L-3793151,00.html.

[33] Smriti. Mallapaty, *Asteroid dust recovered from Japan's daring Hayabusa2 mission*. NATURE DECEMBER 15 (2020); Chelsea Gohd, *NASA's Perseverance rover gears up to capture its 1st Mars rock sample*, SPACE.COM July 21, 2021 https://www.space.com/nasa-perseverance-rover-first-mars-rock-sample (last visited July 27, 2021).

[34] See, e.g., Aaron J. Berliner, Tomohiro Mochizuki & Kenneth M. Stedman, *Astrovirology: viruses at large in the universe*, 18 ASTROBIOLOGY 207 (2018); Idan Ginsburg, Manasvi Lingam, and Abraham Loeb, *Galactic panspermia*, *The Astrophysical Journal Letters* 868.1 L12 (2018); Aleksandar Janjic, *The need for including virus detection methods in future Mars missions* 18 ASTROBIOLOGY 1611 (2018).

[35] OFFICE OF SAFETY AND MISSION ASSURANCE, *supra* note 31, at 4 (citing the need to "Preclude backward contamination of Earth by extraterrestrial life and bioactive molecules, such as prions, in returned samples from habitable worlds").

[36] Don Lincoln, *The billionaires' space race is only just beginning*, CNN July 19, 2021 https://edition.cnn.com/2021/07/19/opinions/jeff-bezos-space-flight-blur-origin-lincoln/index.html (last visited July 27, 2021).

protection agreement. The seventh section provides an alternative suggestion: everyone for themselves, the development of unilateral enforcement, an approximation of what is currently happening in the United States via various laws, federal agencies, and their regulations. The final section suggests some conclusions and stopgap methods in light of the reality that most countries will not set up regulatory enforcement, but the current lack thereof will likely impede investment in space technologies that seek consistency and bright line rules.

II. Failure of Planetary Protection Protocols?

The elucidation of the Space Treaty articles is becoming increasingly important. It was recently published that Tardigrades (aka water bears), a microscopically cute and exceedingly hardy organism,[37] as well as plant and human cells, were allegedly delivered to the moon by the Los Angeles based Arch Mission Foundation (pronounced Ark)[38] on the privately funded SpaceIL Beresheet Lunar Lander.[39]

The Arch Mission Foundation, a non-profit with the goal of "preserving the knowledge and biology of our planet in a solar system wide project," [40] intentionally, and admittedly surreptitiously, included the biological matter within a coin sized ostensibly hermetically sealed library of texts and pictures pertaining to human heritage.[41] The still unsubstantiated disclosure, which was first published on August 5th —five months after the Beresheet launch— was quickly followed by clarifications that Arch's payload is theirs alone and that SpaceIL was not involved in creating their payload and did not have any knowledge of the Tardigrades or DNA layers. [42]

Conspicuously, in 2018 the China National Space Administration also intentionally sent biological material to the moon in the form of a mini biosphere. The self-contained device included dirt, nutrients, water, cotton, rapeseed oil, potato, *Arabidopsis* seeds, and silkworm eggs.

---

[37] See Erdmann Weronika & Kaczmarek Łukasz, *Tardigrades in Space Research-Past and Future*, 47 ORIGINS OF LIFE AND EVOLUTION OF BIOSPHERES 545-553 (2017).

[38] As in Noah's Ark which preserved the flora and fauna during a catastrophe, see, e.g., Amy Woodyatt, *Crashed spacecraft may have left tiny but tough creatures on the moon*, CNN (Aug. 7, 2019), https://edition.cnn.com/2019/08/07/world/water-bear-space-intl-scli-scn/index.html ("In an attempt to create a 'Noah's ark' or a 'back-up' for the Earth, non-profit organization The Arch Mission sent a lunar library—a stack of DVD-sized disks that acts as an archive of 30 million pages of information about the planet—to the moon").

[39] Daniel Oberhaus, *A Crashed Israeli Lunar Lander Spilled Tardigrades on the Moon*, WIRED (Aug. 5, 2019), https://www.wired.com/story/a-crashed-israeli-lunar-lander-spilled-tardigrades-on-the-moon/.

[40] *Our Vision*, ARCH MISSION FOUNDATION, https://www.archmission.org/our-vision (last visited Nov. 29, 2020).

[41] *See, e.g.*, *The Lunar Library: Genesis*, ARCH MISSION FOUNDATION, https://www.archmission.org/spaceil (last visited Nov. 28, 2020). "The Lunar Library contains a 30 million page archive of human history and civilization, covering all subjects, cultures, nations, languages, genres, and time periods. The Library is housed within a 100 gram nanotechnology device that resembles a 120mm DVD contain[ing] more than 60,000 analog images of pages of books, photographs, illustrations, and documents … a specially designed "Primer" that teaches over a million concepts in pictures and corresponding words across major languages, as well as the content of the Wearable Rosetta disc . . . a series of documents that teach the technical specifications, file formats, and scientific and engineering knowledge necessary to access, decode and understand, the digital information encoded in deeper layers of the Library … several private archives, including an Israeli time-capsule for SpaceIL, containing the culture and history of Israel, songs, and drawings by children … Collectively, the digital layers contain more than 100GB of highly compressed datasets, which decompress to nearly 200GB of content, including the text and XML of the English Wikipedia, plus tens of thousands of PDFs of books—including fiction, non-fiction, a full reference library, textbooks, technical and scientific handbooks, and more. The digital layers also contain the PanLex datasets from the Long Now Foundation, a linguistic key to 5000 languages, with 1.5 billion translations between them." *See also*, Nova Spivak, *The Lunar Library Genesis Mission Space IL Beresheet Lander*, ARCH MISSION FOUNDATION (Aug. 20, 2019), https://www.archmission.org/lunar-library-overview.

[42] @archmission, TWITTER (Aug. 6, 2019), https://twitter.com/archmission/status/1158666619301662724.

Chinese scientists hypothesized that the symbiotic relationship between the organisms would allow them to survive on the moon. [43] The cotton apparently sprouted but has long since withered.

While China essentially got away with it, Arch's actions may raise a range of legal concerns from compliance with international commitments, to specific compliance with US regulations and contractual obligations with its launch partners such as Spaceflight industries which provided the launch services and mission management, SpaceX, who provided the launch vehicle, and SpaceIL. To wit: as a result of the Arch's efforts, SpaceIL which housed the potentially problematic payload admittedly did not accurately fill in the relevant launch documents with both the regulatory and private stakeholders.[44] There isn't a public record of any legal repercussions or sanctions for these actions.[45]

Heretofore there was some level of trust that existed in space exploration between the explorers and the relevant regulators.[46] Arch may have forever changed that. Fortunately, at least for the lunar environment, according to information provided by the foundation, the Tardigrades were safely sealed in epoxy and supposedly cannot reproduce on the Moon. [47]

Arch's assertions of attention to safety notwithstanding: (1) Are the actions of the Chinese, SpaceIL, or the Arch Mission Foundation violations of international laws and norms? And, (2) are private endeavors, like Arch and Beresheet, bound by the space treaties to which their respective countries joined, but that never envisioned commercial space exploration to the degree that it has become?

With regard to the second question, international space law likely does not bind private actors *per se*, rather it instructs nations only to develop rules to regulate those private actors.[48] Unfortunately, most governments, including the United States, lack sufficient and proper regulatory oversight over private enterprise in space.[49] This ongoing regulatory gap is a liability

---

[43] Neil Conner, *China plans to grow flowers and silkworms on the dark side of the moon*, THE TELEGRAPH (Apr. 13, 2018), https://www.telegraph.co.uk/news/2018/04/13/china-plans-grow-flowers-silkworms-dark-side-moon/.

[44] For example, as per 14 CFR Subchapter C – LICENSING; *see generally*, *Legislation & Policies, Regulations & Guidance*, FED. AVIATION ADMIN., https://www.faa.gov/space/licensing_process/regulations/ (last visited May 5, 2021).

[45] William B Altabef,. "*The Legal Man in the Moon: Exploring Environmental Personhood for Celestial Bodies* 21 CHI. J. INT'L L. 476, 482 (2020).

[46] There was another instance where a company launched some small satellites into orbit even after their application for launch was rejected. *See*, *e.g.*, Marina Koren, *The Satellites Were Never Supposed to Launch*, THE ATLANTIC (Sept. 27, 2019) https://www.theatlantic.com/science/archive/2019/09/swarm-satellites-fcc/598930/. Supposedly in this case, the relationship was repaired: "The Federal Communications Commission fined Swarm $900,000, but also approved future launches. When Spangelo and I met in Washington, D.C., earlier this month, she had been in meetings with FCC officials and was scheduled to meet with the agency's chairman, Ajit Pai, the following day."

[47] @archmission, TWITTER (Aug. 6, 2019), https://twitter.com/archmission/status/1158691641114234882.

[48] *See*, *e.g.*, SERGIO MARCHISIO, NATIONAL JURISDICTION FOR REGULATING SPACE ACTIVITIES OF GOVERNMENTAL AND NON-GOVERNMENTAL ENTITIES 16-19 (2010) "2. Article VI and VIII of the OST: State's responsibility In this regard, a special significance must be attached to Articles VI and VIII of the 1967 Outer Space Treaty (OST), which provide for obligations to be implemented by States Parties in their domestic legal order by enacting, when necessary, specific legislation. Article VI establishes that State Parties 'shall bear international responsibility for national activities in outer space … whether such activities are carried on by governmental agencies or by non-governmental entities', and for 'assuring that national activities are carried out in conformity with the provisions' of the Treaty. International responsibility in the sense of Article VI of the OST is the equivalent of attribution to the State of all its national activities in outer space. Another important effect arising from the accountability provided for in Article VI is the recourse by a State to take legislative action at the national level in order to answer for private space activities and their legal consequences for which the State is internationally responsible."

[49] Letter from John P. Holdren, Director and Assistant to the President for Science and Technology, to Chairman Thune & Chairman Smith (Apr. 4, 2016),

for every government given their obligations under the Outer Space Treaty to supervise their national non-governmental organizations.[50] This is an important national requirement as the treaty places no direct requirements on the non-state actors themselves.

As private space activities of their citizenry rapidly increase, some governments are slowly recognizing and appreciating these obligations. For example, in July 2019, the US House sought to create such oversight. The bill also includes a requirement to review existing best practices for United States entities to avoid the harmful contamination of the Moon and other celestial bodies.[51] Nothing much has happened since. In fact, many bills relating to space have been introduced in the most recent U.S. Congress (116th). However, few, if any, have progressed within the legislative chambers.[52]

In addition to U.S. efforts, Australia has legislation and regulation that binds its nationals both in Australia and extraterritorially and has both civil and criminal penalties.[53] Other countries that include various legislations, regulations, and executive orders include Norway, in 1969,[54]Austria,[55] the UK,[56] Denmark,[57] Belgium,[58] France, Sweden,[59] Russia, [60] Kazakhstan[61] and most recently, Finland.[62]

Returning to the two questions posed at the beginning of this section: In the case of Arch's Tardigrades, as part of the licensing process for US based launches (SpaceIL launched its lander from Cape Canaveral FL), the US Federal Aviation Administration (FAA) likely required disclosure of biological payloads. Under the current U.S. regulatory environment however, even if SpaceIL knew to disclose the clandestine payload, the FAA would almost certainly not have obstructed the launch.

With regard to the first question, it is a bit more complicated, but the answer seems to be reflected in the lack of concern by the National Academies of Science, a private, nonprofit

---

/https://obamawhitehouse.archives.gov/sites/default/files/microsites/ostp/csla_report_4-4-16_final.pdf (report submitted in fulfillment of a requirement contained in the U.S. Commercial Space Launch Competitiveness Act).

[50] See MARCHISIO, *supra* note 49.

[51] American Space Commerce Free Enterprise Act of 2019, H.R. 3610, 116th Cong. § 80109(e)(5) (2019).

[52] Search query for "space,"https://www.congress.gov/search?searchResultViewType=expanded&q=%7B%22source%22%3A%22legislation%22%2C%22search%22%3A%22SPace%22%2C%22type%22%3A%22bills%22%7D.

[53] Space Activities Act 1998 (Austl.)

[54] Act on launching objects from Norwegian territory etc. into outer space, 13 June. No. 38. 1969 (Nor.).

[55] Regulation of the Federal Minister for Transport, Innovation and Technology in Implementation of the Federal Law on the Authorisation of Space Activities and the Establishment of a National Space Registry (Outer Space Regulation) BGBl. II No. 36/2015 (Austria).

[56] Outer Space Act 1986 (U.K.).

[57] Exec. Order No. 552 (2016) (Den.) https://ufm.dk/en/legislation/prevailing-laws-and-regulations/outer-space/executive-order-on-requirements-in-connection-with-approval-of-activities-in-outer-space-etc-_final.pdf.

[58]Arrêté royal portant exécution de certaines dispositions de la loi du 17 septembre 2005 relative aux activités de lancement, d'opération de vol ou de guidage d'objets spatiaux [Law of 17 September 2005 on the Activities of Launching, Flight Operation or Guidance of Space Objects], MONITEUR BELGE [M.B.] [Official Gazette of Belgium], Nov. 4, 2008, 19517.

[59] Act on Space Activities (1982:963) (Swed.).

[60] *Russian Federation*, tabbed in *National Space Law Collection*, U.N. OFFICE FOR OUTER SPACE AFFAIRS, https://www.unoosa.org/oosa/en/ourwork/spacelaw/nationalspacelaw/index.html.

[61] Law of the Republic of Kazakhstan on Space Activities (Jan. 6, 2012), https://www.unoosa.org/documents/pdf/spacelaw/national/kazakhstan/528-IV_2012-01-06E.pdf.

[62]Act of Space Activities, Ministry of Economic Affairs and Employment, Finland (2018), http://finlex.fi/en/laki/kaannokset/2018/en20180063.pdf.

organization of the leading researchers in the US, for private space missions to the Moon.[63] Should that be the case?

III. Planetary Protection of the Moon and Celestial Bodies under the OST

The current position of the National Academies was not always the case. early research advocated for extensive sterilization efforts prior to lunar missions, given the perceived remote but non-negligible possibility of bio-contamination.[64] Initially, even returning Apollo astronauts were extensively quarantined, given the possibility of returning stowaway life. [65]

In fact, as far back as 1958, the Committee on Space Research (COSPAR), an international non-governmental organization with the goal of promoting scientific research in space, now under the International Science Council (ISC), developed standardized policies that are considered a consensus standard for compliance with the various Space Treaties.[66]

These standards are comprised of five levels of planetary protection protocols for space-bound missions, depending on the contamination possibilities, for various asteroids, moons or planets, and contingent on whether the spacecraft is destined to land, crash or orbit a celestial body. The levels circumscribe both forward-contamination (emanating from Earth) and backward contamination (returning to Earth from a celestial body). These categories range from missions requiring the lowest level of protection, such as some flybys, which require no particular precautions, to level V landings on potentially life-sustaining planets, the highest level of precaution.

In general, the realization of most of COSPAR's non-binding aspirations are non-trivial, especially as space exploration has become significantly more complicated, multinational, commercial, and budgetarily constrained. And, without any real enforcement mechanism, COSPAR's suggestions can be easily ignored, especially when the goal is to reduce costs. Some have even argued that pre-flight sterilization is futile: while it effectively destroys the vast majority of Earth based organisms, those organisms wouldn't have survived the entire space journey in any event. And those microbes that are resistant to the current sterilization techniques, now find themselves without microbial competition, and are thus able to flourish under the sterilization conditions and even the harsh conditions of space. A prime example: *Tersicoccus phoenicis*, a member of the *Micrococcaceae* bacterial family, has only been found in two places on Earth: the Payload Hazardous Servicing Facility at Kennedy Space Center in Florida, and the Herschel Space Observatory's clean room at the Guiana Space Centre in Kourou, French Guiana. The hardy microbe likely exists elsewhere on the planet but in miniscule and undetectable numbers, whereas

---

[63] Comm. on the Rev. of Planetary Prot. Pol'y Dev. Processes Space Stud. Bd. Div. on Eng'g and Physical Scis., Review and Assessment of Planetary Protection Policy Development Processes, National Academies of Science 85-88 (2018).

[64] Carl Sagan, *Biological Contamination of the Moon*, 46 PROCEEDINGS OF THE NATIONAL ACADEMIC SCIENCES 396, 402 (1960); Conference on Spacecraft Sterilization Policy, Pasadena, California (Nov. 16-18, 1965), https://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19670005432.pdf.

[65] B.C. Wooley, *Apollo experience report: Protection of life and health*, NASA, Technical Note TN D-68 (1972), https://ntrs.nasa.gov/search.jsp?R=19720017450.

[66] J.D. Rummel, *Seeking an International Consensus in Planetary Protection: COSPAR's Planetary Protection Panel*, 30 ADVANCES IN SPACE RES. 1573, 1574 (2002).

humanity has allowed it to thrive in spacecraft sterilization facilities and potentially on spacecraft hurtling to Mars and beyond.[67]

Another of the aforementioned complications for which space exploration is still ill-equipped are non-nominal landings onto other celestial bodies (aka, crashes). For example, SpaceX reportedly did not sterilize the Tesla Roadster now potentially hurtling towards Venus or Mars.[68] The Roadster also contains an Arch Mission Foundation library in the glove compartment, [69] potentially with living Tardigrades. And, indicative of the ongoing engineering difficulties in sterilization, if the Tesla does actually reach Mars, [70] then Starman, Tesla's dummy pilot, may come across the microbial bioburden of hundreds of strains of bacteria and fungi that unintentionally accompanied, and may have survived, Curiosity's 2012 trip to Mars and its ongoing explorations across the Martian landscape. [71]

But that is Mars with the prospect of ancient or even current life.[72] Given the especially harsh environment of the moon, current sanitation protocols and sterilization efforts for lunar missions tend to now be very limited. From the outset of lunar exploration, in fact, the sterilization procedures of both the Americans and the Russians, Carl Sagan's concerns notwithstanding,[73] have actually been weak at best.[74] A recent study confirms this by extrapolating the bioburdens of the nearly 80 major spacecraft components from the USA, USSR, Japan, India and China that have landed, crashed or orbited the moon since the mid-20th century.[75]

In fact, even COSPAR's guidance for the moon conservation has been marginal. Missions to the moon were once Level I,[76] and since at least 2008, are still only at Level II.[77] NASA's recent guidance suggests even lesser conservation efforts.

---

[67] See generally, Parag Vaishampayan et al., *Description of Tersicoccus Phoenicis Gen. Nov., Sp. Nov. Isolated from Spacecraft Assembly Clean Room Environments*, 63 INT'L J. OF SYSTEMATIC & EVOLUTIONARY MICROBIOLOGY 2463, 2464 (2013).

[68] Or wherever it ends up. There is no planned final destination. *See, e.g.*, Amanda Kooser, *Will Elon Musk's Tesla Roadster Crash into Earth or Venus?*, CNET (Feb. 15, 2018), https://www.cnet.com/news/will-elon-musk-space-x-tesla-roadster-crash-into-earth-venus/; *see also Where is Starman? Track Elon Musk's Tesla Roadster in Space*, WHERE IS ROADSTER, https://www.whereisroadster.com/ (last visited Dec. 8, 2020) (for the current location of the vehicle).

[69] *See* Keith A. Spencer, *Violating International Treaties, Elon Musk's Space Tesla Doesn't Seem to Have Been Sterilized*, SALON (Feb. 13, 2018), https://www.salon.com/2018/02/12/why-sending-a-tesla-into-orbit-is-a-slap-in-the-face-to-science/.

[70] Marina Koren, *Where Is Elon Musk's Space Tesla Actually Going?*, ATLANTIC MONTHLY (Feb. 8, 2018), https://www.theatlantic.com/science/archive/2018/02/tesla-elon-musk-mars-spacex-asteroid-belt/552719/.

[71] Jyoti Madhusoodanan, *Microbial Stowaways to Mars Identified*, NATURE (May 19, 2014), https://www.nature.com/news/microbial-stowaways-to-mars-identified-1.15249.

[72] Rhawn G. Joseph et al., *Evidence of Life on Mars*, 1 J. OF ASTROBIOLOGY AND SPACE SCI. REV. 40 (2019); Alfonso F. Davila & Dirk Schulze-Makuch, *The Last Possible Outposts for Life on Mars*, 16 ASTROBIOLOGY 159, (2016); Dov Corenblit et al., *The Search for a Signature of Life on Mars: A Biogeomorphological Approach*, 19 ASTROBIOLOGY 1279, (2019); Bronwyn L. Teece et al., *Biomolecules from Fossilized Hot Spring Sinters: Implications for the Search for Life on Mars*, 20 ASTROBIOLOGY 537 (2020).

[73] Sagan, *supra* note 65, at 396.

[74] Daniel P. Glavin et al., *Biological Contamination Studies of Lunar Landing Sites: Implications for Future Planetary Protection and Life Detection on the Moon and Mars*, 3 Int'l J. of Astrobiology 265, 266 (2004).

[75] Andrew C. Schuerger et al., *A Lunar Microbial Survival Model for Predicting the Forward Contamination of the Moon*, 19 Astrobiology 730,732-34 (2019).

[76] Nat'l Rsch. Council, PREVENTING THE FORWARD CONTAMINATION OF MARS, 26 (2006).

[77] G. Kminek et al., *COSPAR's Planetary Protection Policy*, at 16 https://cosparhq.cnes.fr/assets/uploads/2019/12/PPPolicyDecember-2017.pdf (last visited May 5, 2021).

What this means is that beyond documentation to describe the impact target and an inventory of all organic compounds present in excess of one kg,[78] no further precautions are necessary (backward missions with the Moon as a stopover to Earth, however, fall under the procedurally onerous category V).[79] The level of protection is similar under the current European Space Agency (ESA).[80] Both outward-bound lunar probes and returning robots from the moon no longer require any sort of pre- or post- sterilization procedures according to the regulations of the various space agencies.

These revised regulations seem practical. Life as we know it would seem to be unable to survive unprotected on the moon. The moon effectively has no atmosphere, lunar dust tends to be biologically aggravating, lunar gravity is only a fraction of the Earth's, the moon is bombarded constantly by ultraviolet and other cosmic radiation, and temperatures fluctuate between around -230°C at the poles and +123°C in the sun.[81]

And yet, contrary to practical procedures and conventional wisdom, microbial contaminants might still survive even under these harshest conditions of space by stowaway or guest extremophile organisms such as the Tardigrades which are amongst the most resilient animals on earth. To wit, in at least one instance, albeit highly disputed, a recovered camera from an earlier lunar mission was purportedly found to have some bio-contamination of *Streptococcus mitis,* even after years on the moon.[82]

A. NASA's New Guidelines

As per NASA's recently announced interim planetary protection guidelines, the Lunar environment has been divided into two potential regulatory sections. The first sector is the general area of the moon. This is protected under NASA Mission Planetary Protection Category I-L (corresponding generally to COSPAR Level I). The new part of the regulations adds a second sector, NASA Mission Planetary Protection Category II-L includes the scientifically interesting and environmentally sensitive areas of the moon.[83] These guidelines, while upgrading some of

---

[78] *Id*. "A spacecraft organic inventory includes a listing of all organic materials carried by a spacecraft which are present in a total mass greater than 1 kg. A complete inventory should include organic products that may be released into the environment of the protected solar system body by propulsion and life support systems (if present), and include a quantitative and qualitative description of major chemical constituents and the integrated quantity of minor chemical constituents present."

[79] COSPAR, *COSPAR Policy on Planetary Protection*, at 5, https://cosparhq.cnes.fr/assets/uploads/2020/07/PPPolicyJune-2020_Final_Web.pdf (last visited May 5, 2021).

[80] *See, No Bugs Please, This is a Clean Planet!* Eur. Space Agency (July 30, 2002), http://www.esa.int/Science_Exploration/Space_Science/Cassini-Huygens/No_bugs_please_this_is_a_clean_planet. Although NASA claims that there are important differences, *see, e.g.,* NASA, *Assessment of Planetary Protection and Contamination Control Technologies for Future Planetary Science Missions* (Jan. 24, 2012), https://solarsystem.nasa.gov/resources/290/assessment-of-planetary-protection-and-contamination-control-technologies/.

[81] David Vaniman et al., *The Lunar Environment, in* THE LUNAR SOURCEBOOK, 27, 28 (1991).

[82] F.J. Mitchell & W. L. Ellis, *Surveyor III: Bacterium Isolated from Lunar-Retrieved TV Camera, in* ANALYSIS OF SURVEYOR III MATERIAL & PHOTOGRAPHS RETURNED BY APOLLO XII 239, 243 (1972), https://ntrs.nasa.gov/api/citations/19720019081/downloads/19720019081.pdf; John D. Rummel, Strep, Lies, and 16mm Film: Did S. mitis Survive on the Moon? Should Humans be Allowed on Mars? 3 Int'l J. of Astrobiology 7(2004).

[83] NASA, NID 8715.128, *supra* note 2 at 5 (including"Permanently Shadowed Regions (PSRs) that have scientific value in the study of the history of the solar system and of significant interest relative to the process of chemical evolution, as well as potential value for In-Situ Resource Utilization (ISRU)," and "b. Apollo landing and other lunar historic sites, which have both historical and scientific value, specifically protecting studies of the biological

NASA's initial attempts in protecting the lunar surface, by and large, also continue to support the general long-standing lack of consideration for the contamination of the lunar surface.

In addition to NASA's new guidelines, COSPAR has similarly updated their guidelines for missions to the Moon's surface, adding two new subcategories for new missions to the Moon.[84] As per the new guidelines, a new Category IIa is limited to missions to the Moon's surface requiring that missions to the moon divulge only organic products that may be released into the lunar environment by the spacecraft's propulsion system. Category IIb relates to missions to permanently shadowed regions of the moon (PSRs) and requires a more extensive list of organic compounds. As per COSPAR, this represents a further relaxation of the suggested rules, but an increasing concern that organic compounds could contaminate any ice deposits in the PSRs.[85] This relaxation is in spite of the fear by some scientists that research efforts might best avoid the ice.[86]

IV. Long History of Lunar Contamination

Arguably, there might be a legal difference between the discussed unintended or negligent at best contamination of unsterilized spacecraft and the intentional depositing of terrestrial organisms by Arch. However, even if that were the case, the US and others have also actively deposited earthly organisms on the lunar surface, seemingly without any concern or legal blowback, as described above.

To wit, the moon is home to at least 96 bags of Apollo mission waste; many are clearly visible in a number of iconic moon landing photos.[87] Some of these not-so-small Jett bags contain human feces,[88] and perhaps some of the 1000 microbial strains that typically make up around fifty percent of our waste survive within.[89] In fact, research at NASA's Long Duration Exposure Facility (LDEF) suggests that some bacteria can survive for extended periods provided they are shielded from solar radiation, such as those in Jett bags placed permanently in the shade under lunar landers, rovers and other man-made artifacts. [90] Moreover, even if these bacteria fail to survive in the harsh lunar environment, they may nevertheless leave organic signatures or biomarkers that might contaminate lunar soil samples eventually examined on Earth.

---

materials left by the Apollo astronauts. For additional information, see NASA Recommendations to Space-Faring Entities: How to Protect and Preserve the Historic and Scientific Value of U.S. Government Lunar Artifacts, (Technical Guidelines) published in 2011. […and this includes] areas of the Moon south of 79°S latitude and areas north of 86°N latitude, based on Lunar Reconnaissance Orbiter mapping.")

[84]COSPAR Panel on Planetary Prot., Cospar Policy on Planetary Protection, June 3, 2021 (https://cosparhq.cnes.fr/assets/uploads/2021/07/PPPolicy_2021_3-June.pdf) (last visited July 27, 2021).

[85] COSPAR updates it Planetary Protection Policy for missions to the Moon's surface, July 15, 2021 (https://cosparhq.cnes.fr/assets/uploads/2021/07/Press-Release_PPP_15July2021_FINAL.pdf) (last visited July 27, 2021).

[86] Alexandra Witze, *Will increasing traffic to the Moon contaminate its precious ice?* 589 NATURE 180 (2021).

[87] LUNAR MODULE AND TRANQUILITY BASE, July 20, 2017, https://www.nasa.gov/image-feature/lunar-module-at-tranquility-base (last visited May 5, 2021).

[88] Working on the Moon, Apollo Jettison Bag (Jan. 6, 2012), https://www.hq.nasa.gov/alsj/WOTM/WOTM-JettisonBag.html; Richelle H. Concio, *Buzz Might Have Left His Poop on the Moon*, Science Times (Apr. 6, 2019), https://www.sciencetimes.com/articles/19764/20190406/buzz-left-poop-moon.htm.

[89] Megan Garber, *The Trash We've Left on the Moon*, The Atlantic (Dec. 19, 2012), https://www.theatlantic.com/technology/archive/2012/12/the-trash-weve-left-on-the-moon/266465/.

[90] Schuerger, Andrew C., et al. *A lunar microbial survival model for predicting the forward contamination of the Moon*, 19 Astrobiology 730, 751 (2019).

Perhaps even more damaging to the moon's environment, a bill was passed last year in the Senate,[91] and is pending in the House,[92] relating to the preservation of America's activities on the moon, including those aforementioned Jett bags. This is part of a decades-long ongoing effort to protect so called American heritage sites on the moon which includes not only the landers, rovers and American flag, but also a hammer, a doll, an eagle feather, golf balls and clubs, and even Eugene Shoemaker's ashes.[93]

A. Legality of Lunar Contamination

Yet, there is seemingly such disregard for OST provisions on planetary protection, regardless as to whether there is any life on the lunar surface. Perhaps this could be because the actions of the United States, Russia, China, and SpaceI may actually be legal.

Under international law set forward by the 1969 Vienna Convention on the Law of Treaties, treaty terms can be defined by "subsequent practice in the application of the treaty which establishes the agreement of the parties regarding its interpretation."[94] So press reports to the contrary, moon contamination has long been both a legal and international effort. In fact, researchers have even proposed that contaminated crash landings on the moon are especially valuable scientifically. Scholars are keen on assessing how microorganisms survive the various stresses of impact into celestial bodies for future travel plans or the long-term persistent survival of bioburdens that are encapsulated in various spacecraft parts across the solar system.[95]

Moreover, the crash may not necessarily be the most interesting phenomenon examined. Once microorganisms survive such stresses, researchers also see great value in assessing how these microorganism regenerate to go on to survive some of the harshest extraterritorial environments ,[96] not only for future seeding efforts, but also to understand historically how the lunar environment might modify ancient bio-signatures accumulated from terrestrial meteorite ejecta that ended up on the moon. [97]

Thus, Beresheet's failed landing might actually turn out to be fortuitous in not only helping to solve the decades long Surveyor mystery as to whether life in any form can survive for extended

---

[91] One Small Step to Protect Human Heritage in Space Act, Pub. L. 116-275, 134 Stat. 3358 (2020); *see also* S. Rep. No. 116-194, at 1 (2020) ("The purpose of S. 1694 is to require any Federal agency that issues licenses to conduct activities in outer space to include in the requirements for such licenses an agreement relating to the preservation and protection of the Apollo 11 landing site, and for other purposes….[I]t establishes the sense of Congress that the Apollo 11 landing site, other historical sites, and artifacts should be preserved. The bill accomplishes this goal by requiring companies seeking U.S. licenses to operate in space to agree to avoid disturbing U.S. Government artifacts and landing sites, including the Apollo 11 landing site, by adhering to NASA guidance on the protection of lunar artifacts. It defines 'lunar activity' in the context of this licensing requirement and allows for the assessment of penalties for noncompliance.").

[92] *Id*.

[93] Roy Balleste & Michelle L.D. Hanlon, *How Blockchain Technology can Track Humanity's lunar Heritage Sites*, The Space Review (June 11, 2018), https://thespacereview.com/article/3512/1; Lucas Laursen, *NASA to Launch Guidelines to Protect Lunar Artifacts*, 333 Science 1207, 1207 (2011); Chelsea Whyte, *Lunar Litter*, 243 New Scientist 42 (2019).

[94] Vienna Convention on the Law of Treaties art. 31(3)(b), May 23, 1969, 1155 U.N.T.S. 331.

[95] Keren Shahar & Dov Greenbaum, *Lessons in Space Regulations from the Lunar Tardigrades of the Beresheet Hard Landing*, 4 Nature Astronomy 208, 209 (2020).

[96] Charles S. Cockell, *Astrobiology—What Can We Do on the Moon?*, 107 Earth, Moon & Planets 3, 5 (2010).

[97] Mark J. Burchell et al., *Hypervelocity Impact Experiments in the Laboratory Relating to Lunar Astrobiology*, 107 Earth, Moon & Planets 55, 59-60 (2010).

periods on the moon, [98] it may also help scientists figure out how to get life to survive the harshness of space and space travel and live legally elsewhere.

V. So What If They Were Ignored on the Moon, What's Wrong with Current Laws?

More practically, how should future efforts, both governmental and private, both for the moon, and as well as pre- and post-biotic celestial bodies, be sensibly regulated to deal with the ever-increasing probabilities of contamination? As noted above, COSPAR's guidelines, [99] while widely respected, are only recommendations, and it seems unlikely that they will become universal customary rule, especially as more private for-profit companies and governments seek to make their mark look skyward. They are effectively unenforceable.

One potential solution is for the members of the COSPAR to actively wield the potential influence of the over 200 member organizations, unions and affiliations of scientific bodies that make up the International Science Council. A joint effort by the member bodies could result in extensively lobbying members' respective governments into incorporating COSPAR's guidelines into more national compliance regulations, and as a condition for private launch licenses. [100]

Alternatively, the establishment of a narrowly focused non-governmental international actual-governing body could be considered, to deal with space-based bio-contamination, as well as the equally problematic emerging area of space debris mitigation and associated concerns with traffic management, especially in low earth orbit. Such a body, designated either directly by the United Nations, or by some international agreement, could promote principles of planetary protection by design, transparency, accountability and even define liability for private enterprises. Additionally, research like which can be extrapolated from the Beresheet crash can be collected to help develop these principles.

In the short term however, the international community might find it useful to look to other international instruments relating to the transfer, albeit terrestrial, of biological materials into protective environments, including their incentive (positive, negative or indirect), compensation, surveillance, and enforcement structures for more immediate solutions.

VI. Looking to IEA agreements to learn how to better Protect the Planets

Given the lack of any sort of national ownership of any celestial body, there is little practical incentive for nation states or their private actors to protect the environment in space. Like the theories underlying the tragedy of the commons, if states had actual property rights in space, they might be better incentivized to maintain the environments. Or, alternatively, abuse them. But property rights could also cause environmental havoc. There will likely always be a gross imbalance of power in space, where those countries that have the weakest space capabilities may be least capable of maintaining their respective space environments, in the unlikely event that they could successfully claim property rights. To wit, consider the failed Bogotá Declaration, where a group of equatorial countries sought to claim rights to lucrative geosynchronous orbits thousands

---

[98] Aaron Gronstal et al., *Lunar Astrobiology: A Review and Suggested Laboratory Equipment*, 7 Astrobiology 767, 771 (2007).

[99] Pascale Ehrenfreund et al., *Toward a Global Space Exploration Program: A Stepping Stone Approach*, 49 Advances in Space Res. 2, 4 (2012).

[100] Scott Millwood, *A Very Famous Payload': The Launch of a Car into Orbit around the Sun Offers an Opportunity to Reconsider the International Framework for the Prevention of Harmful Contamination of Outer Space and the Role of COSPAR's Planetary Protection Policy in the New Space Era*, 43 Air and Space L. 521, 535-36 (2018).

of miles directly above the equator, and were wholly ignored.[101] Had they gained control of those orbits, it is unlikely that they could have adequately policed them.

In seeking to address an environmental issue where there are no ownership rights, it is best to look at how international treaties are done at home, in regulating Earth-based no-mans-land. As such, successful international environmental agreements (IEAs) and treaties between nation stakeholders, and transnational environmental agreements by additional stakeholders in addition to countries, here on Earth, are an optimal comparison for numerous reasons. First of all: there are a lot of IEAs. Researchers counting them suggest that there are anywhere from 100 to over 3000 IEAs (depending on what types of agreements you are counting).[102] Some of these IEAs are even directly on point, covering issues relating to the protection of environments that do not necessarily belong to any one nation state. As such, these IEAs could provide guidance for a future space agreement regarding the environment. For example, even just the simple well-established concept of polluter pays principle.[103]

Second, some of the areas covered by a handful of IEAs are not always radically different locales (environmentally speaking) than space. For example, many compare the isolated and inhospitable Antarctica with space.[104] Some have even looked to national activities in Antarctica as foreshadowing future activities in space.[105] Moreover, many of those IEAs, like current space treaties and any future agreement on space environment, are subject to powerful free-loading incentives, even as they are seemingly designed to provide a universal public good. So there is much to glean from how these legal tools have been used and abused.

A. What can we learn generally from IEAs

Given the various different types of IEAs, it is impossible to review them all here. Rather, it is best to review them broadly, together, and then focus on a handful of especially relevant IEAs. There is expansive literature that seeks to assess the most potent and useful characteristics of successful IEAs. Overall, this literature attempts to tease out what makes or breaks a successful IEA. The result of most of these analyses is that this is non-trivial. Much of this literature looks to game theory, econometrics, and political economy theories to determine how to best design such efforts that are beyond the scope of this paper.[106]

However, some of the general conclusions suggested by these analyses are relevant and could be incorporated into a future attempt at protecting the space environment. These include the

---

[101] Aldo Armando Cocca, *Viewpoints of the Equatorial Countries Toward Geostationary Orbit: Results of 12 Years of Controversy*, 17 Acta Astronautica 621, 622 (1988).
[102] Int'l ENV'T AGREEMENTS DATABASE PROJECT, https://iea.uoregon.edu/ (last visited May 5, 2021).
[103] U.N. Conf. on Env't and Dev., *Rio Declaration on Environment and Development*, U.N. Doc. A/CONF.151/26/Rev.1 (Vol. I), annex I (Aug. 12, 1992); see also Eur. Comm'n, THE POLLUTER PAYS PRINCIPLE, https://ec.europa.eu/environment/legal/law/pdf/principles/2%20Polluter%20Pays%20Principle_revised.pdf (last visited May 5, 2021).
[104] Becky Ferreira, *This Antarctic Base Is More Remote Than the International Space Station*, VICE (Feb. 23, 2015), https://www.vice.com/en_us/article/78xm8e/this-antarctic-base-is-more-remote-than-the-international-space-station.
[105] L.M. Foster & Namrata Goswami, *What China's Antarctic Behavior Tells Us About the Future of Space*, The Diplomat (Jan. 11, 2019), https://thediplomat.com/2019/01/what-chinas-antarctic-behavior-tells-us-about-the-future-of-space/.
[106] Ulrich J. Wagner, *The Design of Stable International Environmental Agreements: Economic Theory and Political Economy*, 15 J. of Econ. Surv. 377, 378 (2001); Scott Barrett, *Self-Enforcing International Environmental Agreements*, 46 Oxford Econ. Papers 878, 878 (1994); Irene Alvarado-Quesada & Hans-Peter Weikard, *International Environmental Agreements for Biodiversity Conservation: A Game-Theoretic Analysis*, 17 Int'l Envtl. Agreements 731, 732-734 (2017).

contentions that any successful IEA, especially where sovereign countries are always free to back-out if they don't find the agreement profitable to their self-interests, must include rational actors working toward their respective and definable national welfares resulting from the agreement. Further, successful agreements do best when they are led by supra-national enforcement authorities. IEAs also work best when they have modest initial goals, clear apprehension of the risks, and specific policy targets. Additionally, research has shown that IEAs, when combined with other more desirable tangential covenants, tend to have more buy-in by stakeholders.

Also, don't think too big. As per the Talmudic teaching: *Tafasta merubeh, lo tafasta*,"[107] If you try for too much, you will get nothing: covenants that work are typically either broad, but shallow, or deep, but limited to only a few stakeholders.[108]

Additionally, research has shown that a single global policy instrument works best. And punishment by a self-enforcing agreement typically works better than incentives. Punishment is however, also often very hard to implement.[109] Research examining a number of IEAs has also shown that unpunishable free riders are especially problematic in areas where leakage by a bad actor can defeat the purpose of the treaty, e.g., if a non-signatory state contaminates a celestial body, all parties suffer and the goals of the treaty are jeopardized.

There are also specific and technical lessons that can be extrapolated from the body of terrestrial environmental treaties. For example, research has shown that treaties and agreements that include clauses that require minimum participatory constraints tend to have more signatories, and as a result, less free-loaders, e.g., those stakeholders who benefit from the treaty but are not signatories to the treaty with all the concomitant burdens and requirements. [110]

Finally, treaties in the environmental area tend to work best when they can be shown to be clearly profitable for the signatories, e.g., they provide a clear benefit to each signing nation. And, that there should be clear incentives to join the IEA that provide a sufficient reason to join, rather than remain outside of the agreement. [111]

B. Drilling down on specific IEAs

The following section of the paper will explore a handful of representative international agreements, some that seem to work better than others, but all of them can be used, to varying degrees, as starting-points in considering the metes and bounds, the structure, and the mechanics of a new international regime dedicated to enforcing planetary protection.

2001 UNESCO Convention on Underwater Cultural Heritage.

In terms of individual treaties, we could consider, for example, the 2001 UNESCO Convention on Underwater Cultural Heritage. The UN Convention for the Law of the Sea (UNCLOS) is somewhat limited in how it seeks to regulate heritage sights in international waters. For the most

---

[107] Rav Ashi et al., Babylonian Talmud, William Davidson Foundation, Yoma80a, 4-5 (c. 375 CE) ("If you grasped many, you did not grasp anything; if you grasped few, you grasped something"), https://www.sefaria.org/Yoma.80a?lang=bi.

[108] Achim Hagen et al., *Transnational Environmental Agreements with Heterogeneous Actors*, 387 OLDENBURG DISCUSSION PAPERS ECON. 1, 5 (Jan. 2016).

[109] Antonio R. Góis et al.., *Reward and punishment in climate change dilemmas*, 9 Scientific Reports 1, 4-5 (2019); *see also* Walid Marrouch & Amrita Ray Chaudhuri, *International Environmental Agreements: Doomed to Fail or Destined to Succeed? A Review of the Literature*, 9 International Review of Environmental and Resource Economics 245 (2016).

[110] Jane Black, Maurice D. Levi & David De Meza, *Creating a Good Atmosphere: Minimum Participation for Tackling the 'Greenhouse Effect'*, 60 Economica 281, 291 (1993).

[111] Marrouch & Chaudhuri, *supra* note 110, at 246.

part, that treaty is limited to heritage sights in territorial waters or at most in the expanded economic zones. The UNESCO convention sought to expand upon UNCLOS as well as deal with heritage sights in the deep sea.

The Convention, which had its beginnings in efforts by UNESCO as far back as 1956,[112] is designed to help countries protect their cultural heritage underwater. To this end, the Convention: "sets out basic principles for the protection of underwater cultural heritage; provides a detailed State cooperation system; [and] provides widely recognized practical rules for the treatment and research of underwater cultural heritage."[113] The convention does not prescribe any technical requirements per se in the protection of underwater heritage, rather it sets the bar law, requiring only that signatories "take measures according to their capabilities."[114] Notably, the "Convention encourages scientific research and public access."[115] The Convention seeks to also protect heritage in international waters.

Like the idea that the environment in space and the celestial bodies is the responsibility of all mankind, this treaty notes the "importance of protecting and preserving the underwater cultural heritage and that responsibility therefore rests with all States."[116] Under a similar construct, it may be possible to designate at least parts of Mars, and other celestial bodies as untouchable world heritage sites, and apply the same protections that are afforded to heritage sites outside of any particular jurisdiction, such as what is applied to the Titanic.[117]

However, for the most part, as defined in the 2001 UNESCO Convention on Underwater Cultural Heritage, most of the obligations only fall within the territorial bounds of each signatory. Thus, given that the treaty allows States to impose sanctions on violations only within its territorial waters, it would be difficult to port this convention to space, where inherently, no state has any political borders, yet. Note also that the Convention does not deal with the issue of ownership, an ongoing concern with outer space. And while it stresses at the outset that it "does not regulate the ownership of underwater cultural heritage nor does it prejudice the rights, jurisdiction or duties of States Parties under international law," major maritime nations still refuse to sign or ratify the convention out of fear that it will erode their rights, like those held under salvage and find laws.[118]

International Seabed Authority

Another solution might look to reproducing something like the agreement that resulted in the International Seabed Authority (ISA), but in space. The areas administered by this international non-governmental organization have many political similarities to space. The United Nations,

---

[112] UNESCO, *The History of the 2001 Convention on the Protection of the Underwater Cultural Heritage*, https://unesdoc.unesco.org/ark:/48223/pf0000189450 (last visited May 5, 2021).
[113] UNESCO, *About the Convention on the Protection of Underwater Cultural Heritage*, http://www.unesco.org/new/en/culture/themes/underwater-cultural-heritage/2001-convention/ (last visited May 5, 2021).
[114] *Id*.
[115] *Id*.
[116] Id.
[117] See Ulrike Guerin, *The Protection accorded to the Titanic by the UNESCO Convention on the Protection of the Underwater Cultural Heritage*, UNESCO 1http://www.unesco.org/new/fileadmin/MULTIMEDIA/HQ/CLT/pdf/The%20protection%20accorded%20to%20the%20Titanic%20wreck%20by%20the%20UNESCO%20Convention%20on%20the%20Protection%20of%20the%20Underwater%20Cultural%20Heritage.pdf (last visited May 5, 2021).
[118] Eden Sarid, *International Underwater Cultural Heritage Governance: Past Doubts and Current Challenges*, 35 Berkeley J. of Int'l L. 218, 226 n. 40 (2017).

under UNCLOS views the seabed as the common heritage of mankind wherein "no state can claim or exercise sovereignty or sovereign rights over any part of the Area or its resources."[119]

And like space, UNCLOS expects that all "activities in the Area must be carried out for the benefit of humankind as a whole, irrespective of the geographical location of states, taking into particular consideration of developing states' interests and needs."[120]

Further, like the ostensible peaceful uses of outer space, the Area under the UNCLOS regime and its resources "are open to use exclusively for peaceful purposes by all states, whether coastal or land-locked, without discrimination; and financial and other economic benefits derived from activities in the Area must be equitably shared, on a non-discriminatory basis."[121]

The ISA, a168 member organization divided into representative regional groups,[122] was implemented under part XI of UNCLOS and a subsequent 1994 agreement.[123] The authority and obligations of the ISA are spelled out under Articles 143 and 144 of UNCLOS. Headquartered in Kingston Jamaica, the ISA considers itself the only international organization that equitably manages a common property resource.[124] The ISA and its regulations, which covers both public and private actors, became operational before the industry of deep-sea mining matured. [125]

The ISA was intended to be an international, intergovernmental, and autonomous organization with the goal of supervising activities conducted by states in the area that is the common heritage of all mankind,[126] the deep ocean sea bed; aka The Area. The Area is not insignificant and covers 54% of the oceans. The ISA, which ostensibly is the only organization that has the legitimacy and authority to regulate the deep sea, is primarily interested in the exploration and mining of the seabed although it is also supposed to promote scientific exploration as well, develop capacity building among developing nations in the area of deep sea research, and it is "mandated to provide for the necessary measures to ensure the effective protection for the marine environment from harmful effects, which may arise from mining activities in the Area."[127]

The ISA is supposed to endeavor to sustain the local biodiversity of the seabed and to make sure that this mining does not harm the environment: "to prevent interference with the ecological balance of the marine environment."[128] To this end it has broad authority to enact the measures and regulations that it deems necessary, and to deal with conflicts between signatories. In fact, the ISA is obligated to continually update its rules and regulations to accommodate changing realities. The ISA seems to have also been granted broad powers to enforce its regulations, including

---

[119] Int'l Inst. for Sustainable Dev., *Summary of the Twenty-fifth Annual Session of the International Seabed Authority (Second Part): 15-26 July 2019*, 25 Earth Negotiations Bulletin, at 2 (July 29, 2019), http://enb.iisd.org/vol25/enb25207e.html.
[120] *Id.*
[121] *Id.*
[122] *See* International Seabed Authority, *Member States*, INTERNATIONAL SEABED AUTHORITY, https://www.isa.org.jm/member-states (last visited May 5, 2021).
[123] *See* International Seabed Authority, *Note on Public Information on Plans of Work for Exploration*, INTERNATIONAL SEABED AUTHORITY, https://www.isa.org.jm/authority (last visited May 5, 2021).
[124] International Seabed Authority, *International Seabed Authority*, YOUTUBE (Oct. 9, 2019), https://www.youtube.com/watch?v=tzP-WqTJR_w.
[125] *See, e.g.*, *Treasure on the Ocean Floor*, THE ECONOMIST (Dec. 2, 2006), https://www.economist.com/technology-quarterly/2006/12/02/treasure-on-the-ocean-floor.
[126] G.A. Res. 2749 (XXV) at 24 (Dec. 12, 1970), https://digitallibrary.un.org/record/201718?ln=en.
[127] Asterios Tsioumanis, et al., *Summary of the Twenty-fifth Annual Session of the International Seabed Authority*, 25 EARTH NEGOT. BULL. (IISD) No. 207, at 1 (Jul. 29, 2019), https://enb.iisd.org/events/2nd-part-25th-annual-session-international-seabed-authority-isa/summary-report-15-26-july.
[128] G.A. Res. 2749 (XXV), supra note 126 at § 11(a).

emergency orders that can employ practical measures as necessary "to prevent, contain and minimize such serious harm or threat or serious harm to the marine environment."[129] Moreover, if forced to employ these serious measures, the infringing party is obligated to reimburse the ISA.

Notably, the ISA has an endowment fund that is intended to help support its activities. A similar idea could be implemented in space where the poorer countries would need help in limiting their impact on the environment.

Further, the ISA also has an entrepreneurial arm –The Enterprise—that seeks to promote international collaboration in the area of deep-sea mining. If a similar instrument would be established in space, a similar entrepreneurial arm could provide access to space that might otherwise not be available for poorer nations. Under UNCLOS, deep sea activities require the acquiesce of the ISA which regulates the activities.

There are many aspects of the ISA that might work well in space. While the ISA's membership is broad and representative, there is a smaller 36 member council (also designed to adequately represent all member states) which acts with executive authority, and an even smaller legal and technical commission. [130] The Council "supervises and coordinates implementation of the elaborate regime established by the Convention to promote and regulate exploration for and exploitation of deep-sea minerals by States, corporations and other entities. Under this system, no such activity may legally take place until contracts have been signed between each interested entity and the Authority. The Council's task is to draw up the terms of contracts, approve contract applications, oversee implementation of the contracts, and establish environmental and other standards."[131] This past year, the ISA endeavored to further develop new regulations to ensure environmental protections in light of industry needs to mine the oceans.[132]

Given all this, the development of an ISA like body for space might prove to be a successful endeavor. However, underwater mining is a relatively expensive proposition, even more expensive than launching a lunar lander or a small satellite. Moreover, this is an emerging technological area and, as such, the ISA is still somewhat unproven in its ability to enforce the protection of the seabed.

1992 Convention of Biological Biodiversity

Another prominent IEA is the multilateral UN 1992 Convention of Biological Biodiversity (CBD) that was developed under the auspices of the United Nations Environment Programme (UNEP). The CBD, negotiated at the Rio Summit in 1992 --in addition to other non-binding soft-law like Agenda 21-- was adopted in Nairobi, and entered into force in 1993 after receiving 168 signatures. Some think that the CBD could provide a framework for space as well.[133]

The CBD recognizes that conservation of terrestrial biodiversity is a common concern of all humankind. With currently an impressive 196 member parties, 97 percent of the signatories have developed national biodiversity strategies and action plans (NBSAPs) as per Article 6 of the convention.[134] "The requirement to integrate consideration of the conservation and sustainable

---

[129] Center for Oceans Law and Policy University of Virginia School of Law, UNICLOS 1982 Commentary: Supplementary Documents, Martinus Nijhoff Publishers 1, 249 (2012).
[130] International Seabed Authority, *Structure and Mandate of the Council*, Int'l SEABED AUTH., https://www.isa.org.jm/authority/council-structure-mandate (last visited May 5, 2021).
[131] *Id.*
[132] Int'l Inst. for Sustainable Dev., *ISA Talks Consider Development of Regulations on Deep-seabed Mining*, IISD (Aug. 8, 2019), https://sdg.iisd.org/news/isa-talks-consider-development-of-regulations-on-deep-seabed-mining/.
[133] Convention on Biological Diversity, May 6, 1992, 1760 U.N.T.S. 79.
[134] Convention on Biological Diversity Secretariat, *National Biodiversity Strategies and Action Plans (NBSAPs)*, CBD SECRETARIAT, https://www.cbd.int/nbsap/ (last visited May 5, 2021).

use of biological resources into national decision-making, and mainstream issues across all sectors of the national economy and policy-making framework, are the complex challenges at the heart of the Convention."[135]

Under Article 8, In-situ conservation, signatories were obligated to establish a system of protected areas, guidelines for management of those protected areas, ensure their conservation and sustainable use, promote the protection of these areas, and promote environmentally conscious development. Unfortunately, the CBD seems to be generally failing at protecting biodiversity in areas such as the Southern Oceans and Antarctica.[136] To this end, there has been an effort to create a new agreement focused on these areas: the Global Ocean Biodiversity Initiative (GOBI). GOBI "is an international partnership advancing the scientific basis for conserving biological diversity in the deep seas and open oceans,"[137] with an aim to help countries reach their CBD goals. GOBI specifically focuses on those areas beyond national territorial control which correlates well conceptually with outer space

2004 Ballast Water Mitigation Convention

Another potentially useful international agreement that might have elements that could be ported into space is the 2004 Ballast Water Mitigation Convention (BWM) also resulting from the 1992 UN Conference on Environment and Development (UNCED) and the 2002 the World Summit on Sustainable Development aims to prevent the transference of invasive species to new environments via the off-loading of ship ballast water. The BWM sets certification and compliance standards as well as approving management systems [138].

Very similar to the concerns associated with Planetary Protection, the BWM was devised to prevent the transport of invasive species from their natural environments at their home port, to a new environment, often bereft of natural predators, via ballast water. Indicative of the political complexity of the problem, especially the various stakeholders, private, non-governmental and national, the convention took three decades to develop, and it came into force as recently as 2017. Eighty-six states have ratified the treaty.[139]

Ballast water is both taken up or discharged depending on the needs of the vessel. For example, either when the vessel is loaded or unloaded or there is a need for the ship to have extra stability in stormy seas. The effects of contaminated ballast water cannot be overestimated, a simple invasive species like the zebra mussel, native principally to the Black Sea, was carried over to the great lakes by likely a single commercial vessel.[140] Besides substantially altering the ecosystem and killing off many organisms, "these mussel species can cause millions of dollars in

---

[135] Convention on Biological Diversity Secretariat, *What is an NBSAP?*, CBD SECRETARIAT, https://www.cbd.int/nbsap/introduction.shtml (last visited May 5, 2021).
[136] University of British Columbia, *Thought Antarctica's Biodiversity was Doing Well? Think Again*, SCIENCEDAILY (Apr. 25, 2017), https://www.sciencedaily.com/releases/2017/04/170425143058.htm.
[137] International Union for Conservation of Nature, *Global Ocean Biodiversity Initiative Brochure – Working Towards High Seas Conservation*, IUCN (Mar. 5, 2010), https://www.iucn.org/zh-hant/node/5463.
[138] Int'; Convention for the Control and Mgmt. of Ships' Ballast Water and Sediments, Feb. 13, 2004, IMO BWM/CONF/36, Agenda Item 8.
[139] Status of Treaties, INT'L MARITIME ORG. 1, 3 (Sept. 10, 2021) (BWM 2004), https://wwwcdn.imo.org/localresources/en/About/Conventions/StatusOfConventions/StatusOfTreaties.pdf.
[140] John R. Bobka, *Defining "Unduly": Resolving Inherent Textual Ambiguity in the IMO's Ballast Water Management Convention*, 60 WM. & MARY L. REV. 267, 268 (2018).

damage to boat engines, power plant and public water intakes by fouling infrastructure, blocking water flow and costing time and money removing them from affected structures."[141]

Managing compliance of this convention is far from trivial: it is estimated that ten billion tonnes of ballast water are transported around the world annually, ferrying an estimated 7000 species back and forth across the planet.[142]

Like a potentially similar space treaty, compliance with the convention happens at port, where an arriving/departing vessel has to provide the relevant data. In space, compliance would take place principally prior to launch. However, unlike space, given that every nation has its own self-interest at heart when demanding this information (to prevent invasive species on their shores), compliance from the collection side results in some ports demanding even more information than required under the convention. However, like space, there is little that a port can do currently to prevent falsification of the reports until advanced testing standards are developed. In the meantime, there has yet to be evidence of any punitive measures being levied on ships.[143]

As per the convention, enforcement mechanisms are supposed to be legislated by each individual state.[144] Fines are not seen to be a good mechanism of enforcement as they can easily be appealed in court. Detention and extra testing, while useful, are unlikely, leave little in the way of any enforcement teeth to the treaty.

The Protocol on Environmental Protection to the Antarctic Treaty (Madrid Protocol)

The Protocol on Environmental Protection to the Antarctic Treaty (Madrid Protocol) is a 1991 addition to the part of the Antarctic Treaty System. The Antarctic Treaty System, like the Outer Space Treaty came about during the Cold War and reflects the mentalities of the time: like the OST, the ATS came about partially to prevent the militarization of an area purported to be the province of all mankind. Antarctica has been described as "outside the circuits of the known world that both preceded the moon as a destination of otherworldly knowledge and is coterminous with outer space."

Both the ATS and the OST have strong scientific, nongovernmental and independent bodies directing them. But unlike the OST that remained a stand-alone treaty with a number of ancillary and less popular treaties expanding upon particular areas, the ATS is a seemingly successful treaty system comprising over 200 additional agreements. In particular, in contrast to the OST, the ATS has extensive environmental oversight provisions that are incomparable to the relative ineffective and unenforceable COSPAR provisions.

Moreover, unlike the OST, which is a UN negotiated treaty and relies on a consensus mechanism among over a hundred states to provide any additional recommendations or binding rules, the ATS is overseen by a small number of countries making up the Antarctic Treaty Consultive Meeting System (ACTM). ACTM is comprised of nations that are particularly committed and motivated to regulate in the Antarctic.

The Protocol, among other things, established a Committee for Environmental Protection. The goal of the Committee is to advise and provide recommendations on implementation of the

---

[141] *Zebra Mussel*, GOVT. OF CANADA, http://www.dfo-mpo.gc.ca/species-especes/profiles-profils/zebramussel-moulezebree-eng.html (last visited May 5, 2021).
[142] Kaushal E. Mapari, et al., *Role of Reporting in Compliance Monitoring and Enforcement of Ballast Water Management*, 35 ASEAN J. Sci. & Tech. Dev. 49, 49 (2018).
[143] Samuel Stalls, et al., *Ballast Water Management: Protecting Marine Environments in Small Island Developing States in the Pacific* 15-16 (2019), https://innovation.luskin.ucla.edu/wp-content/uploads/2019/06/Ballast_Water_Management.pdf. (last visited July 27, 2021).
[144] Int'l Convention for the Control and Mgmt. of Ships' Ballast Water and Sediments, *supra* note 136, at 5, 6.

Protocol. The Protocol requires the development of regular and effective monitoring so that the parties to the protocol can assess predicted and unforeseen impacts. Nevertheless, not all parties have implemented the Protocol to the same degree, allowing violators the opportunity to forum shop for a country with permissive applications of the Protocol.[145]

Claims of violations by nationals of signatories, for example in the permitting process to conduct activities in Antarctica, can result in civil and criminal penalties.[146] In general, while the Antarctic treaty seems like another good paradigm to follow in space, in that it seems that scientific and environmental interests are put in front of economic and political ones, in practice, governance is difficult and often lacking.[147]

Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR),

Another potential environmental treaty: the Convention on the Conservation of Antarctic Marine Living Resources (CCAMLR), also part of the Antarctic Treaty System, is also often referenced when seeking close analogs for the international regulation of space. The convention also sets forth marine protected areas for the preservation of Antarctic organisms and their habitat, as well as the relevant observation and inspection and enforcement [148].

Summary of IEAs

Like these conventions, any continued international efforts to protect the various and varied biospheres of the universe require the necessary knowledge and capacity, as well as significant stakeholder involvement. Without these, we are unlikely to see any change in the near future as other private and even governmental efforts seek opportunities to be the first someone to do something, without a full appreciation of the long-term effects.

Overall, most of the hundreds multilateral environmental treaties don't work fully, if at all, either because their goals are set too low, they lack enforceability, they are understaffed and underfunded and lack even the ability to confirm reported data, and even countries that ratify their commitments often don't follow through. Finally, most if not all environmental treaties lack desirable carrots or enforceable or scary sticks.[149]

We are unable to find a proven model within the IEAs that could be exported to space, and successfully protect celestial bodies from harm caused by international, national and private entities. Given this reality, we argue that those interested in protecting planetary environments look elsewhere for a realistic and workable solution to this imminent problem.

VII. Unilateral Enforcement

An alternative to international laws and treaties is the use of national regulations that were anyway supposed to be put in place by the signatories to the Outer Space Treaty. For example, in the United States, the Federal Aviation Administration (FAA) regulates the licensing and permitting of space launches from its Office of Commercial Space Transportation. As per their

---

[145] Nils Vanstappen, *Challenges for the Antarctic Treaty System*, 38 WERELDBEELD 169 (2014), http://www.vvn.be/wereldbeeld/challenges-antarctic-treaty-system/.
[146] United Kingdom Foreign & Commonwealth Office, *UK Antarctic Enforcement Policy and Procedures*, GOV.UK (Feb. 23, 2015), https://www.gov.uk/government/news/uk-antarctic-enforcement-policy-and-procedures.
[147] *Reform the Antarctic Treaty*, NATURE (June 13, 2018), https://www.nature.com/articles/d41586-018-05368-7.
[148] Convention on the Conservation of Antarctic Marine Living Res., May 20, 1980, 1329 U.N.T.S. 47.
[149] See Lawrence Susskind, *Strengthening the Global Environmental Treaty System*, 25 ISSUES IN SCI. & TECH. 1 (2008).

FAQ, they have licensed more than 370 launches and reentries. The regulations are set forth in 14 CFR 400 as per 51 USC 509.

Under FAA regulation, any United States citizen launching anywhere in the world, or any individual launching in the United States is required to obtain a license for launch or reentry of their spacecraft. For US citizens operating abroad, the FAA will send inspectors to monitor licensed launches.

The licensing procedure of the FAA must be completed within 180 days, a permit in 120. These procedures are intended to review any national security concerns, a determination as to the relevant insuring of the vehicle and its payload, any public safety issues, and importantly for this issue, any potential environmental impacts.

Under the US' National Environmental Policy Act,[150] any space launch or reentry is required to comply with the necessary NEPA reviews and analysis. A review, which can start in the pre-application consultation with the FAA, and is not included within the 120-180 day timeframe, could include one of categorical exclusions for those activities that have historically not had a significant impact on the environment, environmental assessment to determine whether the activity can obtain a Finding of No Significant Impact (FONSI), i.e., it does not have the potential to significantly impact the environment, or an impact statement for when the activity cannot obtain an FONSI. In these cases the FAA must prepare an impact statement which could result in a determination that the license should be withheld. [151]

If even a handful of nations could implement similar laws to these, then concerns relating to planetary protection would be less urgent. But most countries have nothing approaching even this level of regulation when it comes to either national or private space exploration.

VIII. Conclusions

Arch Mission's attempt to surreptitiously land the potentially invasive Tardigrades on the moon, raises fundamental concerns as space exploration rapidly advances as a result of efforts by both private and public actors. The OST is clearly inadequate to provide the necessary scope and nature of planetary protection both due to its inherent vagueness, but also due to the political reality that the treaty only really binds public actors. Thus far, those public actors have for the most part been compliant with suggested rules and regulations for limiting adverse environmental impact on celestial bodies. However, we can no longer rely on the presumption of compliance.

There are numerous possible avenues for dealing with this increasingly relevant failure, ranging for new international agreements, national regulations, and lobbying by powerful NGOs. In seeking out how to best proceed, we argue that we can look to current environmental agreements as sources of both good and ineffective rulemaking, cherry picking those aspects that work and leaving behind those that don't.

Notably, however this is likely a less-than-optimal situation. Countries have had decades to draft, develop and implement their own respective laws and regulations, and yet most have yet to do so. And even those that have, like the aforementioned US governmental organizations are limited in their scope and constantly evolving. Without consistency across nations, and even within nations, this will only serve to inhibit additional private investment. The UN might still be the best bet, even if all the relevant countries can agree on is a simple basic framework that would

---

[150] 42 U.S.C. § 4321.

[151] Press Release, Fed. Aviation Admin., Fact Sheet–Commercial Space Transportation Activities (June 19, 2020) (https://www.faa.gov/news/fact_sheets/news_story.cfm?newsId=19074).

set minimum standards for both private and public actors, even if those standards are simply COSPAR's, at least in the short term.

However, there is a need for more than just rules and regulations. COSPAR ought to provide substantial outreach to both inculcate the importance of this endeavor, but to also provide technical support and know-how to help especially smaller nations and private companies achieve the requisite levels of technology for planetary protection.

In the end, we will need a powerful motive to create universal rules that will eventually be necessary, that will outweigh the economic and political incentives of noncompliance. It's not clear what that motive might be, until then we will need to rely on the goodwill of spacefaring nations and non-governmental actors to act responsibly. Are we doomed to fail?