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Chapter 13

United Nations Deliberations on the Use of Nuclear Power Sources in Space: 1978–1987

Gary L. Bennett
U.S. Department of Energy
Washington, DC 20545

Joseph A. Sholtis, Jr.
Air Force Element
U.S. Department of Energy
Washington, DC 20545

Bruce C. Rashkow
U.S. Department of State
Washington, DC 20520

As a result of the reentry of the Soviet reactor-powered satellite Cosmos 954 over Canada in January 1978, the United Nations Committee on the Peaceful Uses of Outer Space (COPUOS) was called upon to consider what, if anything, should be done regarding the use of nuclear power sources (NPS) in outer space. The U.S. delegation to COPUOS has been an active participant in these deliberations. A special technical working group issued a report in 1981 that remains the definitive technical text. Since then, the focus has shifted to the Legal Subcommittee (LSC) of COPUOS. The LSC has not reached agreement on a complete set of legal principles but has approved two principles relating to notification of a reentry of a malfunctioning space object that creates the risk of contamination from an NPS and to providing assistance to affected States. The conclusion of the 1981 technical report is still a succinct statement of U.N. consensus and of the U.S. position: "The Working Group reaffirmed its previous conclusion that NPS can be used safely in outer space, provided that all necessary safety requirements are met."

Introduction

The United Nations, in one forum or another, has been discussing the use of nuclear power sources (NPS) in outer space since the 1978 reentry of the Soviet reactor-powered satellite Cosmos 954. To date, a full set of principles have not been agreed upon; although progress has been made in the areas of reentry notification and providing assistance to affected States. This paper provides a summary of those deliberations. Appendix A presents a chronology of the various major U.N. activities.

The principal U.N. forums for discussions on the use of NPS in outer space have been the Committee on the Peaceful Uses of Outer Space (COPUOS), its two standing subcommittees of the whole—the Legal Subcommittee (LSC) and the Scientific and Technical Subcommittee (STSC)—and special working groups established within the subcommittees to deal with this topic. Figure 1 shows the overall United Nations organizational system and where COPUOS fits in. COPUOS, which was established in 1959, and its two subcommittees operate on the consensus principle rather than voting. In effect, this means that any member or group of members can prevent COPUOS or its subcommittees from taking action on that topic by formally objecting to such action, whether that action consists simply of adopting a report containing the conclusions of COPUOS or its subcommittees or proposed principles. In practice, the achievement of consensus takes time. This is especially true in regard to topics that are highly scientific or technical in nature and where the science and technology are continuing to evolve. For example, the principles on remote sensing were discussed for over 10 years before being approved by COPUOS. On the other hand, the consensus principle provides a firm and uniform basis of support for any resulting agreement. To date, COPUOS has been responsible for five outer space treaties or conventions and one set of principles. (In U.S. practice no distinction is made between a "treaty" or a "convention" because they are equally legally binding and each must normally go before the U.S. Senate for its advice and consent to ratification.) The five treaties are as follows (with dates they entered into force):

- Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (10 October 1967);
- Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space (3 December 1968);
- Convention on International Liability for Damage Caused by Space Objects (9 October 1973);
- Convention on Registration of Objects Launched into Outer Space (15 September 1976); and
- Agreement Governing Activities of States on the Moon and Other Celestial Bodies. (Adopted by the U.N. General Assembly (UNGA) on 5 December 1979 and entered into force on 11 July 1984, although neither the U.S. nor the USSR has signed or become parties to the treaty.)

Although none of the five treaties expressly refers to the use of NPS in space each of the four treaties signed by the U.S. is sufficiently general to have some bearing on the use of

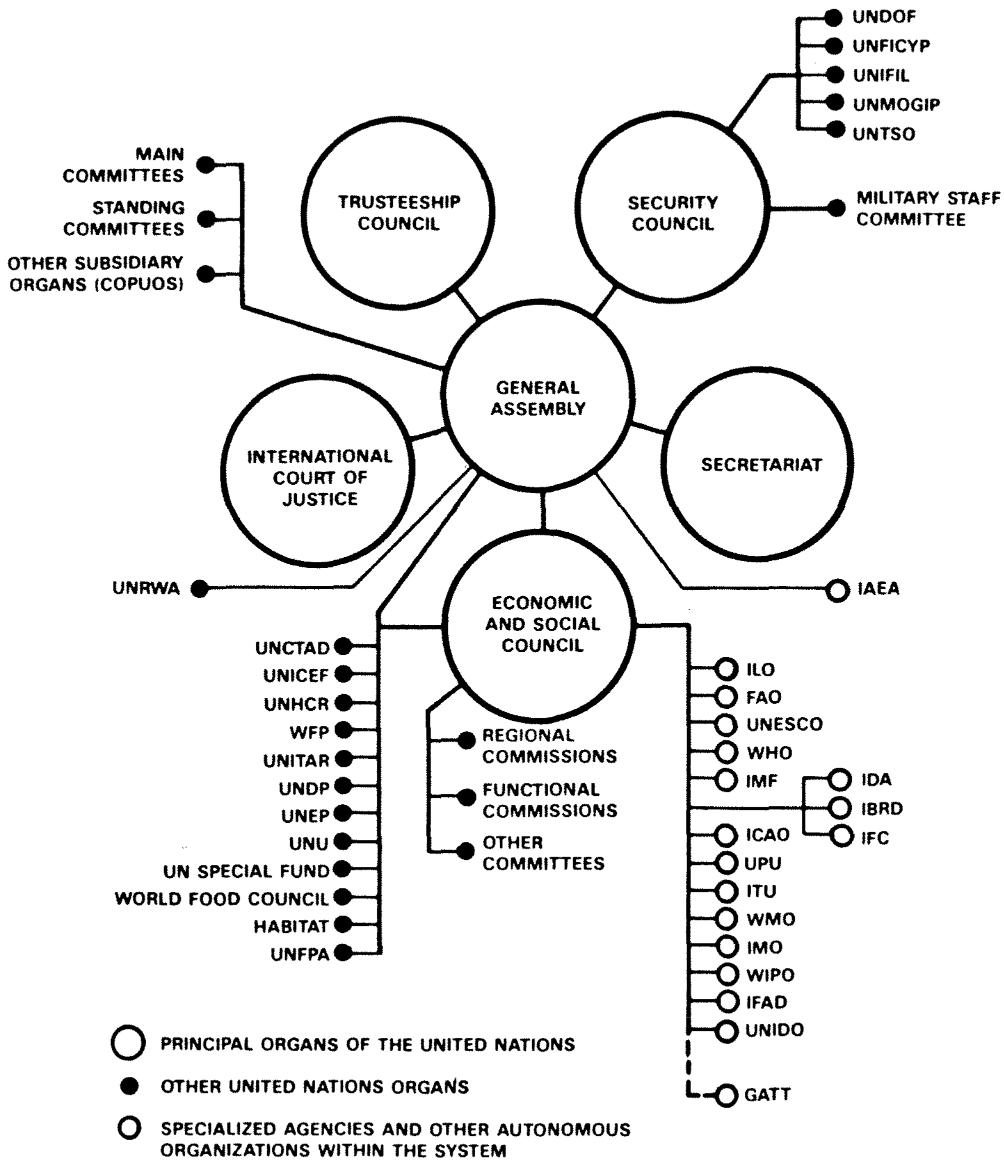

Figure 1 *The United Nations Organizational System. Shown are the organizational locations of the Committee on the Peaceful Uses of Outer Space (COPUOS) and the International Atomic Energy Agency (IAEA).*

NPS in outer space. (A summary of the relevance of these these and other treaties to the use of NPS in space has been provided in Bennett 1988.) In fact, some delegations have argued that these four treaties are sufficient to cover NPS and that no new treaties are required. Although the U.S. agrees that these four treaties govern the use of NPS in outer space, it has consistently expressed support for supplementing that general legal framework.

Cosmos 954

Cosmos 954 was one of a continuing series of Soviet reactor-powered radar ocean reconnaissance satellites (RORSATs). It was launched on 18 September 1977 from Tyuratam into an initial 89.6-minute orbit with a 251-km perigee, 264-km apogee, and 64.9-degree inclination, which allowed it to cross most of the world's land and water surfaces. Cosmos 954 was the active companion to the passive Cosmos 937 elint (electronic intelligence) ocean reconnaissance satellite (EORSAT) launched on 24 August 1977 (Laurent 1983). The EORSATs and RORSATs are designed to " . . . detect, locate, and target U.S. and Allied naval forces for destruction by anti-ship weapons launched from Soviet platforms." (DoD 1985). C. Q. Christol (1984) has written that "Cosmos 954 was a doomed satellite. The first signs of erratic behavior came within weeks after launch . . . "

On 19 December 1977 the U.S. set up a small task force in the White House to deal with the impending reentry. By 6 January 1978 it was clear that control of Cosmos 954 had been lost and on 12 January 1978, President Carter " . . . decided personally to notify the Soviets . . . that we were aware of their problems, to offer our help in monitoring the path of the satellite, and to begin preparing jointly to predict where it would fall and also to prepare for handling it if it should contact the Earth.

"The Soviets replied that it was designed so that it would be destroyed as it came back into Earth, and it was designed also so there was no possibility of an atomic explosion." (Carter 1978).

Following a 22 January 1978 request, the Soviets notified the U.S. on 23 January 1978 that Cosmos 954 would probably reenter the Earth's atmosphere on 24 January 1978. Even with U.S. and Soviet estimates of an early reentry on 24 January 1978, there was uncertainty as to " . . . whether it would hit between Hawaii on a very high curve up to the northern part of Canada or the western coast of Africa . . . " (Carter 1978). Ultimately, Cosmos 954 burned up over the remote Northwest Territories of Canada.

President Carter notified Prime Minister Pierre Trudeau as to the location of the reentry (Carter 1978). The Soviet Union offered emergency assistance to Canada but this offer was not accepted. Soviet information on Cosmos 954 was less than complete for a thorough search and recovery operation. Canada invited the U.S. to help in the tracking and recovery of the debris, a task that eventually cost the Canadian Government approximately $14 million (Canadian). Canada began two simultaneous international efforts relating to the incident with these respective aims: To obtain compensation from the USSR for the cost of search and cleanup operations and to develop an international regime that would ensure safe use of NPS in outer space (Reiskind 1981). Additional views are expressed in Young 1987.

Canada asked the USSR for $6 million (Canadian) and finally received $3 million (Canadian) in 1981. It has been speculated that the Soviet payment was probably motivated by the following factors: The international outcry over the accident, the 1968 agreement on the return of objects launched into outer space, the 1972 Liability Convention, and the decision by the U.N. to discontinue the special working group on NPS in the STSC (based on an agreement between the Soviet Union and Canada) (Christol 1984 and Reiskind 1981).

In terms of risks to the general public and the environment, the Canadian Atomic Energy Control Board report on Cosmos 954 contained these conclusions (Gummer et al. 1980):

- The total deposition per unit area of ^{90}Sr and ^{137}Cs would have been approximately one-fourteenth of the amount received in the Yellowknife area in 1973 from weapons testing fallout;
- The impact on the environment of the unrecovered particles is likely to be insignificant when compared with the fallout deposition that exists currently;
- The inventory of activation products will be a small fraction of the fission product inventory;
- Residual hazards to people from direct radiation were considered negligible because the core had disintegrated; and
- The effects of the debris on any identified or observed part of the natural environment are considered to be insignificant.

A follow-on health impact study by the Canadian Radiation Protection Bureau included these conclusions (Tracy et al. 1984):

- The particles were found to be largely insoluble in water and in dilute acids that approximate digestive juices;
- Field investigations showed no detectable contamination of air, drinking water, soil, or food supplies; and
- Encountering radioactive debris during or after 1983 would give rise to doses that are insignificant from the viewpoint of public health.

United Nations Deliberations

As scheduled in 1977, the STSC held its fifteenth session from 13 February to 2 March 1978. At the first meeting, the Canadian delegation described the accident in detail and said there was a " . . . need to develop safety standards for the uses of nuclear power sources in outer space which would be similar to those already established or being negotiated with respect to the use of nuclear materials on earth." While acknowledging that the obligation to avoid damage or harmful contamination to outer space and the Earth's environment was already covered by various outer space treaties and principles of international law, the Canadian delegation desired " . . . a measured, realistic and constructive response to the issues raised by the incident." The Canadian delegation proposed establishing " . . . a working group of technical and scientific experts to examine all the technical parameters of the problem." (U.N. 1978a).

The delegations of eight other countries joined Canada in submitting a working paper setting forth the proposed terms of reference for this proposed technical working group, which was to be formed within the STSC. Canada and other delegations also expressed the need for clarification of the legal regime governing the use of NPS. The logic of the process was " . . . that any recommendations made by the Working Group which were subsequetly endorsed by the Scientific and Technical Sub-committee would be transmitted to . . . the Legal Sub-Committee for its consideration and follow-up action as appropriate." (U.N. 1978a).

The U.S. delegation supported the Canadian proposal to form a working group, stating a belief that the use of NPS in space could be made safe. The U.S. also supported the logical process of having the STSC consider the technical aspects of any proposed principles before the LSC considered the principles. The U.S. delegation stated that, subject to further fact-finding, a binding multilateral regime could be foreseen based on such elements as establishment of safety requirements, establishment of requirements for notification, and providing assistance to affected States. In addition, the U.S. extended a standing offer to provide assistance in the search and cleanup of radioactive debris from reentering space objects belonging to any country, as well as assistance in providing emergency services to the people of any country injured by such debris. The U.S. delegation presented to the STSC a complete, illustrated description of the U.S. use of NPS in outer space (U.N. 1978a and 1978b).

Most delegations supported the Canadian proposal to develop safety standards for the use of NPS although some eastern bloc delegations expressed the view that the discussion " . . . was to a certain extent influenced by the massive campaign stirred up in mass media of some countries." These delegations believed " . . . that the use of nuclear power sources in outer space was an objective need for scientific and technical progress and that all necessary safety and security measures with regard to the use of nuclear power sources in outer space were effectively undertaken by launching States on the national level." (U.N. 1978a).

A number of delegations from developing countries expressed concern about the inability of their own authorities to deal with such an emergency had it occurred on their territories and stressed the importance of launching States providing full technical and safety information on their nuclear-powered satellites (U.N. 1978a).

Together with a group of 13 co-sponsors, the delegation from Canada put forward a working paper at the 1978 LSC session that requested the LSC, in close cooperation with the STSC, to review existing international instruments with the objective of recommending any necessary additional legal measures. While noting that " . . . the special role of the Scientific and Technical Sub-Committee is recognized in providing the scientific and technical basis for a comprehensive and effective international legal framework with respect to nuclear power sources in outer space . . . " the paper specifically noted the following matters requiring examination: safety measures, notification, and emergency assistance. In the absence of a mandate from the U.N. or COPUOS and in view of the reservations of a number of delegations to consider action of this topic before the STSC had studied it, the LSC declined to take up the topic formally (Australia et al. 1978 and Reiskind 1981).

In a spirit of openness and cooperation, the U.S. delegation submitted to the 1978 meeting of COPUOS a detailed paper on its NPS program, including a description of its three accidents that involved U.S. spacecraft with NPS on board and which had no hazardous consequences, and a description of its launch approval process (U.S. 1978). During this period, the U.S. delegation expressed the hope " . . . that other countries using nuclear power and space-launching capabilities similarly will present this type of information, so that the Sub-Committee might be as fully informed as its current session permits." (U.N. 1978b). To date, no other user of NPS in outer space has submitted a corresponding paper.

In the June 1978 meeting of COPUOS, the delegation from the USSR conceded that consideration should be given by a U.N. working group of experts to the technical aspects and safety measures relating to the use of NPS in space and that the launching State should inform concerned States in the event that a space object equipped with a NPS is malfunctioning and there is a risk of reentry. Both points were incorporated in UNGA resolution 33/16 of 10 November 1978. There was no agreement at that time formally including NPS as an item on the agenda of the LSC. This did not occur until almost two years later.

From this accidental and understandably disorganized beginning, the U.N. began its formal review of the technical and legal aspects of using NPS in outer space. These deliberations were carried out within the larger context of other issues such as direct broadcast satellites, remote sensing, the definition and/or delimitation of outer space, the use of the geostationary orbit, and the militarization of outer space. Terrestrial issues such as the Law of the Sea Treaty and the invasion of Afghanistan also intruded as did debates over the direction COPUOS was going and whether or not it should continue to operate on the consensus principle. While these other issues distracted from the work of COPUOS and its subcommittees on NPS, other factors, such as the subsequent accidents involving Cosmos 1402 and Chernobyl-4, served to maintain the drive to achieve consensus on the use of NPS in outer space. During this period, the U.S. delegation presented working papers, spoke in favor of supplementing the existing general framework of international law with principles relating to the safe and responsible use of NPS in outer space, and worked to achieve consensus on the issue. To date, these deliberations have not resulted in a complete set of principles, although two principles relating to reentry notification and assistance to States were approved by the LSC and COPUOS in 1986. Even those two principles, however, have recently been put into question.

STSC Working Group

In accordance with UNGA resolution 33/16 of 1978, the STSC established a Working Group on the Use of Nuclear Power Sources in Outer Space (WGNPS) to consider the technical aspects and safety measures relating to the use of NPS in outer space. The U.S. delegation has been an active partcipant in the WGNPS meetings and, in addition to U.S. 1978, submitted several papers including

- Use of Nuclear Power in Space by the United States of America (1979);
- Potential Improvements in Predicting Reentry Phenomena (1980); and
- Criteria for the Use of Nuclear Power Sources (NPS) in Outer Space (1980).

Background Papers

Other delegations, most notably Canada, the Federal Republic of Germany, France, Japan, Sweden, and the United Kingdom, were also quite active in submitting working papers.

Some of the reports were of interest to the U.S. NPS program. For example, in reviewing the U.S. 1964 Transit 5BN-3 accident, which involved a SNAP-9A RTG, a Japanese paper estimated an average individual dose of about

0.4 mrem after atmospheric burnup of a spacecraft containing 10 kCi of ^{238}Pu. (SNAP-9A had 17 kCi of ^{238}Pu.) The associated excess risk of lung cancer and bone cancer was estimated to be 8×10^{-9} and 1.6×10^{-9}, respectively (Japan 1979). In an earlier paper, the U. K. delegation observed " . . . that the quantity of ^{238}Pu dispersed in the atmosphere from satellites should not exceed about 500 kCi per year if the accepted population dose limits are to be observed." (U.N. 1978b). This independent work by other national experts supported the U.S. safety design goal of intact reentry.

For reactors, one U. K. working paper noted that "the products of fission are roughly comparable with the products of a weapon of the same thermal power; each megaton of weapons corresponding to around 1,000 million kWh of thermal reactor energy . . . Since the whole nuclear weapons programme has resulted in a radiation dose at its maximum approaching that currently accepted for whole populations, it would take some 10,000 missions of the power expected in 1985 . . . spread over perhaps 10 years to give a comparable population hazard." (U.N. 1978b). A Japanese working paper reported an average individual dose of about 0.002 mrem resulting from the atmospheric burnup of a 100-kWt reactor with 500 kCi of fission products (equivalent to the Canadian estimate of the fission product inventory of Cosmos 954). The Japanese working paper estimated the corresponding excess risk for an individual receiving 0.002 mrem as 2×10^{-10}. (Japan 1979). Both the U. K. and Japanese working papers cited above considered the exposure to direct radiation from a reactor that had reentered intact and noted that the doses depended upon the location of the impact and appropriate safety measures.

Another U. K. working paper summed up the situation as follows: "All activities have some level of risk of injury attached to them . . . Even a cursory comparison . . . indicates that the risk to the population arising as a consequence of the use of nuclear technology in space is small compared to those from other causes. Even compared to the conventional hazard from space operations, the hazards of a peculiarly nuclear nature are small. For instance it was estimated that consequent upon the uncontrolled reentry of Skylab there was a probability of $\sim 6 \times 10^{-3}$ of killing someone. The highest probability of an early death associated with the purely nuclear aspects of radio-isotopic or reactor powered generating systems is estimated to be $\sim 10^{-6}$ per device." (U. K. 1980).

1981 WGNPS Report

Using these and other papers, the WGNPS met formally in three sessions (1979, 1980, and 1981) and, at the conclusion of its third session in 1981, issued a report that remains the definitive U.N. statement on the technical and scientific aspects relating to the use of NPS in space. The U.S. delegation worked actively with the Canadian delegation and the other WGNPS delegations to achieve consensus on the safety and technical aspects of the 1981 WGNPS report in an effort to maintain the momentum toward the LSC. Consequently, the U.S. delegation has consistently supported the text of the 1981 report.

The 1981 WGNPS report reflects a consensus view with regard to various aspects of the use of NPS in space, including the types of NPS, safety measures, notification of reentry, orbit prediction, and search and recovery. The following subsections cover these topics.

Types of NPS

While the WGNPS report noted that various types of power sources are available for spacecraft, it said that " . . . for certain important space missions NPS have been the preferred technical choice. Provided the additional risks associated with NPS are maintained at an acceptably low level, the Working Group considered that *the basis of the decision to use NPS should be technical.*" (Emphasis added.) The WGNPS report observed that "the particular advantages of the use of NPS are their long life, compactness and ability to operate independently of solar radiation." (U.N. 1981).

The WGNPS report dealt with two kinds of NPS: radioisotope generators and ^{235}U reactors. Plutonium-239 reactors were not considered because there was no evidence that any nation was using them. A U. K. working paper, however, noted in comparison with ^{235}U that " . . . a plutonium fuelled reactor would be a somewhat greater risk, but it would take many times the five tonnes of plutonium dispersed in weapon tests before the hazard from fissile material could dominate." (U.N. 1978b).

Safety Measures

From the beginning, the WGNPS set as an objective the requirement " . . . that appropriate design and operational measures be taken, in order to protect the population and the environment for both normal and accidental conditions." The WGNPS report recommended using probabilistic risk assessment techniques to assess the risks inherent in each particular application or project (U.N. 1981).

For radioisotope systems, the WGNPS report said, " . . . the design should ensure minimal leakage of the radio-active contents with a reasonably high level of probability of success in all credible circumstances including launch accidents, reentry into the atmosphere, impact and water immersion." (U.N. 1981). This recommendation is consistent with the current U.S. practice (Bennett 1987).

Because the term "credible" was used in the WGNPS report, some delegations distinguished two classes of NPS reentry:

- Probable scenarios—those with a probability of occurrence of more than 10^{-3} per individual mission; and
- Improbable scenarios—comprising all the more remote failure probabilities, where the International Commission on Radiological Protection (ICRP) approach is not directly applicable, and including many highly unlikely events where the dose limits recommended by ICRP may be exceeded, or even greatly exceeded (U.N. 1981).

For ^{235}U reactor systems, the WGNPS report saw no problem if they were started and operated in sufficiently high orbits to give time for the radioactive materials to decay to a safe level in space. For reactors operated in low Earth orbits, the WGNPS recommended boosting the reactor to a higher orbit after the mission was completed. The report continued, "In the event of an unsuccessful boost into higher orbit the system should in all credible circumstances be capable of dispersing the radio-active material so that when the material reaches the earth the radiological situation conforms to the recommendations of ICRP when relevant." (U.N. 1981).

A 1987 Canadian proposal provides an interesting modification to the reactor safety criteria: "Nuclear reactors shall be designed either to reenter the Earth's atmosphere and land while maintaining the functional integrity of the containment of radioactive materials, or to divide and disperse into fine particles the radioactive materials upon reentry into the Earth's atmosphere . . . " (Canada 1987). This proposal was in keeping with an earlier Canadian view that " . . . there should be no radioactive material dispersed in the atmosphere or deposited on the ground. It would, therefore, be necessary for launching States to design housings for nuclear power packs which would survive intact after re-entry . . . "(U.N 1987b). This view is in concert with the U.S. safety philosophy (Bennett 1987).

The subject of applying radiation standards to accidents involving NPS has been a thorny one for the WGNPS and the STSC as well as the LSC. While the WGNPS report cited paragraph 12 of ICRP publication 26 (ICRP 1977) that " . . . no practice shall be adopted unless its introduction produces a positive net benefit . . . " and " . . . all exposures shall be kept as low as reasonably achievable, economic and social factors being taken into account . . . ", the report also stated "The Working Group noted that ICRP publication 26 does not provide specific guidance for accidents and emergencies although it does address in general terms the circumstances in which remedial action might be taken." (U.N. 1981). The Working Group was well aware from U.K. 1980 " . . . that, in some possible accident situations, the dose limits of ICRP publication 26 could be exceeded." (U.N. 1981). Throughout the WGNPS report is the classic dilemma between the desire to set standards and the recognition that in accident situations such standards are, for all practical purposes, useless. An analogy would be to set standards requiring that no airplane be capable of crashing or, if an airplane crashes, requiring that no passengers be killed. This dilemma has continued to be expressed in the subsequent STSC and LSC deliberations.

Notification of Reentry

Consistent with UNGA resolution 33/16 of 1978, the Working Group " . . . considered that States should be informed of a possible re-entry or malfunctioning of a spacecraft carrying an NPS so that those concerned might take necessary precautionary measures." (U.N. 1981). The WGNPS agreed upon a format for notification based upon the requirements of the 1976 Registration Convention, which entered into force before the reentry of Cosmos 954. That convention requires each State to furnish to the Secretary-General of the U.N., as soon as practicable, the following information:

- Name of launching State or States;
- An appropriate designator of the space object or its registration number;
- Date and territory or location of launch;
- Basic orbital parameters, including nodal period, inclination, apogee, perigee; and
- General function of the space object.

Basically, the format proposed by the WGNPS builds on that given in the Registration Convention with two additions:

- Information required for best prediction of orbit lifetime, trajectory, and impact region; and
- Information on the radiological risk of nuclear power source(s):
  - —Type of NPS: radioisotopic or reactor and
  - —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 (U.N. 1981).

The information provided by the launching State on the reentry of Cosmos 1402 in 1983 fell short of meeting the WGNPS format. As a result, there have been calls on the launching States for stricter compliance with the format and for more timely and wider dissemination of updates on reentering space vehicles containing NPS that may give rise to radiological hazards. The Cosmos 1900 incident has further exacerbated this situation.

Orbit Prediction

The WGNPS report noted that the " . . . prediction of orbit lifetimes and reentry paths of uncontrolled satellites remains at best an inexact science." The report essentially agreed with an earlier U.K. report that " . . . reentry dates can be predicted with an error of about 10 percent of their remaining lifetime. Thus, a prediction of 10 days before reentry would be likely to be in error by one day, and a prediction of 10 hours before re-entry might be in error by about one hour—during which time a satellite travels more than half-way around the world." To improve the accuracy of predictions, the WGNPS recommended " . . . implementation of additional degrees of control, further research and study and . . . extensive and co-operative use of tracking stations and communications lines." (U.N. 1981).

Search and Recovery

The WGNPS report recommended appropriate training be afforded to personnel of States requesting training on hazard evaluation and on performing pertinent search and recovery and emergency planning operations. The WGNPS noted in the 1981 report that the Rescue Agreement obligated a launching State at the request of a State affected to eliminate possible damage or harm caused by its space object and that the Liability Convention obligated a launching State to render appropriate and rapid assistance to an affected State when that State so requests (U.N. 1981).

Subsequent Activities

At the conclusion of its third session on 6 February 1981, the WGNPS ". . . recommended that its work should be suspended and that the Group could be reconvened as requested in accordance with established procedure." (U.N. 1981). This recommendation resulted from negotiations between the delegations of Canada and the USSR. In April 1981 the Soviet government paid the Canadian government $3 million ". . . in full and final settlement of all matters connected with the disintegration of the Soviet satellite 'Cosmos 954' in January 1978." (Reiskind 1981). Although the WGNPS also recommended that the question of using NPS in outer space be retained as a priority item on the agenda of the STSC, once the STSC approved the WGNPS report, the focus shifted to the LSC.

According to published reports, the RORSATs underwent some design and operational changes following the Cosmos 954 reentry. As an example, Cosmos 1266, which was launched on 21 April 1981, displayed the new proper sequence of operations and events. Upon completion of its operational life in a 248-km by 267-km orbit, Cosmos 1266 was split into three parts:

- Object A—reactor plus small kick stage;
- Object B—expended Scarp SL-11 second stage of the launch vehicle; and
- Object C—radar antenna.

The reactor was boosted into a higher orbit and the reactor core was then ejected (Object D) to prevent reentry for some 500 years (Anselmo and Trumpy 1986 and Clark 1985).

This process worked until 28 December 1982 when the satellite Cosmos 1402 (international designation 1982–084A or "Object A") reached the end of its mission. The 9-m radar antenna (1982–084B or "Object B") successfully separated. However, the kick stage did not separate which prevented the boost of the reactor into a higher orbit. The reactor core (1982–084C or "Object C") was then ejected so that it would burn up on reentry (or so it was claimed) (Anselmo and Trumpy 1986).

Because of its low ballistic coefficient, the radar antenna (Object B) reentered on 30 December 1982 soon after separation. Object A, composed of the expended second stage, the spacecraft instrument section and the kick stage, reentered on 23 January 1983 over the Indian Ocean. Object C, with the nuclear fuel, reentered on 7 February 1983 over the southern Atlantic Ocean (Clark 1985). There was a short flurry of statements and papers associated with the Cosmos 1402 reentry, which also occurred just before an STSC meeting.

The information provided by the Soviet Unon on the reentry of Cosmos 1402 in 1983 fell short of meeting the format recommended in the 1981 WGNPS report. As a result, there have been calls on the launching States for stricter compliance with the format, and for more timely and wider dissemination of updates on reentering space vehicles containing NPS which may give rise to radiological hazards. Indeed, throughout the consideration of this topic, there have been calls for information relating to NPS on space objects prior to launch. Notably, the 1981 WGNPS report does not support calls for such information prior to launch. While the report refers to "prior notification" it clearly addresses notification prior to reentry—not prior to launching: "The earliest possible notification of such an occurrence is deemed essential. Even prior notice of a few hours before possible re-entry can be of assistance to authorities planning emergency measures." (U.N. 1981).

The U.S. delegation had worked actively with the Canadian delegation and the other delegations in the WGNPS to achieve the consensus reflected in the 1981 report, and has consistently emphasized the importance of the 1981 report to the development of principles relating to the safe use of NPS, insisting that those principles be consistent with the consensus developed in that report.

As a result of the reentry of Cosmos 1402, the U.S. delegation along with many other delegations supported the reconvening of the WGNPS. The WGNPS was reconvened in 1984 in accordance with UNGA resolution 38/80 of 15 December 1983 but little of substance came of this meeting or the following one in 1985. While discussions of NPS have continued in the STSC, the WGNPS was again suspended in 1986 and remained suspended until 2 December 1987 when the General Assembly determined on the basis of consensus to reconvene it again beginning in 1988 (UNGA resolution 42/68).

At the 1987 meeting of the STSC, the STSC welcomed the conclusions of the two post-Chernobyl conventions on early notification of a nuclear accident and assistance in the case of a nuclear accident or radiological emergency developed by the International Atomic Energy Agency (IAEA). While these conventions focus primarily on terrestrial nuclear accidents they are general enough to cover accidents involving the use of NPS in outer space and were intended to do so.

The Convention on Early Notification generally covers "any nuclear reactor wherever located" and specifically covers "the use of radioisotopes for power generation in space objects." The Convention on Assistance generally covers any nuclear accident or radiological emergency "whether or not such accident or emergency originates within (a State's) territory, jurisdiction or control." While the notification requirements under that convention are mandatory upon parties to it, there is no requirement on State parties to the Assistance Convention to offer or accept such assistance, only a mechanism for doing so. The mandatory requirements under the Assistance Convention relate to the manner in which assistance is to be provided, and reimbursement for such assistance, among other matters. Both conventions provided that they will not affect reciprocal rights and obligations of parties under future international agreements concluded in accordance with the object and purposes of those conventions.

Perhaps motivated by the Chernobyl experience, the 1987 STSC report went on to:

- Underline the need to elaborate the criteria for the safe use of NPS in outer space;
- Agree that the efforts to formulate safety crieria for the use of NPS should be based on but not limited to the 1981 WGNPS report;
- State the opinion that reactors should not be activated until the space objects carrying them had reached their planned operating orbit;
- Note that nuclear safety should be ensured in all phases of a mission of a space object with NPS on board; and identify the need to consider possible additional safety criteria that might be necessary to prevent, or cope with, events other than unplanned reentry into the atmosphere alone;
- Note that in all phases of a mission of a space object with NPS on board, the recommendations of the ICRP should be applied where relevant;
- Recommend that guidelines and criteria for the safe use of NPS should be reviewed, for example, 10 years after adoption;
- Call for further examination of the modalities for assistance to developing countries to improve their ability to cope with problems of radiation caused by any emergency relating to the unplanned reentry of a space object with a NPS on board; and
- Reconfirm the need for guidance to States regarding preplanning of area monitoring and countermeasures for protection of the population and the environment in case of radioactive contamination of their territory from a NPS carried by a space object (U.N. 1987a).

In its 1987 meeting, COPUOS endorsed the agreements and recommendations of the 1987 STSC report (U.N. 1987c).

Legal Subcommittee

As noted earlier, the initial logic of the COPUOS deliberations on the use of NPS in outer space was to develop first the technical background in the WGNPS and STSC then proceed to the LSC. Almost immediately after this logic was informally agreed to, the delegation from Canada took the lead in pressing for parallel studies in the LSC (Australia et al. 1978 and Reiskind 1981). UNGA resolution 34/66, adopted on 5 December 1979, included in the agenda of the LSC an item relating to the use of NPS in outer space. Since 1980 the Canadian delegation has submitted working papers for consideration by the LSC containing ideas for supplementing the legal regime governing the use of NPS. Initially the Soviet and east European delegations resisted any detailed discussion of such a regime in the LSC, arguing that the LSC did not have any mandate to elaborate the legal regime; that there already existed an adequate framework of international rules for the use of NPS in space; and that, in any event, the STSC should finish its work before the LSC considered the legal aspects of the use of NPS in space (Reiskind 1981).

This resistance to discussing NPS in the LSC was overcome by UNGA resolution 35/14, adopted on 3 November 1980, which recommended an even more specific agenda item for the LSC, "Consideration of the possibility of supplementing the norms of international law relevant to the use of nuclear power sources in outer space . . . ", and the establishment of a working group in the LSC in connection with this item.

The LSC Working Group held its first meeting in 1981. Problems began almost immediately. As Reiskind (1981) has admitted, the Canadian strategy was to substitute its own working papers for the consensus 1981 WGNPS report. These papers have consistently included proposals that have departed from if not been at odds with the 1981 report. Examples of these departures include the following (Canada 1981):

- Prelaunch notification (which the Soviet delegation had refused to accept every time it had been proposed in the STSC);
- Application of ICRP publication 26 to accident situations (which both the WGNPS in its 1981 report and the Canadian delegation in 1978 formally acknowledged should not be done); and
- Zero radiation exposure when a spacecraft or debris lands outside the territory of the launching State. (Cosmos 954 showed the impossibility of achieving this.)

In 1982, at both the STSC and LSC meetings, the Canadian delegation pressed for double or triple damages for accidents involving NPS. This was a totally new concept under general principles of international law and inconsistent with the Canadian–USSR settlement on Cosmos 954.

This strategy of submitting working papers which had not been reviewed by the technical experts coupled with a failure to develop informal consensus with all interested States in advance has slowed the work of the LSC on NPS to an almost imperceptible crawl. Nonetheless, the pressure on the LSC to produce guidance in the use of NPS continued unabated, fueled both by Cosmos 1402 and the Chernobyl accidents. Consequently, despite the continuing slow progress, the General Assembly, based upon a recommendation from COPUOS, decided at its 1985 session (resolution 40/162) that the LSC should go beyond considering the possibility of supplementing the norms of international law and, instead, elaborate draft principles relevant to the use of NPS in outer space. This was a position that the U.S. delegation had long supported.

As in previous meetings of the LSC, the Canadian delegation submitted a working paper at the following meeting of the LSC which formed the basis for much of the discussion on NPS. The paper, which built upon earlier discussions in either the STSC or the LSC, proposed five principles relating to (1) safety assessment and notification; (2) guidelines and criteria for safe use; (3) notification of reentry; (4) assistance to States; and (5) responsibility and liability of States. In some respects this paper showed a positive approach by the Canadian delegation to return to working toward consensus. As a result of this constructive approach and progress that the LSC and STSC had previously made on the issues of reentry notification and assistance to States, the LSC working group succeeded in achieving consensus on these two draft principles (see Appendix B). COPUOS endorsed the texts of the two principles at its 1986 meeting (U.N. 1986).

At the 1987 LSC meeting, the Canadian delegation introduced the same working paper that it had introduced at the 1986 meeting, revised to reflect the results of the previous meeting, including the two agreed upon principles on reentry notification and assistance to States. Discussion focused on the other three principles, but no agreement was reached on the text of any of them (U.N. 1987b). Several delegations questioned the approach taken in these principles as being too detailed and prescriptive. Some delegations, including the United States, also expressed the concern that in some respects the three principles, particularly principle 2 on guidelines and criteria for safe use, departed from the 1981 WGNPS report. In this respect, the United States suggested that in order to have technically defensible and meaningful principles the work of the LSC should be based on the 1981 WGNPS report and that if there have been developments or technological advances relating to the use of NPS in outer space since the 1981 WGNPS report, the WGNPS should be reestablished to examine those developments. Finally, the Soviet Union has on many occasions criticized provisions in the draft article calling for notification to the United Nations of information relating to space objects containing NPS prior to the launch of such vehicles.

Conclusion

The U.N. is continuing its deliberations on the use of NPS in outer space. Although no complete set of legal principles has yet been agreed upon, certain scientific and technical criteria for the safe design and use of NPS have been accepted by the STSC and COPUOS. The texts of two draft principles on reentry notification and assistance to affected States have been agreed to by LSC and endorsed by COPUOS.

While the U.N. deliberations on NPS have continued for ten years without producing an agreed-upon set of principles, these deliberations may have had some indirect, positive effects on the use of NPS in outer space. For example, after the reentry of Cosmos 954, the Soviet Union delayed launching another NPS-powered RORSAT for over two years and, as evidenced by the reentry of Cosmos 1402, the Soviets apparently improved their safety system to allow the reactor core to separate when boost from low Earth orbit fails and presumably to burn up during reentry.

While no progress has been made since 1986 on the principles the UNGA did agree in 1987 to the reestablishment of the WGNPS. The U.S. looks forward to the reestablishment of the WGNPS as a vehicle for making progress in this field.

It should be noted that in its 1981 report, the WGNPS concluded that " . . . the Working Group reaffirmed its previous conclusion that NPS can be used safely in outer space, provided that all necessary safety requirements are met." (U.N. 1981). This is also a succinct statement of the U.S. position.

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Appendix A

Chronology of Activities Related to the United Nations Discussions of the Use of Nuclear Power Sources in Outer Space

1978	
24 January	Reentry of Cosmos 954 over Canada.
13 February–2 March	Fifteenth session of the Scientific and Technical Subcommittee (STSC) of the U.N. Committee on the Peaceful Uses of Outer Space (COPUOS). Calls for establishing a Working Group on the Use of Nuclear Power Sources in Outer Space (WGNPS).
13 March–7 April	Seventeenth session of the Legal Subcommitte (LSC) of COPUOS. More calls for work on NPS.
26 June–7 July	Twenty-first session of COPUOS. Discussions on NPS.
10 November	Passage of U.N. General Assembly (UNGA) resolution 33/16 adding to the STSC agenda the use of NPS in outer space and requesting launching States to inform States concerned in the event that a space object with NPS on board is malfunctioning with a risk of reentry of radioactive materials to the Earth.
1979	
12–16 February	First session of the WGNPS in the STSC held in accordance with UNGA resolution 33/16 to consider the technical aspects and safety measures relating to the use of NPS in outer space. Development of initial report.
12 March–6 April	Eighteenth session of LSC. Discussion of NPS.
18 June–3 July	Twenty-second session of COPUOS. Discussion of NPS. Approval of STSC and LSC reports.
5 December	Passage of UNGA resolution 34/66 which included recommendation to include on the agenda of the LSC an item relating to the use of NPS in outer space.
1980	
28 January–1 February	Second session of WGNPS. General agreement on report which was adopted by STSC.
10 March–3 April	Nineteenth session of LSC. Continuing discussion of NPS including a "... review of existing international law relevant to outer space activities with a view to determining the appropriateness of supplementing such law with provisions relat-

	ing to the use of NPS in outer space."
23 June–3 July	Twenty-third session of COPUOS. General discussion of NPS, including possibility of developing legal norms. No consensus.
3 November	Passage of UNGA resolution 35/14 which included recommendation to include in the agenda of the LSC the modified item on NPS " . . . consideration of the possibility of supplementing the norms of international law relevant to the use of NPS in outer space . . . " and to establish an LSC working group on NPS.

1981

2–6 February	Third session of WGNPS. Adoption of final report by WGNPS and STSC. WGNPS recommended that its work be suspended and that NPS be retained as a priority item on agenda of STSC.
30 March–10 April	First session of LSC working group and report of chairman. Canadian paper broke 1981 WGNPS consensus.
22 June–2 July	Twenty-fourth session of COPUOS. Endorsed recommendations of WGNPS that its work be discontinued and NPS be retained as priority item on agenda of STSC.
18 November	Passage of UNGA resolution 36/35 which included recommendations for STSC and LSC to continue their work on NPS.

1982

11–22 January	Nineteenth session of STSC. Discussions held on NPS.
10–18 February	Second session of LSC NPS working group. More papers submitted breaking 1981 WGNPS consensus.
22 March–1 April	Twenty-fifth session of COPUOS. Endorsed STSC and LSC recommendations on NPS.
30 August	Launch of Cosmos 1402
10 December	Passage of UNGA resolution 37/89 which included recommendation that LSC continue its work on NPS.
30 December	Reentry of nonnuclear "Object B" of Cosmos 1402.

1983

23 January	Reentry of nonnuclear Cosmos 1402 structure ("Object A") over Indian Ocean.
7 February	Reentry of reactor core ("Object C") of Cosmos 1402 over Atlantic Ocean.
7–17 February	Twentieth session of STSC. Considerable discussion of NPS with many delegations calling for reestablishment of WGNPS.
22 March–7 April	Third session of LSC NPS working group. Considerable discussion of NPS. General agreement on a text concerning the format and the procedure for reentry notification.
20 June–1 July	Twenty-sixth session of COPUOS. Recommended reconvening WGNPS. Endorsed LSC text on reentry notification.
15 December	Passage of UNGA resolution 38/80 which included recommendation that the WGNPS conduct additional work on the basis of its report on the work of its third session.

1984

13–17 February	Fourth session of the WGNPS. Discussed concept of "nuclear safe orbit." Reaffirmed previous conclusion. No consensus on new items.
19 March–4 April	Fourth session of the LSC NPS working group. Much discussion of which topics to address but no consensus.
12–21 June	Twenty-seventh session of COPUOS.
14 December	Passage of UNGA resolution 39/96 which included recommendation reconvening WGNPS and continuing work in LSC.

1985

11–15 February	Fifth session of WGNPS. Reaffirmed previous conclusion. No consensus on new items.
18 March–4 April	Fifth session of the LSC NPS working Group. Developed language on frequency of notification prior to reentry and on assistance to States. Recommended reformulating agenda item to "The elaboration of draft

	principles relevant to the use of nuclear power sources in outer space."
17–28 June	Twenty-eighth session of COPUOS. General discussion of NPS. Endorsed LSC-recommended reformulation of title.
16 December	Passage of UNGA resolution 40/162 which included recommendations that STSC continue to consider NPS and that LSC undertake the elaboration of draft principles on the use NPS.

1986	
10–21 February	Twenty-third session of STSC. STSC agreed that in the development and implementation of new space systems, attention should be given to further enhancing the safety margin of space objects with NPS on board. STSC recommended more frequent updates on notification of reentry of NPS.
24 March–11 April	Sixth session of the LSC NPS working group. Recorded consensus on texts of two draft principles relating to the themes of reentry notification and assistance to States (based largely on 1983 and 1985 texts).
26 April	Accident at Chernobyl-4.
2–13 June	Twenty-ninth session of COPUOS. Endorsed recommendations of STSC and the texts of the two draft principles adopted by the LSC.
27 October	"Convention on Early Notification of a Nuclear Accident" comes into force. This post-Chernobyl convention applies to NPS in space.
3 December	Passage of UNGA resolution 41/64 which included recommendation that STSC continue work on NPS and that LSC continue to elaborate draft principles on NPS.

1987	
17–27 February	Twenty-fourth session of STSC. STSC underlined the need to elaborate the criteria for the safe use of NPS and reached consensus on several opinions about the safe use of NPS.
26 February	"Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency" comes into force. This post-Chernobyl convention applies to all nuclear accidents.
16 March–1 April	Seventh session of the LSC NPS working group. Discussed three new principles: — safety assessment and notification, — guidelines and criteria for safe use, and — responsibility of States. No consensus reached.
1–11 June	Thirtieth session of COPUOS. Welcomed conclusion of two post-Chernobyl conventions. Endorsed STSC report and recommended LSC should continue to consider NPS.
2 December	Passage of UNGA resolution 42/68 which included the recommendation that the WGNPS be reconvened and that the LSC continue the elaboration of draft principles relevant to the use NPS in space. This resolution also endorsed the recommendation and agreements of the 1987 STSC meeting.
12 December	Launch of Cosmos 1900.

Appendix B

Texts of Two Draft Principles on Nuclear Power Sources Agreed to by the U.N. Committee on the Peaceful Uses of Outer Space in 1986

NOTIFICATION

Any State launching a space object with nuclear power sources on board should (The question whether the term "should" or "shall" is to be used in the texts is to be considered later.) timely inform States concerned in the event this space object is malfunctioning with a risk of reentry 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 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 region.

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.

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

- The information, in accordance with the format above, should be provided by the launching State as soon as the malfunction has become known. It should be updated as frequently as practicable and the frequency of dissemination of the updated information should increase as the anticipated time of re-entry into the dense layers of the Earth's atmosphere approaches so that the international community would be informed of the situation and would have sufficient time to plan for any national response activities deemed necessary.

- The updated information should also be transmitted to the Secretary-General of the United Nations with the same frequency.
- Upon the notification of an expected re-entry into the Earth's atmosphere of a space object containing a nuclear power source on board and its components, all States possessing space monitoring and tracking facilities, in the spirit of international co-operation, shall communicate the relevant information that they may have available on the malfunctioning space object with a nuclear power source on board to the Secretary-General of the United Nations and the State concerned as promptly as possible to allow States that might be affected to assess the situation and take any precautionary measures deemed necessary.

ASSISTANCE TO STATES

- After re-entry into the Earth's atmosphere of a space object containing a nuclear power source on board and its components:
  (a) The launching State shall promptly offer, and if requested by the affected State (The question of the definition of the term "affected State" is to be considered later.), provide promptly the necessary assistance to eliminate actual and possible harmful effects;
  (b) All States, other than the launching State, with relevant technical capabilities and international organizations with such technical capabilities shall, to the extent possible, provide necessary assistance upon request by an affected State.

In providing the assistance in acordance with subparagraphs (a) and (b) above, the special needs of developing countries should be taken into account.

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Edited by

Mohamed S. El-Genk
Institute for Space Nuclear
Power Studies
University of New Mexico

Mark D. Hoover
Lovelace Inhalation Toxicology
Research Institute
Albuquerque, New Mexico

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