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The Prospect of Interplanetary Mission: Are We Ready?

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Abstract

Mars exploration missions in the future will be focused on Mars Sample Return (MSR) and humans as space crew in late 2028 or early 2030 by NASA and other non-government entities, such as Space Exploration Technologies (Space X) and Blue Origin. MSR and sending humans to explore Mars raises environmental contamination issues, which are governed in law by Article IX of the Outer Space Treaty 1968 to "avoid harmful contamination." Though there is no existing international law instrument to address this issue comprehensively, Article IX was not clear to explain harmful contamination. Thus, non-governmental entities involved in future missions to Mars face liability, especially in the case of an accident causing fatalities or adverse environmental impact for the Earth and Mars. This article examines related regulations in corpus *iuris spatialis*, including soft law and elaborating with astrobiological data to encourage new regulation, ensuring liability and environmental safety on future Mars missions.

Keywords: Harmful Contamination, Liability, Mars Exploration, Planetary Environment

A. Introduction

Since the 1960s, when lunar probes and astronauts were sent to the lunar surface for scientific purposes, samples of cosmic material, lunar dust, and rock were returned to Earth for laboratory investigation. In 2017, US President Donald Trump said that NASA, in collaboration with commercial partners,[2] would send humans back to the lunar surface and potentially to Mars. This raises a number of issues that must be explored. To begin, sending probes and humans to Mars may introduce Earth species

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[2] Wegner, John. "Trump criticizes NASA promotion of returning to the moon. He directed it 18 months ago", *Washington Post*, https://www.washingtonpost.com/politics/trump-criticizes-his-administrations-promotion-of-returning-to-the-moon-before-exploring-mars/2019/06/07/b28656b6-894f-11e9-98c1-e945ae5db8fb_story.html?noredirect=on. Accessed on August 27, 2019.

to the Moon and Mars's surface. Second, by bringing Earth organisms to the Martian surface, it is possible to contaminate indigenous ecosystems, with unknown long-term consequences. This also applies to Earth, where possible contamination by Martian organisms on sample return missions and with the return of human crews to Earth is a possibility.

The first attempt to preserve the planets from contamination occurred during the International Astronautical Federation's 7th International Astronautical Congress in 1956, and a program was then developed to prevent contamination on the Moon and other planets by terrestrial microorganisms.[3] COSPAR was founded in 1958 to foster worldwide cooperation in scientific research. COSPAR is tasked with the responsibility of preventing contamination on the Moon, Mars, and other celestial bodies. COSPAR guidelines ensure that exploration is done in such a way that outbound spacecraft do not introduce biological contamination into planetary bodies, jeopardizing the discovery for extraterrestrial life.[4] However, COSPAR, on the other hand, did not organize any legally binding instruments.

Contamination occurs when microbiological organisms are accidently sent to the Moon during missions prior to 1961, when spacecraft were not sterilized ahead of launch.[5] COSPAR enacted the policy requiring spacecraft to be sterilized prior to launch to avoid harmful material from Earth, such as microbiological life, being mistakenly carried away. Sterilization often entails heating the spacecraft with ultraviolet (UV) light between 115ºC and 200ºC in combination with ethylene oxide to reduce the quantity of microbiological beings. Total sterilization, on the other hand, is not conceivable.[6]

It is common for spacecraft to contain fungal species such as Alternaria, Aspergillus, and Bacilli, as well as bacterial species such as Acinetobacter, Alcaligenes, Micrococcus, and Streptococcus.[7] Planetary Protection (PP) was established during the Viking missions to Mars in order to minimize the amount of microbiological life on the surface of Mars.[8] [9] PP was typically applied in launched spacecraft with microbial bio loads of 104-108 microorganism cultures per vehicle.[10] Notably, several missions' spacecraft hardware that landed on the Moon since 1959 was never sanitized, resulting in the introduction of terrestrial microorganisms to the lunar surface.[11]

The most recent incident occurred in April 2019, when an Israeli lunar lander collided with the moon's surface. On-board was a capsule carrying Milnesium Tardigradum, most often referred to as Tardigrades, which was surprising to the international

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[3] Devicanzi, D.L., Stabekis P.D. Barengoltz, J.B, "a Proposed New Policy for Planetary Protection," *Advance in Space Research,* no.8, 1983, pp. 13-21.

[4] Terminal dry heat sterilization protocols just prior to launch reduce bio loads to an estimated 2 x 10^{-4} viable spore forming per lander, *See* at Galvin, Daniel P.J.P. Dworkin, Lupisella, M., Kminek, G., Rummel J.D., "Biological Contamination Studies of Lunar Landing Sites: Implications for Future Planetary Protection and Life Detection on the Moon and Mars," *International Journal Of Astrobiology*, no.0 2004, pp. 1-7 DOI: 10.1017/S1473550404001958

[5] Ibid.

[6] Ibid.

[7] Nicholson, Wayne L., Schuerger, Andrew C., Race, Margater S., "migrating Microbes and Planetary Protection," *Trends in Microbiology*, no.9, 2009, pp. 389-392.

[8] Ibid, at 389

[9] De Vicenzi, Donald L., et.al "Planetary Protection, Sample Return Mission and Mars Exploration: History, Status and Future Needs," *Journal of Geophysical Research*, no. E12, 1998, pp. 28,557-28,585.

[10] Nicholson, *supra* note 7 at 389.

[11] Galvin, Daniel P., et.al "In Situ Biological Contamination Studies of the Moon: Implications for Planetary Protection and Life Detection Missions", *Earth Moon Planets*, no.207, 2010, pp 87-93.

community.[12] Arch Mission Foundation was identified as the perpetrator of this bizarre occurrence; finally, according to the information, they enabled the addition of a "digital library" on the lander dubbed "back up of planet Earth," though they never disclose that they did so with Tardigrades.[13]

Numerous experiments were conducted to obtain scientific data from Mars in the future. NASA and other private groups, such as Space X, have lofty goals of Mars exploration. NASA's InSight (Seismic Investigation, Geodesy, and Heat Transport) project has been launched to examine Mars' surface.[14] This mission's objective is to gain a better understanding of the formation and evolution of terrestrial planets by investigating the interior structure and processes of Mars.[15] This includes determining the core's size, composition, and physical state (liquid/solid), determining the crust's thickness and structure, determining the mantle's form and structure, and determining the interior's thermal state. Additionally, this data can be used by Space X's Mars mission, which will begin in 2022 with a cargo trip to build a facility on Mars and conclude in 2024 with the arrival of a crew.[16] This discovery demonstrates a significant future concern in terms of microbial contamination of the Mars ecology produced by human and indigenous microbial critters.

Furthermore, contamination of the lunar or Mars surface impacts the ecology as a whole and may jeopardize scientific studies into the possibility of life on Mars and the Moon, albeit this effect will not be applicable to a returned planetary sample to Earth due to "backward contamination." This study will demonstrate why we need to enforce PP more tightly and interpret Article IX of the OST 1967 more clearly by utilizing precautionary principles to avoid cross-contamination between Earth and Mars and using the Space IL case as an example.

B. Lunar Biological Protection Effort from Apollo 11 Mission to Space IL; A Case Studies

Cross-contamination has a profound effect on a newly created ecosystem, which is never prepared to accept an alien microbial organism. Cross-contamination is believed to have a detrimental effect. When Europeans arrived in Central America in the twentieth century, they took microbiological species such as cholera with them and disseminated it over the new ecosystem, resulting in the death of the majority of indigenous Americans.[17] Additionally, it will be the same problem if we do not yet have a Planetary Policy as a legally binding instrument. There are four distinct types of contamination associated with space activities: nuclear fuel contamination, space debris pollution, chemical contamination (Ozone), stratospheric contamination, and biological contamination.[18] Exobiological Contamination has been a primary issue for

[12] Lorens Grush, "Why Stowaway Creatures on the Moon Confound International Space Law", *The Verge*. https://www.theverge.com/2019/8/16/20804219/moon-tardigrades-lunar-lander-spaceil-arch-mission-foundation-outer-space-treaty-law?fbclid=IwAR2B9esSSYG8ttRUAqlmQBhTKc_HPf5FuA-dF-q-utlTohiEyUzrUrYsSQI**.** Accessed on August 18, 2019.

[13] Ibid.

[14] NASA (National Astronautics and Space Administration), "InSight, Into the Early Evolution of Terrestrial Planets," https://mars.nasa.gov/resources/22071/insight-fact-sheet/?site=insight. Accessed on 21 August 2019.

[15] Ibid.

[16] Space X, "Making Life multiplanetary." https://www.spacex.com/sites/spacex/files/making_life_multiplanetary_transcript_2017.pdf. Accessed on August 21, 2019.

[17] Ramirez , Ivan J., "Historical Analysis of Cholera in Latin America", *Department of Geography, Michigan State University*" 2006.

[18] Suyudi , Suyud Harsoyo., *Dampak Lingkungan dan Implikasi Hukum Akibat Keruang Angkasaan* [Environmental Effect and Legal Implication on Space Activities] edited by Saefullah Wiradipradja and Mieke Komar Kantaatmadja,

scientists ensuring the safety of all space missions for the Earth and outer space. This concern is mostly directed towards forward and backward biological contamination, which will almost certainly damage terrestrial life. NASA is interested in proposing a new PP or Planetary Quarantine, which has remained mostly unchanged since 1972.[19] Since the launch of Sputnik I into outer orbit, PP has not been applied to artificial objects, including when we dispatched Apollo 11 to the lunar surface.

The Apollo mission anticipated the presence of life on the lunar surface. The Apollo mission was taken seriously in order to prepare for the implementation of planetary protection by involving several departments within the United States of America, including NASA, the United States Public Health Service, the United States Department of Agriculture, the United States Department of the Interior, and the National Academic Sciences, collectively known as ICBC (Interagency Committee on Backward Contamination), which promoted and advised NASA to investigate possible lunar life forms at the time.[20] The most major step taken by CBC was the establishment of the LRL (Lunar Receiving Laboratory) facility, which is devoted to research and investigation of the lunar sample returned by the Apollo 11 astronauts. At least 382 kg of lunar rocks, dirt, and around 2000 individual specimens were returned by the astronauts. As a result, astronauts are included to watch and quarantine for up to 21 days following the mission.[21]

On April 19, Space IL scientists concentrated on two large-screen monitoring systems for the Beresheet lunar lander, the first private business to land on the moon's surface.[22] This lunar lander is loaded with "earth backup data," which is contained on a DVD-sized disc with a thin nickel plate and contains DNA and dehydrated Tardigrades or water bears. Tardigrades are one of the most tenacious species on the planet, living on the summits of mountains, scorching deserts, and subglacial lakes in Antarctica; also, Tardigrades can survive in boiling water up to 149ºC.[23] Tardigrades can survive in almost any environment, including outer space, as long as they are not directly exposed to the Sun's ultraviolet rays. However, Space IL never discloses information about Tardigrades on their payloads to the FAA (Federal Aviation Administration) or the Israeli space authority. The FAA's document just described as "hazardous" payloads made up of non-living elements.[24]

Fortunately, Tardigrades cannot colonize the moon, as the moon lacks water, an atmosphere, and vacuum zones. Thus, Tardigrades are dormant unless they discover water on the moon. According to NASA's Public Policy Office, they are unconcerned about this expedition spitting earth organisms on the moon's surface; also, there are 96 bags

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eds., *Hukum Angkasa dan Perkembangannya,* Remadja Karya, 1988, 187

[19] Devicenzi D.L. *supra* note 3 at 14.

[20] Ibid

[21] *See* further reading at Biomedical results of Apollo, Taylor et al.

[22] WIRED, "*A Crashed Israeli Lunar Lander Spilled Tardigrades on the Moon*", Available at: https://www.wired.com/story/a-crashed-israeli-lunar-lander-spilled-tardigrades-on-the-moon/?verso=true. Accessed on 21 August 2019.

[23] Ian Sample, "Tardigrades may have survived spacecraft crashing on moon", *The Guardian* available at: https://www.theguardian.com/science/2019/aug/06/tardigrades-may-have-survived-spacecraft-crashing-on-moon, Accessed on 21 August 2019.

[24] According to FAA (Federal Aviation Administration) report, Hazardous Payload Materials Contains are: One battery composed of rechargeable lithium-ion cells with a total weight of 2,3 Kg per CFR 172.101 the quantity is below the limitation of 35 Kg Gross weight. The propulsion system Is a bi-propellant system using; MMH (UN#1244) as a fuel with a total weight of 160 Kg. MON-3UL as an oxidizer with total weight of 26 Kg. AGHP (Axially Grooved Heat Pipe) made from aluminum alloy 6063 with sealed ammonia as working fluid and the last Pressurized helium (MEOP 8000 PSI) quantity of 1,26 Kg.

of human excrement[25] ready to be cleansed in a future mission.

Additionally, after years of unsuccessfully looking for indigenous life on the lunar surface using return samples from Apollo missions, Earth to moon missions are now classified as "unrestricted earth return missions."[26] While there is an introduction paper about lunar materials during the moon voyage, there are no further restriction procedures for a return to Earth. This sterilizing constraint may be enforced if the expedition is directed toward three celestial worlds with "indigenous life prospects": Mars, Europa, or Enceladus. However, the Moon and Mars are not comparable in this regard. Mars has an atmosphere and may have an ice surface capable of supporting life. If Tardigrades contaminate the Martian surface, the situation will change.[27]

1. Mars, Setting Up for Colonialization, Mission Sample Return up to Mars Terraforming, the Evidence of Life Form.

Elon Musk, as founder and CEO of Space X, a private spaceflight company based in the United States, has a fantastic plan to colonize the Moon and Mars and to ensure the mission's success; Space X has divided the mission's preparation into three major phases, as we previously reported in 2019, 2020, 2021, and 2022. In Boca Chica, Texas, in 2019, Space X conducted the first "hop test."[28] Second, Space X's focus in 2020 will be on flight testing, including the evaluation of their rocket, followed by their first commercial flight in 2021. The first rocket to Mars will be launched in 2022, and it will be equipped with the following: "Infrastructure for future trips includes a power plant, mining operations, and life support. Additionally, they would confirm the availability of water and identify potential risks. Each ship would have a capacity of approximately 100 tons." This endeavour includes terraforming Mars in order to sustain human life on the planet.

Mars has been attracting scientists for decades, long before Space X began their endeavor, with the fundamental question, "is there life on Mars?" To assuage scientists' curiosity, the US Government launched a project in mid-1970 to investigate the potential of life on Mars by sending two probes to the planet's surface. Not only the United States of America, but also the Soviet Union sent probes to Mars in this circumstance. Fortunately, the US probes became a successful mission, safely landing on the surface of Mars.

As noted previously in this study, we will closely examine what the Viking expedition accomplished in terms of searching for life forms, and how the Mars mission's execution of PP was classified as

[25] Human Waste mostly contains urine and faces from lunar manned mission.

[26] Uhran, Bergit, et.al, "Updating Planetary Protection Considerations and Policies for Mars Sample Return", Space Policy, 2019.

[27] There were several categories on subject mission from I up to V "pertains to all missions for which the spacecraft, or a spacecraft component, returns to Earth. The concern for these missions is the protection of the Earth from back contamination resulting from the return of extra-terrestrial samples (usually soil and rocks). A subcategory called "Unrestricted Earth Return" is defined for solar system bodies deemed by scientific opinion to have no indigenous life forms. Missions in this subcategory have requirements on the outbound (Earth to target body) phase only, corresponding to the category of that phase (typically Category I or II)." *See* at Office of Planetary Protection, NASA, "Protecting Life on Other Bodies," NASA Office of Planetary Protection, https://planetaryprotection.nasa.gov/categories/. accessed on 29 August 2019.

[28] Space X has Bold Timeline for Getting to Mars and Starting the Colony," Hence this test has setting up in close to real condition in Mars when the rocket entry the planet or widely known as "heat test absorbing from interplanetary entry velocities" which is tremendously important to know how far capabilities of Space X rocket.

level V in this regard. NASA issued protocols during the Apollo 11 mission authorizing the quarantine of personnel and mission equipment. Additionally, it has made touch with the lunar surface to verify that contamination does not travel backward.[29] And then there's Mars. Is there a NASA policy requiring all NASA missions to adhere to the limits specified in this paper? Yes, NASA is required to publish the record, and we will conduct a thorough analysis of three major Mars missions.

The key mission objectives of the Viking mission are as follows. The mission's objective is to acquire high-resolution photographs of the Martian surface, analyze its composition and structure, and look for evidence of life.[30] Vikings I and II were two spacecraft comprised of an orbiter and a lander, respectively. The Viking expedition successfully provided a comprehensive view of Mars, including volcanoes, lava, enormous canyons, cratered areas, wind-forms organisms, and evidence of surface water.[31]

Viking mission functions as a "mini-laboratory" on Mars, collecting and analysing samples in situ. Gas chromatography was carried on Viking expeditions[32] They were successfully working on Mars, analysing samples of the planet's surface composition and looking for signs of life; unfortunately, the Viking expedition failed to discover any living organisms during its mission.[33]In 1996, NASA launched the Mars Pathfinder mission at a cheap cost. This mission's objective is to characterize the Martian atmosphere and surface using rock, soil, and radio tracking.[34] Pathfinder is almost certainly a confirmed reversal of the Viking I and II missions, but with more detailed information about Mars.

Mars Phoenix, NASA's most recent mission to Mars that includes a lander, was led by Smith at the University of Arizona with project management provided by NASA's Jet Propulsion Laboratory in Pasadena. By founding water on Mars's surface[35] this expedition astonishes and astounds scientists. As the lead scientist for TEGA (Thermal and Evolved-Gas Analyzer) stated, "We have previously observed evidence for this water ice in observations by the Mars Odyssey orbiter and disappearing chunks observed by Phoenix last month, but this is the first time Martian water has been touched and tasted."[36] The rerouting of Mars water resulted in the Mars pole being placed close or in the Mars north pole being traced mostly by water-sediment tracking[37] Almost majority of these water deposits are beneath Mars' surface or subsurface.

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[29] Robbinsons, George S. "Exobiological Contamination: The Evolving Law," Annals of Air and Space Law, no. 17 1992

[30]David R. Williams, "Viking Mission to Mars," available at: https://nssdc.gsfc.nasa.gov/planetary/viking.html, Accessed on 29 August 2019.

[31] Ibid.

[32] "In order to combine sensitivity and the structural specificity of electron impact mass spectrometry with the separation power of gas chromatography. An obvious approach would have been to mimic terrestrial laboratory procedures by digesting the surface material to be analyzed by wet chemical methods followed by solvent extraction and possibly chemical separation. Thermal volatilization of the organic compounds from the surface material was selected as the simplest and most reliable approach. It was expected that the nature of thermal degradation products would lead to the identification of the set parent's compounds originally present in the sample." *See* at Biemans, K., et al. "the Search of Organic Substances and Inorganic volatile Compounds in the Surface of Mars," Journal of Geophysical Research, no.82 1977.

[33] Ibid

[34]NASA, "NASA Facts: NASA Pathfinder," Jet Propulsion Laboratory, https://www.jpl.nasa.gov/news/fact_sheets/mpf.pdf

[35] Susan Watanabe, "Phoenix Mars Landers: Exploring the Arctic Plains of Mars," NASA, Last Modified July 31, 2008, https://www.nasa.gov/mission_pages/phoenix/news/phoenix-20080731.html. Accessed September 7, 2019.

[36] Ibid.

[37] North Polar Ice form in Mars through gamma ray projection, regions of high ice content are shown in violet and blue and those low in ice content are shown in red. Source: https://www.nasa.gov/mission_pages/phoenix/overview.

As NASA noted, the ice surface lay beneath the Martian surface, demonstrating that life is capable of surviving in severe environments. Tardigrades, for instance, can thrive in this condition provided they are sheltered from ultraviolet radiation by a bottom layer of Mars soil. Additionally, every ten thousand years, as a result of planets wobbling Mars, ice will melt and convert to water, sustaining the habitable environment on Mars.[38] As a result of this scientific fact, it is possible to conclude that Mars still has indigenous life. Mars's environment, on the other hand, requires additional investigation to determine whether it is capable of supporting terrestrial life. NASA and ESA's next mission, MSR (Mars Sample Return), is scheduled to launch in late 2028 and will explore the form of minerals on Earth. This project's objective is to determine the answer directly on Earth; nonetheless, this mission will confront a significant risk of contamination from Mars.

We know that a planet's ability to host life is contingent upon the presence of three essential components: liquid water, carbon compounds, and an energy source. Additionally, there is evidence from the Mars sample that describes prior possibilities for life.[39] The presence of Martian life is indicated by the Martian meteorite ALH84001, which recently discovered bacteriomorph structure in newer Martian meteorites.[40] Despite the fact that bacterial fossils are not always associated with indigenous rock, in this case, they discovered bacteria such as prokaryotes and archaebacteria dating all the way back to Mars' carbon age. Regardless of whether the bacteria are related or not, we can deduce that bacteria can survive in deep basaltic aquifers.[41]

MSR will be classified as a category V mission, which means restricted earth sample mission, during the 2015 planetary subcommittee conference.[42] The MSR mission's central constraint is that it must ensure that Mars samples intended for future use are not contaminated by exobiological matter at any level specified; [1] The probability of introducing a single viable organism into each sample must be less than the limit obtained by multiplying the internal surface area of a sealed sample tube, in m2, by the Viking post-sterilization surface bioburden limit of 0.03 viable organisms per m2. [2] Terrestrial organic contamination will be confined to less than 1 part per billion (ppb) of any Tier 1 organic compounds per sample and less than 10 parts per billion (ppb) Total Organic Carbon per sample. [3] Sample tubes shall be designed to be opened upon return to Earth to avoid contamination of samples during the extraction process.[43]

This fact demonstrates that Mars exploration has been subjected to a lengthy and restrictive process to ensure that Mars and Earth are free of exobiological contamination. NASA, as a government agency, is bound by convention when it comes to its 2020 Mars mission. This reality, however, is insufficient to meet Space X's lofty goal of colonizing Mars in the near future. Thus, up to the present day, international space law recognizes only Article IX of the OST 1967 as a legally binding international law instrument, but COSPAR is not. This difficulty must be overcome in order to establish an appropriate precondition for Mars's use and to ensure that neither planet

[38] NASA,"Objectives,"https://www.nasa.gov/mission_pages/phoenix/mission/objectives.html. Accessed on September 7, 2019.

[39] Westall, Frances. et al. "An ESA study for the search for life on Mars," *Planetary and Space Science,* no. 48, 2000, pp.181-202.

[40] Ibid.

[41] Ibid.

[42] NASA Office of Planetary Protection.

[43] Westall, Frances et al *supra* note 39

is contaminated by exobiology. The following chapter will conduct an in-depth legal analysis.

C. Planetary Protection Legal Framework

1. The Outer Space Treaty 1967

The OST 1967 has five principles which can be found in its articles:

1. Benefit principles for all humankind in Article I mean all space activities shall have and encourage benefit to all humankind on the Earth regardless of their nations.
2. Freedom of exploration principles means every nation has an equal right to explore and use outer space without discrimination regardless of economics and technology.
3. International law, which we know that the OST 1967 and other four major space activities legal document cannot reach all aspects, by these fact International law such as environmental law, the law of armed conflict, and other related with can be applied for those activities.
4. Non-appropriation principles explain that no one of the states can claim their sovereignty in outer space; this principle ensures that freedom of exploration can grant to all states.
5. Cooperation and peaceful principles mean that all space activities are conducted by the spirit of peace and cooperation among other nations to ensure the safety of exploration through consultation.

The OST 1967 is the most relevant legal document that governs space activities in the environment framework[44] through the freedom of exploration principle; the OST 1967 has to ensure that all states can enjoy exploration without discrimination.[45] Hence, this Article has resulted from some space environmental problems caused by pollution, space debris and possibly exobiological contamination.[46] This problem is caused by the raising of an outer space satellite launched in early 2000 in favour of drastic economic change resulting in the third countries having the capabilities to buy or build their satellites. Furthermore, in the following of growing a significant number of satellites launch every year, it causes a catastrophe effect from space debris which we may say as one of the environmental problems. On the other hand, the fact that freedom principles are not equipped enough for environmental issues in the OST 1967 has only one Article that gives attention to outer space environmental issues.

Article IX of the OST 1967[47] mentioned to the state parties to conduct their exploration in the Moon and other

[44] Lotta Viikari, "The Environmental Element in Space Law: Assessing the Present and Charting Future," Leiden, Martinus Nijhoff Publisher 2008 at 59.

[45] Article I of the Outer Space Treaty 1967

[46] Viikari *supra* note 44 at 59.

[47] Article IX of the OST 1967 Stated as follow: "In the exploration and use of outer space, including the Moon and other celestial bodies, States Parties to the Treaty shall be guided by the principle of cooperation and mutual assistance and shall conduct all their activities in outer space, including the Moon and other celestial bodies, with due regard to the corresponding interests of all other States Parties to the Treaty. States Parties to the Treaty shall pursue studies of outer space, including the Moon and other celestial bodies, and conduct exploration of them so as to avoid their harmful contamination and also adverse changes in the environment of the Earth resulting from the introduction of extraterrestrial matter and, where necessary, shall adopt appropriate measures for this purpose. If a State Party to the Treaty has reason to believe that an activity or experiment planned by it or its nationals in outer space, including the Moon and other celestial bodies, would cause potentially harmful interference with activities of other States Parties in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State Party to the Treaty which has reason to believe that an activity or experiment planned by another State Party in outer space,

celestial bodies by avoiding harmful contamination and adverse changes in the environment on the Earth. Nevertheless, the approach of Article IX is more directed toward the protection of human beings rather than the protection of both environments.[48] Furthermore, "avoid harmful contamination[49]" shall be more precise and well explained since there were four contaminations that have different legal implications. Article IX often emphasized that environmental issues can affect the Earth within outer space activities. It can be seen during the Apollo program, which collected lunar samples (mostly containing; Moondust rock) a question among the scientist has appeared about the protection of the Moon; then, the mission implemented all of PP to minimize Earth contamination in the Moon. However, the situation changes to a question of how we can protect the Earth from Moon object contamination at that moment.

According to Article IX of the OST, to limit the Moon contamination to the Earth or "backward contamination," NASA has quarantined all astronauts from Apollo 11,12 and 14 into quarantine for 21 days appeared more exobiological but still had a medical concern.[50] The protection of samples and astronauts seem to protect a Lunar sample from Earth microbial and protect the Earth from possibilities of exobiological contamination; however, NASA researchers do some biotest with injecting Lunar dust to a Guinean pig. There is no side reaction that Moon has declared as "sterile."[51] Protection of primary mission to the Lunar surface has shown us that Article IX has been followed well by the U.S. government to avoid "backward contamination."

However, this small example from Apollo quarantine by the U.S. government is not answered much on this substantial matter regarding Martian protection against biohazard contamination. First of all, we need to ensure that environmental law is applied and can be extended to outer space, and COSPAR in this regard is the organs which is one of their focused-on handling environmental issues in outer space. The future mission to send a human to Mars has sparked many countries to be involved in this mission; henceforth, the PP and its implementation regulation shall be ready to facilitate future missions and even further beyond Mars's mission. According to the human Mars mission, there was categorization part in Mars divided based on the Mars structures formation[52], under the intention of life search in Mars, COSPAR by 1992 added

including the Moon and other celestial bodies, would cause potentially harmful interference with activities in the peaceful exploration and use of outer space, including the Moon and other celestial bodies, may request consultation concerning the activity or experiment." The first sentence of Article IX was imported from 1963 UNGA Resolution. It promulgates the principles of cooperation and mutual assistance with respect to space activities. *See.* Gupta, Vishakh, "Critique of the International Law on Protection of the Outer Space Environment," *Astropolitics*, no.14 2016, pp.20-43.

[48] William R. Kramer, "Extraterrestrial environmental impact assessments e A foreseeable prerequisite for wise decisions regarding outer space exploration, research and development," *Space Policy*, no.30 (2014): 215-222, doi: 10.1016/j.spacepol.2014.07.001.

[49] Contamination has different mean depend on the subject, however, in this case we may interpreted as; the presence of alien biological matters in some area which has affected on its environment.

[50] Arnould, Jacques, "Viewpoint: From Quarantine to Exploration: Space Agencies and the Ethical Challenge of Astrobiology," *Astropolitics,* no.10 2015, pp.10:176-182.

[51] Ibid.

[52] Mars structure formation means, Mars surface commonly known as too cold and dry in the surface which almost possible to growth Earth organism, however as this paper mentioned, their subsurface area is warmer and wetter which has more hospitable to support Earth organism to growth and reproduction, *See* Catherine A. Conley, John D. Rummel. "Planetary protection for human exploration of Mars," *Acta Austronautica*, no. 66 (2010) 792-797, DOI: 10.1016/j.actaastro.2009.08.015

additional categories for Mars exploration tightened the protection requirements on such mission.[53] COSPAR categorization defined it as "special region" which need protection under COSPAR policy and "special region" as COSPAR stated as follow; "a region within which terrestrial organisms are likely to replicate" and also include "any region that is interpreted to have a high potential for the existence of extant Martian life forms." In 2008 regarding answering the future challenge on Mars exploration, COSPAR was redefined as "Special Regions" to include measurable parameters that can be used to determine whether a particular location on Mars requires additional protection."

COSPAR policy has discussed Mars's mission, including the type of mission from IV.[54] Mission in category IV, as we have seen in Vikings I&II mission in mid-1970, intends to restrict all of Earth microbial contamination, which can disturb the sample in searching for life mission in Mars. Besides that, concern COSPAR also has requirement restrictions for the future mission of MRS to protect backward contamination through quarantine of samples.

Both NASA and COSPAR policies in Article IX framework on active protection on human exploration to avoid cross exobiological contaminations was in line with the precautionary principle, which is better understood as "better to prevent, rather than sorry." It seems to work on environmental protection in "the area of seabed and BBNJ (Biodiversity Beyond National Jurisdiction)." as scientific data have shown, Mars's surface is inhospitable to support life form, but in other words, some of the other parts of Mars, such as the subsurface, are hospitable to support it. This condition made some possibilities sample returned to Earth will have several exobiological creatures. Relating to COSPAR Policy, NASA also issues similar documents for the Mars mission, namely known as; "a draft test protocol for detecting possible biohazards in Martian samples returned to earth", which declares all Mars samples must be sterilized. "This protocol aims to reduce the risk of significant adverse effects of samples distributed into the scientific community, and the sterilization process will be using gamma rays with temperatures up to approximately 105ºC."[55]

MSR mission will be facing the challenge on the most critical issues that shall be resolved, which can be found on the NEPA (U.S. National Environmental Policy Act).[56] NEPA has enacted a policy

[53]Macauley, Molly K., "Environmentally Sustainable Human Space Activities: Can Challenges of Planetary Protection be Reconciled?" *Astropolitics,* no.5, 2007, pp. 209-236.

[54] Categories IV in COSPAR Policy stated as follows: "missions comprise certain types of missions (mostly probe and lander) to a target "Remote" here implies the absence of environments where terrestrial organisms could survive and replicate, or a very low likelihood of transfer to environments where terrestrial organisms could survive and replicate. body of chemical evolution and/or origin of life interest and for which scientific opinion provides a significant chance of contamination which could compromise future investigations. Requirements imposed include rather detailed documentation (more involved than Category III), including a bioassay to enumerate the bioburden, a probability of contamination analysis, an inventory of the bulk constituent organics and an increased number of implementing procedures. The implementing procedures required may include trajectory biasing, cleanrooms, bioburden reduction, possible partial sterilization of the direct contact hardware and a bio shield for that hardware. Generally, the requirements and compliance are similar to *Viking*, with the exception of complete lander/probe sterilization. Category IV specifications for selected solar system bodies are set forth in the Appendix to this document. Solar system bodies considered to be classified as Category IV also are listed in the Appendix." *See;* COSPAR Planetary Protection Policy (2017).

[55] NASA, "draft test protocol for detecting possible biohazards in Martian samples returned to earth" (2002).

[56] Robinsons, George S *supra* note 29.

that "requires all federal agencies to conduct comprehensive reviews and interdisciplinary analyses of environmental impacts before decision-making."[57] This provision is regulated to ensure that one mission has met all minimum criteria of exploration and exploitation from launch up to MSR mission, led by multi agencies and interdisciplinary cooperation under the directive of the U.S. President. One by one, agencies' requirements must be satisfied before the MSR mission is undertaken by 2028[58] and so on which stands next Article IX of the OST 1967.

Thus, PP on MSR mission is so transparent that everything must be sterilized to prevent any hazardous contamination in both ecosystems by reducing of bioburden through the sterilization process, the scientist is likely impossible to overcome human bioburden through this way,[59] and COSPAR, unfortunately, does not have any clear procedure to do it.

2. The Moon Agreement 1979

In MA 1979 at Article VII is improvement from Article IX OST 1967 which consisted of provision of Moon exploration and exploitation program by state parties.

In exploring and using the moon, States Parties shall take measures to prevent the disruption of the existing balance of its environment whether by introducing adverse changes in that environment, by its harmful contamination through the introduction of extra-environmental matter or otherwise. States Parties shall also take measures to avoid harmfully affecting the environment of the earth through the introduction of extraterrestrial matter or otherwise.

"In exploring and using the moon, States Parties shall take measures to prevent the disruption of the existing balance of its environment" if referred to Article IX OST 1967, MA 1979 provision have distinguished and clear position regarding environment protection beyond the Earth. Reflected to that phrase, the state parties or launching states that have activities on the Moon surface shall bear responsibility to prevent and adverse result from their activities and avoid any potential distraction to the balances of the Moon environment. compared with "avoid harmful contamination" on Article IX OST 1967, Article VII MA 1979 is crystal clear on its intention and purposes[60] further, "disruptive to environment" have stronger notion[61] to the Moon and planetary environment. Additionally, in the next phrase have "States Parties shall also take measures to avoid harmfully affecting the environment of the earth through the introduction of extraterrestrial matter or otherwise" if read in conjunction with Para 2 "state parties shall inform the secretary general of united nations" it may be seen as MA 1979 require EIA as one of the method, because through EIA any parties who have mission on the Moon could detailed seen any future challenges ahead to the Moon

[57] *See* also Donald D.L. Devicenzi "Planetary Protection, Sample Return Mission and Mars Exploration: History, Status and Future Needs."

[58] This NEPA provision is applied for the U.S. entities and Space Object Launching from U.S. Soil.

[59] Alberto G. Faire, Dirk Schulze-Makuch., et.al "Planetary Protection and the astrobiological exploration of Mars: Proactive steps in moving forward, *Advance in Space Research*, no.63 2019, pp.1491-1497

[60] Gupta, Vishakha*supra note* 47.

[61] Sterns ,Patricia M., Tennen, Leslie I., *Lacuna in the updated planetary protection policy and international law*, 23 Life Sciences in Space Research 2019, pp. 10–21

environment as impact from their activities on the Moon surface.

Furthermore, MA 1979 have mandated to use EIA through terms "take measures to avoid" otherwise, this provision has in line with Rio Declaration 1992 and Bergen Declaration 2002. It slightly different than what was deliver in the OST 1967 that EIA and consultation just leaving in grey area. Unfortunately, MA 1979 has not been ratified by many countries, particularly by space power countries and the effectiveness of MA 1979 will be questioned.

3. BUENOS AIRES INTERNATIONAL INSTRUMENT ON THE PROTECTION OF THE ENVIRONEMENT CUASED BY SPACE DEBRIS 1994

In 1994 International Law Association (ILA) drafted an international instrument on space debris that intertwined with "environment" aspects. This draft became interesting because it has directed to the environmental issues in space activities, as Article I of this draft mentioned.

1. Contamination/pollution" means a human modification of the environment by the introduction of undesirable elements or by the undesirable use of those elements.
2. "Contamination/pollution" will be considered as synonyms and are inclusive of all harmful elements other than space debris.
3. "Space debris" means man-made objects in outer space, other than active or otherwise useful satellites, when no change can reasonably be expected in these conditions in the foreseeable future.
4. "Environment", for the purposes of this Instrument, includes both the outer space and earth environments within or beyond national jurisdiction.

Based on Article I, this draft has been arranged with careful consideration because this draft has been included many terms that incorporated environmental issues with clear and comprehensive; this fact is opposite if referred to OST 1967. Furthermore, in the second phrase, "and are inclusive of all harmful elements other than space debris," if analysed *in sensu lato*, this phrase will include biological contamination related and not only "debris" and in concluded this draft not only attempt to govern abiotic debris but the possibility of biotic maters in space debris.

D. Liability of Concern on Mars Mission

The safety of Space X's future MSR and Mars missions becomes a key consideration, given the mission's vulnerability to exobiological contamination. The OST, COSPAR, NASA, and even farther NEPA have made scant attempts to cover and assure compliance with all criteria for each category of high-risk missions. Nonetheless, if private companies fail to meet all conditions and spread "hazardous exobiological pollution" on Earth and Mars, a fundamental question regarding private entities will arise.

Article VI of the OST 1967 states that "...States party to the treaty assume international responsibility for their national actions in outer space..." whether such activities are conducted by governmental or non-governmental entities...non-governmental entities' actions in outer space, including the moon and other celestial bodies, shall need authorization and ongoing monitoring by the appropriate treaty party...."

Authorization and continued supervision require Space X to comply with all applicable

laws and regulations, including those mandated by the OST 1967, COSPAR, NASA, NEPA, and the FAA, if they conduct such a mission into outer space, particularly if the Space X Mars mission is launched entirely from American soil. Then the US government will bear any liability if a Space X rocket malfunctions during launch and/or the mission results in fatalities on Earth, as stated in Article I of the Liability Convention. The phrase "launching" state refers to the following: [1] A state that launches or arranges for the launch of a space object; [2] A state from whose territory or facility a space object is launched...." If other non-US commercial entities launch a similar mission outside of the United States and the United States is not a member of the launching state, the NASA, NEPA, and FAA provisions will not apply. However, if the launching states lack a national PP, there will be complications.

If there is an exobiological contamination liability convention that does not provide a clear declaration about what happens if both entities fail to meet PP standards, Article I can be construed broadly to indicate "...damage means death, personal harm, or other impairment of health..." This clause is frequently Earth-centric and divides liability into two categories: absolute liability and fault-based liability. The OST and Liability Convention, as a result of this legal fact, is a fundamental law with a restricted international application. We require a complete law governing PP in relation to COSPAR policy, which is a set of non-binding texts.

E. Conclusion

Whether government-led or private-sector-led, future Mars exploration will be governed by existing legislation. Space X has a strong stake in human spaceflight and, more importantly, in colonizing Mars in the near future, despite the fact that NASA and ESA collaborate on the MSR mission, which aims to search for life and conduct associated scientific research. MSR and colonizing Mars are risky endeavours due of our lack of information about Mars's environment and larger morphology. As there has never been a human foot on Mars's surface, the Probe mission provides critical information for conducting in situ study that may not be as exhaustive as what a human performs in the laboratory.

To avoid such unintended repercussions and to ensure that humans do not negatively damage the possibility of indigenous life on Mars, we must ensure that all aspects of this mission adhere to the OST, COSPAR, NASA PP, and NEPA. The advancement of measures in Article IX of the OST 1967 will strengthen safety standards that will have a direct impact on future outer space missions, particularly on environmental and exobiological challenges. On the other hand, legal academics must redefine "harmful contamination," as there are other forms of contamination that can impact individuals in a variety of ways, not just exobiological ones.

Bibliographies

Journal

Arnould, Jacques "Viewpoint: From Quarantine to Exploration: Space Agencies and the Ethical Challenge of Astrobiology," *Astropolitics,* no.10 (2015) 10:176-182, doi: 10.1080/14777622.2012.696017.

Bieneman, K., et al. "the Search of Organic Substances and Inorganic volatile Compounds in the Surface of Mars," Journal of Geophysical Research, no.82 (1977).

Conley A. Catherine, Rummel, John D, "Planetary protection for human exploration of Mars," *Acta Austronautica*, no. 66 (2010) 792-797, doi: 10.1016/j.actaastro.2009.08.015

DeVincenzi, D. L., P. D. Stabekis, and J. B. Barengoltz. 1983. "A Proposed New Policy for Planetary Protection." *Advances in Space Research* 3 (8): 13–21. https://doi.org/10.1016/0273-1177(83)90167-9.

Devincenzi, Donald L., Margaret S. Race, and Harold P. Klein. 1998. "Planetary Protection, Sample Return Missions and Mars Exploration: History, Status, and Future Needs." *Journal of Geophysical Research E: Planets* 103 (E12): 28577–85. https://doi.org/10.1029/98JE01600.

Faire, G. Alberto, Dirk Schulze-Makuch, Lyle Whyte, Victor Parro a Alexander Pavlov, Javier Gomez-Elvira, Armando Azua-Bustos, Wolfgang Fink, Victor Baker, Planetary Protection and the astrobiological exploration of Mars: Proactive steps in moving forward, *Advance in Space Research*, no.63 (2019):1491-1497, doi: 10.1016/j.asr.2019.01.011

Glavin, D. P., J. P. Dworkin, M. Lupisella, G. Kminek, and J. D. Rummel. 2004. "Biological Contamination Studies of Lunar Landing Sites: Implications for Future Planetary Protection and Life Detection on the Moon and Mars." *International Journal of Astrobiology* 3 (3): 265–71. https://doi.org/10.1017/S1473550404001958.

Glavin, Daniel P., Jason P. Dworkin, Mark Lupisella, David R. Williams, Gerhard Kminek, and John D. Rummel. 2010. "In Situ Biological Contamination Studies of the Moon: Implications for Planetary Protection and Life Detection Missions." *Earth, Moon and Planets* 107 (1): 87–93. https://doi.org/10.1007/s11038-010-9361-4.

Gupta, Vishakha, "Critique of the International Law on Protection of the Outer Space Environment," *Astropolitics*, no.14 (2016) 20-43, doi: 10.1080/14777622.2016.1148462

Harsono, Suyud Suyudi "*Dampak Lingkungan dan Implikasi Hukum Akibat Keruang Angkasaan*" in Saefullah Wiradipradja and Mieke Komar Kantaatmadja, eds., *Hukum Angkasa dan Perkembangannya,* Remadja Karya, 1988.

Kramer, William R, "Extraterrestrial environmental impact assessments e A foreseeable prerequisite for wise decisions regarding outer space exploration, research and development," *Space Policy*, no.30 (2014): 215-222, doi: 10.1016/j.spacepol.2014.07.001.

Macaulay, Molly K, "Environmentally Sustainable Human Space Activities: Can Challenges of Planetary Protection be Reconciled?" *Astropolitics,* no.5 (2007): 209-236,

Nicholson, Wayne L., Andrew C. Schuerger, and Margaret S. Race. 2009. "Migrating Microbes and Planetary Protection." *Trends in Microbiology* 17 (9): 389–92. https://doi.org/10.1016/j.tim.2009.07.001.

Robinson, George S, "Exobiological Contamination: The Evolving Law," Annals of Air and Space Law, vol.17. 1992.

Uhran, Bergit, Catharine Conley, and J. Andy Spry. 2019. "Updating Planetary Protection Considerations and Policies for Mars Sample Return." *Space Policy*, no. xxxx: 1–7. https://doi.org/10.1016/j.spacepol.2019.04.001.

Sterns ,Patricia M., Tennen, Leslie I., *Lacuna in the updated planetary protection policy and international law*, 23 Life Sciences in Space Research 2019, pp. 10–21

Viikari, Lotta "The Environmental Element in Space Law: Assessing the Present and Charting Future", Leiden, Martinus Nijhoff Publisher 2008

Westall, Frances, et al. "An ESA study for the search for life on Mars," *Planetary and Space Science,* no. 48 (2000), 181-202.

Websites

Grush, Lorens, "Why Stowaway Creatures on the Moon Confound International Space Law", Available at: https://www.theverge.com/2019/8/16/20804219/moon-tardigrades-lunar-lander-spaceil-arch-mission-foundation-outer-space-treaty-law?fbclid=IwAR2B9esSSYG8ttRUAqlmQBhTKc_HPf5FuA-dF-q-utITohiEyUzrUrYsSQI. Accessed on 18 August 2019.

NASA (National Astronautics and Space Administration), "InSight, Into the Early Evolution of Terrestrial Planets", Available at: https://mars.nasa.gov/resources/22071/insight-fact-sheet/?site=insight. Accessed on 21 August 2019.

NASA, "NASA Facts: NASA Pathfinder," Jet Propulsion Laboratory, https://www.jpl.nasa.gov/news/fact_sheets/mpf.pdf

NASA, "Objectives,"https://www.nasa.gov/mission_pages/phoenix/mission/objectives.html. Accessed on September 7, 2019.

Office of Planetary Protection, NASA, "Protecting Life on Other Bodies", available at: https://planetaryprotection.nasa.gov/categories/ accessed on 29 August 2019.

Sample, Ian, "Tardigrades may have survived spacecraft crashing on moon", available at: https://www.theguardian.com/science/2019/aug/06/tardigrades-may-have-survived-spacecraft-crashing-on-moon, Accessed on 21 August 2019.

Space X, "Making Life multiplanetary," Available at: https://www.spacex.com/sites/spacex/files/making_life_multiplanetary_transcript_2017.pdf. Accessed on 21 August 2019.

Watanabe, Susan, "Phoenix Mars Landers: Exploring the Arctic Plains of Mars," NASA, Last Modified July 31, 2008, Accessed September 7, 2019, https://www.nasa.gov/mission_pages/phoenix/news/phoenix-20080731.html.

Wegner, John, "Trump criticizes NASA promotion of returning to the moon. He directed it 18 months ago", Available at: https://www.washingtonpost.com/politics/trump-criticizes-his-administrations-promotion-of-returning-to-the-moon-before-exploring-mars/2019/06/07/b28656b6-894f-11e9-98c1-e945ae5db8fb_story.html?noredirect=on Accessed on 27 August 2019.

Williams, R. David, "Viking Mission to Mars," available at: https://nssdc.gsfc.nasa.gov/planetary/viking.html, Accessed on 29 August, 2019.

WIRED, "*A Crashed Israeli Lunar Lander Spilled Tardigrades on the Moon*", Available at: https://www.wired.com/story/a-crashed-israeli-lunar-lander-spilled-tardigrades-on-the-moon/?verso=true. Accessed on 21 August 2019.

Treaty on Principles Governing the Activities of States in Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, 1967.

Convention on International Liability for Damage Caused by Space Objects, 1972.

COSPAR Planetary Protection Policy

NASA, A Draft Test Protocol for Detecting Possible Biohazard in Martian Samples Returned to Earth 2002.