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SPACE BORNE NUCLEAR POWER SOURCES—THE STATUS OF THEIR REGULATION

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I. INTRODUCTION

The future of space exploration, space commercialization, and space militarization may depend upon the development of new and more powerful space borne energy sources. While research continues in the areas of solar and chemical energy systems, some experts believe that nuclear power will be the ultimate solution. Unfortunately, though, the use of nuclear power sources (NPS) presents many safety problems and therefore many legal issues. So far most of these issues have gone unaddressed by international law.

This article attempts to expose those legal issues by reviewing the history of NPS use, NPS technology, the hazards created by NPS use, the current international law regulating NPS use, and the current efforts within the United Nations Committee on the Peaceful Uses of Outer Space to update international law regarding NPS use. Following the survey a structure for effective regulatory machinery is suggested.

II. THE NEED TO REGULATE

After a slow period during the mid- to late- 1970s, the western world has again developed an interest in space exploration. Much of this excitement has been generated by the commercial possibilities space exploration holds. For example, results from recent protein crystal growth experiments conducted aboard the space shuttle could lead to powerful new anticancer drugs.[1]

To take advantage of these new commercial opportunities, as well as some military opportunities, more reliable and powerful energy sources must be developed. It is estimated that by the mid-1990s the planned United States space station will required upwards of 400 kilowatts of power to operate the commercial materials processing then one of the station's many functions.[2] Also, some aspects of the

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1. Covault, *Shuttle Crystal Growth Tests Could Advance Cancer Research*, AVIATION WEEK & SPACE TECH., Feb. 25, 1985, at 18.

2. *Space Station Nuclear Power Studied*, SPACE BUS. NEWS, Jan. 14, 1985, at 8.

Reagan Administration's Strategic Defense Initiative (SDI) program, such as space based radar and directed energy weapons, will require reliable sources of kilowatts and even megajoules of energy.[3]

One energy source, nuclear power, is viewed by many as the answer to these needs. Nuclear power has many advantages when compared to other sources now in use: it is reliable, it is independent of the sun, it is relatively light, it has a long life, and it is capable of supplying greater quantities of heat and energy.[4] Foreseeing the need for a more powerful energy source, the United States Government has initiated a program, dubbed SP-100, to produce a nuclear power source (NPS) for space use. Managed by the SDI office, it is hoped that the SP-100 program will produce an NPS capable of providing hundreds of kilowatts and eventually multi-megawatts of power.[5] Although the program is managed by the military, private industry has also expressed interest in using NPSs in space.[6]

A. *The History of NPS Use*

Between June, 1961, and August, 1985, the United States launched twenty-four nuclear power sources[7] and the Soviet Union launched at least twenty-two.[8] Twenty-three of the twenty-four U.S. launches were radioisotope thermoelectric generators (RTGs) and one was a nuclear reactor. All of the Soviet launches are believed to be reconnaissance satellites powered by nuclear reactors.[9] RTGs have

3. *Space Power Project Moves to SDI Office*, AVIATION WEEK & SPACE TECH., Oct. 29, 1984, at 19 [hereinafter cited as *Space Power Moves to SDI*].

4. W. Wirin, The Sky is Falling—Managing Space Objects 3 (Oct. 8-13, 1984) (a report presented at the XXXV Congress of the International Astronautical Federation Colloquium on Cooperation in Space).

5. *Space Power Moves to SDI*, *supra* note 3, at 19.

6. Booz-Allen and Hamilton, Inc., a firm under contract with the Jet Propulsion Laboratory to explore NPS application has been approached by an unidentified company about using an NPS on a space processing platform. *Booz-Allen Uncovers Nuclear Mission*, SPACE BUS. NEWS, Jan. 28, 1985, at 2, 3.

7. The National Aeronautics and Space Administration hopes to launch three NPSs aboard a May, 1986, space shuttle mission. Two of the NPSs will power the Galileo Jupiter probe mission and one NPS will be aboard the European Ulysses solar-polar mission. Necessary White House approval has not yet been given to proposed launches because of the lengthy process required to certify that the NPSs will survive a launch accident. *Washington Roundup*, AVIATION WEEK & SPACE TECH., Oct. 28, 1985, at 17.

8. W. Wirin, *supra* note 4, at 3; *Soviet Nuclear-Powered Satellite Boosts Naval Surveillance Capability*, AVIATION WEEK & SPACE TECH., Aug. 19, 1985, at 18 [hereinafter cited as *Soviet Satellite*].

9. W. Wirin, *supra* note 4, at 3. *See also Soviet Satellite*, *supra* note 7, at 18.

been used by the United States to power and heat navigational satellites, communication satellites, meterological satellites, lunar mission equipment, Mars mission equipment, and planetary explorers.[10] The only nuclear reactor launched by the United States was aboard the experimental Snapshot spacecraft in 1965.[11]

Of the forty-six known launches of NPSs, five have failed to reach orbit or remain outside the earth's atmosphere. Three of the five were United State's NPS missions. The first, a Navy Transit-5BN-3 navigation satellite, failed to reach earth orbit and burned upon reentry over the Indian Ocean east of Africa.[12] Its RTG was vaporized during reentry, releasing 17,000 curies of radioactive plutonium into the stratosphere.[13] High altitude atmospheric sampling done by the U.S. indicated that the radiation was dispersed world-wide.[14]

The other two U.S. NPS accidents did not release radioactive material into the atmosphere. In 1968 the launch of a National Aeronautics and Space Administration (NASA) Nimbus B-1 meteorological satellite was aborted at an altitude of 100,000 feet when a guidance error developed. The spacecraft and its RTGs fell into the Santa Barbara channel where they were recovered intact.[15] The Apollo 13 mission, which was aborted on its way to the moon in April of 1970, carried lunar experiments powered by RTGs. After reentering over the South Pacific, the nuclear fuel cask sank 20,000 feet to the bottom of the Tonga Trench where it remains today.[16]

The Soviet space program has experienced two NPS accidents: COSMOS 954 in 1978 and COSMOS 1402 in 1983. It is the COSMOS 954 accident which generated international concern over NPS use in outer space.

On January 24, 1978, COSMOS 954 entered the atmosphere above Canada's Northwest Territories and disintegrated over the Great Slave Lake. Canadian and American search parties were immediately dis-

10. W. Wirin, *supra* note 4, at 9 (summary of space nuclear power systems launched by the United States).

11. *Id.*

12. Uses of Radio-active (nuclear) Materials by the United States of America for Space Power Generation, U.N. Doc. A/AC.105/L.102 (1978) (a report submitted by the United States to the U.N. Committee on the Peaceful Uses of Outer Space) [hereinafter cited as Uses of Radio-active Materials by the United States].

13. Dembling, *COSMOS 954 and the Space Treaties*, 6 J. SPACE L. 129, 131 (1978).

14. Uses of Radio-active Materials by the United States, *supra* note 12, at 5.

15. *Id.* at 6.

16. *Id.*

patched to search for debris and to determine if radioactive fallout was present.[17] Operation Morninglight, the name given the clean up operation by the U.S., continued for over three months, until April 17, 1978. During operation Morninglight, radioactive material was detected over a 124,000 square kilometer area of the Northwest Territories. Fortunately the area is sparsely populated and no personal injuries occurred. The clean up, including the removal of contaminated flora and soil, cost $13,970,143.66 (CDN).[18]

Launched on September 18, 1977, COSMOS 954 was officially described by the Soviet Union as an outer space exploration satellite. The White House, however, described it as an ocean surveillance satellite designed to track warships. COSMOS 954 had been one of two satellites in a 150 mile high orbit that provided surveillance coverage for almost two-thirds of the earth every two weeks.[19] The COSMOS type of ocean surveillance satellite, which by this time had been used for some time, generally remained in its 150 mile high orbit for no more than two months.[20] At the end of its two month life, COSMOS satellites were normally raised to a 600 mile high orbit.[21] There the satellites and their nuclear reactors would remain for hundreds of years.[22] Unfortunately, this did not happen with COSMOS 954. In late December of 1977 an attempt to fire COSMOS 954's engines failed. Its orbit began to decay and shortly thereafter COSMOS 954 crashed into Northern Canada.[23]

Weighing about five tons, COSMOS 954 was equipped with an active radar system. Such a radar system requires substantial electrical power. That electrical power was supplied by a 100 kilowatt nuclear reactor stocked with an estimated fifty kilograms of enriched uranium 235.[24] If the reactor was turned on shortly after launch in September, and turned off around December 25th of the same year, then it would have produced approximately 100,000 curies of the fission products strontium 90, cesium 137, and iodine 131.[25]

No warning of COSMOS 954's possible reentry was given by the Soviet Union. The first communication between Canada and the Soviet

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17. Dembling, *supra* note 13, at 129.
18. W. Wirin, *supra* note 4, at 1.
19. Dembling, *supra* note 13, at 129.
20. *Id.* at 130.
21. *Id.*
22. *Id.*
23. *Id.*
24. W. Wirin, *supra* note 4, at 2.
25. Dembling, *supra* note 13, at 130.

Union took place on January 24, 1978, when the Canadian Department of External Affairs asked the Soviet Ambassador whether the satellite carried an NPS and expressed surprise that the Canadian Government had not been given prior warning.[26] In response, the Soviet Union said that it had expected COSMOS 954 to burn completely in the earth's atmosphere and reenter over the Aleutian Islands where little local pollution would result.[27]

Although Canada's total cost for the search and clean up of COSMOS 954 was $13,970,143.66 (CND), Canada decided to only claim $6,941,174.70 (CND) from the Soviet Union.[28] This lower amount represented those costs which Canada would not have incurred if the incident had not happened (e.g., Canada did not claim the salaries of military personnel involved in the clean up).[29] The Soviet Union objected to this lower amount though. It asserted that Canada had taken measures beyond what was necessary and that it had a right to participate in the search and recovery.[30] On November 21, 1980, after three negotiating sessions, the Soviet Union agreed to pay Canada $3,000,000 as a full and final settlement.[31]

The second Soviet NPS accident was not as serious. COSMOS 1402, another in the COSMOS series of ocean surveillance satellites, reentered the atmosphere over the Indian Ocean on January 23, 1983, and came down off the coast of Argentina on February 7, 1983.[32] With this incident TASS, the official Soviet News Agency, gave advanced warning of the satellite's likely reentry on January 15, 1983.[33] TASS also admitted that COSMOS 1402 was powered by a nuclear reactor containing uranium 238 enriched with uranium 235 and encased in a beryllium reflector.[34] Unlike COSMOS 954, COSMOS 1402 was designed to separate into three pieces.[35] One of the three pieces, the nuclear reactor, was to be boosted to a higher orbit where it would remain for some time. This did not happen, but fortunately no damage was caused by COSMOS 1402's reentry.[36]

26. W. Wirin, *supra* note 4, at 1.
27. *Id.*
28. *Id.* at 2.
29. *Id.*
30. *Id.*
31. *Id.*
32. *Id.* at 2, 3.
33. *Id.*
34. *Id.*
35. *Id.*
36. *Id.*

B. Technical Background

Two types of nuclear power sources have been launched: radioisotope thermoelectric generators (RTGs), and nuclear reactors.

Radioisotope Thermoelectric Generators

RTGs contain radionuclide fuels, generally plutonium 238 or plutonium 210, surrounded by an energy conversion system. As the radioisotope spontaneously decays, ionizing radiation is absorbed as heat and then converted to electricity.[37] The plutonium fuel has a half-life of eighty-seven and one-half years and within existing NPSs, produces from 1800 to 280,000 curies.[38]

RTGs generally produce twenty-five to thirty watts of electrical energy and 500 watts of heat from about one kilogram of plutonium. So far the energy conversion efficiency rate is only about five percent. Systems with an efficiency rate of from eighteen to thirty percent, which can produce up to 1000 watts, are under development.[39] While an RTG's operating life is only a few hundred hours, the short half life and alpha emission decay scheme of its plutonium fuel allows relatively little shielding, thus making it light and reliable.[40]

Nuclear Reactors

The controlled fission of enriched uranium 235 creates the thermal energy produced by a nuclear reactor. The thermal energy is captured by reflector material and converted into electrical power.[41] More complicated than RTGs, nuclear reactors carry between five and one hundred kilograms of uranium 235 fuel. The half life of uranium 235 is 713 million years.[42]

Nuclear reactors are capable of producing significantly more energy than RTGs. Project SP-100 is attempting to create a reactor capable of producing 100 kilowatts of power. Reactors, however, produce more radiation than RTGs and therefore require added protec-

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37. Report of the Working Group on the Use of Nuclear Power Sources in Outer Space on the Work of Its Third Session, U.N. Doc. A/AC.105/C.1/L.126 (1981) (submitted to the U.N. Committee on the Peaceful Uses of Outer Space) [hereinafter cited as Report of the Working Group—Third Session].

38. C. CHRISTOL, THE MODERN INTERNATIONAL LAW OF OUTER SPACE 765 (1982).

39. Jasentuliyana, *A Perspective of the Use of Nuclear Power Sources in Outer Space*, 6 ANNUALS AIR & SPACE L. 519, 523 n.12 (1979).

40. Uses of Radio-active Material by the United States, *supra* note 12, at 4.

41. Report of the working Group—Third Session, *supra* note 37, at 2.

42. C. CHRISTOL, *supra* note 38, at 765.

tive measures. For example, a reactor system envisioned for the U.S. Space Station would require either thirty-five to forty-five metric tons of shielding for an onboard reactor, or a tethering system with twelve to twenty metric tons of shielding for a reactor in tow, or a free-flying reactor some 700 kilometers away able to beam its power to the station.[43]

C. Hazards

The hazards presented by an NPS to the terrestrial and extra-terrestrial environment are primarily limited to radiological hazards.[44] The severity of the danger created by a malfunctioning NPS depends on the type of NPS in use, the prelaunch precautions taken, the measures taken when reentry is likely, and the location of reentry.

It is unlikely that an NPS would explode in space.[45] Unless the NPS is sent into deep space, a satellite carrying an NPS will inevitably reenter the earth's environment. The greatest danger is obviously presented by the uncontrolled reentry of an NPS which results in the release of radioactive material. Depending on the amount and location of a release, animals and humans can be harmed by the inhalation, ingestion, or external contact of radioactive material.[46]

The most dangerous NPS accident is the uncontrolled reentry of a nuclear reactor which has failed to respond to a remote control shut down order. A nuclear reactor and its uranium 235 fuel, before the reactor is activated, is relatively safe when compared to the products of the fission process.[47] When reentry is inevitable the safety philosophy has been to burn and disperse the radioactive material in the upper atmosphere.[48] Should this happen, the resulting radioactive material would descend globally over a period of several years. Individually, the dose would not exceed the recommended limits set by the International Commission for Radiological Protection (ICRP) for human exposure.[49] Collectively, though, the dose would be undesirable.[50]

43. *Space Station Nuclear Power Studied*, SPACE BUS. NEWS, Jan. 14, 1985, at 8.
44. Jasentuliyana, *supra* note 39, at 528.
45. C. CHRISTOL, *supra* note 38, at 766.
46. *See, e.g.*, Dembling, *supra* note 13, at 130 (the milk of cows that have eaten contaminated grass is often destroyed).
47. Jasentuliyana, *supra* note 39, at 530.
48. *Id.* at 524.
49. *Id.* at 532.
50. *Id.*

The danger from a reentering NPS can be greatly reduced if the exact landing location could be calculated ahead of time. Unfortunately, even though the United States conducts extensive surveillance of space objects, technology has not progressed to the point where exact predictions can be made.[51] The earth's atmosphere is not uniform and objects often "skip" when reentering.[52] A miscalculation of the reentry time by one minute can cause an error of 300 miles.[53]

The United States North American Aerospace Defense Command tracks all man-made objects in earth's orbit. The Command's Space Surveillance Center keeps a record of an object's position and through the Tracking Impact Prediction (TIP) program, attention is focused on those objects which may reenter the atmosphere within twenty days.[54] Even with all of this attention the error factor of TIP calculations is plus or minus twenty percent.[55] With the reentry of COSMOS 1402, the location of its landing could not be reasonably predicted until two hours before reentry, and no official statement was given because of this lack of absolute certainty.[56]

Still, the current probability of an NPS reentering the earth's atmosphere and landing in a populated area is not very high.[57] With three-quarters of the earth's surface consisting of deep ocean, the odds are against an NPS landing in a populated area.[58] Further, it is estimated that it would take about 10,000 NPS missions, as they are used today, over a ten year period, to create the same radiation hazard to the earth's population as already exists from all of the nuclear weapons tests conducted since 1945.[59]

Nonetheless, with the expected increase in NPS use, a danger does exist. With this technical background, the next step is to assess the state of the law regulating the use of NPS's in outer space.

III. THE STATE OF THE LAW

To present a clear and uncluttered survey of the law covering nuclear power use in outer space, the following discussion will be first

51. W. Wirin, *supra* note 4, at 5.
52. *Id.*
53. *Id.*
54. *Id.*
55. *Id.*
56. *Id.*
57. Hosenball, *Nuclear Power Sources in Outer Space*, 6 J. SPACE L. 119 (1979).
58. Jasentuliyana, *supra* note 39, at 531.
59. *Id.* at 530 n.34.

divided into the two major categories that have naturally developed: (1) pre-accident law, and (2) post-accident law (liability). Within these major categories the discussion will be further divided into the areas of space law and environmental law. Because there is no one source of international law governing NPS use, such as a multilateral convention, the sources of existing law are diverse and often less than directly on point.

A. Pre-accident Law

1. Space Law

Three multilateral space conventions and the Chicago Convention on International Civil Aviation in some way regulate pre-accident NPS use.

(a) Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space Including the Moon and Other Celestial Bodies (Outer Space Treaty)[60]

Article 1 of the Outer Space Treaty establishes that outer space shall be free for exploration and use, on the basis of equality, in accordance with international law and that exploration "shall be carried out for the benefit and in the interest of all mankind. . . ."[61] Therefore, there exists the basic right to use outer space in any fashion which does not violate international law or harm mankind.

Under Article 9, states shall avoid uses which contaminate outer space and interfere with other states' use of outer space. Should a state "have reason to believe that an activity . . . would cause potentially harmful interference . . . it shall undertake appropriate international consultations before proceeding with any such activity or experiment."[62] As designed and intended, an NPS does not constitute a harmful contamination of outer space or a roadblock to the use of outer space. Strictly reading Article 9, then, consultation prior to launch does not appear necessary.

When an NPS is damaged or malfunctions, Article 9 clearly requires consulation if it presents a threat to the outer space environment. The absence in Article 9 of a reference to potential harm to

60. Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies, Jan. 27, 1967, United States—United Kingdom—U.S.S.R., 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205 [hereinafter cited as Outer Space Treaty].

61. Outer Space Treaty, art. 1, 18 U.S.T. at 2412, T.I.A.S. No. 6347.

62. Outer Space Treaty, art. 9, 18 U.S.T. at 2416, T.I.A.S. No. 6347.

the earth's environment is curious. This omission would seem to excuse notice when only the earth's environment is at risk. However, a persuasive argument can be made that the requirement in Article 9 that parties to the Treaty shall conduct their outer space activities "with due regard to the corresponding interest of all other States Parties to the Treaty"[63] obliges consultation when there is a potential for harm to the earth's environment.

(b) Convention on Registration of Objects Launched into Outer Space (Registration Convention)[64]

Article 4 of the Registration Convention supplements and expands upon Article 11 of the Outer Space Treaty. Although it is more detailed, Article 4 of the Registration Convention contains the same basic loopholes as Article 11 of the Outer Space Treaty.

A launching state must report to the U.N. Secretary-General the date, territory of launch, basic orbital parameters, and general function of the space object launched. Such a report need only be done "as soon as practicable."[65] These reporting requirements only affect NPS use if the launching state wishes them to. Because only the general function, and not the power source, need be reported, other nations are not put on notice of an NPS's use unless the launching state exceeds the bare requirements and includes details of the power source used.

(c) Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (Moon Treaty)[66]

The Moon Treaty, which came into force on July 11, 1984, contains the most specific regulation of NPS use to be found in the space treaties. The Moon Treaty's importance and place among the other widely accepted space treaties is in doubt though. Because of the Treaty's controversial language concerning the moon's natural resources[67] the space capable nations have not yet ratified it. Without their ratification, the Moon Treaty's impact on space activities is questionable.

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63. *Id.*

64. Convention on Registration of Objects Launched into Outer Space, *opened for signature* Jan. 14, 1975, 28 U.S.T. 695, T.I.A.S. No. 6347, 1023 U.N.T.S. 15.

65. Registration Convention, art. 4, 28 U.S.T. at 699, T.I.A.S. No. 6347.

66. G.A. Res. 34/68, 34 U.N. GAOR Supp. (No. 46) at 77, U.N. Doc. A/34/46 (1979).

67. Although there is disagreement over the interpretation of Article 11 of the Moon Treaty, there is a considerable body of opinion that Article 11 effectively prohibits the exploitation of the moon's natural resources by anyone other than the international regime envisioned by Article 11. Moon Treaty, art. 11, G.A. Res. 34/68, 34 U.N. GAOR Supp. (No. 46) at 77, U.N. Doc A/34/46 (1979).

As it concerns the moon's environment, the Moon Treaty contains several relevant provisions. Paragraph one of Article 7 obligates states to avoid disruption of the moon's environment by the introduction of contaminating "extra-environmental matter or otherwise."[68] Article 7, like Article 1 of the Outer Space Treaty, creates a duty to be careful. Thus, when using NPSs on the moon, states must take measures to avoid the release of radioactive material.

Paragraph two of Article 7 is the most significant for NPS use. States, "to the maximum extent feasible,"[69] must notify, in advance, the U.N. Secretary-General of all placements of radioactive material on the moon and the purpose of the placement. This provision significantly expands the information required by the Outer Space Treaty and Registration Convention. Strangely, Article 7 of the Moon Treaty does not oblige the Secretary-General to pass the information on to the U.N. membership. It is not clear whether the Moon Treaty's preamble reference to the Outer Space Treaty incorporates Article 11 of the Outer Space Treaty and thereby the Secretary-General's obligation to disseminate reported information. Without the dissemination of information there appears to be little purpose in the reporting requirements though.

The second sentence of paragraph one in Article 7 presents an interpretation problem. The majority of the sentence is straightforward and clear: "States Parties shall also take measures to avoid harmfully affecting the environment of the earth through the introduction of extraterrestrial matter. . . ."[70] But the last two words, "or otherwise," of that sentence, appear to greatly expand a state's obligation to avoid harming the terrestrial environment. There is no way to predict how much this expands a state's obligation. It is enough at this point to take note of it.

Article 5 of the Moon Treaty holds several notice requirements that indirectly affect the use of NPSs. The first notice provision, in paragraph one, follows the requirements of the Outer Space Treaty and Registration Convention. States must inform the Secretary-General "to the greatest extent feasible and practicable" of their moon activities.[71] "As soon as possible after launching" the Secretary-General

68. Moon Treaty, art. 7, G.A. Res. 34/68, 34 U.N. GAOR Supp. (No. 46) at 77, U.N. Doc. A/34/46 (1979).

69. *Id.*

70. *Id.*

71. Moon Treaty, art. 5, G.A. Res. 34/68, 34 U.N. GAOR Supp. (No. 46) at 77, U.N. Doc. A/34/46 (1979).

is to be informed of the time, purpose, location, orbital parameters, and duration of a moon mission.[72]

The second notice provision of Article 5, found in paragraph two, requires bilateral pre-launch information exchange when two moon missions will be operating in close proximity. Also broadly worded, this provision requires the exchange of mission timing and plans for operation. Whether plans for operation includes the use of an NPS remains to be seen.

The remaining provisions of the Moon Treaty only slightly effect NPS use. Article 4, paragraph two, requests cooperation and mutual assistance among states in the moon's use. Article 12, paragraph three, provides that in the event of a life threatening emergency, States Parties may use another Party's equipment. Article 13 requires notice to the Secretary-General of an unintended landing on the moon. These three provisions, particularly Article 12, under unique circumstances may effect the way in which an NPS is used. For instance, might Article 12 permit another state to shut down an NPS that is life threatening?

(d) Convention of International Civil Aviation (Chicago Convention)[73]—Annex 18

Annex 18 to the Chicago Convention is titled "The Safe Transport of Dangerous Goods by Air." It contains international standards and recommended practices adopted by the International Civil Aviation Organization (ICAO) pursuant to Article 37 of the Chicago Convention. Under the provisions of the Chicago Convention, international standards are regulations recognized as necessary for the safety of international air navigation. International standards are binding upon parties to the Chicago Convention unless notification of a difference (inability to comply) is submitted to the ICAO Council. Recommended practices are similar to international standards in function, but are not binding, and notification of a difference is not mandatory but encouraged.

Chapter 4, section .1, of Annex 18 forbids the transport of dangerous goods by air unless the safety procedures detailed in it are followed. Radioactive material is listed as a dangerous good.[74]

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72. *Id.*

73. Convention on International Civil Aviation, Dec. 7, 1944, 61 Stat.(2) 1180, 3 Bevans 944, T.I.A.S. No. 1591, 15 U.N.T.S. 295.

74. The Safe Transport of Dangerous Goods By Air, ICAO Annex 18, sec. 3.1, ICAO Order No. 418004 (1st ed. Jan., 1983).

Therefore, nuclear material transported by air must be done according to the requirements of the *Technical Instructions for the Safe Transport of Dangerous Goods by Air* (an ICAO document incorporated by reference to Annex 18),[75] and must meet the other miscellaneous requirements of Annex 18. For example, section 8.7.4 reads: "packages of radioactive material . . . shall be separated from persons, live animals and undeveloped photographic film according to the separation distances tabulated in the Technical Instructions."[76]

Whether the regulations of Annex 18 apply to the use of NPS is not clear. The Chicago Convention does not contain unequivocal terms of application. Article 3 has the only language of application which reads: "This Convention shall be applicable only to civil aircraft and shall not be applicable to state aircraft."[77] From Article 3 it would appear that the Chicago Convention applies to vehicles classified as aircraft and not to the physical territory classified as air space.[78] Therefore, whether Annex 18 coverage extends to the civil use of an NPS in outer space depends on whether the vehicle it is transported in or that it powers can be categorized as an aircraft. That question is beyond the scope of this paper. It is enough here to point out that the Space Transport System has both the capacity to transport an NPS and the capability to return to earth as an aircraft.

(e) United National General Assembly Resolutions

United Nation General Assembly resolutions, though not listed as a source of international law by Article 38 of the Statute of the International Court of Justice,[79] at times play a formative role in the development of international law. To that extent General Assembly Resolution 33/16 of November 10, 1978, might become important.[80] That resolution, among other things, requests that launching states inform those states at risk of the possible reentry of an NPS. However, con-

75. U.N. Doc. No. 9234-AN/905.

76. ICAO Annex 18, sec. 8.7.4.

77. Chicago Convention, art. 3, Dec. 7, 1944, 61 Stat. (2) 1180, 3 Bevans 944, T.I.A.S. No. 1591, 15 U.N.T.S. 295.

78. ICAO Annex 7 further defines aircraft covered by the Chicago Convention. However, it is of no help in determining whether a civilian shuttle system is covered by the Chicago Convention. This is particularly so if the plan to have a shuttle-type craft take off as an ordinary aircraft is realized. Aircraft Nationality and Registration Marks, ICAO Order No. 407007 (4th ed. July, 1981).

79. Statute of the International Court of Justice, art. 38, June 26, 1945, 59 Stat. 1055, T.S. No. 933.

80. G.A. Res. A/33/16, 33 U.N. GAOR Supp. (No. 45) 66, U.N. Doc. A/33/45 (1978).

sidering the present technical difficulties in predicting the exact location of a space object's point of reentry and the secrecy surrounding the military use of some NPSs, Resolution 33/16 will have difficulty gaining the legally binding status that some other General Assembly resolutions have achieved.[81]

2. Environmental Law

Because nuclear power by its nature presents a potential for environmental harm, environmental law plays a role in the regulation of NPS use. As will be seen, just as with space law, international environmental law does not contain specific regulation of NPS use.

(a) Convention on the High Seas[82]

Article 25 of the 1958 Convention on the High Seas, in its first paragraph, mandates that every state shall take measures to prevent pollution of the seas from the dumping of radioactive waste. In doing so, states shall take into account the regulations of competent international organizations. The competent international organization in this instance is the International Atomic Energy Agency (IAEA).[83] Further, paragraph two of Article 25 requires cooperation between all states and "the competent international organization" to prevent pollution of the seas and air space above from radioactive materials.[84] Consequently, should a launching state intend to disperse the radioactive waste of an NPS into the air space above the open seas, as has happened, IAEA standards and regulations must be followed. Also, if there is a possibility that an NPS will return to earth and land in the open seas, IAEA standards must be met.

(b) The International Atomic Energy Agency

The IAEA is an autonomous organization associated with the United Nations. It was enacted by statute in 1957.[85] Its primary pur-

81. A few widely supported United Nations General Assembly Resolutions have come to be accepted as declaratory of customary international law. The Universal Declaration of Human Rights is often thought to have obtained this legal status. Universal Declaration of Human Rights, G.A. Res. 217, 3 U.N. GAOR, U.N. Doc. 1/777 (1948).

82. Law of the Sea: Convention on the High Seas, *opened for registration* Apr. 29-Oct. 31, 1958, 13 U.S.T. 2312, T.I.A.S. No. 5200, 450 U.N.T.S. 82.

83. Jasentuliyana, *supra* note 39, at 542 n.78.

84. Convention on the High Seas, art. 25, 13 U.S.T. at 2319, T.I.A.S. No. 520 (1958).

85. Statute of the International Atomic Energy Agency, *opened for signature* Oct. 26, 1956-Jan. 24, 1957, 8 U.S.T. 1093, T.I.A.S. No. 3873, 276 U.N.T.S. 3, *amended* October 4, 1961, 14 U.S.T. 135, T.I.A.S. No. 5284, 471 U.N.T.S. 334 [hereinafter cited as IAEA Statute].

pose is to promote the peaceful and safe use of atomic energy. The IAEA is perhaps best known for providing atomic material, technology, equipment, and inspection services to those states which agree to abide by IAEA standards and regulations.[86]

Called the Safety Series, the IAEA has created a set of standards and regulations for the safe management of radioactive material. Though not binding by terms of the IAEA statute, Safety Series standards and regulations are applicable to NPS use as described in the immediately above section, "(a) Convention on the High Seas." Some of the IAEA Safety Series publications relevant to NPS use include: No. 5, *Radioactive Waste Disposal in the the Sea*; No. 6, *Regulations for Safe Transport of Radioactive Materials*; and, No. 12 *Management of Radioactive Waste Produced by Radioisotope Users.*

(c) Customary Law and General Principles of Law

While there is not complete unanimity of opinion, the general consensus, according to one observer, is that international customary law contains no rules of environmental protection.[87] Further, those principles which are recognized by some authorities as customary law generally apply to questions of liability. There are, however, rules of customary law and general principles of law relevant to pre-accident NPS regulation.

The customary rules of state responsibility, territorial sovereignty, and freedom of the high seas bear upon the use of NPSs. State responsibility and territorial sovereignty combine to create a restraint on the abuse of another state's environment. Freedom of the seas directly implies the non-exhaustive enjoyment or sharing of the sea environment.[88] Add to these customary rules the general principle of *sic utere tuo ut alienum non leadas* (use your property so as not to injure your neighbor) and the result is a duty to use NPSs as safely as possible.[89]

Professor Gunther Handl asserts that there is an international duty of prior notification and consultation when planned activities carry a significant risk of transnational environmental harm.[90] In sup-

86. *See* IAEA Statute, art. III, 8 U.S.T. at 1095-97 T.I.A.S. No. 3873, 276 U.N.T.S. at 6.

87. Brownlie, *A Survey of International Customary Rules of Environmental Protection*, 13 NAT. RESOURCES J. 179 (1973).

88. *Id.*

89. B. JOHNSON, INTERNATIONAL ENVIRONMENTAL LAW 9 (1976).

90. Handle, *The Environment: International Rights and Responsibilities*, in PRO-

port of his claim he cites Principle 21 of the Stockholm Declaration[91] and several U.N. General Assembly Resolutions.[92] If Professor Handl is correct, states may be obliged to give prelaunch notice and information about NPS use. This however assumes that NPS use creates a significant risk of transnational environmental harm and that contrary customary law has not been established by the twenty-four years of NPS launches without prior notice.

(d) Subsidiary Sources of Law

(i) Decisions of International Tribunals

Two decisions have had an indirect effect on NPS use. Together the *Trail Smelter Arbitration*[93] and the *Corfu Channel Case*[94] have placed upon every state the "obligation not to allow knowingly its territory to be used for acts contrary to the rights of other states."[95]

Although both of these well worn cases dealt with the use of sovereign territory in a way that harmed the property of another sovereign state, the principle can be transferred to space craft. Under the Outer Space Treaty, the Registration Convention, and the Moon Treaty, a space object retains the nationality of the state of registration after launch. A space object can therefore be considered for some purposes to be a piece of sovereign territory. The state of registry must therefore take measures to prevent harm that its space objects may cause to the territory of another state.

(ii) Declaration of the United Nations Conference on the Human Environment (Stockholm Declaration)[96]

The Stockholm Declaration is a collection of principles and recommendations concerning the human environment. The principles are not binding international law in the formal sense, but they are in some instances a restatement of customary law[97] and in other instances evidence of state practice and thought. Three of the principles have some impact on NPS use.

CEEDINGS OF THE 73RD MEETING OF THE AMERICAN SOCIETY OF INTERNATIONAL LAW 223, 224 (1980).

91. Report of the United Nations Conference on the Human Environment, U.N. Doc. A/Conf., 48/14 (June 5-16, 1972).

92. Handle, *supra* note 90, at 225.

93. 3 R. Int'l. Arb. Awards 1905 (1935).

94. U.K. v. Alb., 1949 I.C.J. 4.

95. *Id.*

96. U.N. Doc. A/Conf. 48/14 (June 5-16, 1972).

97. Principle 21 is thought by several authorities, including Ian Brownlie, to be existing customary law. *See* Brownlie, *supra* note 87, at 188.

Principle 6 reads:

> The discharge of toxic substances or of other substances and the release of heat, in such quantities or concentrations as to exceed the capacity of the environment to render them harmless, must be halted in order to ensure that serious or irreversible damage is not inflicted upon ecosystems. The just struggle of the people of all countries against pollution should be supported.[98]

The relatively strong language of Principle 6 could render the United States policy of scattering the radioactive material of returning NPSs throughout the upper atmosphere illegal.[99] However, Principle 6 so far only represents the thoughts of some states.

Principle 7, which reads: "[s]tates shall take all possible steps to prevent pollution of the seas by substances that are liable to create hazards to human health, to harm living resources and marine life, to damage amenities or to interfere with other legitimate uses of the sea,"[100] is similar in effect to Article 25 of the Convention on the High Seas.[101] It is different from Article 25 in its broader application. For NPS use, Principle 7 on its face creates a more compelling duty to protect against the release of radioactive material from NPSs that splash into the earth's seas. Principle 7, like Principle 6, is, however, no more than evidence of state thought.

The third of the Stockholm Principles which bear upon NPS use is number 21. Principle 21, thought by some observers to be a restatement of customary law,[102] reads:

> States have, in accordance with the Charter of the United Nations and the principles of international law, the sovereign right to exploit their own resources pursuant to their own environmental policies, and the responsibility to ensure that activities within their jurisdiction or control do not cause damage to the environment or other States or of areas beyond the limits of national jurisdiction.[103]

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98. Declaration of the United Nations Conference on the Human Environment, U.N. Doc. A/Conf. 48/14 (June 5-6, 1972).

99. This policy is only in place for nuclear reactors. *See* Uses of Radio-active Materials by the United States, *supra* note 12, at 5.

100. *Id.*

101. Convention on the High Seas, art. 25, 13 U.S.T. at 2319, T.I.A.S. No. 520 (1958).

102. *See supra* note 97 and accompanying text.

103. Declaration of the United Nations Conference on the Human Environment, U.N. Doc. A/Conf. 48/14 (June 5-16, 1972).

Principle 21 represents a delicate balance between a state's right to control matters within its territory and a state's responsibility to ensure that these matters do not cause damage outside its territory.[104] The primary impact of Principle 21 is post-accident, reinforcing the principle of state liability for transnational pollution, discussed below. For pre-accident use, Principle 21 does what many other previously discussed rules do, namely create a duty to be careful. It can also be argued that Principle 21, in its recognition of a state's right to exploit its own resources, permits the use of NPSs.

B. Post-accident Law

1. Space Law

(a) Convention on International Liability for Damage Caused by Space Objects (Liability Convention)[105]

The crash of COSMOS 954 provided an excellent opportunity to test the utility of the Liability Convention. The test results are not conclusive, but the examination process has put more flesh on the bones of the Liability Convention than exists on any of the other space treaties. The exact role played by the Liability Convention in settling Canada's claim may never be known, but any future NPS accident settlements will have the COSMOS 954 precedent to follow.

The Liability Convention expands upon Article 7 of the Outer Space Treaty. The Convention's primary features may be found in Articles 2 and 3. Under Article 2, a launching state is absolutely liable for the damage caused by its space object on the surface of the earth or to an aircraft in flight. According to Article 3, if the damage is caused elsewhere than the surface of the earth, the launching state is liable only when it is at fault. Under the Convention's scheme, for damages caused on earth, three elements must be proven: damage, the presence of a space object, and that damage was caused by the space object.[106]

When dealing with an NPS and radioactive contamination, the primary question becomes the definition of damage covered by the Convention, as it did in the COSMOS 954 incident. COSMOS 954

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104. Sohn, *The Stockholm Declaration on the Human Environment*, 14 HARV. INT'L L.J. 423, 485-86 (1973).

105. Convention on International Liability for Damage Caused by Space Objects, Mar. 29, 1972, United States—United Kingdom—U.S.S.R., 24 U.S.T. 2389, T.I.A.S. No. 7762 [hereinafter cited as Liability Convention].

106. Gorove, *COSMOS 954: Issues of Law and Policy*, 6 J. SPACE L. 137, 138 (1978).

caused little physical damage. Its primary harm was in the form of radioactive residue.[107] The cost incurred by Canada was primarily for the search and clean up of contaminated material. When faced with Canada's claim for damages, the Soviet Union stated: "That the radiation situation over the entire examined territory judging by the level of external radiation could be recognized as practically safe for population. In similar conditions further search on the Soviet Union's territory would evidently be discontinued."[108] By this statement it appears that the Soviet Union intended to indirectly point out that it felt Canada's clean up effort could not be included in a damage claim under the Liability Convention.

Article 1 defines damage as the "loss of life, personal injury or other impairment of health; or loss of or damage to property of states or of persons, natural or judicial, or property of international intergovernmental organizations."[109] If a space object powered by an NPS strikes a person, there is no question but that the launching state is liable for the resulting personal injuries. But when the NPS leaks radioactive material, the plain language of Article 1 does not unequivocally indicate whether the launching state is liable for the resulting nuclear injuries, pollution, and clean up efforts.

Authorities who have studied the drafting history of the Liability Convention generally agree that personal injuries caused by nuclear power sources are covered by the Convention.[110] The history shows that the inclusion of nuclear injuries was debated at length with the majority of states supporting its inclusion.[111] Whether pollution of the environment and a subsequent clean up effort are included as damages is less certain. Professor Carl Q. Christol, reasoning that environmental pollution "can produce an unacceptable interference in valid expectations for beneficial and peaceful uses and activities in space," believes that pollution is covered by the Convention.[112] Also, Jason Reiskind believes that the settlement of Canada's COSMOS 954 claim for three million dollars supports the position that "damages to property of a state" includes nuclear contamination.[113] However, Nundasiri Jasen-

107. W. Wirin, *supra* note 4, at 1.

108. *Id.* at 2.

109. Liability Convention, art. 1, 23 U.S.T. at 2392, T.I.A.S. No. 7762.

110. Jasentuliyana, *supra* note 39, at 548.

111. *Id.*

112. Christol, *Protection of Space From Environmental Harm*, 4 ANNALS AIR & SPACE L. 433, 450-52 (1979).

113. Reiskind, *Toward a Responsible Use of Nuclear Power in Outer Space—The Canadian Initiative in the United Nations*, 6 ANNALS AIR & SPACE L. 461, 463 (1981).

tulyana, a staff member of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS), believes that pollution per se may not be covered and that the question of clean up costs has to yet be decided by COPUOS.[114]

A complete and full discussion of the Liability Convention is not the purpose of this article, but a few more details about the Convention are in order. The statute of limitation periods found in Article 10 are relevant. A claim must be presented through diplomatic channels within one year after the date damage was incurred.[115] If the full extent of the damage is not known, the claim may be revised within one year after the full extent is known or should have been known through the exercise of due diligence.[116]

If an amount which will restore the claimant to the condition that existed prior to the injury[117] is not agreed upon within one year, then a claims commission may be established by the request of either party under Article 14. The claims commission is to be composed of three members chosen by the method specified in Article 15. The commission's decision will be binding if the parties so agree, but in all cases it will be made public.[118] A nonbinding decision is to be considered in good faith.[119]

(b) Outer Space Treaty[120]

The Outer Space Treaty contains the general principles upon which the Liability Convention was built. Article 6 creates international responsibility for a state's activities in outer space. Article 7 places international liability on the state which launches, procures the launch, or allows the launch from its territory of a space object which causes damage to another State Party. However, after the coming to force of the Liability Convention, the Outer Space Treaty does little more than supplement the Liability Convention in this area. Although, according to Professor Christol, the Outer Space Treaty, by not specifying that an object must reach orbit, creates liability for aborted launches.[121] This may be significant to NPS use if an aborted launch results in nuclear contamination.

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114. Jasentuliyana, *supra* note 39, at 546.
115. Liability Convention, art. 10, 24 U.S.T. at 2396, T.I.A.S. No. 7762.
116. *Id.*
117. Liability Convention, art. 12, 24 U.S.T. at 2397, T.I.A.S. No. 7762.
118. Liability Convention, art. 19, 24 U.S.T. at 2400, T.I.A.S. No. 7762.
119. *Id.*
120. 18 U.S.T. 2410, T.I.A.S. No. 6347, 610 U.N.T.S. 205.
121. C. CHRISTOL, *supra* note 38, at 797.

(c) Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (Rescue Agreement)[122]

As with the Liability Convention, the Rescue Agreement played a major role in the COSMOS 954 incident. The Soviet Union's failure to ask for the return of the debris from COSMOS 954 was likely because it wished to avoid the requirements of Article 5, paragraph five, of the Rescue Agreement.[123]

Each contracting state that finds a space object within its territory has an obligation to notify the launching state and the Secretary-General of its presence.[124] Then, if the launching state requests, the state where the object has been found is to take such steps as are practical to recover and return the object or its component parts.[125] The catch is that under Article 5, paragraph five, the launching state is to pay the expenses incurred. Therefore, if the Soviet Union had asked for the return of COSMOS 954, or what was left of it, the Soviet Union would have been obligated to pay the expenses incurred.

Paragraph four of Article 5 is of particular relevance to NPS use. Paragraph four provides that when a contracting state discovers a hazardous space object in its territory, it may request that the launching state take immediate steps, under the victim state's direction, to eliminate the danger. This provision may be particularly important if an NPS leaks radioactive material after landing in a state that does not possess the technical ability to deal with the danger. Should a victim state not request aid from the launching state, the liability of the launching state is not lessened.[126] Yet the Soviet Union insisted that it had a duty—the equivalent of a right—to assist in the clean up of COSMOS 954 under the Rescue Agreement.[127]

(d) Moon Treaty

Article 14 of the Moon Treaty repeats Article 6 of the Outer Space Treaty in stating that States which are Parties to the Moon Treaty bear international responsibility for their national activities

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122. Agreement on the Rescue of Astronauts, The Return of Astronauts and the Return of Objects Launched into Outer Space, *opened for signature* April 22, 1968, 672 U.N.T.S. 119 [hereinafter cited as Rescue Agreement].

123. W. Wirin, *supra* note 4, at 2.

124. Rescue Agreement, art. 5, para. 1, 672 U.N.T.S. at 122.

125. Rescue Agreement, art. 5, paras. 2 and 3, 672 U.N.T.S. at 122.

126. W. Wirin, *supra* note 4, at 2.

127. *Id.*

on the moon. For NPS use this emphasizes the responsibility for any harm caused by an NPS on the moon.

2. Environmental Law

(a) International Conventions

There are four conventions which deal with environmental damage caused by nuclear power use. Of the four conventions, three are not in force and the remaining convention has not been ratified by any of the space powers.

The Convention on Civil Liability for Nuclear Damage (Vienna Convention),[128] which has not come into force, contains several provisions that could be very relevant to NPS use. The Vienna Convention contains the following principles applicable to the operation of a "nuclear installation:" (1) absolute liability of the facility operator (strict liability) (Art. 4); (2) a limitation on the operator's liability (Art. 5); (3) a statute of limitations (Art. 6); and (4) mandatory insurance coverage (Art. 7).[129] It is very possible, though, that NPSs do not fit within the definition of a nuclear installation. Section 1(j)(i) of Article 1 defines a "nuclear installation" as "any nuclear reactor other than one with which a means of sea or air transportation is equipped for use as a source of power, whether for propulsion thereof or for any other purpose."[130] During the negotiations of the Convention on International Liability for Damage Caused by Space Objects, it was decided to include coverage of nuclear damage because of the uncertainty over whether the Vienna Convention covered NPS use.[131]

Of the three remaining conventions, the two that deal directly with nuclear liability are similar to the Vienna Convention. Both the Convention on Third Party Liability in the Field of Nuclear Energy (Third Party Liability Convention)[132] and the Convention on the Liability of Operators of Nuclear Ships (Ship Operators Convention)[133] create absolute liability and limit collectable damages. The Third Party Convention is in force, but the Ship Operators Convention is not.

128. Convention on Civil Liability for Nuclear Damage, I.A.E.A. Doc. No. CN-12/46 (1963).

129. *Id.*

130. *Id.*

131. C. CHRISTOL, *supra* note 38, at 799.

132. Convention on Third Party Liability in the Field of Nuclear Energy, O.E.E.C. Doc. No. C (60), at 93 (1960).

133. Convention on the Liability of Operators of Nuclear Ships, *reprinted in* 57 AM. J. INT'L L. 268 (1963).

The remaining convention with relevance to NPS liability is the 1982 Law of the Sea Convention.[134] Article 235 of that convention reads "States are responsible for the fulfillment of their international obligations concerning the protection and preservation of the marine environment. They shall be liable in accordance with international law."[135] Should the Law of the Sea Convention come into force, Article 235 may add to and extend international liability for leaks of radioactive material over the high seas. Under current international law, damages can be collected only when an international entity has been harmed or when an international entity represents a damaged non-international entity. In most cases this menas that a state or one of its citizens must be damaged. However, under the Law of the Sea Convention, international liability may be extended to damage to the marine environment of the high seas alone.

Article 157, paragraph two,[136] of the Law of the Seas Convention, enumerates the powers of the Authority.[137] Among those powers are "such incidental powers, consistent with this Convention, as are implicit in and necessary for the exercise of those powers and functions with respect to activities in the Area."[138] The Authority may exercise those powers to protect the Area's environment under Article 215.[139] It could be reasonably argued that the Authority's powers include enforcement of the international liability recognized by Article 235. If this line of reasoning is correct, states might be liable, in some fashion or another, for radioactive material released by an NPS returning to earth over the high seas Area.

(b) Customary Law and General Principles of Law

Authorities agree that states bear international liability for transnational pollution resulting from a violation of international law.[140] For example, a state would be internationally liable for nuclear damage resulting from the detonation of a nuclear weapon in earth orbit. There

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134. Third United Nations Conference on the Law of the Sea, part IX, art. 235, Responsibility and Liability, U.N. Doc. A/Conf. 62/122 (Oct. 7, 1982) [hereinafter cited as Law of the Sea Convention].

135. *Id.*

136. *Id.* at Part XI, Art. 157.

137. The "Authority" is defined by Article 1 as "the International Sea-Bed Authority." The "General Provisions" governing the Authority can be found in section 4 of Part XI.

138. Law of the Sea Convention, Part XI, Art. 157, U.N. Doc. A/Conf. 62/122 (Oct. 9, 1982).

139. *Id.* at Part XII, Art 215.

140. Handle, *supra* note 90, at 229.

is, however, debate over whether states are strictly liable for transnational pollution in the absence of a violation of international law.

Mr. Ian Brownlie argues that strict liability exists for transnational pollution.[141] He maintains that while a certain amount of contamination is tolerated, the *Corfu Channel Case*,[142] the *Trail Smelter Arbitration*,[143] and state practice concerning the responsibility for harboring armed bands demonstrates that states are strictly liable for harm caused to other states or their nationals.[144] The majority of writers do not find the *Trail Smelter Arbitration* and the *Corfu Channel Case* to authoritatively establish strict liability for transnational pollution injury though.[145] The majority's position is supported by the recent debates within the International Law Commission drafting sessions for Article 23 of its draft articles on state responsibility.[146]

While strict liability for transnational pollution may not yet exist, strict liability for harm caused by ultrahazardous activities may constitute a "general principle of law recognized by civilized nations."[147] The Canadian Government expressed this opinion in its note claiming damages of the Soviet Union for the COSMOS 954 incident.[148]

Another principle that might constitute customary law, which is relevant to NPS use, is the concept of self help.[149] On behalf of all humanity, a nation possessing the technical means to reorbit a faltering NPS might follow the example of the British Government in the Torrey Canyon incident and mitigate the results of a potential disaster.[150] The United States Space Transport System now creates this possibility.

(c) Subsidiary Sources of Law

The most common subsidiary source of international environmental law; namely, the decisions of international tribunals, have been

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141. Brownlie, *supra* note 87, at 180.

142. U.K. v. Alb., 1949 I.C.J. 4.

143. 3 R. Int'l Arb. Awards 1905 (1935).

144. Brownlie, *supra* note 87, at 180.

145. Handle, *supra* note 90, at 229.

146. *Id.*

147. "[G]eneral principles of law recognized by civilized nations" are a source of international law recognized by the International Court of Justice. Art. 38(1)(c), Statutes of the International Court of Justice, June 26, 1945, 59 Stat. 1055, T.S. No. 933.

148. Handle, *supra* note 90, at 230.

149. C. CHRISTOL, *supra* note 38, at 809, *quoting* DeSaussure, *An International Right to Reorbit Earth-threatening Satellites*, in PROCEEDINGS OF THE 21ST COLLOQUIUM ON THE LAW OF OUTER SPACE 95 (1979).

150. Brownlie, *supra* note 87, at 186.

greatly overworked. The *Trail Smelter Arbitration* between the United States and Canada,[151] and the *Corfu Channel Case* between the United Kingdom and Albania[152] have been mandatory material for every commentary on state responsibility and environmental law; yet, there is no uniform reading of their value. Some authorities cite them as conclusive proof of state responsibility for transnational pollution, while other authorities find them inconclusive. Nonetheless, in their general terms, they must be read as supporting the principle of state responsibility for damage caused by NPSs.

Domestic law, as either a subsidiary source of law or an indication of state practice, has relevance here. This is particularly so when it is the domestic law of a nation using NPSs. Under the United States' National Environmental Protection Act,[153] several administrative agencies assess the potential environmental effect of a proposed NPS. Further, every NPS must be personally approved by the President prior to launch.[154]

A potential, but not yet contributing, source of law is the United Nations Environmental Program (UNEP). Formed by the 1972 United Nations Conference on the Human Environment, and adopted by General Assembly Resolution,[155] the UNEP is basically designed to coordinate international pollution policy and aid programs to fight transnational pollution. As of yet it is not the source of international law effecting the use of NPSs. However, if operating as designed, the UNEP could aid in the clean up of NPS accidents.[156]

IV. Current Efforts to Regulate

While Canada was still involved in the search and clean up effort following the crash of COSMOS 954, the Scientific and Technical Subcommittee of the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) convened on February 13, 1978. Canada immediately brought the incident to the Subcommittee's attention. Concerned about the lack of safety standards for NPS use, Canada, along with eight other nations, submitted a proposal for the creation of a

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151. 3 R. Int'l Arb. Awards 1905 (1935).
152. U.K. v. Alb., 1949 I.C.J. 4.
153. 42 U.S.C. sec. 4321-61 (1976 & Supp. IV 1980).
154. Hosenball, *supra* note 57, at 122.
155. U.N. Gen. Ass. 2997 (XXVII), December 15, 1972.
156. The UNEP has four operating bodies, which are: (1) the Governing Council of the United Nations Environmental Program; (2) the Environment Secretariat; (3) the Environment Fund; and (4) the Environment Co-ordination Board.

working group within the Scientific and Technical Subcommittee to consider the safety issues involved in the use of NPSs and to create operation standards.[157] By resolution 33/16, the General Assembly endorsed Canada's proposal and established the Working Group on the Use of Nuclear Power Sources in Outer Space (Working Group) on November 10, 1978. The Working Group held its first meeting in February of 1979.

A. The Working Group

The Working Group met three times between 1979 and 1981. At these meetings the Working Group focused on three issues: safety, search and recovery, and notification. During discussions of each issue, two groups with different perspectives developed. The first group, lead by Canada, pressed for the creation of detailed standards. The second group, composed of the Eastern European delegations, was of the opinion that existing regulations sufficiently governed the use of NPSs.[158]

During the three years many positions were put forth. Some states called for notice to all other states prior to the launch of an NPS, while others proposed a moratorium until NPS use could be fully regulated.[159] Still others suggested that a limit on the number of NPSs allowed in orbit at one time be set.[160] At the conclusion of its third meeting the Working Group issued a report which generally took the middle ground. Believing its work to be completed, the Working Group then decided to cancel further meetings.

The highlights and conclusions of the 1981 report of the Working Group can be summarized as follows:

> (1) The safety of radioisotope systems was being assured by "designing them to contain with a high probability of success the radio-isotope for normal and credible abnormal conditions."
>
> (2) The safe operation of nuclear reactors can be greatly improved if they are only started and operated in

157. Jasentuliyana, *supra* note 39, at 533 n.42.
158. Reiskind, *supra* note 113, at 465.
159. W. Wirin, *supra* note 4, at 4.
160. *Id.*

high orbits which allow the radioactive material to decay to safe levels. If used in low earth orbits, the safe operation of NPSs depends on the ability to boost them into higher orbit after their missions are completed.

(3) Any release of radioactive material into the earth's atmosphere should conform with standards created by the International Commission on Radiological Protection (ICRP).

(4) Missions employing an NPS should take the radiation protection methods recommended by ICRP publication number 26.

(5) States launching an NPS should conduct an assessment of radiation risks prior to launch.

(6) As recommended in ICRP publication No. 26, the annual dose for nuclear industry workers should not exceed 50 mSv (5 rem) and for the public 5 mSv from all man-made sources.

(7) States should be informed of the possible reentry of an NPS at the earliest possible time. The following format for notification should be used:

1. *System parameters*

1.1 Name of launching State or States including the address of the authority which may be contacted for additional information or assistance in case of accident.

1.2 International designation.

1.3 Date and territory or location of launch.

1.4 Information required for best prediction of orbit lifetime, trajectory, and impact.

1.5 General function of spacecraft.

2. *Information on the radiological risk of nuclear power source(s)*

2.1 Type of NPS: radio-isotopic/reactor.

2.2 The probable physical form, amount and general radiological characteristics of the fuel and contaminated and/or activated components likely to reach the ground. The term "fuel" refers to the nuclear material used as the source of heat or power.

(8) NPSs can be safely used if all recommended safety measures are taken.[161]

On December 15, 1983, the General Assembly asked the Working Group to reconvene.[162] The important points in the report of the Working Group's 1984 meeting are as follows:

(1) Some delegations expressed the view that international criteria for design and operations of an NPS should be established.

(2) Some delegations expressed the view that nuclear reactors should only be used in orbits with a life time of at least 300 years after reactor shut-down. Further, that nuclear reactors in a lower orbit should be boosted to the 300 year height in all cases. Also, the planned disposal method should never include dispersion of radioactive material into the earth's atmosphere.

(3) Some delegations expressed the view that compliance with ICRP recommendations should not include prelaunch notification.[163]

The fourth session of the Working Group (1984 meeting) failed to produce recommendations for the regulation of NPSs. The Group requested that member states submit their views and suggestions for consideration by the Group during its fifth session on, among other issues, the following: (1) "[q]uestions of assessing the safety and reliability of the use of nuclear power sources;" (2) "[m]ethods, form and frequency of communication of notification;" and, (3) "[e]mergency procedures and action plans in case of unplanned re-entry of NPS."[164] From the list of issues the Working Group is considering requesting input on, it is apparent that no real progress has been made and that basic disagreements remain.

B. *Work of the Legal Sub-Committee*

Although Canada and thirteen other co-sponsors submitted a working paper to the Legal Sub-Committee of COPUOS in 1978, detailed discussions did not take place until 1981. This delay was due in part to the opinion of some states that the Legal Sub-Committee

161. U.N. Doc. A/AC.105/C.1/L.126 (1980).
162. G.A. Res. 38/80, 38 U.N. GAOR Supp. (No. 47) at 98, U.N. Doc. A/38/47 (1983).
163. U.N. Doc. A/AC.105/336 (1984).
164. *Id.*

should wait for the Working Group to finish its work, and in part the delay was due to delaying tactics employed by Eastern European delegations. The Eastern European delegations argued that there already existed a framework of international rules for the use of NPSs.[165]

When the Legal Sub-Committee finally addressed the NPS issue it followed the lead of Canadian working papers and focused on four issues. Those issues are:

> (1) Safety measures: The establishment of effective international standards, safeguards, and limitations.
>
> (2) Notification: the establishment of notification obligations at various stages in the use of NPSs in space.
>
> (3) Emergency assistance: the development of international legal measures for search, recovery, and clean up operations in case of a reentry of an NPS.
>
> (4) Liability for damage caused by the use of NPSs.[166]

Still, the Canadian effort met with stiff resistance. The Soviet Union, as the only nation presently using nuclear reactors, resisted changes in existing law.[167] Further, the Canadian position that present NPS use creates unacceptable risks met with opposition from several states. The opposition asserted that the conclusion of the Working Group that NPSs can be safely used was correct.[168] Faced with this opposition, Canada revised its position. Canada now admits that a general legal regime exists, but asserts that it needs clarification and amplification.[169] Canada has also taken a pragmatic approach toward its former position that states which receive no benefits from NPS use should bear none of the risks from their use. Realizing that it must obtain the cooperation of the space capable nations, Canada is now prepared to modify this position.[170]

During the Legal Sub-Committee's work on the issue, one agreed text has been produced for notification in the case of a reentering NPS. So far, though, no agreement has been reached on a form for

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165. Reiskind, *supra* note 113, at 465.
166. Jasentuliyana, *supra* note 39, at 538-39.
167. C. CHRISTOL, *supra* note 38, at 784.
168. *Id.* at 789.
169. Reiskind, *supra* note 113, at 468.
170. *Id.* at 470.

the text.[171] The text is very similar to the notice format developed by the Working Group.[172]

Some of the highlights of the Legal Sub-Committee's discussions are as follows:

> (1) Canada proposed supplementing the liability provisions of the Outer Space Treaty and Liability Convention to clarify that states are responsible for "indirect" damages (clean up) caused by NPSs. Other states felt this was not necessary.
>
> (2) Debate, inconclusive to date, over the obligation of a launching state to render search and clean up aid took place. Some states have put forth the view that a launching state has the right to investigate the crash of an NPS.
>
> (3) Debate over the need to supplement existing international law continued between the Canadian led group and the Soviet led group.[173]

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171. Jasentuliyana, *Review of the Work of the Committee on the Peaceful Uses of Outer Space*, 12 J. SPACE L. 52, 55 (1984).

172. Any State launching a space object with nuclear power sources on board should timely inform States concerned in the event the space object malfunctions and there is a risk of re-entry of radioactive materials to the earth. The information should be in accordance with the following format:

1. System parameters:
   1.1 name of launching State, including the address of the authority which may be contacted for additional information or assistance in case of accident;
   1.2 international designation;
   1.3 date and territory or location of launch;
   1.4 information required for best prediction of orbit lifetime, trajectory and impact region; and
   1.5 general function of spacecraft.
2. Information on the radiological risk of nuclear power source(s):
   2.1 type of nuclear power source: radio-isotopic/reactor; and
   2.2 the probable physical form, amount and general radiological characteristics of the fuel and contaminated and/or activated components likely to reach the ground. The term 'fuel' refers to the nuclear material used as the source of heat or power.

This information should also be transmitted to the Secretary-General of the United Nations.

173. Report of the Legal Sub-Committee on the Work of its Twenty-First Session, U.N. Doc. A/AC.105/305 (Feb. 24, 1982), *summarized at* 37 U.N. GAOR Supp. (No. 20) at 8, U.N. Doc. A/37/20 (1982).

V. Conclusion and a Suggestion

Space borne nuclear power sources are here to stay. Their utility is far too high and their risk too low to realistically expect space faring nations to give them up. Aside from their military uses, which is likely the reason a ban on NPS use has not been seriously considered, NPSs have great potential. For example, the Center for Space Policy estimates that by the year 2000, annual revenues from material processing could be over twenty-five billion dollars.[174] The power to operate material processing operations in space will likely be supplied in part by NPSs.

Faced with this reality, the international community should focus its attention on ensuring the safe use of NPSs and the existence of an equitable liability system for any NPS accidents. The question then becomes whether existing law meets these objectives.

It is clear from the Outer Space Treaty and customary law that NPS use is not prohibited. While some nations have suggested in COPUOS discussions that NPS use should be temporarily discontinued, such suggestions do not amount to the formal protests necessary to render NPS use illegal. Freedom of access and use of space, coupled with twenty-four years of use, has established the right to launch NPSs. It is also clear that, as much as some states would wish to the contrary, there is no requirement of notice prior to launch. Even if there is a customary law requirement of prior notice for ultrahazardous activities, as claimed by Professor Gunther Handl, it can be reasonably argued that the use of NPSs does not constitute an ultrahazardous activity.

The Outer Space Treaty and customary environmental law do require that states take every reasonable safety measure when using NPSs. If reentry into the earth's atmosphere is planned, whether shortly after launch or hundreds of years later, under Article 25 of the Convention on the High Seas, NPS users must attempt to meet IAEA safety standards. If the safety measures suggested by the COPUOS Working Group on NPS use are taken, meeting IAEA safety standards should prove to be no problem.

If safety measures fail, what is a launching state's liability for the resulting damage? Personal injury and direct property damage, including radiation injury, are clearly covered by the Liability Con-

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174. *Space Commercialization Group Includes Non-Aerospace Firms*, AVIATION WEEK & SPACE TECH., Mar. 4, 1985, at 20.

vention. Liability for damages to the environment and resulting clean up measures is not certain. However, it is possible to argue that states are responsible for environmental damage and clean up measures which result from NPS use. The argument is as follows:

> First, under customary law, states are responsible for environmental harm caused by their breaches of international law;
>
> second, the reentry of an NPS, without prior consent, violates a state's sovereign air space, as established by Article 1 of the Chicago Convention, thereby creating a violation of international law;
>
> third, the COSMOS 954 settlement serves as precedent for the inclusion of clean up liability.

It is clear from the preceding survey that there is insufficient law specific to NPS use. This is unfortunate, because the safe use of NPSs in outer space will demand tangible and detailed regulation. With this in mind, the following is proposed. In the short run, for NPSs, a system of technical regulations similar to those created by ICAO in its Annexs should be established. International Standards and Recommended Practices could be created by an inter-governmental organization, for example the IAEA, to guide the use of NPSs. In the long run, however, NPS regulation will need more comprehensive treatment. Also, other areas, such as liability rules and traffic rules for space, will require technical as well as legal guidelines. Therefore, it is suggested that the international community establish an organization for space tailored after ICAO. ICAO, for all its flaws, is one of, if not the best, inter-governmental problem solving organization. The development of space, like the development of commercial aviation, would benefit from one central organization charged with providing technical and legal guidelines.