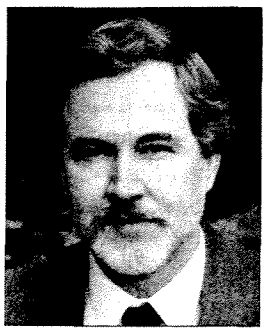
VIEWPOINT

Reaching the outer planets—with or without the U.N.



Gary L. Bennett, aerospace consultant, has over 30 years of experience in nuclear power and propulsion. He retired from NASA Headquarters in 1994 as Manager of Advanced Space Propulsion Systems. From 1980 to 1988 he was a member of or an adviser to U.S. delegations to the U.N., and he prepared the U.S. position papers on the use of nuclear power sources in space. In 1995 he shared in the AIAA Aerospace Power Systems Award (and Medal) for his management of the safety and nuclear operations of the Ulysses mission.

Exploring the outer planets and even sending missions beyond the solar system have long been among the top goals of the U.S. space science program. The four spacecraft that have ventured into these uncharted and hostile regions, where sunlight is dimmer than moonlight is on Earth, have carried their own electrical power sources in the form of radioisotope thermoelectric generators (RTGs). Unfortunately, some presumably well-intentioned but technically ill-advised actions by the U.N. may inhibit or eliminate future missions beyond Jupiter.

Questions of safety

In early 1978, a Soviet radar ocean reconnaissance satellite known as Cosmos 954 malfunctioned and reentered the Earth's atmosphere over Canada. Cosmos 954 carried a small nuclear reactor to power its radar system. Although the reactor reportedly disintegrated in the atmosphere and caused no known health effects, the reentry raised immediate questions about the safety and risks of using nuclear power sources (NPS) in Earth orbit, particularly in LEO.

Under a Canadian-led initiative, and with active U.S. support, the U.N. took up these questions in meetings of its Committee on the Peaceful Uses of Outer Space. COPUOS, formed in 1959, comprises delegations from all the spacefaring nations and other interested countries. Early on it developed documents such as the Agreement on the Rescue and Return of Astronauts and the Return of Objects Launched into Outer Space (the "Rescue Agreement"); the Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, Including the Moon and Other Celestial Bodies (the "Outer Space Treaty"); Convention on International Liability for Damage Caused by Space Objects (the "Liability Convention"); Convention on Registration of Objects Launched into Outer Space (the "Registration Convention"); and the

Agreement Governing the Activities of States on the Moon and Other Celestial Bodies (the "Moon Treaty," which the U.S. has not signed).

A basic procedural logic was developed for considering whether or not to supplement existing international regimes to cover the use of nuclear power sources. First, technical experts in the Scientific and Technical Subcommittee of COPUOS would submit and review technical working papers. Next, those technical principles on which the technical experts agreed would be passed on to the Legal Subcommittee to be considered for possible inclusion in a legal regime, if the Legal Subcommittee deemed such a regime was necessary. (In practice, participants in the technical and legal meetings were usually the same people. In fact, in the NPS deliberations, COPUOS and its two subcommittees seemed to be comprised largely of political and legal people, with very few experts on NPS.) Depending upon the outcome of these deliberations in COPUOS and its two subcommittees, some sort of legal regime (such as a treaty, committee report, or U.N. General Assembly resolution) might result.

A consensus on NPS

By 1981, the Scientific and Technical Subcommittee had reached consensus on a set of principles covering the technical and scientific aspects of using NPS in outer space. The group's report recognized the technical realities of reducing risk given the uncertainties of an accident. It described the general safety measures or goals for space reactors and radioisotope power sources, while leaving the detailed design features to the discretion of the designers.

The report itself was nonjudgmental about the use of NPS, stating, "the basis of the decision to use NPS should be technical." In closing, the report said, "the Working Group reaffirmed its previous conclusion that NPS can be used safely in outer space, provided that all necessary safety requirements are met." This conclusion represented not only a consensus of international technical experts but also a succinct statement of the U.S. position.

When international principles governing technical areas are developed without sufficient technical expertise, the consequences can be far-reaching

Sudden about-face

And then the carefully crafted consensus process disintegrated. When the Legal Subcommittee members arrived in Geneva in March 1981, they found that several delegations, led by the Canadian contingent, had introduced working papers proposing new or different technical principles. In effect, these delegations had jettisoned the 1981 technical agreement they had approved less than two months earlier. Moreover, they were overturning four years of deliberative meetings, the outcomes of which they had earlier approved.

A rumored basis for this move was Canadian displeasure with plans by the new Reagan administration to change the U.S. position on the Law of the Sea Treaty, which Canada strongly supported. To a number of people on the U.S. side it appeared almost as if the Canadian delegation had decided to punish the U.S., rather than the Soviet Union, for the accidental reentry of the Soviet Cosmos 954 reactor.

In any case, the Canadians made it very clear in private conversations with U.S. delegates over the succeeding years that they were unhappy with the 1981 technical report that they had helped draft and then formally agreed to, and that they planned to develop a new set of principles no matter how many years it took. As a result of this break in consensus, the U.S. and several other delegations were forced into the passive role of waiting to see what the Canadian-led effort would produce.

However, as Steven Aftergood of the

Federation of American Scientists reported in 1992 in *Space Policy*, the U.S. was also playing a passive role in order to embarrass the Soviet Union. Beginning in 1978, the U.S. and Soviet delegations had held bilateral meetings at the U.N. to ensure that neither country's space program would be hurt by the U.N. activities on NPS. In late 1979, the Soviet Union invaded Afghanistan, and the U.S. administration took a much harder line in discussions with Soviet delegations.

Afghanistan and other issues gradually turned some U.S. policy people against anything the Soviet Union might be doing in space, even if this position worked to their own country's disadvantage. In not actively fending off some of the wilder Canadian proposals, the U.S. delegation hoped to see the Soviets remain on the defensive for their role in Cosmos 954 and the later Cosmos 1402 reactor reentry. The U.S. strategy, it seemed, was basically to gamble that the Soviets would be the only ones whose space nuclear program would be hurt by the Canadian-led initiative. This gamble failed when the Soviet delegates deciphered the State Dept. game plan in the late 1980s and stopped objecting to the principles.

The payoff of persistence

The Canadians' persistence paid off for them at the 1990 Scientific and Technical Subcommittee meeting. At this meeting, the U.S. delegation, operating without technical input from U.S. user agencies (NASA and DOD), and in violation of long-standing U.S. positions, agreed to a set of principles that were greatly at variance with the 1981 consensus report and with U.S. policy and practices. The principles adopted in 1990, had they been left unamended or unclarified, would have prohibited most proposed nuclear propulsion missions (either nuclear electric or nuclear thermal) and all future planned radioisotope-powered missions (such as Cassini).

Many of the principles appeared to have been written by nonexperts who were pursuing a political agenda rather than an honest nuclear safety one. For example, some of the technical requirements were impossible (the equivalent of asking airplanes or automobiles not to crash) or nonsensical (asking radioisotope power sources not to be radioactive).

When the U.S. delegation informally proposed the possibility of some changes a month later at the 1990 Legal Subcommittee meeting, they were informed by the same delegations that had broken the 1981 consensus that it was not possible to break the new one. Putting other delegations on notice that the U.S. wanted changes in the principles, Bruce Rashkow of the State Dept. formally stated in 1990, "our agreement to any principle is subject to the understanding that at some stage a complete set of principles will have to be considered in its entirety, as was the case with the principles this Subcommittee developed in regard to Remote Sensing. Some changes are inevitable as we understand better the interrelationship between the principles." Unfortunately, the State Dept. was unwilling to change any of the safety principles directly.

These principles, if implemented literally, probably would have closed the door on any further missions to the outer planets. In fact, many of the U.S. NPS missions, such as Pioneer, Viking, Voyager, Galileo, and Ulysses, probably could not have met a literal interpretation of the 1990 principles. As a result, U.S. technical experts pressed for a revision that would make the principles technically and operationally realistic. However, the policy people, particularly those at the State Dept., resisted any technical changes to the safety principles and suggested instead inserting "clarifying" language in the preamble or in the definitions.

Technical inaccuracies

It is worthwhile to look at the principles and see where the problems are and how some were eventually "fixed" using the State Dept. approach. First it should be noted that the final document the U.N. General Assembly adopted by resolution in 1992 contains two separate preambles and 11 principles covering such topics as applicability of international law; use of terms (definitions); guidelines and criteria for safe use; safety assessments; notification of reentry; consultations; assistance to states; responsibility, liability, and compensation; settlement of disputes; and a principle on future review and revision.

Most of these are not much different from principles already in effect in such legal documents as the Outer Space Treaty, the Liability Convention, and two post-Chernobyl conventions. The most troublesome principle was the third one, "Guidelines and Criteria for Safe Use," as it contained flawed and technically inaccurate statements.

One of the most disturbing parts of the

third principle was the requirement for meeting certain radiation dose limits in an accident. This is a stipulation that is not applied in the U.N.'s International Atomic Energy Agency (IAEA), the International Committee on Radiological Protection (ICRP), or the U.S. Nuclear Regulatory Commission except in those isolated cases of well-defined "design basis events" where everything is specified ahead of time. But because a real accident is by definition a series of events out of human control, placing radiation dose limits on hypothetical nuclear accidents is akin to placing limits on how many people can be injured in airplane or automobile accidents—an absurd concept.

Even the IAEA representative spoke out against the concept of dose limits in a statement that concluded, "The sole use of the individual-related dose limits, rather than the complete ICRP system of radiation protection (including source-related constraint), is, in the Agency's view, inappropriate and does not conform with the aims of the ICRP recommendations." The IAEA representative continued that since the ICRP had recently issued new recommendations on dose limitation, "It might, therefore, be problematic to issue guidelines and criteria of safe use of NPS in outer space that would be outdated from their inception."

In other words, what the U.N. was doing was analogous to designating a national speed limit in 1789 and enshrining it in the U.S. Constitution—something that would be difficult to change as technology advanced. The U.S. delegation pointed out just this absurdity in a statement read by Peter Smith of NASA in 1992: "One significant example [of the need for technical accuracy] is in the area of dose limits. In November 1990 the International Commission on Radiological Protection has published new recommendations, in the form of ICRP-60, which supersede the approach taken in Principle 3 when it was developed earlier that year."

The U.S. delegation tried to ameliorate the impact of this technically flawed principle by delimiting in the definitions section the types of accidents to which it could be applied. Unfortunately, this "diplomatic fix" does nothing to overcome the fact that existing U.S. RTGs violate the dose limits in their normal operating mode.

The original 1990 principles would have applied the concept of "defense in depth" to all NPS. Defense in depth is a term with particular meanings for large-scale terrestrial nuclear facilities, which often operate for decades in fixed locations. The term was not appropriate to transitory space NPS. COPUOS allowed the U.S. to modify the definitions to exclude application of the terrestrial concept. The U.S. delegation also noted that the original principles would have prevented the use of nuclear propulsion in space and would have created a safety risk by precluding prelaunch testing of NPS. Under U.S. pressure, some clarifying words were added to eliminate these problems.

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Another part of the principles is as troubling as the dose limits. This is the requirement that radioisotope generators be able to withstand any kind of relevant reentry such that "no radioactive material is scattered into the environment" and "the impact area can be completely cleared of radioactivity by a recovery operation." This section sets a more rigorous standard for radioisotope power sources than for reactors, which presumably are allowed to scatter radioactive materials in the environment. The section does not consider the use of mission design and operation to minimize the reentry probability, nor does it consider the internationally accepted practice of using probabilistic risk analyses to perform safety assessments.

There is also a glaring technical inconsistency between this section and the dose limits section: Even if current-generation RTGs met all of the containment requirements, the natural radioactive emissions of the radioisotope fuel would still violate the somewhat arbitrary dose limits.

The irony is that the Canadian government, which pushed strongly for this principle, showed through analyses that it did not need to completely clear the radioactive debris from Cosmos 954. Adding to this irony is the Canadian government's acceptance of less than the full cost of cleanup from the Soviet government.

The publicly expressed U.S. diplomatic

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"We continue to believe that the principles will only be as strong as their scientific and technical underpinnings, and that the recommendations of this Subcommittee should reflect the best and most current data available. Only in this way will the principles derived from them...be a credible contribution to the safe use of nuclear power sources in space."

view of the technically flawed principles was perhaps best summarized in a 1992 statement by Smith to the Scientific and Technical Subcommittee of COPUOS: "The United States stands ready to finalize the principles, provided that our concerns with respect to their technical accuracy, their appropriateness, and the scope of their coverage are adequately addressed. We continue to believe that the principles will only be as strong as their scientific and technical underpinnings, and that the recommendations of this Subcommittee should reflect the best and most current data available. Only in this way will the principles derived from them...be a credible contribution to the safe use of nuclear power sources in space."

A rear-guard action

Unfortunately for U.S. technical experts, officials from the State Dept. conducted a rear-guard action in 1991 and 1992 through the National Security Council to prevent any substantive changes in the safety criteria. One could speculate that it was apparently more embarrassing for a few individuals to lose face than it was for the whole government to be wrong.

In 1992, when the U.N. General Assembly adopted the principles, the Orwellian nature of the U.S. view was expressed by Kenneth Hodgkins of the State Dept.: "The United States did not block the consensus recommendation of the Committee to forward the principles to the General Assembly, nor will the United States oppose their adoption here. On some points, however, it remains our view that the principles related to safe use of nuclear power sources in outer space do not yet contain the clarity and technical validity appropriate to guide safe use of nuclear power sources in outer space. The United States has an approach on these points which it considers to be technically clearer and more valid and has a history of demonstrated safe and successful application of nuclear power sources. We will continue to apply that approach." In short, the U.S. may have voted for the principles, but it does not intend to abide by them.

In an internal memorandum dated December 2, 1992, D. Allan Bromley, then the president's science advisor and the person responsible for approving the launches of U.S. NPS, was even more blunt: "As our delegation made clear, pending necessary technical revisions, the U.S. government will not look to these flawed principles as standards of review for space launches involving nuclear power sources." Elsewhere, the memorandum stated that "Over the past 2 years, the United States has worked diligently to improve the scientific and technical validity of these principles, as well as to ensure their consistency with established U.S. safety practices. On some points, however, it is our view that the principles do not yet contain the clarity and sound technical standards necessary to serve as a basis for decision making in this area."

The memorandum closed with, "The United States will continue to employ its stringent design and operational flight safety measures to protect the public and the environment under normal operations and postulated accident scenarios. The overall safety review...conducted by an independent Interagency Nuclear Safety Review Panel...will continue to ensure that nuclear power sources undergo a thorough safety assessment prior to launch, and will serve as the standard by which the safety of these launches is determined."

Subsequently, the then-new Clinton administration conducted a review of the U.S. position, and it was determined (as reported

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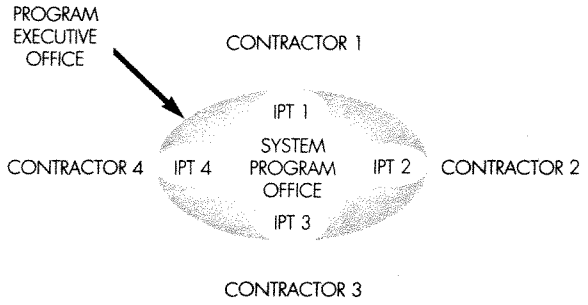
payload processing, and incorporation of advanced launch system concepts.

• McDonnell Douglas is evolving the current Delta II and soon-to-be Delta III launch systems into a Delta IV family. The program combines the upper stages of current vehicles with a new operable low-cost common booster core. Its development of the Delta III cryogenic upper stage and integration of a new Delta II avionics system with fault-tolerant avionics and automation of the launch processing control system provide operational validation of the new system's building blocks.

A wide variety of ground support system concepts for launch processing operations were proposed. Although each was oriented toward optimizing a particular overall system concept, all sought to make maximum use of existing facilities and support services. This is critical with limited funding for EELV development, which includes all facilities work and modifications.

Each contractor will bring its concept to maturity and attempt to show that it will reduce the cost of space launch over the national mission model provided. All the contractors recognized the importance of introducing concepts based on commonality of component elements to reduce the cost of launch systems. This heritage allows development costs and risk to be minimized.

EELV GOVERNMENT INSIGHT MODEL



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The EELV program is entering an era of great change. Transition to a new method of doing business may cause people to feel uncertain and intimidated. However, both the space industry and the economy can be reinvigorated by meeting the challenge of gaining affordable access to space in the 21st century. ▲

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in one 1994 internal government memorandum) that "U.S. policy and practice in the use of nuclear power sources in outer space is fully consistent with the overall objective and intent of the Principles. The U.S. has a rigorous safety review process prior to launch of nuclear power sources, and intends to continue to apply that approach. The Principles will not affect currently planned U.S. missions with NPS on board." (Given what the principles say about radioisotope power sources, this last statement can be disputed.)

In particular, the memorandum noted, "...the proposed position *does not* confer U.S. approval of any specific provisions of the Principles, but only declares that U.S. policy and practice is consistent with their *overall objective and intent,* which is the safe use of NPS in outer space." Again, this is simply another way of saying that the U.S. voted for the principles, but intended to do it its own way.

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Since this situation arose, U.S. policy people have done little to correct the problems they have created, preferring to hide behind statements that the principles are "nonbinding" and only "recommendatory" in nature. In fact, the U.S. has resisted any attempt to reopen the principles (as the principles themselves require), in the hope that this whole matter will quietly disappear. However, many U.S. technical experts have remained concerned about the very existence of a technically invalid document in which some can interpret night to mean day. The principles can be seen as a time bomb waiting to be set off through legislative action.

In a sense these principles are symptomatic of the age in which we live, one in which beliefs and wishes and ideology seem to count for more than technical reality. Policy decisions made in a technical vacuum are ultimately just vacuous statements that are soon discarded, leaving everyone cynical about the "policy wonks." Whether the issue is NPS, remote sensing, orbital debris, the definition and delimitation of outer space, or direct broadcast satellites, it is essential that qualified technical experts be involved in the development of any international principles affecting that area. ▲