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Evolution of the planetary protection policy: conflict of science and jurisprudence?

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This paper is dedicated in memory of my grandmother, Mary Liberbaum

Abstract

The policy of protecting pristine celestial environments is accepted with virtual unanimity, and has been incorporated into positive international law. Originally phrased by the scientific community in terms of planetary quarantine requirements, the implementation of the strictures of planetary protection have been drastically relaxed over the years for most bodies within the solar system, which now are deemed to be of little or no biological or chemical interest in regard to the search for the origins of life. However, the jurisprudential considerations which underlie the planetary protection policy do not necessarily recognize the same scientific distinctions and assumptions which have provided the rationalization for the reduced application of active planetary protection mechanisms. This paper examines the potential for conflict between the scientific and jurisprudential considerations of planetary protection.
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1. Introduction

The necessity of protecting natural celestial environments was among the earliest policies articulated at the dawn of the space age. There are three basic interests which are sought to be safeguarded by the planetary protection policy: first, the prevention of contamination of pristine celestial environments by terrestrial sources; second, the prevention of the contamination of the Earth by the return of extraterrestrial materials; and third, the prevention of interference with the activities of states in the peaceful exploration and use of outer space. Comprised of both scientific as well as legal considerations, the subject of planetary protection has received attention from several international fora, most notably the United Nations, COSPAR, and the International Institute of Space Law of the International Astronautical Federation.

The planetary protection policy has not been static, but has been re-examined over the years, with revisions made by the scientific and the legal communities. These revisions, however, were not made in conjunction with each other, nor were they necessarily consistent. The divergences in the scientific and the legal perspectives of planetary protection become apparent by an examination of the development of the separate components of the policy.

2. Origins of the planetary protection policy

The subject of protecting natural celestial environments was considered in 1956 at the Congress of the International Astronautical Federation in Rome, under the foresight of Andrew Haley. The development of the planetary protection policies followed parallel courses. One the one side were the activities of the international scientific community, while on the other side were the diplomatic and legal actions. In 1957, the US National Academy of Sciences requested the International

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Council of Scientific Unions (ICSU) to assist in the development of means to prevent contaminating celestial environments [1]. In response and reaction to the launch of Sputnik, the United Nations General Assembly created the Ad Hoc Committee on the Peaceful Uses of Outer Space (COPUOS), and directed that it identify legal problems associated with the advent of mankind's exploration of space [2].

3. Scientific development of the planetary protection policy

The ICSU acted on the request of the National Academy of Sciences, and formed the Ad Hoc Committee on Contamination by Extraterrestrial Exploration (CETEX) [3]. CETEX considered celestial bodies to be scientific preserves, and stated four primary objectives: freedom of exploration of celestial bodies, subject to limitations such as planetary quarantine requirements; disclosure to COSPAR of information concerning activities and experiments; the conducting of experiments only which are likely to yield useful scientific data; and nuclear explosions should not occur near the surface of celestial bodies. In the case of the Moon, CETEX also recommended that no soft landings requiring the use of large quantities of gas should take place pending further investigations [4].

In 1961, pursuant to an ICSU request to assume the duties of studying the potential for contamination by extraterrestrial exploration, COSPAR formed the Consultive Group on Potentially Harmful Effects of Space Experiments [5]. In 1964, the COSPAR Consultive Group published recommended planetary quarantine requirements in the form of a COSPAR resolution [6]. Pursuant to the resolution, decontamination techniques were to be employed to reduce the probability of contamination of a celestial environment by a single viable terrestrial organism aboard any spacecraft intended for planetary landing or atmospheric penetration to less than 1×10^{-4}. The probability limit established by COSPAR for an accidental planetary impact by an unsterilized fly-by or orbiting spacecraft was to be 3×10^{-5} or less.

The probability of contamination was to be determined by a mathematical formula, which multiplied the initial microbial burden, after decontamination, of an interplanetary probe at launch, by factors relating to the probability of survival of the rigors of launch, transit, entry, release and growth in the target alien environment. These planetary quarantine requirements were to apply for the initial period of planetary exploration of 10 years [7]. Nations were allocated specific fractions of the overall probability limits which were apportioned by the recipient state among the missions planned to be conducted under its jurisdiction [8].

The planetary quarantine requirements were re-examined periodically, and revisions made thereto, often at the initiative of NASA [9]. In 1969, COSPAR revised the planetary quarantine requirements, and stated:

> as the basic objective for planetary quarantine of Mars and other planets deemed important for the investigation of extraterrestrial life, or precursors or remnants thereof, a probability of no more than 1×10^{-3} that a planet will be contaminated during the period of biological exploration ... ending in 1988 [10].

This decision by COSPAR made two significant alterations to the planetary quarantine requirements: first, it reduced the probability of contamination limit by a full order of magnitude; second, it limited the application of the quarantine requirements to "*Mars and other planets deemed important*" in the search for extraterrestrial life.

In 1978, the Space Studies Board (SSB) of the National Research Council re-evaluated the application of the formula for determining the probability of contamination. The SSB concluded that for many planetary bodies of the solar system, the probability of growth of a terrestrial organism in their hostile extraterrestrial environments was sufficiently low so as to negate the necessity of engaging in any active decontamination techniques [11]. As a matter of policy, the assignment of negligible values to the probability of growth factors began to transform planetary protection from the planetary quarantine requirements, whereby the application of active bioload reduction techniques would no longer be the norm but would be the exception [12].

In 1984, the transformation from planetary quarantine requirements was completed, when the applicable guidelines were relaxed to provide that planetary protection constraints may be imposed, depending upon the nature of the mission and the target body or bodies to be explored. These guidelines completely eliminated the overall probability of contamination restrictions. For missions to target bodies which were deemed not to be of biological interest in the search for life, including the Moon, the policy did not require any planetary protection techniques to be utilized, nor was any specific documentation required. The classification of missions to other target bodies was to be determined on a case by case basis for planetary protection purposes [13].

The planetary protection policy was revisited again and revised in 1994, particularly in relation to exploratory missions to Mars. Specifically, the 1994 revisions to the policy tied the utilization of decontamination and cleanliness controls to whether the mission objectives included life-detection experiments. That is, craft landing on Mars which carried life detection instruments were subject to Viking level sterilization. However, landing craft without such life detection instruments were subject to substantially less stringent decontamination techniques [14].

Pending before COSPAR is a proposed update and consolidation of the planetary protection policy. Pursuant to this proposal, planetary missions will be classified into one of five categories, depending upon the pre-determined "planetary protection status" of the target body, and the mission plan. The categories range from targets which are "not of direct interest for understanding the process of biological or chemical evolution", to missions which involve the return of extraterrestrial samples to Earth [15]. An intermediate category has been introduced for planetary bodies which, while of interest concerning biological or chemical evolution, can be considered to present "only a remote chance that contamination by spacecraft could jeopardize future exploration" [16].

Stringent bioload reduction requirements are imposed only for a limited range of missions, to a small number of target bodies, notably Mars and Europa. Viking level sterilization is mandated only for landing craft which are intended to conduct life detection experiments. Other landing crafts and fly-by missions are subject to lesser strictures, with a notable exception: a new category, that of "special region", has been established, where it is believed that H_2O, in the form of surface or subsurface ice, may be present. For these "special regions", landing craft must achieve Viking level sterility, even where the craft is not intended to conduct life detection experiments [17].

4. Jurisprudential development of the planetary protection policy

The General Assembly directed the Ad Hoc COPUOS to identify the legal issues presented by the movement of mankind into space. In July, 1959, the Ad Hoc COPUOS reported:

> Scientific studies indicate that certain activities related to lunar and planetary impacts might result in biological, chemical, and radiation contamination jeopardizing subsequent physical and chemical studies and endangering possible living organisms. Release of chemical markers, radio-activity resulting from nuclear explosions, generation of gases in connexion (sic) with 'soft' landings and the spreading of terrestrial micro-organisms carried within space vehicles represent possible sources of contamination to the moon and planets. The re-entry of space vehicles which have effected landings on the moon and planets might contaminate the earth on their return. It will probably be desirable to continue such studies of this problem as are already under way, for example, in COSPAR, with a view to arriving at appropriate agreements to minimize the adverse effects of possible biological, radiological, and chemical contamination [18].

In March of 1962, Chairman Khrushchev wrote an eloquent letter to President Kennedy about, what he termed, "heavenly matters". Included in the points he urged to be considered was: "It should, perhaps, be specified that any experiments in outer space which may hinder the exploration of space by other countries should be the subject of preliminary discussion and of an agreement concluded on a proper international basis" [19]. In this letter, the issue of contamination of a celestial environment was inexorably linked to the potential for such contamination to interfere with the rights of states to conduct activities in space. The focus of concern was not on the negative impact contamination may have on the celestial body, but rather with how the contamination may impact on the activities of other states.

Khrushchev's letter was only one of several significant events which occurred in 1962 that would have important implications for planetary protection. COPUOS, which by then was a permanent Committee reporting to the General Assembly [20], agreed to establish two sub-committees: a legal sub-committee, and a scientific and technical subcommittee [21]. COPUOS also agreed to dispense with voting and conduct its activities on the basis of consensus [22]. Finally, the Soviet Union submitted for consideration a draft document entitled "Declaration of the Basic Principles governing the Activities of States pertaining to the Exploration and Use of Outer Space" [23].

The proposal of the Soviet Union incorporated the linkage established by Khrushchev between contamination of a celestial environment and interference with the activities of other states. The USSR Draft Declaration provided:

> 6. Co-operation and mutual assistance in the conquest of outer space shall be a duty incumbent on all States; the implementation of any measures that might in any way hinder the exploration or use of outer space for peaceful purposes by other countries shall be permitted only after prior discussion of and agreement upon such measures between the countries concerned [24].

The primary thrust of this proposal was to give states a veto over the activities of other states by withholding agreement. The interest in maintaining the integrity of pristine celestial environments was implied only obliquely in the Soviet draft. During the course of the discussions of the COPUOS Legal Sub-Committee, some representatives noted this deficiency, and it was suggested that "prevention of contamination of or from outer space and celestial bodies" be given further examination [25]. Such further examination was conducted the following year by both the COPUOS Scientific and Technical Sub-Committee, as well as by the Legal Sub-Committee.

The Legal Sub-Committee reached consensus on the Soviet draft Declaration of Principles in 1963. The Declaration set forth several fundamental principles to govern the movement of mankind into space, including the non-appropriation doctrine, and that outer space is to be utilized exclusively for peaceful purposes [26]. Significantly, among the initial principles adopted by the global community was:

> 6. In the exploration and use of outer space, States shall be guided by the principle of co-operation and mutual assistance and shall conduct all their activities in outer space with due regard for the corresponding interests of other States. If a State has reason to believe that an outer space activity or experiment planned by it or its nationals would cause potentially harmful interference with activities of other States in the peaceful exploration and use of outer space, it shall undertake appropriate international consultations before proceeding with any such activity or experiment. A State which has reason to believe that an outer space activity or experiment planned by another State would cause potentially harmful interference with activities in the peaceful exploration and use of outer space may request consultation concerning the activity or experiment.

Paragraph 6 of the Declaration incorporated the consultation concept embodied in the USSR draft proposal, and maintained the nexus between the contamination of a celestial environment and interference with the activities of other states. It was noted by COPUOS that this provision took into account the conclusion of the Scientific and Technical Sub-Committee that the problem of preventing potentially harmful interference with the peaceful uses of outer space required urgent attention [27]. The Canadian delegation commented that states were not specifically asked in the Declaration to partake in consultations if an experiment would harm the natural environment of the Earth. However, they were confident that any state contemplating such an experiment "would spontaneously undertake consultation" [28]. On November 22, 1963, COPUOS unanimously agreed to submit the Declaration of Principles to the General Assembly, which adopted the instrument as Resolution 1962 in December, 1963 [29].

The Scientific and Technical Sub-Committee took keen interest in the COSPAR planetary quarantine requirements recommended by the Consultive Group on Potentially Harmful Effects of Space Experiments in 1964. The matter was considered sufficiently significant that COPUOS reprinted in its official report the full COSPAR resolution of May, 1964 [30]. The Chairman of COPUOS remarked, in his opening statement, "For the first time since the United Nations has been dealing with outer-space matters, reference has been made in the Scientific Sub-Committee's report to a COSPAR resolution of 20 May 1964, affirming that the search for extra-terrestrial life is an important objective of outer space research" [31].

The Scientific and Technical Sub-Committee recommended a form of resolution to be adopted by COSPAR as follows:

> Urges that all Member States proposing to carry out experiments in space should give full consideration to the problem of possible interference with other peaceful uses of outer space, as well as of possible harmful changes in the natural environment caused by space activities and, where Member States consider it appropriate, should seek a scientific analysis of the qualitative and quantitative aspects of those experiments from the COSPAR Consultative Group on Potentially Harmful Effects of Space Experiments, and should give due consideration to the results of this analysis; this does not preclude other recourse to international consultations as provided for in General Assembly resolution 1962 (XVIII) [32].

The Report of COPUOS additionally noted the Report of the Executive Council of the COSPAR Consultative Group, which stated: "The Group recommends early action to *declare Mars a biological preserve* to ensure that in the exploration of this planet, *considerations of biological research receive priority* over others (emphasis added)" [33]. Finally, COPUOS recognized the Report of the Panel on Standards for Space Probe Sterilization, which stated:

> 3. A study of the prebiological chemistry of a planet which proves to be sterile would nevertheless be of major biological significance [34].
>
> The standards of space vehicle sterilization are, we believe, unrelated to the probability of indigenous life on a planet in question; except in the limiting case that indigenous life and the proliferation of terrestrial contaminants can both be firmly excluded. While there is a sizeable probability that the surface temperatures of Venus are too high for either indigenous or exogenous organisms, this conclusion is based on indirect lines of argument. Also, we cannot entirely exclude the possibility of biological contamination of the clouds of Venus. Until unambiguous astronomical information is available, we recommend that Martian standards of sterility control should also apply to Venus. In the case of the Moon, the surface conditions are rigorous enough to reliably exclude biological contamination of the surface. We cannot exclude the possibility that conditions several tens of metres below the lunar surface will permit microbial replication. Such depths, however, are unlikely to be reached unintentionally during lunar landings. Accordingly, we recommend such less rigorous sterilization techniques as bioclean-room assembly and terminal gaseous sterilization of all spacecraft intended for lunar landings; but rigorous sterilization of drills designed for lunar subsurface boring. Our information about the conditions on other planets is insufficient to form a basis for definitive recommendations at this time [35].

The parallel courses in the development of the planetary protection policy converged in COPUOS. From the perspective of jurisprudence, the Legal Sub-Committee had drafted the Declaration of Principles which was approved by the General Assembly. On the scientific side, the Scientific and Technical Sub-Committee recognized, endorsed and encouraged the dissemination of and adherence to the stringent planetary quarantine requirements adopted by COSPAR.

The COSPAR planetary quarantine requirements were a function of scientific self-regulation, but did not carry the force of law. Similarly, the Declaration of Principles, as a resolution of the General Assembly, did not constitute positive international law. It was recognized that a more formal treaty document would serve the interests of mankind in the exploration and use of outer space. On May 7, 1966, President Johnson issued a statement in which he proposed a draft treaty specifically applicable to activities in outer space. Among the points to be included in the consideration of such a

treaty was to "avoid harmful contamination" of celestial environments [36].

The following month, the US submitted a Draft Treaty Governing the Exploration of the Moon and Other Celestial Bodies to COPUOS [37]. Article 10 of the draft treaty provided that "States shall pursue studies of, and, as appropriate, take steps to avoid harmful contamination of celestial bodies and adverse changes in the environment of the Earth resulting from the return of extraterrestrial matter" [38]. The US draft expanded the concern regarding contamination to both forward and back contamination, and expressed the rights of all states to freedom for scientific exploration. However, unlike the Declaration of Principles, the US draft did not provide for consultations for activities which may cause interference with the activities of other states.

The Soviet Delegation, in June, 1966, made its own proposal concerning a Draft Treaty of Principles Governing the Activities of States in the Exploration and Use of Outer Space, The Moon and Other Celestial Bodies. In article VIII of the USSR proposal, the provisions of paragraph 6 of the Declaration of Principles were restated, with the addition of the following new sentence, which was inserted after the original first sentence: "States Parties to the Treaty shall conduct research on celestial bodies in such a manner as to avoid harmful contamination" [39]. The US and the USSR draft treaties went beyond the provisions of paragraph 6 of the Declaration of Principles by referring to the concept of "avoiding harmful contamination" [40].

The US and Soviet draft proposals were referred to the Legal Sub-Committee, which met in two sessions in the summer and fall of 1966 [41]. During the first session, discussions were conducted through a Working Group, and consensus was reached on nine articles of a proposed treaty [42]. These nine articles, in general, incorporated and carried forward the provisions of the Declaration of Principles, including the policy of protecting natural celestial environments.

The expression of the planetary protection policy was not met with serious opposition in the Legal Sub-Committee, and therefore did not provoke extended debate. The primary issues that emerged during the discussions related to the voluntary versus compulsory nature of disclosures to be made regarding activities conducted, and the role, if any, of the Secretary-General of the United Nations [43]. Within the Legal Sub-Committee and the Working Group, only the Japanese delegation raised objections, based on its belief that neither proposed draft was sufficient to protect natural celestial environments, and noted: "Great care must therefore be taken to preserve their resources and their natural milieu" [44].

The Japanese delegation was not convinced that the text, as adopted by the Working Group, was adequate to require states to exercise maximum care for the preservation and conservation of the natural resources and environment of celestial bodies. Japan was unsuccessful in offering an amendment to that effect. The Japanese delegation suspected that the amendment was rejected due to fears that it might unduly restrict future activities on celestial bodies. In the view of Japan's delegation, such fears were groundless, but in a spirit of co-operation did not press the amendment, thereby allowing consensus to be achieved [45].

The language that emerged as article IX of the Outer Space Treaty [46] is as follows:

> 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 co-operation 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, 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 Working Group blended the US and Soviet drafts, and the provision as adopted was similar to paragraph 6 of the Declaration of Principles. The modifications to the text of paragraph 6 of the Declaration incorporated the terminology proposed by the Soviets to protect against forward and back contamination. In addition, minor grammatical adjustments were made, and the phrase "including the moon and other celestial bodies" was added to the reference to outer space. The final modification from the Declaration restricted the applicability of the paragraph to "states parties", that is, all other states party to the treaty, rather than "other states" as referenced in the Declaration.

On July 3, 1970, Argentina proposed a "draft agreement on the principles governing activities in the use of the natural resources of the moon and other celestial bodies" [47]. This proposed agreement focused on the sharing of benefits from the use of extraterrestrial resources, and did not mention either contamination of

celestial environments nor the potential for interference with the activities of "other states" or "states party" [48]. The following year, on June 4, 1971, the USSR proposed a "Draft Treaty Concerning the Moon" to the General Assembly [49], which referred the document to the COPUOS Legal Sub-Committee [50]. The Soviet Draft provided, in article VI:

> 1. States parties shall explore and use the Moon by reasonable means avoiding the disruption of the existing balance of the lunar environment.
> 2. States Parties shall explore and use the Moon in such a way as to prevent adverse changes in the lunar environment and its contamination through the introduction of extralunar matter. Where necessary, consultations shall be held between the States Parties concerned.

In 1972, the Legal Sub-Committee reported that agreement had been reached on 21 substantiative articles, including much of article VI. A lack of consensus still remained, however, concerning a number of issues, including whether the treaty was to be restricted to the Moon or whether it was to include other celestial bodies within its scope [51]. The approved text of draft article VI, with areas of dispute in parentheses, was as follows:

> 1. In exploring and using the Moon (and circumlunar space) (and other celestial bodies) States parties shall take measures to prevent the disruption of the existing balance of (its) (their) environment(s) whether by introducing adverse changes in such environment(s) (its) (their) harmful contamination through the introduction of extra-environmental mater or otherwise. States parties shall also take measures to prevent harmfully affecting the environment of the earth through the introduction of extra-terrestrial matter or otherwise.
> 2. (States parties planning missions to the Moon (and other celestial bodies) shall notify the Secretary-General of measures being adopted to minimize the disruption of the existing balance of the environment(s) of (those bodies). Such reports shall include the trajectories to be flown the distance of closest approach, and specific measures taken to control micro-organisms on and in the spacecraft).
> 3. States parties shall notify the Secretary-General of plans to place radio-active material on or in orbit or other trajectory around the Moon (or other celestial bodies) and shall give similar notification with regard to the conditions and effects of such placement when it occurs.
> 4. States parties shall report to other States parties and to the Secretary-General concerning areas of the Moon (and other celestial bodies) having special scientific interest in order that consideration may be given to their designation as international scientific preserves for which special protective arrangements are to be agreed, without prejudice to the rights of other States parties to this Treaty [52].

The draft text required the disclosure of detailed information, including the specific measures taken to control the number of micro-organisms on and in a spacecraft. Consensus was reached by the Legal Sub-Committee on the text of a revised draft article VI in 1973. This revised text modified the reporting requirements, and combined paragraph 3 with the balance of the previous paragraph 2. The revised text provided:

> 1. 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 such environment, its harmful contamination through the introduction of extra-environmental matter or otherwise. States parties shall also take measures to prevent harmfully affecting the environment of the Earth through the introduction of extra-terrestrial matter or otherwise.
> 2. States parties shall inform the Secretary-General of the measures being adopted by them in accordance with paragraph 1 of this article and shall also notify him of all placements by them of radioactive materials on the Moon and of the purposes of such placements. (Points of time of information and notification to the Secretary-General to be resolved.)
> ..
> 4. States parties shall report to other States parties and to the Secretary-General concerning areas of the Moon having special scientific interest in order that, without prejudice to the rights of other States parties, consideration may be given to the designation of such areas as international scientific preserves for which special protective arrangements are to be agreed in consultation with the competent organs of the United Nations [53].

The Moon Agreement incorporated this revised text, with minor modifications, as article 7 [54]. The General Assembly, without a vote, approved and opened the Moon Agreement for signature in December, 1979 [55]. In addition, the General Assembly specifically took note of the Report of COPUOS, which clearly expressed that the intention of this article was not to prohibit exploitation of natural resources, but rather to protect the existing balance of the natural celestial environments [56].

The Moon Agreement entered into force in 1984 [57], but it has been ratified by only a handful of states [58]. Nevertheless, the Moon Agreement does establish a legal regime applicable to the states which have ratified or signed the instrument [59]. The provisions of the Moon Agreement also may be applicable to all states which participate in a cooperative mission with one or more states which have signed the document. In such circumstances, states will have an affirmative duty to take steps to prevent the disruption of the existing balance of the environment, and to inform the Secretary-General of the measures so adopted.

5. Conflicts between scientific and legal approaches to planetary protection

The planetary protection policy as set forth in the law of outer space has been consistent in both its philosophy and its expression. While modifications have been made in terminology from the Declaration of Principles, to the Outer Space Treaty, to the Moon Agreement, those changes have expanded the scope of the policy to encompass the three main considerations of preventing forward contamination, back contamination, and interference with the activities of states. The *corpus juris spatialis* has refrained from grafting exclusions, exemp-

tions and exceptions to the policy. The same cannot be said of the scientific approach to planetary protection. What began as a presumption by CETEX that celestial environments are scientific preserves, has evolved into a selective policy applicable only to a limited subset of missions only to a limited subset of target bodies.

The origins of the planetary protection policy were based on the recognition that pristine celestial environments presented a unique opportunity for scientific study and exploration which must be protected. The criterion was expressed that definitive recommendations should not be made in the absence of unambiguous astronomical information. However, alterations began to be introduced to the planetary protection policy based on indirect lines of reasoning, much of which concerned a re-evaluation of the factor of the probability of growth of a terrestrial organism in an alien environment.

These alterations consistently have eroded the requirement to employ active decontamination techniques, even for Mars. The result of this process is that the original planetary quarantine requirement, i.e., that the probability of contamination by a single viable organism be less than 1×10^{-4}, has been eliminated in favor of a standard which can allow for a pre-launch contamination level of 300 spores per square meter for landing craft for Mars [60]. The situation is even more unsettling in relation to fly-by crafts. The probability limit of less than 3×10^{-5} has been abandoned, and crafts have been sent to Mars which were subject to relatively minimal decontamination techniques.

The intention to conduct life detection experiments should not be the determining factor in whether to apply strict bioload reduction requirements to an interplanetary spacecraft, nor should the presence of a craft in a "special region". There have been significant failures of both landing and fly-by craft sent to Mars in the recent past. These missions have not just ended in failure, but the space objects were lost after reaching the red planet. These lost craft could have impacted the surface at unknown locations, including within "special regions". Thus, probes sent to Mars, even if not intended to land in a special region, or to land at all, have carried a substantial risk of contaminating undetermined areas of the planet.

The reductions in the applicability of strict decontamination techniques often have been effected based on little or no relevant data from in situ experimentation for the search for life. Moreover, the definition of "life" is constantly expanding, and the experimentation which has been conducted frequently enhances the arguments in favor of strengthening rather than lessening the planetary protection policy [61].

There are two distinct developments which converge in astrobiology, and which support a robust planetary protection policy: first, the discovery of H_2O on a variety of celestial bodies, which hitherto were unimaginable as sources of water, including the Moon, asteroids, and Mars; and second, the study of extremophiles. The confirmed discovery of water on many celestial bodies is a crucial development for the search for life on alien worlds [62]. The study of extremophiles has expanded the realm of what is considered possible for life to exist, even to thrive, in formerly unthinkably hostile environments. Clearly, the possibility must be acknowledged that life, as we are capable of detecting it, or perhaps as we are as yet unable to comprehend or even recognize, may exist or have existed in celestial environments. The indications are that we should find life on Mars, as all of the essential building blocks are present. If we do not discover life, or the remnants or precursors thereof, it would underscore the uniqueness of Earth [63]. We are still in the early stages of planetary exploration and discovery, and definitive astronomical information must await future experimentation.

Two revisions which have been made to the planetary protection policy merit special mention, as they represent a positive approach: first, the creation of the category of target bodies which are of interest for biological or chemical evolution, but which are considered to present only a remote chance that contamination could jeopardize future exploration; second, the establishment of "special regions" where it is believed H_2O may be present. The first of these revisions carries the implicit recognition that target bodies may be of interest in the search for life, even if it is believed that target body is barren. Nevertheless, as recent discoveries have demonstrated, virtually all celestial bodies should be considered of potential interest for biological or chemical evolution. The "special region" designation, on the other hand, while significant, also may be too restrictive, especially if the refining element is the possible existence of water. Given the extensive evidence of liquid water on the surface of Mars in the past, can the presence of subsurface water, past or present, be definitively ruled out in the absence of experimentation, even in areas outside of the "special regions"?

6. Conclusion

The law of outer space requires states to avoid harmful contamination of celestial environments. The *corpus juris spatialis* does not distinguish between celestial bodies based on whether or not they are "deemed important for (the) investigation of extraterrestrial life" [64], nor whether or not they are deemed of interest for biological or chemical evolution [65]. The modifications of the planetary protection policy based on such distinctions unfortunately have failed to adequately protect Mars from possible contamination. As such, the policy may be deficient vis-a-vis international treaty commitments. Moreover, the evolution of the planetary pro-

tection policy has lost sight of one of the basic propositions on which the policy was founded: a sterile celestial environment would be of major biological significance [66]. Finally, an important distinction must be noted in the perspective of the two major disciplines engaged in the search for life on celestial bodies: astrobiologists and SETI. The planetary protection policy has been driven by astrobiology, and the universe of celestial bodies which are subject to rigorous planetary protection techniques consistently has been reduced, based on the indirect deduction that life is incapable of growth in such alien environments. The SETI community, on the other hand, has been actively searching the skies for new planetary systems, with the implicit assumption that not just life, but intelligent life, may be present on any worlds which may be discovered. It is respectfully submitted that reductions to the planetary protection policy are premature in the absence of extensive study and experimentation.

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[5] W.C. Jenks, Space Law 34 (1965).

[6] COSPAR Res. 26, 20 COSPAR Info. Bull. at Annex 4 (1964); see text & notes 30-35, infra.

[7] Report, Committee on the Peaceful Uses of Outer Space, at 13, U.N. Doc. A/5785 (November 13, 1964). See Committee on Planetary Biology and Chemical Evolution, Space Science Board, Recommendations on Quarantine Policy for Mars, Jupiter, Saturn, Uranus, Neptune and Titan 27 (1978).

[8] Sterns & Tennen, Protection of Celestial Environments Through Planetary Quarantine Requirements, in Proceedings of the 23rd Colloquium on the Law of Outer Space 107 (1981).

[9] See, e.g., Outbound Spacecraft Basic Policy Relating to Lunar and Planetary Quarantine Control, NASA Policy Directive 8020.7 (1967); Outbound Planetary Biological and Organic Contamination Control, NASA Policy Directive 8020.10A (1972); Quarantine Provisions for Unmanned Extraterrestrial Missions, NASA Hand Book 8020.12A (1976); Biological Contamination Control for Outbound and Inbound Planetary Spacecraft, NASA Management Instruction 8020.7A (1988).

[10] COSPAR Decision No. 16, 50 COSPAR Info. Bull. 15–16 (July, 1969), quoted by Stabekis, supra note 1.

[11] Space Science Board, Recommendations, supra note 7, at 27–28 (Appendix C).

[12] Id. Nevertheless, the SSB continued to recommend that crafts intended for such celestial bodies employ clean room techniques. It justified such recommendation not on planetary protection considerations, but on the basis that the use of clean rooms would reduce the possibility of growth of organisms which might compromise the functioning of the spacecraft or its payload. Id. at 15–16.

[13] COSPAR Internal Decision 7/84, quoted by Stabekis, supra note 1, Appendix C, at C-6.

[14] See An Exobiological Strategy for Mars Exploration 49 (1995), NASA Pub. No. SP-530; see also DeVincenzi, Planetary Protection Issues and the Future Exploration of Mars, in 12 Adv. S. Res., No. 4, 121 (1992); D.L. DeVincenzi, H.P. Klein & J.R. Bagby, JR., Planetary Protection Issues and Future Mars Missions, NASA Conf. Pub. 10086 (1991).

[15] See generally COSPAR/IAU Report, supra note 1.

[16] Id. at chap. 1.

[17] Id.

[18] Report, Ad Hoc Committee on the Peaceful Uses of Outer Space, U.N. Doc. A/4141 (July 14, 1959).

[19] Letter dated March 21, 1962, transmitting letter of March 20, 1962, from Chairman Khrushchev to President Kennedy, at 5, U.N. Doc. A/AC.105/2 (March 21, 1962).

[20] G.A. Res. 1472 (December 12, 1959).

[21] Report, Committee on the Peaceful Uses of Outer Space, at 4, U.N. Doc, A/5181 (September 27, 1962).

[22] Id. at 3-4.

[23] Id. at 5, text reprinted in U.N. Doc. A/AC. 105/C.2/L/1.

[24] Report, Legal Sub-Committee, Committee on the Peaceful Uses of Outer Space, U.N. Doc. A/AC. 105/6 (July 9, 1962).

[25] Id. at 8, para. 14.

[26] See, G.A. Res. 1721 (December 20, 1961).

[27] Report, 1962 Legal Sub-Committee, COPUOS, supra note 24, at Annex, p. 3.

[28] Id. at 10.

[29] Additional Report, Committee on the Peaceful Uses of Outer Space, at 2, U.N. Doc. A/5549/Add.l (November 27, 1963).

[30] 1964 Report of COPUOS, supra note 7, at 17.

[31] Id. Annex I, at 6.

[32] Id. at 17–18, para. 3.

[33] Id. Annex III, at 3.

[34] Id. Annex III, Appendix 4, at 11.

[35] Id. at 13–14.

[36] Christol, supra note 4, at 134, n. 16; Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, Senate, Comm. On Commerce, Science and Transportation, 96th Cong., 2nd Sess., 5–6 (Comm. Print 1980).

[37] U.N. Doc. A/AC.105/32 (June 17, 1966).

[38] Id. at 6.

[39] Report, Legal Sub-Committee,Committee on the Peaceful Uses of Outer Space, Annex I, at 11, U.N. Doc. A/AC. 105/35 (September 16, 1966); see also Report, Committee on the Peaceful Uses of Outer Space, U.N. Doc. A/6431 (September 22, 1966) (US and USSR drafts).

[40] Christol, supra note 4, at 135.

[41] 1966 Report of COPUOS, supra note 39, at 1, para. 1.

[42] Id. at para. 3.

[43] See generally Legal Sub-Committee, Committee on the Peaceful Uses of Outer Space, Summary Record of the 68th Meeting, 26 July 1966, Geneva, at 3–11, U.N. Doc. A/AC. 105/C.2/SR.68 (October 21, 1966) (statements of USSR, US, Japan, and Canada); Legal Sub-Committee, Committee on the Peaceful Uses of Outer Space, Summary Record of the 71st Meeting, 4 August 1966, Geneva, U.N. Doc. A/AC.105/C.2/SR.71 and Add.l, at 13–14 (October 21, 1966) (statements of Japan, Australia, and Bulgaria).

[44] Legal Sub-Committee, COPUOS, Summary Record of the 68th Meeting, supra note 43, at 6.
[45] Legal Sub-Committee, COPUOS, Summary Record of the 71st Meeting, supra note 43, at 13–14.
[46] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, opened for signature January 27, 1967, 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205, text reproduced in United Nations Treaties and Principles on Outer Space 3 (2002) [hereinafter referred to as the Outer Space Treaty].
[47] Report, Legal Sub-Committee, Committee on the Peaceful Uses of Outer Space, Annex I, at 6–7, U.N. Doc. A/AC.105/101 (May 11, 1972).
[48] Committee On Commerce, Science and Transportation, supra note 36, at 7.
[49] U.N. Doc. A/8391 and Corr. 1, annex (1971); see also U.N. Doc. A/AC.1/L.568 (November 5, 1971).
[50] G.A. Res. 279 (XXVI) (November 29, 1971).
[51] Report, Committee on the Peaceful Uses of Outer Space, GAOR 27th Session (Supp. 20), Part II, Report, Legal Sub-Committee, at 3, para. 12, U.N. Doc. A/8720 (1972).
[52] Report, Committee on the Peaceful Uses of Outer Space, 28th Session (Supp. 20), at 28, U.N. Doc. A/9020 (1973).
[53] Id. at 34–35. References to the moon were considered to include other celestial bodies as well. See id. at 25, n. a.
[54] The modifications were, in paragraph 1, the terms ''that was substituted for ''such and ''avoid for ''prevent; in paragraph 2, notification was to be made to the maximum extent feasible in advance; and paragraph 4 was renumbered to paragraph 3.
[55] G.A. Res. 34/68, U.N. Doc. A/RES/34/68 (December 14, 1979).
[56] See Committee on Science, Technology & Commerce, supra note 36, at 44.
[57] Agreement Governing the Activities of States on the Moon and Other Celestial Bodies, entered into force July 11, 1984, 1363 U.N.T.S. 3, text reproduced in United Nations Treaties and Principles on Outer Space 27 (2002), and 18 I.L.M. 1434 (1979) [hereinafter referred to as the ''Moon Agreement''].
[58] As of January 1, 2001, the Moon Agreement has been ratified by Australia, Austria, Chile, Kazakhstan, Mexico, Morocco, the Netherlands, Pakistan, the Philippines, and Uruguay. In addition, the Moon Agreement has been signed by France, Guatemala, India, Peru, and Romania. See Terekov, Annual Report 2001: Status of International Agreements Relation (sic) to Activities in Outer Space, in Proceedings of the 44th COLLOQUIUM on the Law of Outer Space 389, 393–401 (2002).
[59] Vienna Convention on the Law of Treaties, art. 18, text reproduced in 8 I.L.M. 679 (1969).
[60] Debus, Runavot, Rogovsky, Bogomolov, Khamidullina & Trofimov, Mars 96 Planetary Protection Program and Implementation for Mars Environment Preservation, in Proceedings of the 40th COLLOQUIUM on the Law of Outer Space 220 (1998).
[61] See, e.g., Hydrogen-Fed Bacteria May Exist Beyond Earth, NASA Press Release 02-37AR (April 3, 2002); ''NASA Scientists Create Amino Acids in Deep-Space-Like Environment'', NASA Press Release 02-33AR (March 27, 2002).
[62] ''Jupiter's Moon UA Scientist Finds Water and Life Sustaining Nutrients on Europa'', University of Arizona, Report on Research 5 (2002); ''Odyssey Finds Water Ice in Abundance Under Mars' Surface'', 2001 Mars Odyssey Press Release (May 28, 2002).
[63] 1964 Report of COPUOS, supra note 7, Annex III, at 3.
[64] COSPAR Decision 16, supra note 10.
[65] COSPAR/IAU Report, supra note 1.
[66] 1964 Report of COPUOS, supra note 7, Annex III, appendix 4, at 11.