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Hazardous Biological Activities in Outer Space

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HAZARDOUS BIOLOGICAL ACTIVITIES IN OUTER SPACE*

by

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Space differs from aviation, pollution and nuclear energy in being a spatial concept — a place where ultra-hazardous liability may occur or originate and not a type of activity, damage or risk from which such liability may arise. Space liability may include examples or analogues of aviation, pollution and nuclear liability, but calls for special consideration because of the milieu where such liability occurs or originates.

— C. Wilfred Jenks[1]

I. INTRODUCTION

With the advent of new space transport systems like the shuttle, the frontier of outer space is opening up to activities previously associated only with Earth. As a result, space is being popularized and sold as a site for research, experimentation, and manufacture.[2] The reasons for this use are such things as the effect of microgravity on natural processes, isolation for activities that may be too hazardous on earth, and even mere economics.[3]

The benefits of space could accrue to both the researcher/manufacturer and the public consumer. For example, cures for specific illnesses may be discovered and produced in volumes not feasible on earth,[4] spent nuclear fuel may be disposed of without earth contamination,[5] and virulent organisms may be

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[1]Jenks, *Liability For Ultra-Hazardous Activities In International Law*, 117 RECUEIL DES COURS 99, 147 (1966) (hereinafter cited as Jenks).

[2]Vilkin, *Space Law*, CAL. LAW., Feb. 1982, at 28; NASA Technology for Earth Benefit, ANN. REP. NASA (1983), Spinoff 50 (hereinafter Spinoff); Waltz, *The Promise of the Space Factory*, TECHNOL. REV. May, 1977 at 38, (hereinafter cited as Waltz); Christol, *International Liability for Damage Caused by Space Objects*, 74 A.J.I.L. 346, 348 (1980); Bocksteigel, *Legal Implications of Commercial Space Activities*, Proc. of the 24th Colloquium of the L. of Outer Space 1 (1981); Report of the Second United Nations Conference on the Peaceful Uses of Outer Space, U.N. Doc. A/Conf./101/10 (1982) (hereinafter cited as 2nd UNCOUPOS).

[3]Some unique properties of space include: the presence of different magnetic and electrical fields; lack of gravity; electro-magnetic radiation; high vacuum properties, and also its action as a heat sink. *See generally* Committee on Commerce, Science, and Transportation, Agreement Governing The Activities of States on the Moon and Other Celestial Bodies, 96th Cong., 2nd Sess. 276, pt. 3, 418, pt. 4 (Committee Print 1980) (hereinafter cited as Committee Print).

[4]*See* Spinoff, *supra* note 2; San Jose Mercury, Sept. 7, 1983, at 10A; Covault, *Payload Tied To Commercial Drug Goal*, 116 Av. Week. Sp. Tech. 26, May 31, 1982.

[5]Rice (Batelle Columbus Laboratories), *U.S. Program Assessing Nuclear Waste Disposal In Space:* A Status Report, INT. ASTRO. FED. 31 I.A.F. Congress, Tokyo, Japan, (preprint 80-1-AA-50), (hereinafter cited as the Batelle report).

contained and isolated in a sphere far removed from where they may cause damage.[6]

However, as more people and organizations became involved in space, regulation and legal issues will become more important. Furthermore, even though states are responsible for their own activities and those of their citizens,[7] increased private participation[8] will strain state control over space activities. The possible result could be the uncontrolled and unplanned growth of potentially non-responsible entities and when these activities are overly hazardous the chances of misadventure become much greater.

The purpose of this article is to focus on space acts that may be classified as ultrahazardous[9] (specifically microbiological research) and to discuss how these activities are or will be affected by current or future legal regulations. Legal standards from both a United States and an international perspective will be discussed.

The Second Restatement of Torts[10] defines the term "abnormally dangerous activity" by utilizing a combination of factors:

(a) existence of a high degree of risk of some harm to the person, land or chattels of others;
(b) likelihood that the harm that results from it will be great;
(c) inability to eliminate the risk by the exercise of reasonable care;
(d) extent to which the activity is not a matter of common usage;
(e) inappropriateness of the activity to the place where it is carried on; and
(f) extent to which its value to the community is outweighed by its dangerous attributes.

Further explanation is provided in the section comment which states that "abnormal dangers arise from activities that are in themselves unusual, or from unusual risks created by more usual activities under particular circumstances."[11] Presence of all the factors noted above are not required to meet the test, rather some may weigh more heavily than others in determining whether the act is indeed ultrahazardous.

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[6]NASA Scientific and Technical Information Branch, Orbiting Quarantine Facility, The Antaeus Report, NASA SP-454 (1981) (hereinafter cited as the Antaeus Report).

[7]Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial bodies, Oct. 10, 1967, 18 U.S.T. 2410, T.I.A.S. No. 6347; 610 U.N.T.S. 205 (hereinafter cited as the Outer Space Treaty).

[8]Bockstiegel, *Legal Aspects of Space Activities by Private Enterprises — Introductory Report*, Proc. of the 19th Colloquium of the L. of Outer Space 234 (1976); *see also* Bockstiegel, *supra* note 2.

[9]The term ultrahazardous is employed here for those acts that would normally be similarly classified on Earth, as opposed to those who gain their status by virtue of their use in space.

[10]Restatement (Second) of Torts § 520 (1967).

[11]*Id.*

Jenks tracks the Restatement definition with his own internationally oriented principle:

> Ultra-hazardous activities comprise all activities which involve a risk of serious harm on an international scale which cannot be eliminated by the exercise of the utmost care; subject to any exception accepted by common usage as not involving such a risk they include all activities which involve or may occasion a substantial change in the natural environment of the earth or another State, significant pollution of air or water, the release of nuclear or other sources of energy liable to escape from human control, disturbance of the equilibrium of geophysical forces and pressures, the modification of biological processes, the creation of automata a major error of which may be irreparable, and impact damage from such sources as aircraft in flight and spacecraft.[12]

Even though the act of spaceflight may itself be considered ultrahazardous, the focus here is on those activities that may be considered abnormally dangerous in themselves. In this instance whether they are on earth or in space should have less importance because their status is primarily dependent on what is done, and secondarily on where it is done.

II. New Uses For Outer Space

The lack of gravity affects the transfer of heat, growth of crystals, orientation of living organisms, purity of substances, flow of blood and a thousand other known and unknown processes.[13] Some of the more advanced ideas for the use of space are listed as follows:

A. *Materials Processing*[14] *and Space Manufacturing*

In the field of drug studies MacDonnell Douglas, Johnson and Johnson and NASA have entered into a joint venture agreement to use space to purify and attempt to produce larger and purer amounts of drugs to combat human illnesses.[15] The joint venture is separating drugs by continuous flow electrophoresis[16] and although they are still in an experimental state, MacDonnell Douglas/Johnson and Johnson plan to expand their facilities to a permanent

[12]Jenks, *supra* note 1, at 195.

[13]*See generally* Waltz, *supra* note 2; Naumann & Herring, Materials Processing In Space: Early Experiments, NASA SP-443 (1980).

[14]For general information on materials processing see Naumann & Herring, *supra* note 13.

[15]*See* Spinoff, *supra* note 2; Covault, *supra* note 4.

[16]Electrophoresis may be defined as the separation of chemical compounds based on their electrical and physical properties. In continuous flow electrophoresis a constant flow of buffer solution is maintained through the electrophoretic apparatus. "The sample is injected continuously, and the individual constituents are deflected by the horizontally applied electric field. Each constituent is deflected differently according to its superficial electric charge, and the separated sample plus buffer is collected by a series of sample tubes at the bottom of the chamber." Naumann & Herring, *supra* note 13, at 32. Results of the first experiment show that 450 times the normal amount of the drug was produced and later missions hope to show a five fold increase in drug purity, Spinoff, *supra* note 2; Covault, *supra* note 4.

orbiting manufacturing satellite once the process has been perfected.[17] Future experiments should include protein and cell separation, cell culture, and product assay.[18]

Silicon chip formation is another field that will benefit from space manufacture. Due to the vacuum and microgravity environment, a purer crystal may be formed with much greater electrical properties which in turn will result in a long-term cost savings.[19]

Materials processing forecasts by NASA and industry show that there are approximately 500 other materials that could be advantageously produced in outer space and 250 companies that were listed as seriously interested in space processing.[20] Consequently, it is only a matter of time before private enterprise takes the intiative and uses the unique environment of space for production and experimentation.[21]

B. *Energy from Space*

The idea of converting solar power into useful energy is one that has existed throughout the ages. However, the thought of placing satellites in earth orbit to collect and transmit solar energy to earth in the form of microwaves or laser energy is a relatively new concept. A solar power satellite (SPS) would collect and convert solar energy into electricity then to microwave or laser energy to be directed to a receiving station based on earth.[22] Even though the SPS idea is not technically or economically feasible today, technology is advancing at a rate that should enable SPS to become economically competitive in another ten to twenty years.[23] "The transition to renewable non-polluting energy sources is inevitable, and the SPS is a major option for assuring a secure and continuous supply of electricity on a global scale."[24]

The way in which this space activity may be classified as ultrahazardous could be in the mode and manner of energy transmission back to the earth

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[17] *See* Spinoff, *supra* note 2; for feasibility of orbiting bio-satellites *see* General Electric, Biomedical Experiments Scientific Satellite, System Design Study, NASA CR-164686 (1978) (Access limited to NASA personnel and contractors only).

[18] *See* Spinoff, *supra* note 2, Covault, *supra* note 4.

[19] *See* Waltz, *supra* note 2; also Naumann & Herring, *supra* note 13.

[20] *See* Spinoff, *supra* note 2.

[21] *See* Waltz, *supra* note 2.

[22] *See* generally condensed extract from U.S. Office of Energy Research Report DOE/ER-0021/1, Vol. 1, edited by U.S. Dept. of Energy pub. 1978 reprinted in 2 Adv. Space Res. 94 (1982); (hereinafter cited as Condensed Abstract); for discussion of legal issues of the SPS system *see* Gorove, *Internationalization of Solar Power Satellites: Some Legal and Political Aspects*, Proc. of the 23rd Colloquium of the L. of Outer Space 169 (1980); *see also* Proc. of the 22nd Colloquium of the L. of Outer Space (1979), and Proc. of the 25th Colloquium of the L. of Outer Space (1982).

[23] Glaser, *Space Industrialization — The Context for Energy from Space*, Proc. of the 25th Colloquium of the L. of Outer Space 339, 340 (1982); *See also* roundtable discussion on this topic in the same volume.

[24] *Id.* at 341.

bound receiving station. Microwave radiation may cause unknown physiological damage to plants and animals and the environment in general,[25] disrupt communications, or heat the troposphere which may result in increased precipitation.[26] The alternative use of lasers or reflected light to transmit the energy would not only cause excessive atmospheric heating, but could also cause ocular damage along with possible damage to matter that intrudes into the beam.

C. *Mining*

As with energy from space, space mining may become more attractive once the technology makes the idea more feasible. A potentially unlimited ore supply would then be available without any earth based harmful ecological effects; this would also cut down the amount of material that will be required from earth to be used in space. The resulting cost savings and availability of material would be a major factor in space settlement.[27] Factors that may be considered ultrahazardous and inhibit the use of extraterrestrial mining would be the effect on the space environment itself and the risks that are taken on with mining in general.

D. *Nuclear Use Of Space*

This area involves the use nuclear reactors to transmit power to earth, and disposal of nuclear waste.[28] The risks accompanying these activities are quite self evident and each has the potential for great harm.

Siting nuclear reactors in space would not only have many of the same dangers as SPS energy transmission to earth, but also the added hazards inherent in the use of nuclear fuel. The rationale for placing nuclear power stations in space is that the risk of accidental release of radioactive material would be transferred from earth to space. However, it is obvious that while the terrestrial risk is eliminated the risk to the space environment is increased. Similarly, disposal of spent terrestrial nuclear fuel would also present the same ultrahazardous issues. Like nuclear power plants, the danger is not created once the activity enters space, it exists because the risk that is created is high and that risk may not be eliminated by reasonable care. It exists on earth and is independent of the additional problems created in the airless microgravity of space. The purpose for this disposal of nuclear waste was much the same as the placement of reactors in space, i.e. to transfer the risk to the extraterrestrial environment.

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[25] *See* Condensed Extract, *supra* note 22; Handl, *An International Legal Perspective On The Conduct Of Abnormally Dangerous Activities In Frontier Areas: The Case Of Nuclear Power Plant Siting*, 7 ECOLOGY L. Q. 1, 2 n. 6 (1978).

[26] *See* Condensed Extract, *supra* note 22.

[27] *See* Committee Print, *supra* note 3, part 3 at 277, part 4 at 419.

[28] *See* The Battelle Report, *supra* note 5.

These two uses of nuclear fuel in space have the potential for damaging or destroying the space environment and creating hazards to navigation. If an accident did occur and spill some radioactive material, it is possible that the end result may be worse than what would have occured on earth simply due to the higher dispersion and dissemination capability. The insidious and invasive nature of this risk is highly analogous to the danger of hazardous biological materials. Consequently, the following discussion on that topic may more fully illustrate the nature of the problem and the fact that proper regulatory procedures will be necessary for more than an isolated number of space activities.

E. *Studies Involving Micro-organisms*

There are many types of activities in space that may be deemed ultrahazardous to persons or things based on earth, in space, or other celestial bodies.[29] As previously stated, this paper will focus on space based microbiological studies due to their unique invasive properties, the unknown effect of space on their behavior, and their ability to perpetuate themselves and increase in number.[30] These abilities carry special consequences when considering the control of their release into the outside environment.

> The biologists are now entering the picture with experiments which, we are responsibly told, can fundamentally reshape the constituent elements of life, memory and learning. Molecular biology may become for the mind what nuclear physics has become for matter. How far will these experiments create, as the progress of nuclear physics has done, new problems for the law? It is not untimely to pose, though premature to attempt to answer, this general question. . . . There may well be cases in which the current experiments of molecular biologists involve dangers which pose

[29] *See* 2nd UNCOPUOS, *supra* note 2 at 73.

[30] Even in the presence of adequate facilities and good containment equipment, the success of attempts to control microbiological contamination depends in part on the work techniques of the involved personnel. Although no inclusive list of correct techniques would be appropriate for all areas of application of microbiological contamination control, some fundamentals that suggest correct techniques and some general types of procedural rules that shall be followed are listed below:

1) Fundamental ideas
   a. Microbial contamination can exist and yet be not readily detectable in the usual sense.
   b. The contamination may be odorless, tasteless, and invisible.
   c. Instantaneous monitoring devices for microorganisms, comparable with devices for detecting radioactive contaminants are not available.
   d. It is important to understand the ease with which microorganisms can be made airborne, and their ability to remain airborne in small particulate form and to move from place to place in air currents.
   e. It is significant that the physical state of a microbiological contaminant is related to the ease or difficulty of containment. Thus dried, micronized, powdered, or lyophilized microbial preparations are much more difficult to contain than contaminants in a wet or fluid state.

NASA/Baylor University College of Medicine, (NASA Contract No. NAS-9-6157), A Preliminary Protocol Outlining Studies to be performed on Lunar Material in the Lunar Sample Receiving Laboratory, Manned Spacecraft Center, NASA, Houston, Texas, submitted 12/16/66. For a general discussion of space borne biological experiments *see* Klein, *U.S. Biological Experiments in Space,* 8 ACTA ASTRONAUTICA 927 (1981); for discussion on effects of microbiology in space see Phillips, The Planetary Quarantine Program — Origins and Achievements — 1956-1973, NASA SP-4902 (1974); Werber, Objectives and Models of the Planetary Quarantine Program, NASA SP-344 (1975).

acutely the problem of liability for the objective risk involved in ultrahazardous activities.[31]

Microbes are significant in this context for a variety of reasons including increased commercial exploitation[32] and studies involving hazardous research.[33] The most observable industrial usage of microorganisms these days is in the field of genetic engineering and recombinant DNA (rDNA).[34] Bacteria are being used for such things as drug and monoclonal antibody[35] production because "no other procedure, not even chemical synthesis, can provide pure material corresponding to particular genes."[36] For that matter, chemical synthesis may not even produce compounds as cheaply or in the same volumes as genetically engineered organisms.

Genetic engineering may also provide certain organisms with completely new characteristics that could become more efficient tools for man (i.e. oil degrading bacteria, nitrogen fixing and frost impairing bacteria).[37] The rDNA technology may also be used to understand the makeup of the cell genome and its order of expression, thereby permitting scientists to screen for defective gene sequences or oncogenes.[38] The use of space may be practical due to the lack of regulations governing the activity, the effects of microgravity, and the remoteness of the laboratory. The use of rDNA may be deemed ultrahazardous because of its unknown potential for expressing the traits of other organisms (i.e. pathogenic microbes).[39] If so, then the environment of earth, space and other celestial bodies may be affected if genetically engineered bacteria are released.[40]

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[31] Jenks, *supra* note 1, at 169.

[32] *See* collected articles in 245 SCI. AM., Sept. 1981; and also 249 SCI. AM., Aug. 1983.

[33] *See generally* CDC-NIH, U.S. Dept. of Health and Human Services, Draft Guidelines on Biosafety in Microbiological and Biomedical Laboratories, 1-3 (1983) (hereinafter cited as Biosafety Draft).

[34] *See generally* Office of Technology Assessment, Impacts of Applied Genetics: Micro-Organisms, Plants, and Animals (1981) (hereinafter cited as OTA Report); see also collected works in 12 U. TOL. L. REV. 803, 803-957 (1981); 248 SCI. AM. June 1983 at 50, 249 Sci. Am. Nov. 1983, at 126 and works collected at note 32, *supra*.

[35] "Antibodies derived from a single source or clone of cells which recognize only one kind of antigen." OTA Report *supra* note 34, at x.

[36] 41 Fed. Reg. 27,902, 27,904 (1976).

[37] *See* Talbot, *Introduction to Recombinant DNA Research, Development and Evolution of the NIH Guidelines and Proposed Legislation,* 12 U. TOL. L. REV. 804 (1981); OTA Report, *supra* note 34; 41 Fed. Reg. 27902 (1976); Chemical Control Division, Office of Toxic Substances, EPA, Draft on Regulation of Genetically Engineered Substances Under TSCA, March 1983 (hereinafter EPA Draft); Statement of Don R. Clay, Acting Asst. Administrator, EPA Office of Pesticide and Toxic Substances Before the Subcommittee on Science Research And Technology And Subcommittee On Investigations And Oversight, Committee on Science and Technology, House of Representatives, Apr. 21, 1983 (hereinafter cited as statement of Don Clay).

[38] OTA Report, *supra* note 34.

[39] *Id.*

[40] Open environment bacteria are designed to be released into the environment to perform such tasks as oil degradation, nitrogen fixation, or protection of plant roots from frost. *See* EPA Draft and Statement of Don Clay, *supra* note 37. *See also* Rissler, *Research Needs For Biotic Environment Effects of Genetically Engineered Microorganisms,* 7 RECOM. DNA TECH. BULL. 20 (1984); D.H.H.S./N.I.H. Request For Public

Microbiological experiments in space may also come in the form of hazardous research. The use of a receiving laboratory has been discussed for analyzing incoming samples from other worlds and to experiment with and contain extraterrestrial life forms in much the same way microbiological laboratories do here on earth.[41] The advantage would be that the experimental station may be extremely well isolated and may assess the potential virulence of an organism before it becomes an actual threat.[42] In an orbiting facility an experimenter could study a sample microbe and delay its introduction to earth until he feels that it is safe to do so.[43] If the sample proves dangerous he could either retain it indefinitely, sterilize it, or isolate the laboratory.[44] As a last resort, he could even place the entire facility into a higher earth orbit if he finds that the sample had contaminated the laboratory.[45] Obviously these remedies are not available to ground based researchers.

Additionally, the research performed at one of these orbiting facilities could be similar to what is done at the Center for Disease Control (CDC), that is to isolate and identify unknown virulent terrestrial agents. Assuming that many of the practical problems are overcome (i.e. continual staffing of the facility, sample and equipment transport, etc.) the advantage of this laboratory would be a great reduction in potential earth contamination when high risk work is performed.[46] Even though the existing facilities provide an adequate degree of safety, breaches of the containment area still occur[47] and with the increasing density of population the problem of an epidemic grows larger.[48] For that reason it may be more desirable to have "space as a buffer between such organisms and the terrestrial biosphere."[49] Even though the use of rDNA and infectious disease studies are the most common of the hazardous microbiological experiments, the most probable candidate for outer space hazardous research is experimentation on extraterrestrial microbiological samples.

Upon comparison of the above discussion with the Second Restatement definition of ultrahazardous activity,[50] it is evident that microbiological studies

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Comment on the Recommendations in the Report "The Environmental Implications of Genetic Engineering" 49 Fed. Reg. 17,682 (1984).

[41]*See* The Antaeus Report, *supra* note 6.

[42]*Id.* at 1 and 130.

[43]*See generally* The Antaeus Report, *supra* note 6.

[44]*Id.*

[45]*Id.*

[46]*Id.* at 1.

[47]*See* Biosafety Draft, *supra* note 33; Cripps, *Avenues of Compensation For Genetic Engineering Accidents,* 9 N.Z.L.R. 150 (1980); Karny, *Regulation Of Genetic Engineering: Less Concern About Frankenstein But Time For Action On Commercial Production,* 12 U. TOL. L. REV. 815, 835 n. 94 (1981).

[48]L.D. FOTHERGILL, *Potential Ecological Consequences Of Air Contaminated With Infectious Agents,* in THE GLOBAL IMPACTS OF APPLIED MICROBIOLOGY 476 (1963).

[49]The Antaeus report, *supra* note 6, at 1.

[50]*See* notes 10-11 and accompanying text. For an explanation of factors a-c, *see* Restatement (Second) of Torts, § 520 comments g, f (1977).

fulfill the first and second requirements of high risk and major harm. Furthermore, since the history of microbiological research is replete with incidents of accidental infection, exposure and release (regardless of the precautions taken) it is logical to assume that the risk may not be eliminated by reasonable care.[51]

The remaining factors, common usage, inappropriateness to the locality, and value to the community, do not really add much to the determination and are already considered to be of minor importance.[52] Even so, these microbiological studies would not be considered in common usage as they are fairly scarce even on earth. They would not lose their ultrahazardous status as the likelihood of them becoming very common in space is not great. Value to the community is equally as inappropriate; this factor pertains to those situations where the livelihood of the entire surrounding populace depends on the activity in question.[53] It is unlikely that the crew that would service the facility would be any different than those existing on earth today servicing similar facilities. The locality consideration also focuses on the surrounding area, only it keys on the absence of persons within the range of danger.[54] Since there probably will not be people close by for other purposes this factor also becomes less important.

Even though the site of a lab in space may be quite remote, the danger of infection and contamination to others would still exist. As previously illustrated, the contagion may be carried by persons, particles, or solar winds to areas far removed from the original source.[55] As a result, the doctrine of ultrahazardous liability would be especially applicable to microbiological research studies as organisms may escape from within their confines and cause physical or economic damage to persons on board a space craft, in space, or on other celestial bodies. Here, a "non-natural"[56] condition is being contained and isolated in space because of its known or suspected dangerous propensity.

Much of the technology necessary to set up a station for microbiological research in space exists today.[57] The shuttle may be used to transport the people, materials, and the actual laboratory which would be based on a structure akin to Skylab or Spacelab.[58] In 1978, NASA commissioned a study to design an orbiting quarantine facility for the purpose of isolating incoming extraterrestrial samples. The product of this effort was the Antaeus report, published

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[51] *See generally* Phillips, *Back Contamination*, 1 ENV. BIO. MED. 121 (1971).

[52] Restatement (Second) Of Torts § 520 Comment h (1977).

[53] *Id.*, comment k.

[54] *Id.*, comment j.

[55] This is an example of "front contamination," ie. the carrying of terrestrial organisms to extraterrestrial areas. "Back contamination" is the opposite, and involves bringing back extraterrestrial organisms to Earth. *See generally* Phillips, note 51.

[56] *See* Rylands v. Fletcher, L.R. 3 H.L. 330 (1868).

[57] *See* The Antaeus Report, *supra* note 6.

[58] *Id.*

in 1981. Even though the participants were gathered for planetary quarantine considerations (i.e., the receiving, containing and analyzing samples from Mars), specific mention was made for alternate uses of the facility.[59] The commission stated that since the facility had already been designed to last 15 or more years, it was "appropriate to consider the adapatability and utility of the Orbiting Quarantine Facility (OQF) for purposes other than the quarantine mission . . . (since) . . . it was possible that the chemical and biological studies . . . (would) not detect any life forms, in which case the mission (would) be completed as early as 60 to 90 days."[60] As a result, "[t]he superior containment afforded by an OQF could make it attractive as a site for the pursuit of currently prohibited recombinant DNA research or other research on hazardous systems."[61] Consequently, we know that the technology is currently available to put a station in orbit and an interest is served by the use of the OQF (that being hazardous research). However, even though the experimental risks to earth are greatly reduced, no one may say for certain that they are eliminated.[62]

III. Scenarios And Consequences Of A Possible Release Of Biological Organisms

Assuming that a space structure like the OQF contained samples that were biologically active, any crash or accidental release could potentially have catastrophic environmental results.[63] This contamination could cause biological pollution or infection and could arise in a number of ways, for example:

Crash on Earth — This would represent the most direct and most observable type of contamination, notorious examples of this are the Skylab and the two Cosmos incidents.[64] If a deorbit did occur and transfer viable organisms to earth, the consequences could range anywhere from insignificant to a massive

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[59]*Id.* at 127.

[60]*Id.*

[61]*Id.* at 5.

[62] Policies on defense against back contamination must be based on the proposition that if infection of the Earth by extraterrestrial organisms is possible, it will occur. Decontamination methods can reduce the number of viable organisms to almost zero, but since these methods are based on a logarithmic order of death, it is both mathematically and practically impossible to reach zero. Phillips, *Back Contamination,* 1 ENV. BIO. MED. 121, 136 (1971).

[63]*See generally* FOTHERGILL, *supra* note 48; Phillips, The Planetary Quarantine Program, 1956-1973, NASA SP-4902 (1974); Sterns & Tennen, *Protection of Celestial Environments Through Planetary Quarantine Requirements,* Proc. of the 23rd Colloquium of the L. of Outer Space 107 (1980) (hereinafter cited as Sterns & Tennen); Christol, *Protection of Space from Environmental Harms,* 4 ANNALS OF AIR AND SPACE LAW 433 (1979); P. Sand, *Space Programs and International Environmental Protection,* 21 INT'L & COMP. L.Q. 43 (1972); Bhatt, *An Ecological Approach to Aerospace Law,* 4 ANNALS OF AIR AND SPACE LAW 385 (1979); *See generally,* Sohn, *The Stockholm Declaration on the Human Environment,* 14 Harv. INT'L L. J. 423 (1973). *See also* Werber, *supra* note 30, at 3 (discussing Arrhenius' pan-spermia hypothesis on the cosmic dissemination of spores).

[64]Skylab, the orbiting U.S. facility, fell to earth in a manner similar to the Russian nuclear powered satellites Cosmos 954 and 1402.

earth pandemic,[65] depending on the infectivity of the organism.[66]

Landing on a Celestial Body — This could result from accidental or intentional landing.[67] Once a space object has crashed, normal erosion of the vehicle would disseminate the interior biological material which in turn would result in the contamination of the celestial body.[68] Even if the landing was intentional all that would be required for accidental release would be mere inadvertence or lapse in the quarantine or sterilization procedures.[69] Whatever the source, the likelihood of the spread of "exotic" terran microbes is more than a slim chance.[70]

The perpetuation of terran organisms on a hostile alien soil may be just as unlikely as extraterrestrial organisms on terran soil.[71] If however, the environment is somehow compatible to the specific microbe, logarithmic growth curves may be possible which could result in the foreign agent overwhelming the indigenous flora.[72] This could disrupt the planet's ecological balance and destroy its scientific or historical value by allowing the foreign microbe to outcompete other life forms or to decompose nutrients that would not have been used otherwise.[73]

Accidental Release In Space — An orbiting quarantine facility might release a sample either internally or externally. If internal release occurred, the danger of contamination to the crew would result (this would be most signifi-

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[65]It must be remembered that attempts to control epidemics today usually depend heavily on the availability of specific and effective medical agents such as vaccines or antibodies. When such a specific, highly effective medical agent is not available, epidemics can be expected to run their course and to end only when natural forces intervene. It is most unlikely that effective weapons would be immediately available to control an unknown extraterrestrial biologic agent. Phillips, *supra* note 62, at 133.

[66]It is less likely that a non-terrestrial organism would adapt well to terrestrial conditions because it would not be familiar with the available hosts or substrates. Microorganisms tend to have a limited host, chemical, and temperature specificity. *See* Jakes, *Evolution And Back Contamination*, 15 LIFE SCIENCE & SPACE RESEARCH 9 (1976); Favero, *Public Health Considerations Associated With A Mars Surface Sample Return Mission*, 16 LIFE SCIENCE & SPACE RESEARCH 33 (1977); Werber, *supra* note 30 at 7.

[67]Phillips, *supra* note 55, at 134.

[68]*See* Taylor, *Reevaluation of Material Effects of Microbial Release from Solids*, 10 LIFE SCI. AND SPACE RES. 23 (1972) (Official journal of COSPAR); Gustan, *Effects of Aeolian Erosion on Microbial Release from Solids*, *id.* at 29; Sterns & Tennen, *supra* note 63; Werber, *supra* note 30 at 5, and collected works cited therein.

[69]Phillips, *supra* note 67.

[70]*See generally* the articles collected at notes 47 and 48.

[71]*See note 68, supra.*

[72]With regard to the possible existence of extraterrestrial organisms, it is not possible, in fact, to establish a rational basis for the classification of such forms as pathogenic or nonpathogenic. An organism that might be dormant or innocuous in the relatively hostile environment of the Moon or Mars could, when moved to the comparatively lush conditions of Earth, create a hazard simply by overgrowing or outgrowing terrestrial life forms. There is also the possibility that an organism with unfamiliar metabolic capabilities might, through various pathways, contribute to the blocking of one of nature's essential cycles such as the nitrogen or sulphur cycles. Phillips, *supra* note 65, at 133. *See also* Sterns & Tennen, *supra* note 63, at n. 15.

[73]*See* Phillips, *supra* note 65, at 133, 138; *See generally* Sterns & Tennen, *supra* note 63; Werber, *supra* note 30.

cant in the case of known pathogens[74] but there are some current fears among NASA personnel that due to a diminished immunological response brought on by living in space, man may be susceptible to less than normally pathogenic organisms[75]). This in turn may mandate that the OQF be quarantined and all exposed persons forbidden from returning to earth for a significant period of time. The situation may even require that the facility be permanently isolated from earth contact if the nature of the exposure may present substantial risk to the populace of earth.[76]

If the release is external (possibly by accidental flushing, contact with another vehicle, crash with another space object, etc.) it would be possible for organisms to survive the harsh conditions of space by being shielded from the sun's damaging ultraviolet radiation.[77] Consequently, contamination may result to earth, space or other celestial bodies by simple dispersion once the sample reached an area where it may be captured by the planet's gravity.[78]

Intentional Acts Which May Result In Contamination — A state could also intentionally introduce foreign material into space as its primary experimental objective. This was unilaterally done by the United States in Project West Ford, where a very large number of copper dipoles were released in space for telecommunication purposes. Other states raised objections based on the possible adverse navigational and communication effects of these objects in space. Even though the United States did not seek any international consultation, the experiment ran its course without any deleterious results. Activities such as waste flushing or degassing may also be classified as an intentional polluting act. This would be analogous to oil tankers flushing out their tanks at sea which has the potential for causing damage to coastal areas. In space, orbiting facilities may similarly wish to eject used and/or contaminated material from the spacecraft for either convenience or necessity.[79] Obviously, with the expected increase in space travel, an unregulated system that would allow excessive space debris to accumulate and cause hazards to navigation, communication, and health would be unacceptable.

An intentional or accidental release of microbiological organisms could

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[74]*See generally* Phillips, *supra* note 65 for possible modes of incubation and transmission of invasive organisms in spaceflight.

[75]Conversation with Dr. Harold Klein, Director of Life Sciences, NASA/Ames Research Center.

[76]*See* 14 C.F.R. § 1211 (1982); for a discussion of the power of the NASA administrator to quarantine astronauts *see* Robinson, *Earth Exposure to Extraterrestrial Matter: NASA's Quarantine Regulations,* 5 INT'L L 219 (1971), Robinson, *Earth Exposure to Mart'an Matter: Back Contamination Procedures and International Quarantine Regulations,* 15 COLUM. J. TRANSNAT'L L. 17 (1976).

[77]The extreme cold and high vacuum would also have to be overcome, presumably something like a bacterial spore would have the highest chance of success. *See* Horneck, *Survival of Microorganisms in Space: A Review,* 19 LIFE SCI. AND SPACE RES. 39 (1981).

[78]*See* Werber, *supra* note 30, at 61; Sterns & Tennen, *supra* note 63, at 111-113.

[79]A joint study between NASA and DOE contemplated the use of space as a dumping ground for nuclear waste. *See* Batelle Report, *supra* note 5.

have severe consequences: physical, environmental, or economic.[80] In the worst case there could be physical infection and possible death to the researchers, astronauts, or persons on celestial bodies such as earth.[81] The effects could be environmental as well, for instance, there could be the disruption of normal ecological balance[82] or merely contamination of open space.[83] The last type of harm could be classified as economic. This could occur when the release of microorganisms creates a situation where only monetary interests are involved, such as depletion of oil resources by genetically engineered oil degrading bacteria,[84] alteration of crop growth by genetically engineered nitrogen fixing or frost inhibiting bacteria,[85] or even contamination, quarantine, or destruction of a specific area of space that could have had exploitation potential.[86]

Each of these types of harm may occur in space itself, on earth, or other celestial bodies and this, in turn, should dictate the choice of law. Effects in space or on other celestial bodies will generally be governed by international law and cooperative agreements,[87] while effects on earth may have the additional element of the specific states' municipal law.[88] Furthermore, when municipal law is used, the probability for recovering monetary damages or equitable relief should also be more likely. When the territory of a state is involved the (existing or threatened) damage will tend to be more direct and less speculative. As a result, a court may be more prone to protecting the interests of its state.

Possibilities for recovery will also change depending on who is affected.

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[80]*See* Phillips, *supra* note 65, at 134.

[81]*Id.*

[82]Such as blue green algae blooms here in terrestrial lakes and ponds where too much dissolved phosphate promotes growth. *See generally* Phillips, *supra* note 65, also at 138.

[83]*See* Miklody, *Some Remarks To The Legal Status Of Celestial Bodies And Protection Of Environment*, Proc. 25th Colloquium of the L. of Outer Space 13 (1982); Moore & Leaphart, *Manipulation and Modification Of The Outer Space Environment: International Legal Considerations*, *id.* at 15; Okolie, *Legal Requirements For the World's Protection Of Outer Space And Earth Environments within the Perspective Of Directed Energy Weapons*, *id.* at 25; Szilagyi, *Protection Of Outer Space Environment — Questions of Liability*, *id.* at 53; van Traa-Engelman, *Environmental Hazards From Space Activities: Status And Prospects Of International Control*, *id.* at 55, Woetzel, *Responsibility for Activities In Outer Space With Special Reference To Article IV of The Outer Space Treaty Of 1967*, *id.* at 159. Christol, *supra* note 2, at 355, suggests that damage to the environment of space may not be compensable.

[84]*See* EPA Draft and Statement of Don Clay, *supra* note 37.

[85]*See* note 37 *supra*' Phillips, *supra* note 65, at 133, 134.

[86]This would be analogous to bacteria that make use of iron ore deposits in mines to create sulfuric acid, or bacteria that contaminate a building so that it has to be razed and burned. *See* FOTHERGILL, *supra* note 48, at 486.

[87]Some aspect of municipal law exists as each State has jurisdiction over space objects that are registered under its flag. *See infra* notes 123-125 and accompanying text.

[88]*See* Convention on International Liability for Damage Caused by Space Objects, Art. III, Oct. 9, 1973, 24 U.S.T. 2389, T.I.A.S. No. 7762 (hereinafter cited as Liability Convention); Vereschetin, *Interaction of International Space Law And Domestic Law In Space And Time*, Proc. of the 23rd Colloquium of the L. of Outer Space 209 (1980).

The Convention on Liability of Space Objects[89] defines damage by place and person. Absolute liability will result if damage occurs to Earth affecting people who do not reside in the launching state.[90] A system of fault is described for injury in space and absolute liability will not recompense persons who reside in the launching state or are within the launching state for purposes of viewing the spacecraft launch.[91] Consequently, the remedies and rights available will depend heavily on who and what is affected, and where.[92]

IV. Possible Prohibitions And Procedural Prerequisites

Since space activity is, by practical definition, located beyond the Earth and its atmosphere (a place that is the property of all mankind[93]) the rights and remedies of states would be governed by international law. Municipal law may also apply and will be more important for activities that produce an effect within a launching state's own territorial jurisdiction.[94]

A. *International Regulation*

There are some international treaties and principles that may establish a right of review by non-launching states of spaceborne microbiological experiments. However, some writers may counter this by saying that prescriptive requirements are couched in general language and therefore lack the implementation necessary for binding enforcement.[95] Additionally, this view of unhampered space activity may be substantiated in Article 1 of the Outer Space Treaty which states that "[t]here shall be freedom of scientific investigation in outer space. . . ."[96] If this line of reasoning is to be followed, it would serve the individual interests of the exploring states very well, but with the concomitant sacrifice of international responsibility, it may not be the best choice for the welfare of all nations.

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[89]*See* note 88 *supra.*

[90]Liability Convention, *supra* note 88, Articles II-III.

[91]Liability Convention, *supra* note 88, Articles III-VII.

[92]*See also* Vereschetin, *supra* note 88.

[93]*See* Outer Space Treaty, *supra* note 7, Art. I; Gorove, 10 J. SPACE LAW 65 (1982); *but see* Goedhius, *Some Observations On The Efforts To Prevent a Military Escalation in Outer Space,* 10 J. SPACE LAW 13, 16 (1982).

[94]*See* notes 90 and 91, *supra; also* Bockstiegel, *supra* note 2, at 10.

[95]*See* Kolossov, *Legal Aspects Of Outer Space Environmental Protection,* Proc. of the 23rd Colloquium L. of Outer Space 103, 104 (1980); Dekanov, *Juridical Nature And Status Of The Moon And Other Celestial Bodies, id.* at 5; Moore & Leaphart, *supra* note 88, at 16; Christol, *Protection of Space From Environmental Harms,* 4 ANNALS OF AIR AND SPACE LAW 433, 443 (1979).

[96]*See also* Article 6 of The Agreement Governing the Activities of the States on the Moon and Other Celestial Bodies (open for signature). However, the Moon Treaty is not in force at this time. For a discussion on a scientist's first amendment right to scientific inquiry *see generally* Daedalus, J. AM. ACA. OF ARTS AND SCIENCES (Spring 1978); Delgado & Millen, *God, Galileo, and Government: Toward Constitutional Protection for Scientific Inquiry,* 53 WASH. L. REV. 349 (1978); Ferguson, *Scientific Inquiry and the First Amendment,* 64 CORNELL L. REV. 639 (1979); Robertson, *The Scientists Right to Research: A Constitutional Analysis,* 51 S. CAL. L. REV. 1203 (1978).

Space is the "province of all mankind"[97] and therefore all states should have some decision-making right concerning hazardous experiments that may jeopardize this "global commons."[98] To substantiate this, Articles V, IX, and XI of the Outer Space Treaty,[99] and Articles 5, 7 and 10 of the Moon Treaty[100] put forth what appear to be an affirmative environmental obligation.[101] The experimenting state must report activities that may be deemed harmful to the environment, that may constitute an interference with the peaceful exploration of space, or those which may result in danger to the life and health of astronauts.[102] One of the mechanisms by which a launching state may make information known about its own activities is through the requirement of international consultations. A consultation may generally be defined as a diplomatic procedure designed to allow other states to provide their input into a specific topic.[103] It is an informal, nonbinding requirement used to promote international understanding and cooperation, somewhat akin to formal negotiation[104] (it has sometimes been referred to as "diplomacy in action").[105] Although the most important consultation provision for the purpose of this paper is in the Outer Space Treaty,[106] other relevant Treaties include: the Moon Treaty;[107] the Convention on Liability;[108] the Agreement on the Rescue of Astronauts, the Return of Astronauts, and the Return of Objects Launched into Outer Space;[109] the Convention on the Prohibition of Military or any other Hostile use of Environmental Modification Techniques;[110] and the Agreement for a Cooperative Program Concerning a Space Lab in Conjunction with the Space Shuttle.[111]

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[97]*See supra* note 93; *see generally* Moore & Leaphart, *supra* note 83, at 16; Sterns & Tennen, *supra* note 63.

[98]Almond, *A Draft Convention For Protecting The Environment Of Outer Space*, Proc. of the 23rd Colloquium of the L. of Outer Space 100 (1980); Aninat, *The Contamination Of The Environment And Space Law*, *id.* at 153; Moore & Leaphart, *supra* note 83 at 16; The David Davies Institute of International Studies, *Draft Code of Rules on the Exploration and Uses of Outer Space*, 29 J. AIR L. & COM. 141, 146 § 2-4 (1963).

[99]*See* note 7, *supra*.

[100]*See* note 94, *supra*.

[101]However, for a contrary opinion see Kolossov, *supra* note 95.

[102]*See* notes 99-101 and accompanying text.

[103]Sztucki; *International Consultations and Space Treaties*, Proc. of the 17th Colloquium of the L. of Outer Space 159 (1975).

[104]*Id.* at 154.

[105]*Id.* at n. 42, citing Van Asbeck.

[106]Outer Space Treaty, *supra* note 7, Articles IX and XII.

[107]*See* Outer Space Treaty, *supra* note 7, Articles VII and XV.

[108]*See* Liability Convention, *supra* note 88, Article XXI.

[109]Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, Art. II, Dec. 3, 1968, 19 U.S.T. 7570, T.I.A.S. No. 6599, U.N.T.S. 119 (hereinafter cited as Rescue Agreement).

[110]Convention on the Prohibition of Military any Other Hostile Use of Environmental Modification Techniques, Art. III & V, Jan. 17, 1980, 31 U.S.T. 333, T.I.A.S. No. 9614.

[111]Agreement for a Cooperative Program Concerning the Development, Procurement and Use of a Space

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The provision in the Outer Space Treaty that is most pertinent states:

> 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 of 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.[112]

Thus the experiment must create a foreseeable danger, and it must constitute what *that* party would consider to be a potentially harmful interference before consultation need be undertaken.[113] The foreseeability should be of the type that is normally associated with the experiment, frequency or probability should not influence this consideration. For example, a hazardous microbiological experiment will create a foreseeable danger of infection, but with modern containment facilities, that risk may be quite low. So, even though the probability is low the risk is still known and foreseeable. The danger must also be significant enough as judged by the experimenting party.[114] Obviously this creates the potential for avoidance of consultations by states which do not wish to have their space projects subject to another's proscription. "So long as the launching state is, or may credibly pretend to be not aware of potential interference of its space project with activities of other

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Laboratory in Conjunction with the Space Shuttle, Art V and IX Aug. 14, 1973, 24 U.S.T. 2049, T.I.A.S. No. 7722, (hereinafter cited as Space Lab Cooperative Agreement).

[112]Outer Space Treaty, *supra* note 7, Art. IX.

[113]*See* Sztucki, *supra* note 103, at 164.

[114]*Id.*

States, it may lawfully proceed with that project without appropriate international consultations."[115] Because of the verification difficulties, good faith efforts become more important.[116]

Even though the experimenting party has control over the information regarding its space activity, a second state may *request* a consultation if it believes that the first state would conduct potentially harmful experiments.[117] However, obtaining enough information to jus. .y a request or simply to be aware of a dangerous experiment may be difficult for the non-launching state. Practically speaking, the information may be generally withheld as a matter of course[118] or because of some proprietary considerations.[119] Whatever the reason, it is possible that other states may never learn the details of potentially hazardous experiments. Once the launching state makes the unilateral decision not to consult, that decision is final and stops further review.

Additionally, compliance with the consultation requirement does not necessarily mean that an accord will be reached or the experiment modified. The only requirement that exists is simply to seek consultations, and they give rise to no obligations for any end result. If, however, a state intentionally does not seek a consultation at least one writer has stated that it may constitute a material breach of the treaty and in turn give an absolute liability for all damage.[120] However, this is not exactly a result that provides much comfort to a party which wishes to modify or otherwise call attention to an experiment that is potentialiy hazardous. As a consequence, this right, although appealing in a system where all parties act in good faith, may be ineffective and unenforceable in the real world where each nation puts its own interests first and global interests second.

Previous to the Outer Space Treaty of 1967 Jenks focused on the aims of the consultation requirement and summed it up in six basic principles:[121]

> Unknown Hazards: the Obligations of Consultation and Inquiry . . . The first and basic principle is that scientific and technological experiments, tests or development schemes which may have a substantial influence on the natural environment of another State are a matter of international concern.

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[115] *Id.*

[116] For a discussion of verification problems with the International Satellite Monitoring Agency *see* Goedhuis, *supra* note 93, at 22.

[117] Outer Space Treaty *supra* note 7, Article IX. The requesting state would be one whose space activities would be adversely affected by the experimenting state's action. Sztucki, *supra* note 103, at 160.

[118] Russian spaceflights are generally kept secret.

[119] Joint agreements for development of new products may be subject to proprietary restrictions, i.e. Johnson and Johnson/MacDonnel-Douglas joint venture with NASA. *See also* Spacelab Cooperative Agreement, *supra* note 111, Art. 6.

[120] Herczeg, *Introductory Report Provisions of the Space Treaties on Consultation*, Proc. of the 17th Colloquium of the L. of Outer Space 141, 142 (1975).

[121] Jenks, *supra* note 1, at 173-74.

The second principle is that any State proposing to sponsor or permit an experiment, test, or development scheme which may prejudice the natural environment of another State should notify in advance the nature and anticipated and possible consequences of the proposed experiment, test or development scheme. As a corollary to this principle it might be necesary to develop new forms of interim protection of prospective rights for patent purposes in view of the degree of disclosure of proposed experiments or tests which would be required.

The third principle is that any State, the natural environment of which may be prejudiced by a proposed experiment, test or development scheme, which has been notified should have a recognized right to seek fuller information and, if necessary in the light of the information supplied, to make representations, concerning the possible consequences of the proposed experiment, test or development scheme.

The fourth principle is that, where the explanations of the State responsible for the proposed experiment, test or development scheme and any representations made by the other State or States concerned do not result in settlement of the matter by negotiation or agreement, it should be open to any State concerned and to appropriate international organizations to call for an impartial international inquiry.

The fifth principle is that if an impartial inquiry is requested the proposed experiment or test should not take place or the proposed development scheme remain in abeyance until the State responsible has considered fully the outcome of the inquiry. Provision for the inquiry to be completed within a reasonable period would of course be necessary.

The sixth principle is that an appropriate international authority should be entitled to restrain by injunction procedure, either absolutely or by requiring compliance with certain conditions, experiments, tests or development schemes calculated to modify the natural environment of another State. Absolute prohibition of a proposed experiment, test or development scheme would appear to be justifiable only where the degree of risk, to mankind generally or to other States which would be affected, involved in the scheme in the state of knowledge existing at the time was disproportionate to the possible beneficial results. Such absolute prohibition should not be used to preserve the *status quo* where there is a measurable and definable conflict of interest, but solely for the purpose of protecting from the possible consequences of ill-conceived or premature experiments, tests or development schemes elements of natural environment the preservation of which is important for the general welfare of mankind. . . .

A civilized international society is entitled to protect itself against irresponsible conduct by its members in juggling with nature in disregard of her laws. Some such code of principles formulating obligations of consultation and inquiry concerning unknown hazards is a vital element in such protection.

B. *Laws of the United States That May Affect Outer Space Activities*

This section will illustrate how some national laws may govern hazardous activities of United States registered space vehicles.[122] Article II of the Convention on Registration of Objects Launched into Outer Space[123] requires the launching state[124] "to register the space object by means of an appropriate registry which it shall maintain and inform the Secretary General of the United Nations of this record." Article VIII of the Outer Space Treaty further submits that "[a] state, party to the treaty, on whose registry an object launched into outer space is carried shall retain jurisdiction and control over such object, and over any personnel thereof, while in outer space or on a celestial body." Therefore once registered, an object should be subject to the municipal laws of the state of registry.[125]

1. National Environmental Policy Act (NEPA)

The National Environmental Policy Act states that all federal agencies must comply with its requirements.[126] As a result the National Aeronautics Space Administration (NASA) is compelled to prepare, in advance, a statement of its actions that will have a significant affect on the environment.[127] Hazardous microbiological experiments may affect the environment in the ways noted above and since NASA takes part in most United States launches into space, its participation would be enough to mandate compliance the requirements of NEPA.

The NASA regulations[128] implement the directives of NEPA to "protect and enhance the quality of the environment . . . (from) actions which may have

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[122]There may be other United States Laws and regulations that affect microbiological experiments (i.e. rules regarding the transport of hazardous materials, air and water quality, occupational safety and health, etc.), but they will not be discussed in this paper.

[123]Registration of Objects Launched into Outer Space, Sept. 15, 1976, 28 U.S.T. 695, T.I.A.S. No. 8480.

[124]Launching state is defined as "A state who launches or procures the launching of a space object; (or) a state from whose territory or facility a space object is launched." Art. I. Registration Convention, *supra* note 123.

[125]Examples of entities that do or may have objects that are subject to United States laws are: (1) Government agencies like NASA or DOD: (2) private entities flying aboard NASA flights; (3) Private entities flying from within U.S. territory; and (4) foreign governments flying aboard the Shuttle. *But See* DeSaussure, *Do We Need A Strict Liability Regime In Outer Space?*, Proc. of the 22nd Colloquium of the L. of Outer Space 117 (1979). Note — This article will not address conflict of laws or criminal jurisdiction issues. For that information *see generally* Robbins, *The Extension of United States Criminal Jurisdiction to Outer Space*, 23 SANTA CLARA L. REV. 627 (1983); Vereschetin, *supra* note 88, at 33.

[126]42 U.S.C. § 4321 *et seq.*; *see also* Concerned About Trident v. Rumsfeld, 555 F.2d 817, 823 (D.C. Cir. 1977) (hereinafter cited as C.A.T. v. Rumsfeld).

[127]42 U.S.C. § 4332 (c) (1977).

[128]14 C.F.R. § 1216 (1984).

an impact on (it)."[129] This requirement applies to "all NASA actions which may have a impact on the quality of the environment"[130] and "those performed under contract, grant, lease or permit."[131] Even though the most salient type of NASA action is Research and Development (R&D)[132] this too is included in the types of activities subject to an environmental assessment.[133]

NASA regulations further describe how extensive the review must be.[134] Whether or not a cursory or more detailed study will have to be performed "depend(s) on the scope of the action and the context and intensity of any environmental effects expected to result."[135] Consequently, either an Environmental Assessment (EA) or an Environmental Impact Statement (EIS) will be required to determine if "NASA actions (are) expected to have significant effect on the quality of the human environment."[136] EA's are generally required for: "specific spacecraft development and flight projects in space and terrestrial applications; . . . reimbursable launches of non-NASA spacecraft or payload; . . . and actions to alter ongoing operations at a NASA installation which could lead, either directly or indirectly, to natural or physical environmental effects."[137] An example of a specific NASA action that requires a more formal[138] EIS is the "development and operation of space vehicles likely to release substantial amounts of foreign materials into the earth's atmosphere, or into space."[139] Even though the NASA regulations make a distinction between these two reports it is merely a matter of degree. Essentially, the choice between an EA or EIS is on a sliding scale, functionally dependent on the probability and gravity of the potential environmental risks.[140] The end result is that some type of environmental determination should be made for all hazardous activities in which NASA plays a part.

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[129] 14 C.F.R. § 1216.102 (a), (d) (1984).

[130] 14 C.F.R. § 1216.301 (b) (1984).

[131] 14 C.F.R. § 1216.102(b) (1984). Reimbursable launches of non-NASA spacecraft or payloads are included in the types of things that are the subject to environmental assessments. 14 C.F.R. § 1216.305(b) (5) (1984).

[132] Research and Development may be defined as "those activites directed towards attaining the objectives of a specific mission, project, or program . . . (and whose) funds are expended chiefly for contractual research and development and research grants." 14 C.F.R. § 12167.302 (a) (1) (1984).

[133] 14 C.F.R. § 1216.301 (b) (1984).

[134] 14 C.F.R. § 1216.305 (1984).

[135] 14 C.F.R. § 1216.385 (a) (1984).

[136] 14 C.F.R. § 1216.305 (c) (1984). For example an EIS was prepared for the first set of rDNA Guidelines, *see* 41 Fed. Reg. 27902 (1976); for an example of a finding of no significant impact of a NASA action *see* 49 Fed. Reg. 4285 (1984).

[137] 14 C.F.R. § 1216.305 (b) (2), (5), (7) (1984).

[138] An EA is used to determine if an EIS is required. 14 C.F.R. § 1216.306 (1984).

[139] 14 C.F.R. § 1216.305 (c) (2) (1984).

[140] 14 C.F.R. 1216.305 (d) mentions a category of exclusions from the requirement of an EA or EIS, putting in its place a scaled down version called an environmental analysis. However, if any exclusion were to be applied to hazardous research, that regulation may be questionable in light of the absolute language of NEPA and of the cases. *See* C.A.T. v. Runsfeld, 555F2d 817, 823 (D.C. Cir. 1977); City of Willcox v. F.P.C., 567 F.2d 394, 417 (D.C. Cir. 1977). For a lower scale analysis, *see* 49 Fed. Reg. 4285 (1984).

In this hypothetical situation of risk created from an orbiting microbiological lab, the probabilities may be difficult to assess, but they are not impossible. Mathematical calculations were made for potential contamination in planetary quarantine studies[141] and presumably they could be conducted for this hazard as well. Even if the probability for contamination is difficult to calculate,[142] the potential consequences (i.e. the ability of the organism to multiply unrestrained under some conditions) are great enough to classify the risk as very significant once an expected leak occurs. Government agencies may be exempted from the NEPA requirements if the effect is too speculative,[143] however, the fact that the consequences are so grave for so small an accident may mandate a closer degree of scrutiny.[144] This would also be supported by case law that requires the agency to take a "hard look" at the *possible* environmental effects.[145]

In discussing the effect of an accident, one must also take into consideration where that effect is to take place. Even though NEPA is generally considered to apply to the jurisdictional boundaries of the United States, consideration may also be given to extraterritorial areas.[146] NASA regulations extend NEPA extraterritorially "(i)f the Headquarters official determines that an action may have a significant environmental effect abroad."[147] Specifically, the regulations cite areas such as the "global commons" and foreign nations with respect to biological agents under regulation by Federal law.[148] Consequently, NASA has acknowledged that the potential effects of its activities in outer space take on an international scope and should be scrutinized with an eye for global, not parochial effects.[149]

Since NEPA is being extended extraterritorially, it may be inferred that other countries may play as much a part in assessing the potential environmental effects of acts of the United States as they will be beneficiaries of the assess-

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[141]Sterns & Tennen, *supra* note 63; *See also* Werber, *supra* note 30.

[142]Sterns & Tennen, *supra* note 63; *See also* Werber, *supra* note 30.

[143]*See* C.A.T. v. Rumsfeld, *supra* note 126 at 828; Crosby v. Young, 512 F. Supp. 1363, 1371 (E.D. Mich. 1981).

[144]"[E]xtraterrestrial life and the concomitant possibility of back contamination must be presumed to exist. To presume otherwise could lead to inadequate planning of precautionary measures and failure to foresee a danger that might be avoided." Phillips, *supra* note 65, at 133. Furthermore, 14 C.F.R. § 1216.321 (d) (1984) states that an assessment is to be made if a NASA Act "*may* have a significant effect."

[145]C.A.T. v. Rumsfeld, *supra* note 126 at 824.

[146]14 C.F.R. § 1216.321 (1984). *See also* Natural Resources Defense v. Nuclear Regulatory Commission, 647 F.2d 1345 (D.C. Cir. 1981) C.A.T. v. Rumsfeld, 555 F2d 817; National Organization for the Repeal of the Marijuana Laws v. U.S., 452 F. Supp. 1226 (D.D.C. 1978); Note, *The Extraterritorial Scope of NEPA's Environmental Impact Statement Requirement,* 74 MICH. L. REV. 349 (1975).

[147]14 C.F.R. § 1216.321 (d), § 1216.100 (1984).

[148]14 C.F.R. § 1216.321 (1984). Note that genetic engineering experiments may be now classified as under federal regulation, *i.e.* The Toxic Substances Control Act. *See* Statement of Don Clay, *supra* note 37.

[149]14 C.F.R. § 1216.102 (c) (1984).

ment. The NASA regulations provide for public participation in the NEPA process,[150] and case law gives the same result.[151] A logical extension of this would provide the foreign entity with a qualified right of pre-flight assessment of the dangers and such assessment could be employed as an adjunct to the methods described above for preliminary consultations. Consequently, a similar result is reached by both international and United States national law.

2. NIH Guidelines on DNA Research[152]

Since the recombinant DNA (rDNA) issue first became a reality, arguments have ensued over the potential consequences of its use.[153] It was feared that "the occurrence of an accident or the escape of a vector (the vehicle that transmits the DNA molecule) could initiate an irreversible process with a potential for creating problems many times greater than those arising from the multitude of genetic recombinations that occur spontaneously in nature."[154] Initially, some scientists urged an absolute ban on the research,[155] but as time passed and more was learned of the technique it became less of a forbidding mystery and more generally hailed as a beneficial tool for mankind.[156] As a result, the confinement restrictions that were placed on the facilities in the late 1970's were gradually relaxed.[157]

Because there was so little known of the entire process federal legislators were reluctant to enact any binding regulatory scheme to govern the research.[158] Rather, a series of voluntary guidelines, outlined by the Director of the National Institute of Health (NIH), were first published in the Federal Register in 1976.[159] Since then there have been revisions to the guidelines, but they remained voluntary[160] with continued speculation over possible sources of power for future binding rules.[161] Many statutes were considered, but it was the Toxic Substances Control Act (TSCA) that was recently chosen by the Environmental Protection Agency (EPA) as its basis for regulating the rDNA

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[150]14 C.F.R. § 1216.309 (1984) Public involvement; § 1216.316 (1984) Cooperation with other agencies.

[151]Wilderness Society v. Morton, 463 F.2d 1261 (D.C. Cir. 1972); People of Saipan v. Department of the Interior, 356 F. Supp. 645 (D. Haw. 1973), *cert. denied,* 420 U.S. 1003 (1975); *see also* 74 MICH. L. REV. 349 (1975).

[152]Dept. of Health and Human Services (HHS), NIH Guidelines for Research Involving Recombitant DNA Molecules, 48 Fed. Reg. 24,555 (1983).

[153]*See* G. Karny, *Regulation of Genetic Engineering: Less Concern About Frankensteins but Time for Action On Commercial Production,* 12 U. TOL. L. REV. 815 (1981).

[154]41 Fed. Reg. 27,902 (1976).

[155]Karny, *supra* note 153. *See also* Legal Times Wash., Jan. 1, 1982 at 17.

[156]*See generally* note 153.

[157]*Id.*

[158]Karny, *supra* note 153, at 817.

[159]41 Fed. Reg. 27,092 (1976).

[160]48 Fed. Reg. 24,563, IV-D-5, VI (1983).

[161]*See supra* note 153. *See also* legal times Wash., Jan. 1, 1982 at 17.

technology.[162] While EPA has not yet published its own guidelines the latest NIH revisions should still be in effect. Whatever the new regulations turn out to be it is a logical conclusion that they should apply to future space studies involving the technology.[163]

The guidelines propose two types of protection against a potential biohazard; physical and biological.[164] Physical containment systems are easily understood. They utilize tangible barriers and specific procedures designed to confine the microbial agent to a designated area.[165] Typical examples of this would be the use of laboratory hoods, air filters, negative air pressure, restricted access by personnel, a ban on aerosol producing techniques and equipment, etc.[166] Physical confinement systems are ranked from P1 to P4 (in order of increasing security) for different categories of potentially hazardous bioagents.[167] Currently, DNA studies are generally permitted in facilities that provide P3 or P4 protection.[168] Considering the rationale for physical containment and the fact that space is so far removed from earth, it is not hard to see its allure as a site for this research.

Recombinant DNA technology utilizes a host-vector (HV) system in which vectors (typically plasmids, organelles, or a virus) insert foreign DNA into a new host (such as a bacterial, plant, or animal cell).[169] Biological containment arises in this system by "the use of vectors or hosts that are crippled by mutation so that the DNA is incapable of surviving under natural conditions"[170] and also to ensure that there is not "transmission of the vector from the propagation host to other non-laboratory hosts."[171] This could come about by building into the vector or host a deficiency (in an essential enzyme for example) so that it may only grow or reproduce if the missing element is artificially provided. Furthermore, to ensure that some potentially harmful traits are never expressed there are bans on the use of certain pathogenic bacteria or the insertion of specific resistant genes (i.e. antibiotic immunity) because of the increased danger of harmful consequences.[172]

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[162]EPA Draft and Statement of Don Clay, *supra* note 37.

[163]*See* notes 123-125 and accompanying text.

[164]48 Fed. Reg. 24,556, II (1983).

[165]*See* 45 Fed. Reg. 6725-26, 6744 (1980); Antaeus Report, *supra* note 6; Phillips, *supra* note 65.

[166]48 Fed. Reg. 24,556 (1983); 45 Fed. Reg. 6726 (1980).

[167]*See generally* 48 Fed. Reg. 24,556 (1983).

[168]45 Fed. Reg. 6730 (1980).

[169]48 Fed. Reg. 24,576, Appendix I (1983).

[170]41 Fed. Reg. 27,904 (1976); *See also* Talbot, *Introduction to Recombinant DNA Research, Development and Evolution of NIH Guidelines, and Proposed Legislation*, 12 U. TOL. L. REV. 804, 809 (1981).

[171]45 Fed. Reg. 6730 (1980).

[172]*See generally* 48 Fed. Reg. 24,565, Appendix B (1983).

In the current NIH guidelines, containment facilities and the host vector systems (HV1, HV2, and HV3) must be certified before any experimentation may take place. This would apply to the space borne equipment so that both the physical and biological systems would have to be assessed before the flight. Certain equipment and HV systems have been approved in advance,[173] but others that deviate from this narrow path must be approved by the Director of NIH and the Recombinant DNA Advisory Committee (RAC).[174] The approval is subject to change and if given, it extends only to the primary HV system and no major modifications will be allowed.[175]

Other administrative procedures must be followed as well. The investigating institution must seat an Institutional Biosafety Committee (IBC) consisting of five members with the experience to assess the possible consequences of a genetic engineering experiment.[176] Among other things their duties are to review project proposals,[177] to provide for public access to their meetings,[178] and to set up a plan for cleaning up any potential spill.[179] On the government side, the NIH director's advisory body, the RAC, must be comprised of experts from a large number of fields with at least 20% of those members "knowledgeable in the applicable law standards of professional conduct, public attitudes, the environment, public health, occupational health, or related fields."[180]

The extent of the review of DNA experiments or H-V classifications depends on whether or not the determination is classified as a major, lesser, or other action.[181] Major actions, as the name implies, involve considerably more risk and must undergo extensive review. The proposed action must be reviewed by the RAC, IBC, interested federal agencies and published in the Federal Register for 30 days of comment.[182] Experiments that require IBC approval must submit information on: (1) the source of DNA, (2) the nature of the sequence, (3) HV systems to be used, (4) whether gene expression will be attempted, and (5) containment conditions.[183] Lesser actions eliminate the need

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[173] *Id.*

[174] For each of three HV Systems a report designating specific certeria must be met. The degree of thoroughness increases as the hazard increases. *See generally* 48 Fed. Reg. 24,565, Appendix B, 24576, Appendix I (1983).

[175] 48 Fed. Reg. 24,576, Appendix I-II A (1983).

[176] The institute is also required to designate a Principle Investigator and could be required to provide a Biosafety officer. 48 Fed. Reg. 24,559, IV (1983). For general discussion on these issues, *see supra* note 153.

[177] 48 Fed. Reg. 24,555, 24,560, IV-B-3-a (1983).

[178] 48 Fed. Reg. 24,560, IV-3-a (1983).

[179] 48 Fed. Reg. 24,560, IV-B-3-f (1983).

[180] 48 Fed. Reg. 24,562 IV-C-2 (1983). *See also* note 153, at 838-839.

[181] *See* 48 Fed. Reg. 24,561-62, IV-C-1-b-(1) and (2) (1983).

[182] 48 Fed. Reg. 24,561-62, IV-C-1-B-(1) (1983); 48 Fed. Reg. 24,557, III-A (1983).

[183] 48 Fed. Reg. 24,558, III-B (1983).

for public and Federal agency comment[184] and other actions require only IBC approval.[185] As a result, the researching organization must go through both internal and external (NIH or EPA) review before any experiment may begin. This compliments the extensive efforts that are undertaken to solicit public comment from all persons who may be considered interested parties.[186]

However, this is not to say that the Guidelines are a rigid document and that the NIH expects their reporting procedure to be infallible.

> The Guidelines cannot anticipate every possible situation. Motivation and good judgement are the key essentials to protection of health and the environment . . . These Guidelines will never be complete or final, since all conceivable experiments involving recombinant DNA cannot be foreseen. *Therefore, it is the responsibility of the Institution and those associated with it to adhere to the intent of the Guidelines as well as to their specifics.*[187] (emphasis in original)

The use of these reporting and review procedures illustrates the importance in allowing all interested parties the chance to provide their input. This is especially true when we consider the international scope of the DNA issue.[188] Any breach in containment could have an effect that may not be stopped by any physical or national barriers and could transmit infective agents much like the case of Dutch Elm disease in this country. The use of these public reporting procedures is analogous to those in NEPA and the consultative requirements in the international treaties. It provides third parties, and conceivably foreign governments, with a published advance notice of any new DNA studies. The Guidelines also ensure that an adequate mechanism is set up to review proposed DNA experiments to determine whether they may have potentially harmful effects. Clearly, the policy of all three legal sources noted above indicates that for activities that have a potential impact on all of mankind, multilateral, not unilateral action must be taken.

3. Draft Report on Biosafety in Microbiological and Biomedical Laboratories

Experiments that involve research of hazardous agents also have their own guidelines. A draft of these rules is put out by NIH and the Center for Disease Control (CDC) and is titled Biosafety in Microbiological and Biomed-

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[184] 48 Fed. Reg. 24,562, IV-C-1-b-(2) (1983).

[185] 48 Fed. Reg. 24,562, IV-C-1-b-(3).

[186] *See* Talbot, *Introduction to Recombinant DNA Research Development and Evolution of NIH Guidelines and Proposed Legislation,* 12 U. TOL. L. REV. 804, 809 (1981).

[187] 48 Fed. Reg. 24559, IV-A (1983).

[188] *See* Legal Times Wash., Jan. 18, 1982 at 18.

ical Laboratories[189] (hereinafter CDC Draft). They were created due to the acknowledged danger and occurrence of laboratory infections and were designed to protect both the lab workers, the workplace, and the general public from exposure to infectious agents.[190] These rules would be applicable to space research on hazardous microbiological agents in the same way the DNA Guidelines were applicable before enforcement by the EPA, i.e. voluntarily, with the only sanction for non-compliance being the loss of government funding.

The Biosafety report parallels the DNA Guidelines in many ways, most notably in the use of four containment levels.[191] However, due to the nature of the research (i.e. you cannot or do not design a weakness into the microbiological agent that you are working on and trying to learn more about) there are no analogous levels of biological containment. The Biosafety report relies on three elements of physical protection: (1) laboratory practice and technique, i.e. personal training and awareness; (2) safety equipment, such as different types of hoods, protective gloves, and coats; and (3) facility design, such as segregation and separation of building facilities from other areas.[192]

Somewhat analogous to the DNA Guidelines, the Biosafety report requires the person conducting the research to bear the burden of complying with the rules.

> It is the responsibility of the laboratory director to establish standard procedures in the laboratory which realistically address the issue of the infective hazard of clinical specimens . . . (he) must make a risk assessment of the activities conducted and select practices, containment equipment, and facilities appropriate to the risk, irrespective of the volume or concentration of (the) agent involved.[193]

However, unlike the DNA Guidelines, there are no additional requirements of internal and external committee review.[194] Studies involving infectious diseases generally *have* to be done and are not elective, so they are automatically carried out in the highest containment facilities.

Recombinant DNA studies generally do not have to be performed and conceivably could produce something more virulent than could arise from nature. This is again largely due to the nature of the research. For this reason the provisions in the biosafety rules for a unilateral determination of containment systems might not be acceptable for those types of research that involve unknowns, like extraterrestrial organisms. Absent the potentially beneficial

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[189] *See supra* note 33. For spacecraft sterilization methods, *see* Sneath, COSPAR Technique Manual Series, Manual 34, Sterilization Techniques for Instruments and Materials as Applied to Space Research (1968).

[190] Biosafety Draft, *supra* note 33, at 4.

[191] *Id.* at 6.

[192] *Id.* at 4.

[193] *Id.* at 7, 36.

[194] *See generally* Biosafety Draft, *supra* note 33.

outside sources of input, a project director conceivably may not properly assess the hazards that exist on a given project.

Since an orbiting laboratory will be dealing with either known highly infectious organisms or unknown potentially infectious organisms it is assumed that the project director will choose the highest level of containment anyway. "[A] higher level of containment may be indicated by the unique nature of the proposed activity . . . or by the proximity of the laboratory to areas of special concern."[195] Since the use of space would be unique and of special concern, it is likely that the above requirement would be met. This level would not only protect space and the astronauts, but, the actual laboratory itself. The cost of manufacture, transportation and maintenance of an orbiting facility is too high to be jeopardized by an accidental release of contaminating bacteria, and it is safer to use a more secure lab for less harmful organisms than vice versa.

The report does not add any new dimensions to the microbe regulation in space issue, it simply extends some of the more common ideas about the match of the level of preventative measures to the type of agent involved. However, like the DNA guidelines, the Biosafety report is not a rigid set of rules even though specifics are given throughout the document.[196] This policy may direct a researcher to treat unknown, potentially harmful agents as they do in the DNA Guidelines, i.e. with the utmost caution and at the highest containment level. For these cases, it may be advisable to obtain a secondary assessment of each case, allowing more persons to provide their input as to the proper way to handle the agents. As the biosafety provisions are voluntary,[197] a challenge based on non-compliance with rules may not be very effective if the activity is not funded by the United States government or has its approval. Their usefulness may be limited to providing a standard of care for those cases in which negligence has been or could be alleged.

4. Remedies

One remedy is an injunction that may be sought to challenge a hazardous microbiological experiment in space. A potential plaintiff may seek to enjoin this research before it takes place due to the fact that he may be irreparably harmed if an accident occurs. Legal bases for this procedural device may be a common law nuisance theory,[198] or for non-compliance with one of the applicable Federal statutes, such as NEPA.[199] Such a suit has already been filed in

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[195] *Id.* at 36.

[196] "[T]he application of these recommendations to a particular laboratory operation should be based on a risk assessment of the specific agents and activities rather than as a universal and generic code applicable to all situations." *Id.* at vi.

[197] *Id.*

[198] *See* Restatement (Second) of Torts § 520, comment c, § 882, comment a (1965).

[199] If NEPA applies, an EIS must be prepared, *see* notes 126-151 and accompanying discussion.

the United States District Court in Washington, D.C. In *Foundation on Economic Trends v. Margaret Heckler, Director of Health and Human Services,*[200] the plaintiffs are trying to force the NIH to withdraw permission from two University of California at Berkeley scientists who wish to introduce genetically engineered bacteria into the open environment.[201] Foundation is relying on a federal common law nuisance claim and NEPA's EIS requirement in their allegations that the environmental effects have not been properly assessed.[202] In the foregoing case it is relatively easy to determine that the plaintiffs have a proper basis for alleging the impairment of their rights, however, a plaintiff seeking to enjoin an experiment in *space* may be hard pressed to show proper standing or how his interests are directly threatened. The Supreme Court has stated that "pleading must be something more than an ingenious academic exercise in the conceivable. A plaintiff must allege that he has been or will in fact be perceptibly harmed by the challenged agency action, not that he can imagine circumstances in which he could be affected by the agency's action."[203] A plaintiff's standing to sue could be based on the potential threat to his interests on earth,[204] but it may be argued by a defendant that no plaintiff could raise a claim over space or other celestial bodies because the required property interest is lacking.[205] No one may make a proprietary claim over space because both the Outer Space and the Moon Treaty ban appropriation of space by states or individuals.[206] Since no one may own space, no property right is threatened to any cognizable interest, and therefore there is no right to sue. On the other hand it may be argued that a United States or foreign citizen may have an interest in outer space as illustrated by the "Common Heritage of Mankind" principle found in those same treaties.[207] The Outer Space and Moon Treaties state that outer space is the property of all mankind, and if this is to be interpreted literally then each individual person does have an interest in space even though the area may not be subject to terrestrial claims.[208] International law only prohibits appropriation of space, not the maintenance of an interest

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[200]Civil action #83-2714 (D.D.C. 1983).

[201]San Francisco Chronicle, Aug. 11, 1983 at 4.

[202]Plaintiffs are claiming that the permission by NIH constitutes a major federal action and thereby the EIS requirement is invoked.

[203]United States v. SCRAP, 412 U.S. 669, 688-689 (1973).

[204]The standing requirements in environmental cases have been liberalized, *see* Sierra Club v. Morton, 405 U.S. 727 (1972); United States v. SCRAP, 412 U.S. 669 (1973); Sierra Club v. Andrus, 581 F.2d 895 (D.C. Cir. 1978). The plaintiffs would have to argue that the possibility of great impact of an accident may outweigh the slight probability of its occurrence. However, this argument may be tenuous.

[205]However, if a plaintiff establishes one basis for standing he may litigate the other issues in the public interest. Sierra Club v. Adams, 578 F.2d 389 (D.C. Cir. 1978).

[206]Article II of the Outer Space Treaty and Article II(2) of the Moon Treaty.

[207]R. Aninat, *supra* note 98, at 158; H. Almond, *supra* note 98 at 104.

[208]Aninat, *supra* note 98 at 158; Jenks, *supra* note 1, at 157; Sterns & Tennen, *supra* note 63, at 115.

in it.[209] Furthermore, if a person was not allowed to litigate a claim over space based on this interest, the court system would be closed to the plaintiff and he would be without an effective remedy. A court should perceive that even though a specific injury to a potential plaintiff may be theoretically slight, the standing requirement should be relaxed and a suit should be allowed on the policy consideration that the issue would not otherwise get resolved.[210]

Once the standing requirement has been met, the plaintiff may use NEPA to force NASA to file an EIS or EA when there will be an impact on the global commons.[211] As in the *Foundation* and other cited cases, this may be used to force NASA to more carefully consider the effects of a space experiment, to plan alternatives, or even challenge the validity of the experiment itself. Additionally, if a court finds the potential threatened intrusion too great it may permanently enjoin the experiment on a nuisance theory.

In the International Court of Justice, an injunction to prohibit an experiment that may create serious transnational or outer space harm may be less well received.[212] The Nuclear Test Cases[213] presented the issue of whether transnational pollution without proof of actual damage could be the basis of a prior restraint.[214] Here, Australia and New Zealand sought to enjoin the detonation and release into the atmosphere of nuclear radiation from a site within French territorial sovereignty.[215] Even though this presented an obvious risk of harmful transnational environmental effects, the International Court of Justice (ICJ) failed to decide the merits of the legality of the French atmospheric testing. Rather than limiting the sovereignty of the testing state, the court held that the case was moot because the French claimed to stop future testing. However, indications by some of the justices shows that they were not receptive to the request for an injunction. They felt that it would be an unwarranted intrusion on French rights without any legal bases for a corresponding right in the plaintiff to stop such action.[216] If this lack of enthusiasm over enjoining a certain risk of transnational harm signifies the current direction of this court, the mere possibility of risk would evoke even a lesser response.

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[209]R. Aninat, *supra* note 98, at 158; H. Almond, *supra* note 98, at 104. A hazardous microbiological experiment may have the result of appropriating space. If an accident occurs it may contaminate an area and make it useless for research, navigation, or exploration. It could be argued that this would be analoguous to a theory of private condemnation.

[210]Similarly, standing should not be denied "simply because many people suffer the same injury." United States v. SCRAP, 412 U.S. 669, 688 (1973).

[211]*See* notes 146-148 and accompanying text.

[212]*See* G. Handl, *An International Legal Perspective on the Conduct of Abnormally Dangerous Activities in Frontier Areas: The Case of Nuclear Power Plant Siting,* 7 ECO. L.Q. 1 (1978).

[213]Australia v. France and New Zealand v. France, [1974] I.C.J. 253.

[214]Handl, *supra* note 212, at 12.

[215]For a discussion of the case, *see supra* note 212, at 10-12.

[216]There is a general presumption in favor of the sovereignty of states, so that states may perform any act not expressly prohibited or limited by international law. Bockstiegel, *supra* note 2, at 9.

5. Standard of Liability for Assessing Damage

In the event that a person suffers injury from a space borne microbiological experiment, that person may attempt to seek damages to compensate for the harm caused.[217] However, before compensation may be made a decision must be made concerning the standard of liability the defendants will be held to for the purposes of judging their responsibility.

Absolute or strict liability may be defined as responsibility for the harm suffered without proof of fault, and it may arise in a number of ways. Article II of the Convention On International Liability For Damage Caused By Space Objects[218] provides that a state will be held absolutely liable for injury on earth caused by one of its space objects.[219] However, it exempts from this standard the injuries suffered by citizens of the launching state, and by citizens of other states who are present at the launch. Injuries that occur in space are treated differently, but are not judged by an absolute liability standard either.[220] As a result, a system based on fault will have to be used for those exemptions.

Even though the Convention describes a fault standard for injury in space or to a citizen of the launching country, common law absolute liability may be more appropriate for activities that are deemed ultrahazardous for reasons other than their location in space.[221] The reason for excluding injury in space from the standard of absolute liability is because persons in space are presumed to have accepted the risks of all normally related space activities. People on the ground are not presumed to have accepted such risk as they engage in their day-to-day affairs and do not directly participate in space related action.[222] However, this concept of assumption of the risk applies to hazards normally associated with the rigors of spaceflight. The injury caused by microbiological agents would not normally be associated with space and therefore other astronauts could not be said to have assumed the risk. Furthermore, with the increase in spaceflight space will lose much of its reputation for danger and will simply become a place to work like earth. Once this happens it will be easier to

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[217]For a discussion on the tort waiver provision between shuttle "users" in a shuttle launch contract, *see* Sloup, *Liability and Insurance Aspects of the Space Transport System Under the New Section 308 of the Nasa Act*, 4 ANNALS OF AIR AND SPACE LAW 639 (1979); M. Tepfer, *Allocation of Tort Liability Risks in the Space Shuttle Program*, 23 AIR FORCE L. REV. 208 (1983).

[218]*See supra* note 88.

[219]This applies to states that are signatories to the treaty. Bockstiegel, *supra* note 8, at 238. For a discussion of international liability for private acts, *see* Handl, *State Liability for Accidental Transnational Environmental Damage by Private Persons*, 74 AMER. JOUR. INT. L. 525 (1980).

[220]Articles III, IV and VII of the Liability Convention, *supra* note 88, at 211. A system of fault will be used for the cited exemptions. For a criticism of the absolute liability theory, Kolossov, *supra* note 95.

[221]There may be a recognition of an absolute liability in international common law for ultrahazardous acts, but some states may interpret international law restrictively so that this liability is not implied. Jenks, *supra* note 1, at 176-77. This theory will apply to the laws of the U.S. and most common law jurisdictions as well as countries who are not signatories of the Liability Convention.

[222]Jenks, *supra* note 1, at 153.

see that ultrahazardous activities, whose classification is not caused by their location in space, should be governed by strict liability and not fault.

The seminal case for absolute liability for ultrahazardous activities and abnormally dangerous conditions is *Rylands v. Fletcher.*[223] According to *Rylands* absolute liability will attach if a person engages in a "non-natural" use of his property and allows it to escape and cause harm.[224] This theory is also borne out in the Second Restatement of Torts:

(1) One who carries on an abnormally dangerous activity is subject to liability for harm to the person, land or chattels of another resulting from the activity, although he has exercised the utmost care to prevent the harm.

(2) This strict liability is limited to the kind of harm, the possibility of which makes the activity abnormally dangerous.[225]

The comment on this section further explains that "the liability arises out of the abnormal danger of the activity itself, and the risk that it creates, of harm to those in the vicinity."[226]

The policy basis for absolute liability for ultrahazardous activities is that people who create an abnormal risk of harm for their own benefit should suffer the responsibility of relieving the harm when it does occur.[227] Furthermore, since the experimenting institution is usually deriving monetary benefits[228] from the research it may be in a better financial position to spread the loss among a greater amount of individuals. This policy would also apply because the one who is performing the experiment is in the best position to guard against accidental release. They have the funding and the expertise in the field to properly assess the risks and design a secure facility. As a result, to recover under a strict liability standard the only requirements the injured plaintiff should have to show are the fact of injury and the causal connection between the injury and the dangerous condition.[229]

Another basis for using absolute or strict liability would be the spaceworthiness analogy to the common law rule of seaworthiness as outlined in

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[223]L.R. 3 H.L. 330 (1868).

[224]*Id.* at 338.

[225]Restatement (Second) of Torts § 519 (1965).

[226]*Id.*, comment c. Section 165 complements this idea by stating that an actor will be liable for the harm caused if, by reason of his ultrahazardous activity, either he or his agent trespasses on another's land. Restatement (Second) of Torts, § 165 (1965).

[227]*See supra* note 226. Aninat, *supra* note 98, at 154; DeSaussure, *supra* note 125.

[228]It is not necessary to get a pecuniary benefit for absolute liability to be invoked. Restatement (Second) of Torts § 520, comment d (1965).

[229]Szilagyi, *Protection of Outer Space Environment — Questions of Liability,* Proc. of the 25th Colloquium of the L. of Outer Space 53 (1982). For a discussion of absolute liability of genetically engineered bacteria in the product liability area, *see* Note, *Strict Product Liability for Injuries Caused by Recombinant Bacteria,* 22 SANTA CLARA L. REV. 117 (1982).

Mitchell v. Trawler Racer.[230] In *Mitchell* the Supreme Court stated that the owner of a ship has an absolute duty to provide a ship free from all dangerous conditions.[231] In the event that a person[232] on board a (space) ship is injured the owner is strictly liable for the harm caused. However, this obligation is not overly broad as the owner is not under an obligation to furnish an accident free ship, only to provide one that is reasonably fit for its intended use.[233] The fact that the ship is engaged in an ultrahazardous activity will simply bear on the reasonableness of the equipment that is in use.[234]

If absolute liability for injury in space is not accepted for ultrahazardous activities the principle of negligence outlined in the Liability Conference may be employed. Here, the injured person must establish that the harm resulted from the fault of the defendant, i.e. that his conduct dropped below some standard of care.[235] This may be difficult to prove in situations where the injured plaintiff has difficulty in gaining access to evidence that may establish the defendant's guilt. A United States common law principle called res ipsa loquitor[236] lessens the plaintiff's burden in these difficult proof cases. It is a rule of evidence that provides the plaintiff with an inference of negligence that may be rebutted by the defendant with evidence to the contrary. The rule requires that the instrument (in this case a microbe) be within the control of the defendant, the plaintiff must be free of any contributory negligence, and the accident must be the type that would not occur if reasonable care had been used. If the plaintiff established this prima facie case and the defendant fails to provide evidence showing that his duty was not breached, the plaintiff will win.

If res ipsa loquitor is not available to the plaintiff he will have to prove his entire case. In the United States a typical negligence prima facie case involves the existence of a duty, a breach of that duty, the proximate cause link between the breach and the injury and damage.[237] In the context of microbiological experimentation we may assume that the experimenter has a duty to exercise all reasonable precautions in confining his hazardous organisms and prevent them from causing injury to third person. To determine when a breach has occurred and what is reasonable care we may analyze defendant's conduct under many different standards. Reasonable levels of care could be

[230]362 U.S. 539 (1960). DeSaussure *supra* note 125, for parallels between navigating on the high seas and in space.

[231]Mitchell v. Trawlee Racer, 362 U.S. 539, 550 (1960).

[232]The duty extends to any person who works on board, including scientific personnel. *See* Presley v. Vessel Carribean Seal, 709 F.2d 406 (5th Cir. 1983) *cert. denied,* 104 S.C. 699 (1984). Seas Shipping Co. v. Sieracki, 328 U.S. 85 (1946).

[233]Mitchell, *supra* note 230, at 933; Martinez v. United States, 705 F2d 658 (2nd Cir. 1983).

[234]Martinez, *supra* note 233, at 660.

[235]For a discussion of tort law and negligence, *see* Prosser, Prosser on Torts (4th ed. 1971).

[236]Res ispa loquitur may be defined as "the thing speaks for itself." Blacks Law Dict. 1173 (5th ed. 1979).

[237]*See supra* note 235.

shown by compliance with the NIH recombinant guidelines, the biosafety guidelines, general levels of care in the industry or rules of the specific investigating or researching organization. All these factors may go into the determination of what is reasonable given the risks and the benefits of the activity. After that has been determined, specific evidence showing that the defendant failed to conform to that standard must be demonstrated by the plaintiff. Once this has been shown, the plaintiff must finally prove that the link between the breach of the duty and the harm suffered is sufficiently direct so that the defendant may be held culpable for his actions. Proof of these factors by a preponderance of the evidence will result in culpability of the defendant.[238]

The choice between absolute liability or negligence will be made based on what the exploring countries feel outer space should be used for. Since the concept of fault was introduced, it has generally favored development over absolute protection. Conversely, the standard of absolute liability is designed to protect persons and the environment and allow the costs of operation to be properly borne by those persons who create the risks.[239] The fundamental question is one of policy, for example how socially useful is each protected interest? Once that assessment is made and then balanced against the other, the appropriate policy may be implemented. As a result, the standard by which we judge the person who creates the harm will dictate a corresponding level of protection of the interest at issue.

V. FUTURE CONTROLS

The Moon Treaty states that it is necessary to create an international regime to manage outer space resources.[240] However, in the absence of any current effort we may inquire whether hazardous space activities should be left unregulated, should they be prohibited, or should we approach a middle ground of partial regulation? An argument for keeping the status quo (i.e. no more regulation) would be that the current legal situation is adequate to cover any future eventuality. Proponents of this theory could point to the past and show that there has not yet been an unmanageable situation and that this may continue in the future. However, at the opposite end of the spectrum, some persons may wish to have a total moratorium on hazardous space research, much like the initial response to the rDNA studies. Because of the possible catastrophic nature of the risks, it may be thought that these risks would outweigh the potential benefits.[241]

These two extremes may both prove unwieldy as legal regimes because they do not fit the needs or the aims of the conceived uses of space. The use of

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[238] *Id.*

[239] *Id.* at 494-95. *See also* Restatement (Second) of Torts 519, 520 (1965); Jenks, *supra* note 1, at 194, (1).

[240] *See* Article II (5-7) of the Moon Treaty.

[241] *See supra* notes 153-154.

space for all types of experiments, hazardous or not, is enlarging (because space may be the best place to conduct this research) and past domestic or international legal regulations may not be adequate to cover the totally new emerging areas. Likewise, a total prohibition may be overreacting to the potential danger. As with the rDNA and hazardous research experiments, sufficient legal and practical controls may be instituted so that safety may be assured while benefits are received.

Since the area at issue is the Earth and outer space, any new regime that is contemplated should be international in scope.[242] However, the problem that is created is, who in this international regime will advise or exercise control? There are some current international organizations which give advice on outer space activities that may be considered for this role. Although they do not have any enforcement powers, they are still important in planning and shaping world exploration of space.

A. *Who Should Control?*

> Environmental control of space activities and its legal implications should be approached from an international point of view. Only this method will have a reasonable chance to guarantee an adequate protection against the manifold hazardous consequences due to an advanced use of outer space.[243]

In 1958 The International Council of Scientific Unions (ICSU) established a committee to deal with extraterritorial contamination, the Ad Hoc Committee on Contamination by Extraterrestrial Exploration (CETEX).[244] Later in 1961, CETEX left this duty of studying planetary exploration and possible contamination to a branch of the ISCU, The Committee on Space Research (COSPAR).[245] Within COSPAR there is a specific section, working group V on Planetary Biology now called ISC F, that handles space biology.[246] As a result, the use of the COSPAR section to act as a forum for international consultations would have a twofold advantage. First, there is no need to build an organization from scratch (i.e. pick the members, seek funding, obtain a consensus from participating states, etc.) and second, the group has already dealt with this type of problem before in the form of back and inbound contamination, planetary quarantine, the effects of a microbiological accident, etc.[247]

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[242] H. Almond, *supra* note 98, at 100. Sterns & Tennen, *supra* note 63; Aninat, *supra* note 98; H.L. van Traa-Engelman, *Environmental Hazards from Space Activities: Status and Prospects of International Control*, Proc. of the 25th Colloquium of the L. of Outer Space 55 (1982); Sand, *supra* note 63, at 58. 2nd UN-COPUOS, *supra* note 2, at 78-106.

[243] H.L. van Traa-Engleman, *supra* note 242, at 55. *See also* Christol, *Alternative Models for a Future International Space Organization*, Proc. of the 25th Colloquium of the L. of Outer Space 173 (1981).

[244] Werber, *supra* note 30, at 1; Sterns & Tenner, *supra* note 63, at 111; Christol, *supra* note 95, at 436.

[245] Werber, *supra* note 30, at 1; Sterns & Tenner, *supra* note 63, at 111; Christol *supra* note 95, at 436.

[246] Sterns & Tennen, *supra* note 63, at 111-112, and notes cited therein.

[247] *See supra* note 244.

This international body of specialized scientists could be used to carefully study the scope of each particular type of experiment and explore the possible risks involved since the body does not represent any state in particular. The input from a variety of scientists would not only supply advice from different perspectives, it would ensure that proper representation of other global interests has been met. Consequently, this would follow the language in the international treaties that require consultations for experimentation of a hazardous nature, with many or most countries represented in the advisory group a type of democratic process may be obtained along with the forum to air reservations on the matter.[248]

B. *Ways to Regulate the Experiments*

As stated previously, there is no enforcement power of COSPAR[249] although its advice is highly regarded and has generally been followed. Practically speaking, it is not reasonable to make a body of scientists responsible for keeping all the space activity up to a specified standard of compliance, they simply do not have the regulatory background.[250] The existing COSPAR group would be most effective in an advisory capacity and not in the role of a policeman.[251] That duty would best be handled by some sort of bi or multilateral agreement between the states involved to conform to the advice of the consulting group.[252] This could be instituted in at least two ways: the creation of a separate judicial enforcement agency much like that of the International Telecommunications Union[253]; or by using the national space agency of each launching state to assist with compliance. Of the two, the latter choice could possibly be the easiest to implement. Organizations such as NASA could tailor effective guidelines to conform to the advice of COSPAR or domestic law could be used to supplement the power of the advice.[254]

Regardless of the international arrangements, NASA, as the representative space agency of the United States, could implement the advice of COSPAR on a domestic level. It may implement its policy through the launch contract, its own procedures of internal review and regulation, or by working with the legislative and executive branches of the government to adopt some type of domestic law.

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[248]This could be analogous to the International Telecommunications Union which is an international group set up to control radio frequencies. Sand, *supra* note 63, at 57-58.

[249]J. Sztuki, *supra* note 103, at 163.

[250]*Id.*

[251]*Id.*

[252]Bockstiegel, *supra* note 2, at 9.

[253]Christol, *supra* note 243, at 176.

[254]However, if there was no binding bi or multilateral treaty to cover this compliance, about the only thing to do would be to fall back on the good faith of each nation. Since international law is based on this premise of mutual cooperation and global harmony, it would probably still be workable even it not internationally enforceable. *See generally* the Moon and Outer Space Treaties. S. Bhatt, *supra* note 63, at 386.

Currently, the launch contract is used to implement certain NASA policies, an example of which is the waiver of liability over tort claims between shuttle users.[255] This same mechanism could be used to force user compliance with the advice or safety recommendations made by COSPAR. Since the large majority of people who wish to go into space have to deal with NASA, the agency may set its own guidelines with the assurance that they will be followed. Internal review and regulations within the agency could be issued to make the guidelines more enforceable. In fact this type of route was followed with the issue of planetary quarantine. NASA incorporated COSPAR's advice into internal policy directives and set up a Planetary Quarantine Group within the agency.[256] The planetary quarantine policy shares much the same interest in avoiding an accident from a hazardous microbiological experiment: [B]ecause the existence of life and life related molecules on the planets is possible and because the conduct of scientific investigations of possible extraterrestrial life forms must not be jeopardized, contamination of the planets with terrestrial micro-organisms and organic constituents shall be controlled.[257]

NASA could also seek compliance with the goals of an international advisory body by playing a part in the domestic lawmaking process. Even though this method would not be necessary to cover NASA flights,[258] domestic laws may be necessary to cover those people who fly into space via privately owned launch vehicles. This is analogous to the rDNA situation in that the first years were governed by rules that were monetarily enforceable over government agencies and their grantees, but voluntary as to private industry.[259] Now due to the vast involvement by private concerns, rDNA research (and presumably the guidelines) will become part of the regulatory regime of the EPA enforceable under United States Federal Law.[260] The same situation may be tracked here. Currently, in the United States, the government is the major exploiter of space research and transport systems, but private industry is expanding rapidly with the near-future ability to place material into outer space. As a result, internal regulations whose scope is limited to projects flown or funded by the government, may lose their effectiveness once private industry is more self sufficient. If so, the need for Federal legislation would arise.

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[255]Sloup & Michaleski, *supra* note 217; Bockstiegel, *supra* note 2, at 14.

[256]NHB 8020.12A, Quarantine Provisions for Unmanned Extraterrestrial Missions, Feb. 1976; Sterns & Tennen *supra* note 63; Werber, *supra* note 30. However, in later years NASA unilaterally dropped the quarantine and decontamination procedures, Sand, *supra* note at 50.

[257]NASA Policy Directive (NPD) 8020.10A, Outbound Planetary Biological and Organic Contamination Control: Policy and Responsibility, issued 8-4-72; see also NPD 8070.7, Outbound Spacecraft: Basic Policy Relating to Lunar and Planetary Contamination Control, issued 9-7-67; NHB 8020.12A *supra* note 256.

[258]As long as NASA could implement its policy through the launch contract or internal review, domestic regulation would not be necessary.

[259]*See supra* note 160.

[260]*See supra* notes 161-163 and accompanying text.

C. *Types of Regulation*

The future controls that may be designed could be fashioned on several levels. Assuming that proper international consultations have been made and other states have been adequately informed, restrictions on types, methods, conditions, and locations for research could all be employed to control the experiments and the consequences once an accident occurs.

Some ideas have been mentioned already, but one example could be the advance preparation of a plan for decontamination of the affected environment in the event an accident occurs. The analogy to an EIS is obvious, but the suggestion is still useful to effectuate the intent behind the consultative requirements in international law. If a launching state were to set up a contingent plan for the time when a serious accident occurs not only would that much time be saved on the preparation, but the launching state would have the benefit of a second look at the possible consequences with the potential for outside advice.

To ensure that any future problem (i.e. clean up, victim compensation, etc.) may be dealt with, a type of fund may be instituted to provide money for this purpose. Contributions could be made by the launching states on a scale that would reflect use or any other feasible measuring system. A similar device is currently in use by the EPA to manage and dispose of toxic wastes and is termed the "superfund." In the event that this is necessary this idea could conceivably be extrapolated to space under the care of some type of governing body or a agreement.

Restrictions on hazardous experiments may also be by location. Studies in space are isolated by their very nature, however to ensure maximum protection to earth or other celestial bodies, the site of hazardous activity may be moved further away from these areas. A scheme may be developed where regions are designated for use based on risk to the earth (or other celestial bodies). The factors that would be most important in deciding the exposure liability for a given area would be the zone's proximity to earth, the possible dispersion of contaminating material by the solar wind, and even simple gravitational attraction. In describing areas, earth could be used as the center point with concentric circles radiating outward, obviously the more hazardous experiments could be placed further away and "downwind." Once these areas have been planned the appropriate governing body could allocate or assign the activity to the area designated. This allocation could be performed similarly to what is done for radio frequencies by the International Telecommunications Union.

VI. CONCLUSION

Technology and space research are growing logarithmically. To ensure that legal regulation keeps pace with this we must consider possible future problems and form contingency plans before they become major stumbling blocks. The topic of ultrahazardous microbiological experiments in outer space is simply a convenient tool to illustrate this problem. The experiments may take different forms, but nonetheless, they may present a danger to the welfare and environment of earth, outer space, and other celestial bodies. Different legal sources, both national and international, can be used to govern these experiments, but as they become more frequent, involved, or potentially dangerous, a new specific international regime may be appropriate to handle this problem more effectively. It need not be created out of whole cloth, but may be adapted from an existing group such as COSPAR. If such a desire is there, the appropriate procedural and regulatory obstacles may be overcome by agreements between states. This is not a novel idea, simply an institutionalization of many of the trends and interests of both domestic and international law that have arisen in the discussion above.

It is important that it has been recognized that space experiments have the real potential to create an impact on a large area and a large number of people. This is shown by the organization of international and national groups that have arisen in the past several decades. However, now comes the time when we begin to get accustomed to the idea that space is going to be used on a regular and common basis. As a result, each entity that ventures out into this "province of mankind" must do so with mutual cooperation and responsibility with an eye towards protecting the region for future explorers, businessmen and settlers.