DISCUSSION ON EXTENDING/MODIFYING THE 1992 NUCLEAR POWER SOURCES PRINCIPLES TO BROADER SPACE OPERATIONS

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Abstract

After more than 10 years of existence, the 1992 Nuclear Power Source Principles stands now at the crossroads. Various parties have expressed the idea of extending NPS for broader space operations. While theoretical debates on the feasibility of such application do not help much in practice, pragmatic approach should be adopted: formulating new framework to accommodate the new demands. As a result, the revisit of the Principles is justified. This revisit shall be extensive, including the substantial aspects as well as the formality of the Principles. It is expected that the improved Principles shall well accommodate the renewed call for application of NPS in broader space operations and the well-being of modern society as a whole.

1. INTRODUCTION

Nuclear power sources (NPSs) have been used since 1961 for the purpose of generating energy for space objects[1] and have since then been recognized as particularly suited or essential to some space operations. The use of NPS in outer space aims at providing electric power for spacecraft sub-systems such as altitude control, communications, and command, as well as for the operations of various equipments on board. Two types of NPS are presently in outer space, namely, isotopic source and nuclear reactor.[2]

In the mid-1960s American government and industry looked to a cheaper and reliable alternative to chemical rocket engines. Other than Russian nuclear achievements in space at that time, no other entity had won at demonstrating the raw power of crafted nuclear rocket propulsion except Project Rover in the US.

However, the risks inherent in using NPS caused much concerns.[3] The risk and the disastrous consequence were well demonstrated by the incident in 1978 when the Russian nuclear-powered satellite Cosmos 954 crashed on Canada.[4] Discussions started since then on an international technical framework for the regulation of NPS in outer space.[5] Years of deliberation has finally led to the adoption of the United Nations (UN) Resolution on the safe use of NPS in 1992,[6] listing 11 principles for the safe application and assessment of NPS. While acknowledging the fact that national activities involve the use of NPS in outer space, it recognizes that certain restrictions are necessary to ensure the safe use of NPS. The Resolution aims to promote the protection of persons and 'the biosphere' against radiological hazards.[7]

According to Principle 11, these Principles shall be opened for revision no later than two years after their adoption. To date, however, revisions have not been made. After more than ten years' existence, it is time to take a serious look at the Principles again considering the rapid development of modern technology and the drastic change of the political atmosphere.

The present paper takes up the position in discussing the possible modification to the Resolution. Part 2 gives an overview of the Resolution and describes the necessity of making modification. Part 3 concentrates on the substantial areas for improvements and modification, which is followed by Part 4 dealing with the improvement on the formality of the Principles. A short conclusion in Part 5

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portrays a prospect for the Principles in the new century.

2. BRIEF REVIEW OF THE 1992 NPS PRINCIPLES

The 1992 Principles apply to NPS in outer space devoted to generation of electric power on board space objects for non-propulsive purposes. It considers only the use of nuclear fuel as it relates to NPS.[8] Principle 1 sets a broad framework for NPS: international treaties and customs shall be valid in the regulation of NPS. The present resolution is a further statement of these rules in the specific activity. Principle 2 defines the terms to be applied in this resolution. This shall help clarify the ambiguity concerning "launching State" and "State launching".

Principle 3 offers guidelines and criteria for safe use. It is the heart of the Resolution.[9] The use of NPS is strictly limited to space missions which cannot be operated by non-nuclear energy sources. Such use shall further be conducted in a reasonable way. The obligation of safety assessment is provided in Principle 4 in accordance with the criteria for safe use contained in Principle 3. Rules of the notification of re-entry, for consultation and requests for additional information between states are respectively provided in Principle 5 and 6. The issues concerning assistance to States, responsibility, liability and compensation, dispute settlement are ruled down in the next four Principles.[10]

The Principles provide the basic document guiding the use of NPS in limited situation. The necessity of the Principles is obvious: the high risks entailed in the use of NPS. This also justifies the limited use of NPS: not for propulsion purposes. The provisions satisfy the needs in the early 1990s with the existence of strong arms control advocates and environmentalists.[11] However, with the development of space technology and the enthusiasm for further exploration of outer space, the use of NPS again becomes the topic for heated discussion. The National Aeronautics and Space Administration (NASA) is now moving to revive its scheme to build nuclear-propelled rockets[12] and expand its use of atomic power to generate electricity on space probes and planetary rovers.[13] The program called Nuclear Systems Initiative is trying to develop safe and reliable nuclear power and propulsion systems.[14] The NASA announced its intention to revisit the issue of NPS in space early in 2002, shortly after the September 11th Event.[15] This announcement has on the one hand, advocated the use of NPS beyond non-propulsion purposes; on the other hand, closely referred to war against terrorism. The situation nowadays is no longer like that in 1994 or even later (two years or longer after the adoption of the Principles), the technical advancement and the reality has urged revision of the Principles and further accommodations.

3. IMPROVEMENT ON SUBSTANTIAL ASPECTS OF THE 1992 PRINCIPLES

Heated discussions had been in place before the adoption of the Principles. Various scholars recognized the necessity of rules guiding the legitimate use of NPS. After years of deliberation, the Principles were able to be successfully adopted. However, comments and evaluations continued to be presented on the merits and demerits of the Principles. In general, the Principles offer a platform for space activities involving the use of NPS. This set of Principles can be viewed as a great leap forward in the history. Considering the sensitive nature of NPS, it is appropriate to have a set of Principles in the first place: something is better than nothing. Nevertheless, it has been obvious to all even at the time of adoption that further revision is necessary. For various reasons, the speculated revision has not been made so far. But the necessity of revision is now at the forefront when the US put forward the plan of using NPS for propulsion purposes and other applications. Confronting the new challenge, it is, accordingly, the right time to study the Principles and make possible improvements.

3.1. Applicable Scope

The Principles have set clear applicable scope. As stated above, NPS shall be only allowed for non-propulsive purposes. According to the analysis of some scholars, the Principles do not refer to the use of NPS on celestial bodies including the Moon.[16] However, the reality is that NPS has been used[17] and can be further used for space operations, not only in outer space, but also at the stage before and after the space objects entering the outer space; not only as electric power, but also as propulsion power. Several NASA notables have mentioned publicly that nuclear power in space transportation deserves a closer look. The comments indicate that if public relation efforts can gain acceptance for the possibility, future interplanetary missions may include nuclear-power options.[18] The former "taboo" of not using NPS for propulsion purposes has been under severe challenge.

The efforts from the US's side serve as the powerful motive force. The justification presented is no doubt strong enough to stand against those sticking to the restrictive use of NPS. The European Space Agency (ESA), as a support for the restrictive use of NPS, is devoted to developing safer ways of propelling rockets and energizing space probes and planetary landers, which include solar electric propulsion and the use of "solar sails" and other solar technologies that stress the generation of electricity with new high-efficiency solar cells.[19] Nevertheless, such a position shall not prescribe the fact of using NPS for wider space operations. Outer planet exploration using advanced radioisotope electric propulsion has been evaluated by teams at the NASA Glenn Research Center in Cleveland, Ohio, as well as The Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland.[20]

Some might quote the 1963 Treaty Banning Nuclear Weapons in the Atmosphere, in Outer Space and under Water (Limited Test Ban Treaty)[21] as proof against the use of nuclear fission as a means of space propulsion by referring to the provision that outlaws any nuclear weapon test explosion or any other nuclear explosion.[22] However, according to the provision, it directly refers to the prohibition of NPS application by means of explosion, the Treaty does not prohibit the use by means other than explosion. Moreover, this Treaty basically deals with nuclear weapons, not the use for normal space activities.

While witnessing the actual development, we should acknowledge that theoretical debates on feasibility of NPS's extensive use are meaningless, or at least diverging our regulatory direction. We have only two possible outcomes: either the Space will be colonized illegally, or the laws are to be changed.[23] Politically speaking, the right attitude should be to formulate an appropriate legal framework for their legitimate and safe application, offering a guideline for possible use of NPS in space operations (including heat, power or propulsion) in interplanetary traveling, in celestial bodies, in Earth orbit, beyond earth orbit, or even for launching spacecraft from the surface of the Earth. This is a pragmatic means to realize order in the use of NPS, which also represents the extension of positivism in the field of Space Law. The availability of legal framework for extensive use of NPS shall put a safe valve and provide preventive measures against future illegal use of NPS in all other cases.

Considering the ongoing discussions and technical development, it is time to justify the possible areas for extension. The application of NPS for propulsion purposes is one promising area. Nuclear propulsion can take many forms ranging from low thrust nuclear electric propulsion to higher thrust nuclear thermal propulsion and electrical or thermal "Pulsed nuclear" propulsion. Supporting arguments include the sufficient energy for space operation, which can largely shorten the necessary time for space operations. Actually, astronauts are among the most enthusiastic boosters of such a nuclear-powered mission.[24] The restrictive use of NPS will add to the cost, the length of the missions, which will levy burden on the pressure and anxiety of astronauts. Nuclear propulsion can be more efficient than any other traditional chemical propulsion, it has twice the propellant mileage of the chemical propulsion. The mere use of enriched uranium will reduce the efficiency of space operation and entail other disadvantages. Several other advantages have also been quoted: creating artificial gravity, the reuse potential of the nuclear thermal rocket.[25] Some space missions, though can be operated by non-nuclear energy sources, will not be able to enjoy the advantages of NPS. Confident assertion came from the Center for Space Science and Exploration, Los Alamos Laboratory that the future on nuclear activities in space will revolve around Nuclear Electrical Propulsion (NEP) at least in the immediate future involving light payload long duration missions.[26]

However, it is yet to be seen whether it is advisable to extend the use of NPS in the earth orbit or near earth regions. The nuclear powered rockets have been strongly argued not to be used to get off the ground, but only outside the Earth orbit. The nuclear system can be controlled to function only when the desired need to have them work and the distances involved would be far from any earthly influence in any event. Nevertheless, we cannot preclude this possibility with technological improvement. Thus, it is also necessary to bring this possible development into the legal framework: providing clear statement on whether its application in earth orbit is legal or not; if confirmed as legal, then higher standards should be provided.

Scholars have also been arguing whether the Principles apply to the use of NPS systems on planetary surfaces.[27] The Resolution itself does not contain clear guidance. It is thus necessary to clarify this ambiguity. To take the style of Space Treaty, outer space shall include Moon and other celestial bodies. The adoption of this conception shall ensure the consistency of the terms among international space law documents.

The extensive application of NPS shall no doubt add to the danger inherent in the NPS posed to the human beings, animals, plants and natural environments on the earth. Actually the cons over extensive use of NPS have been largely based on the concerns above. Thus, the vital point to substantiate the use of NPS is to provide a convincing mechanism to ensure the safety or lessen the risks entailed from legal and technical angles. Generally speaking, Principles 3 and 4 are appropriate in defining the safe use and assessment from a technical point of view; however, for the purpose of further extension, it is necessary to check the wordings and include the possible extension. This extension and revision shall include the higher level of safety standard, reconsideration of appropriate orbit position, etc. The duty to inform the use of NPS, duty to warn, international consultation, etc. have been defined in other Principles, but it is also necessary to review to keep up with the new development. Furthermore, when reviewing the Principles, we need to refer to the 1967 Space Treaty.[28]

3.2. The "Reasonableness" Test in Principle 3

With possible application of NPS closer to human being, high standards and preventive measures shall be adopted to procure against high risks. This shall have most relevance with the reasonableness test defined in Principle 3. With the availability and feasibility of solar energy well testified, a clear understanding of the term shall be needed. Failing the reasonableness test, relevant States causing the damage should bear higher level of liability accordingly.

The term "reasonableness" basically provides the idea of defining the applicable scope for NPS. The "chapeau" of Principle 3 provides that the use of NPS shall be restricted to space missions which cannot be operated by non-nuclear energy sources in a reasonable way. This chapeau has tried to rule out the use of NPS in other situations, however, the term "in a reasonable way" softens the assertion, which shall subject to an appropriate interpretation. Without defining "reasonable", the Resolution attempts to limit use of NPS while acknowledging that NPS is appropriate for some space operations. Nevertheless, the flexible use of the term has aroused much criticism after the adoption of the Resolution. It is now time to revisit this term.

While offering the chapeau, Principle 3 goes a step further by defining the situations when nuclear reactors and radioisotope generators can be operated. The principle further provides that the reliability of systems important for safety shall be ensured, *inter alia*, by redundancy, physical separation, functional isolation and adequate independence of their components. [29] It also lists several situations when nuclear reactors may be operated: on interplanetary missions; in sufficiently high orbits; and in low-Earth orbits if they are stored in sufficiently high orbits after the operational part of their mission. [30] According to the Resolution, "sufficiently high orbits" are those in which the orbital lifetime is long enough to allow for a sufficient decay of the fission products to approximate the activity of the actinides. Such orbits must be such that the risks to existing and future outer space missions and of collision with other space objects are kept to a minimum.[31]

However, the indeterminacy has been further exacerbated by the use of the terms like "sufficient", "long enough", and "minimum". While this Resolution provides the basic mechanism for securing the safe use of NPS, the crux is how to provide a safe valve for the application, not to preclude the use of NPS. We should take note of two relevant issues: applicable scope and the procurement of safe use within the applicable scope. The definition of "reasonableness" shall be directly related to the two issues above. The status confronting the new development should thus be the extension of NPS to broader space operations and provision of higher level of safety procurement from the technical part.

While the issue of extending applicable scope has been discussed earlier, we should now examine the formulation of appropriate standards for safety procurement. This proves to be a difficult one, having been evidenced by the tedious deliberations during the drafting of the Principle. The constant technological development has high possibility of making newly formulated technical standards outdated very soon. It is almost impossible to stabilize such rules in a legal document. As stated by some scholar, the inclusion of technical regulation in legal guidelines seems to be a resignation of law in the benefit of technology which could not solve its own difficulties and therefore decides to put law under its subordination. [32] One possible way out could thus be to differentiate technical issues from legal guidelines: while developing a treaty with broad and general guidance, the UN can leave to an international technical body to establish standards and recommended practices for States to follow. [33] The International Atomic Energy Agency (IAEA) and the International Commission on Radiological Protection (ICRP) can be appropriate bodies to undertake technical tasks. [34] While providing legal guidelines, the Principle can make express reference to the recommendations of these two organizations. This can resolve the heated debates concerning the adoption of technical standards in a legal document.

3.3. The Issue of Environmental Protection

Environmental protection or sustainable development has been an important issue considering the possible dangers posed to the earth. The issue of space debris has been deeply studied by various space law bodies.[35] We should note the Limited Test Ban Treaty,[36] one important consideration of which has been environmental protection: the prevention of global nuclear contamination, to put an end to the contamination of man's environment by radioactive substances. [37] It can even be viewed primarily as an environmental agreement rather than a military one.[38] The NASA conceded the serious dangers of a

Cassini accident in its Final Environmental Impact Statement for the Cassini Mission, the most recent nuclear space probe mission in 1997.[39] It is proposed that those space activities which might harm the local and global environment are carried out in a manner that limits such effects to the extent possible. [40] However, the discussions did not direct to NPS in space operations. This fact does not underestimate the highly dangerous nature of the pollution resulting from the use of NPS.

While providing the safety guidance for the use of NPS, the Resolution can be argued to have impliedly entailed the idea of environmental protection. Nevertheless, such an implied idea will not impose much strength on the actual performance. It is necessary to insert this principle into the main body of the Resolution, among those include the disposition of nuclear wastes. This shall promote the compliance from Members without further arguments. Moreover, international cooperation could thus be directed at addressing this issue.

By inserting environmental protection in the Preamble, we can have stronger stand and more justifiable commitment to support several measures in the main text, which include avoiding heavily populated parts of the Earth, safety measures, etc. As to state responsibility and liability arising out of the use of NPS, reference can be made to the existing Principle 8 and 9.[41] This is very important since we note that in resolutions relating to environmental questions, State responsibility and liability are not referred to and even in international agreements or conventions a trend can be observed to omit these questions.[42] Considering the magnificent work having been done on space debris, it is also necessary to refer to this achievement as far as the issue of environmental protection is concerned. Anyhow, the Conventions, Resolutions, Treaties, as long as they are related to space regulation, should be integrated and work effectively with the supplement of each other. Only through this way can space operations be carried out for the common interests of all mankind.

3.4. <u>The Issue of War under the Guise of Research</u>

While the high risks entailed in NPS applications were the main concerns for supporters of restrictive use of NPS, another topic can not be disregarded. This becomes even the truth after the September 11th Event with the severe challenge of terrorism. Besides the five original nuclear powers, several other States have claimed or been asserted to hold or have the ability to produce nuclear weapons. Nuclear power is not any more controlled by limited States, the spreading of nuclear power shall also add to the concerns over the legitimate use of NPS.

NASA's announcement, to a certain extent, has relevance to war against terrorism. How the Bush Blueprint on budget deficits and the war against terrorism will affect NASA is still under stressful study. However, states or relevant bodies may carry out space missions under the guise of research. The so-called "peaceful" use of NPS in space can be merely a cover to develop power systems to be used for space-based weapons. Once developed under the guise of space exploration, nuclear reactors could be used to drive dangerous space-based laser weapons. Such concerns are justified, however, such guise is difficult to identify. It is thus claimed that: the military's future testing and deployment of nuclear rocketry is necessary; security only works when people responsible for defense have access to advanced nuclear propulsion in space to perform the tasks.[43] Nevertheless, those concerns cannot hold back the earnest idea of using NPS for broader space missions.

Peaceful use of outer space has been widely advocated and ruled down in several international documents. The Space Treaty provides that States Parties undertake not to place in orbit around the Earth any objects carrying nuclear weapons..., install such weapons on celestial bodies, or station such weapons in outer space in any other manner.[44] The International Space Station (ISS) Agreement[45] also provides the application for the peaceful purpose.[46] However, the sensitive nature of NPS justifies the reiteration of this issue in the preamble of the Principles. The reiteration should, at least from the legal side, firmly rule out the possibility of war in outer space using NPS. Such a reiteration, while well accommodating concerns about war, shall provide a solid basis for claiming international liability in the possible use of NPS in outer space against terrorism.

3.5. Notification, Consultation and Miscellaneous

Naturally there are many other areas requiring improvements. First of all, several terms need to be clarified, including "launching State", "Procuring State".[47] Secondly, due to high risks to human beings and environment, it is necessary to notify and hold consultations with relevant parties well before, during and after the formal launching activities. Principles 5 and 6 have provided basic structure for notification and consultation. With further extension to broader space operations, notification and consultation appears even more essential. Various scholars have specified that Principle 5 is in conflict with the IAEA Convention on Early Notification of a Nuclear Accident,[48] it is necessary to elaborate this issue at this stage. One way out could be to make specific reference to this Convention, ensuring Principle 5 and the Convention are complementary in nature.[49]

Thirdly, to the extent space operations using NPS could harmfully interfere with other States, international consultations must be performed before proceeding with any such activity or experiment. This is also in accordance with the Space treaty.[50] Such an "obligatory" consultation could also provide a possible disincentive to carrying out space activities with military purposes.

4. THE 1992 PRINCIPLES: RESOLUTION VS. TREATY

The General Assembly adopted the Principles as a Resolution in 1992. Considering the pros and cons during the negotiations, it was sensible to adopt such a resolution to fix the guidelines and criteria for safe use as a first step. It is obvious from the nature of UN General Assembly and a Resolution that the Principles are addressed not only to the State Parties to the Space Treaty, but also to all the States.[51] The universal nature can to a certain extent strengthen the claim of the Principles as part of customary international law, which shall further give insight into the politically acceptable treatments of space.[52] However, the Resolution *per se* is not a formal legal instrument.[53] In view of the existing Conventions on space law, this Resolution can be at most regarded as supplement to the provisions of the Conventions with regard to the use of NPS by a set of recommendation.[54] The non-binding nature[55] has aroused some problems in further implementation, even though Members generally highly respect the Resolution. The Resolution only codifies the international perspective on the hazards presented by NPS in space, members have no obligation in strictly complying with the Resolution. Once disputes arise, Members can argue either way supporting their own position. The indeterminacy of the status of the Principles has thus allowed the implementation largely at the discretion of the Members.

Indeed, quite a lot of scholars have acknowledged that several Principles in the Resolution represent customary international law. More specifically this assertion refers to rules concerning notification and use of NPS in outer space that are of a fundamentally norm-creating character such as could be regarded as forming the basis of a general character of law.[56] The international practice has further evidenced this view. Ample examples showed that international society conforms to the Principles defined in the Resolution: sufficient notice, responsibility and liability, etc. The Russian reported to the UN Secretary General of its anticipated launch of the Mars 96 satellite powered by plutonium-238;[57] the US notified the UN of its launch of the Cassini space probe, containing about 35 kg of plutonium-238 dioxide.[58]

To the extent customary law exists for space law at all, it binds all States whether their consent be express or implied by silence in the face of emerging legal norms.[59] However, what little customary law for space there is has been derived from the activity of very few States. This is exact the truth in the use of NPS, only five States publicly claim to hold the nuclear power, and the rate of use has been comparatively low. Furthermore, with the increasingly role of treaties both in international law in general and space law in particular, customary law is of far less importance and its significance for outer space activities has, in many aspects, not been secured.[60] Except for the Principles widely regarded as part of customary international law, the status of other Principles is not settled. This drawback can largely weaken the effect of the Resolution on State practice.

After more than ten years of existence, it is now right time to consider concluding a treaty with regard to this issue. This is in accordance with the objective of the UN to the progressive development and codification of international law. The binding nature of a treaty can provide a strong impetus to the legal use of NPS, even more meaningful to the legitimate use of NPS in the proposed extensive arena. Such a binding treaty can also help provide a mechanism for international society in agreeing to the extended use of NPS and mitigating the anxiety.

5. CONCLUSION

The 1992 Principles provide a good framework for the use of NPS. Over the previous years, the international society has strictly complied with the Principles, creating an orderly regime for the use of NPS in outer space. Nevertheless, with rapid development of space technology, States have claimed that the use of NPS for other possible purpose is well justified. This trend is well led by the US in its NASA program, the ongoing review of the existing structure will no doubt exert heavy influence on the existing legal framework established by this Resolution. Acknowledging the advantages of using NPS in broader space operations, the technicians and space activists are leading the trend toward wider use of NPS. The theoretical debate on the appropriateness of such a wider use should no doubt give way to the pragmatic approach in formulating a proper legal framework in coping with the incoming severe challenge. The improvement of the legal framework shall include not only the substantial part, but also the formality of such a document. The initiative taken by the NASA can be the right incident that touches off the revision of the Resolution, provide an impetus to the realization of a formal treaty in this field, and push the development of space treaty after a blank period of space law legislation. Much cost can be saved or devoted to more promising projects if the result of the revision is known as early as possible. It is expected that the improved Principles shall well accommodate the renewed call for application of NPS in broader space activities and the well-being of modern society as a whole.

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[1] The first nuclear satellite was Transit 4A, a navigational satellite launched on June 29, 1961. It was a time when space and nuclear power were seen by some as coupled.

[2] See further D. Tan, Towards a New Regime for the Protection of Outer Space as the "Province of All Mankind", 25 *Yale Journal of International Law* 149 (Winter 2000).

[3] See generally R.I.R. Abeyratne, The Use of Nuclear Power Sources in Outer Space and Its Effect on Environmental Protection, 25 *Journal of Space Law* 17 (1997).

[4] The satellite was designed for ocean reconnaissance and was powered by a nuclear reactor working on uranium enriched with isotope of uranium-235. For discussion, see further B. Schwartz & M.L. Berlin, After the Fall: An Analysis of Canadian Legal Claims for Damage Caused by Cosmos 954, 27 *McGill Law Journal* 6767 (1982); A.F. Cohen, Cosmos 954 and the International Law of Satellite Accidents, 10 *Yale Journal of International Law* 80 (1984).

[5] M. Benko & K. Schrogl (eds.), *International Space Law in the Making: Current Issues in the UN Committee on the Peaceful Uses of Outer Space* 19-21 (1993).

[6] Principles Relevant to the Use of Nuclear Sources in Outer Space, UN G.A. Resolution A/Res/47/68 (December 14, 1992); GAOR, 47th Session, Supp. No. 20, UN Doc. A/47/20 (1992).
[7] Section 1.1 of Principle 3.
[8] R. Dusek, Lost in Space?: The Legal Feasibility of Nuclear Waste Disposal in Outer Space, 22 *William and Mary Environmental Law and Policy Review* 213 (Fall 1997).
[9] R.A. Ramey, Armed Conflict on the Final Frontier: The Law of War in Space, 48 *Air Force Law Review* 116 (2000).
[10] For further description of the Principles, see I.H.Ph. Diederiks-Verschoor, *An Introduction to Space Law*, 108-109 (Kluwer, 2nd Edition, 1999).
[11] In an attempt to square this circle, the Federation of American Scientists and Soviet colleagues in 1988 proposed a ban on the operation of nuclear reactors in earth orbit that would nevertheless permit their use for space exploration.
[12] P. Pae, NASA Seeks $1 Billion for Nuclear Propulsion Plan, *Los Angeles Times*, February 7, 2002, at 112.
[13] The Return of Space Nuclear Reactors, Secrecy News from the FAS Project on Government Secrecy, Volume 2002, Issue No. 11, January 31, 2002, available at <http://cndyorks.gn/apc.org>.
[14] NASA Administrator Honorable Sean OKeefe, NASA biography of OKeefe, available at <http://www.nasa.gov/bios/okeefe.html>.
[15] K. Grossman, Plutonium in Space (Again!), Global Network Against Weapons and Nuclear Power in Space, Covert Action Quarterly, No. 73, Summer 2002, available at <http://www.globenet.free-online.co.uk/articles/morenukesinspace.htm>.
[16] N. Jasentuliyana, An Assessment of the United Nations Principles on the Use of Nuclear Power Sources in Outer Space, *Proceedings 36th Colloquium on the Law of Outer Space* 316 (Graz, 1993).
[17] The US has launched some two-dozen spacecraft utilizing plutonium-powered electrical generators.
[18] G. Clark, Will Nuclear Power Put Humans on Mars?, available at <http://www.space.com>.
[19] New Solar Cells with Record Efficiency, ESA Press Information Note No. 0794, April 29, 1994.
[20] L. David, NASA to Seek Nuclear-Powered Spaceflight Alternatives, February 1, 2002, available at <http://cndyorks.gn.apc.org>.
[21] Done on August 5, 1963, 14 U.S.T. 1313, 480 U.N.T. 43 (entered into force on October 10, 1963).
[22] G.H. Reynolds & R.P. Mergers, *Outer Space: Problems of Law and Policy* 61 (2nd ed., 1997).
[23] S. de Cordoba, Changing Basic Space Laws: Popularity, Pragmatism and Historical Lessons, *Proceedings 36th Colloquium on the Law of Outer Space* 330 (1993).
[24] A fast mission using nuclear thermal rockets could get astronauts to Mars in as little as 4 months.
[25] For the discussion of the advantages, see further Clark, *supra* note 18.
[26] B. Behrhorst, Nuclear Rocket Power in Space: Generational Legacy, available at <http://www.nuclearspace.com>.
[27] See for example, M.S. Smith, Legal Aspects of Using Nuclear Reactors on the Moon, *Proceedings 35th Colloquium on the Law of Outer Space* 312 (1992).
[28] For example, Article XI of Space Treaty provides the commitment in providing the information to promote international co-operation in the peaceful exploration and use of outer space.
[29] Section 1.4 of Principle 3.
[30] Section 2.1 of Principle 3.
[31] Section 2.2 of Principle 3.
[32] A.A. Cocca, Are the Principles on the Use of Nuclear Power Sources in Outer Space a Progress in Space Law?, *Proceedings 36th Colloquium on the Law of Outer Space* 258 (1993).
[33] N. Jasentuliyana, A Survey of Space Law as Developed by the United Nations, in N. Jasentuliyana (ed.), *Perspectives in International Law* 349 (Kluwer, 1995).
[34] A.D. Terekhov, Review and Revision of the Principles Relevant to the Use of Nuclear Power Sources in Outer Space, *Proceedings 36th Colloquium on the Law of Outer Space* 340 (1993); see also Y. Lodico, Developing Legal Principles for the Safe Use of Nuclear Power Sources in Outer Space, *Proceedings 34th Colloquium on the Law of Outer Space* 134 (1991); E. Galloway, United Nations Consideration of Nuclear Power for Satellites, *Proceedings 22nd Colloquium on the Law of Outer Space* 135 (1979).
[35] J.M. Seymour, Containing the Cosmic Crisis: A Proposal for Curbing the Perils of Space Debris, 10 *Georgetown International Environmental Law Review* 907 (Spring 1998).
[36] Treaty Banning Nuclear Weapon Tests in the Atmosphere, in Outer Space and under Water, August 5, 1963, 14 U.S.T. 1313.
[37] Jankowitsch, Legal Aspects of Military Space Activities, in N. Jasentuliyana (ed.),

Space Law: Development and Scope 143 (1992).
[38] Reynolds & Merges, *supra* note 22, at 54.
[39] Final Environmental Impact Statement for the Cassini Mission, National Aeronautics and Space Administration, Solar System Exploration Division, Office of Space Science, June 1995, at 476. As stated, if an inadvertent reentry occurred and Cassini fell back into the Earths atmosphere, it would break up (it had no heat shield) and 5 billion of the world population could receive 99 percent or more of the radiation exposure.
[40] See further Vienna Declaration on Space and Human Development, Adopted by UNISPACE III, as it concludes two-week session, Third United Nations Conference on the Exploration and Peaceful Uses of Outer Space, UNISPACE III SPACE/V/9, Final Meeting (AM & PM) and Round-Up, July 30, 1999;.
[41] See generally A. Bianchi, Environmental Harm Resulting from the Use of Nuclear Power Sources in Outer Space: Some Remarks on State Responsibility and Liability, in F. Francioni & T. Scovazzi (eds.), *International Responsibility for Environmental Harm*, 231-272 (Graham & Trotman, 1991).
[42] M. Benko, G. Gruber & K. Schrogl, The UN Committee on the Peaceful Uses of Outer Space: Adoption of Principles Relevant to the Use of Nuclear Power Sources in Outer Space, *Proceedings 36th Colloquium on the Law of Outer Space* 238 (1993).
[43] See further Behrhorst, *supra* note 26.
[44] Article IV of Space Treaty (1967).
[45] Agreement Among the Government of Canada, Government of Member States of the European Space Agency, The Government of Japan, The Government of the Russian Federation, and The Government of the United States of America Concerning Cooperation on the Civil International Space Station, January 29, 1998, in S. Gorove (ed.), *United States Space Law: National & International Regulation (IV)*, 98-1 (1998).
[46] Article 1(1) of the Agreement requires that uses of the ISS be reserved for peaceful purposes.
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[58] Is Cassini Risky? Look to Facts, Not Emotion, 147 *Aviation Week & Space Technology*, No. 13, September 29, 1997, at 66.
[59] This is a reiteration of the Article 38 of the Statute of the International Court of Justice with regard to International custom. See further P. Malanczuk, *Akehurst's Modern Introduction to International Law*, 44 (Routledge, 7th edition, 1997).
[60] P. Malanczuk, Space Law as a Branch of International Law, 1994 *Netherlands Yearbook of International law* 147 (1995).