APPENDIX D
RESPONSES TO PUBLIC REVIEW COMMENTS
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The U.S. Environmental Protection Agency (EPA) published a Notice of Availability for the Cassini mission Draft Environmental Impact Statement (DEIS) in the Federal Register on October 21, 1994. The public review and comment period closed on December 20, 1994. Timely comments were received from organizations and individuals listed in Table D-1.

Where no extension of the comment period was requested or otherwise authorized by NASA, untimely comments were considered if received before March 3, 1995 (see Table D-2). As of March 3, 1995, 25 letters were received after the comment period closed, and are included in this Appendix.

This Appendix provides specific responses to the comments received from the individuals and organizations listed in Tables D-1 and D-2. Copies of the comment letters are presented in the following pages. The relevant issues in each comment letter are marked and numbered for identification along with the National Aeronautics and Space Administration's (NASA's) response to each issue. Where changes in the text were appropriate, such changes were noted in the comment response.

The majority of the public comments received raised the following issues on the Environmental Impact Statement (EIS):

- the use of plutonium in space
- the status of solar technology for deep space missions
- the properties of plutonium
- the radiological consequence and risk analyses.

Information on these topics may be obtained in the following sections of the EIS:

The use of plutonium in space - Section 2.2.4 of the EIS describes the plutonium-containing radioisotope thermoelectric generators (RTGs) and radioisotope heater units (RHUs) in detail, including the testing and verification data to ensure containment of the plutonium dioxide fuel under most accident environments. In addition, Section 2.6.3.1 compares the physical properties and the attendant production requirements of alternative radioisotopes to plutonium-238. Section 2.6.3.2 discusses the limitations of the potential alternative conversion technologies to the thermoelectric converter used on the RTGs that would potentially result in the use of less plutonium.

The status of solar technology for deep space mission - Section 2.6.3.4 discusses the level of development of solar technology and the various solar design options that were evaluated for the Cassini mission.
The properties of plutonium—Appendix C of the EIS briefly describes the properties of plutonium-238 and the environmental effects of plutonium dioxide used in the RTGs and RHUs.

The radiological consequences and risk analysis—Section 4.1.5 of the EIS presents: the radiological consequence methodologies, the postulated accident scenarios and the associated probabilities of their occurrence, and the potential source terms. The potential radiological consequences from postulated accidents are described in Sections 4.1.6.2 and 4.2.6 in two ways: the land areas that could be contaminated above the EPA screening level of $7.4 \times 10^3$ Bq/m² ($0.2 \mu$Ci/m²), and health effects (excess latent cancer fatalities). The risk analyses for the mission are presented in Sections 4.1.8 and 4.2.8 from three perspectives: contribution by mission phase/scenario to mission risk (expressed as health effects mission risk); average individual risks; and the risk to the maximum exposed individual.
### TABLE D-1. LISTING OF COMMENTORS

<table>
<thead>
<tr>
<th>Commentor Number</th>
<th>Date of Comment</th>
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<td>Private Citizen</td>
<td>Merilyn Hiller</td>
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TABLE D-2. LISTING OF COMMENTORS RESPONDING AFTER CLOSE OF THE PUBLIC COMMENT PERIOD (Continued)

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<td>Religious Education for the Catholic Deaf &amp; Blind</td>
<td>Rev. René Robert</td>
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RESPONSES TO COMMENTS

Commentor No. 1: Florida Coalition for Peace & Justice
(Bruce K. Gagnon)

Response to Comment 1A:

The Cassini Environmental Impact Statement (EIS) now contains an updated version of the corresponding table from the Ulysses mission Tier 2 EIS (NASA 1990). The plutonium inventories on U.S. spacecraft previously launched have been included in Table 2-2.

Response to Comment 1B:

Solar cells recently developed under laboratory conditions by European Space Agency (ESA) have demonstrated desirable characteristics for missions traveling about two-thirds of the distance to Saturn. For research and development purposes, Deutsche Aerospace and CISE (Milan, Italy) have produced a small quantity of Low-Intensity, Low-Temperature (LILT) silicon solar cells for potential use on space missions such as ESA’s Rosetta comet mission. The cells thus far, have tested favorably under simulated environments for use at nearly 6 astronomical units (AU). (Cassini will need to operate at 9 to 9.3 AU while at Saturn). Calculations suggest that operation at Saturn conditions may subject silicon cells to low temperature freeze out, significantly reducing their performance. However, in view of the margin of error, Jet Propulsion Laboratory (JPL) has assumed that optimum cell performance would be available in all Cassini array studies. The ESA LILT cells are relatively thick compared to other cells evaluated for potential use on the Cassini spacecraft and have low resistance to radiation damage compared to the conventional thin silicon and gallium arsenide space solar cells previously assumed in the array sizing studies. Analysis by JPL spacecraft electrical power systems engineers shows that the improved performance of the LILT cells (25 percent efficiency instead of less than 20 percent achieved by most other cells) would be offset by their increased mass and greater radiation sensitivity (S. Strobel and K. Bogos et al. [in Print] “Si and GaAs Solar Cells for Low Intensity, Low Temperatures Operations,” in the Proceedings of 1st World Conference on Photovoltaic Energy, Hawaii, December 5-9, 1994). As with other solar power options studied for the Cassini spacecraft, the extremely large mass of even the lightest solar configuration is beyond the lift capability of the Titan IV (Solid Rocket Motor Upgrade [SRMU]/Centaur launch vehicle. Even if a heavy-lift booster and a suitable upper stage could be made available, the severe field-of-view problems, greatly increased turn times, and greater operational complexity and programmatic risk associated with an all-solar Cassini design makes such a design, from both mission engineering and scientific perspectives, infeasible.
Even if the solar cells discussed in the ESA press release become available for future application in deep space, these ESA solar cells would not necessarily be applicable for all future deep space missions due to the limitations discussed above. Therefore, radioisotope thermoelectric generators (RTGs) are likely to remain the more feasible power source for certain missions.

Response to Comment 1C:

The RTGs that would be onboard the Cassini spacecraft are not a product of or directed by the nuclear power industry. RTGs were developed by the Department of Energy (DOE) in response to the need for a compact, reliable source of small amounts of electrical power for U.S. deep space missions.

Response to Comment 1D:

This EIS addresses the impacts of preparing for and implementing the Cassini mission. The environmental, safety and health impacts associated with RTG and radioisotope heater unit (RHU) manufacturing processes at DOE facilities are the subject of separate National Environmental Policy Act documentation and are not within the scope of this EIS. For more detailed information, see the reference, Environmental Assessment for Radioisotope Heat Source Fuel Processing and Fabrication (DOE 1991).
RESPONSES TO COMMENTS
Commentor No. 1: Florida Coalition for Peace & Justice
(Bruce K. Gagnon)
(Continued)

Response to Comment 1E:

The risk analysis presented in the EIS is deterministic. Monte Carlo simulations, however, were performed in the estimation of the launch phase initiating accident scenario probabilities and the Earth-Gravity-Assist (EGA) inadvertent reentry probabilities. The Monte Carlo technique is appropriate when evaluating functional relationships involving probability distributions. As part of the launch approval process, DOE will be preparing a more in-depth evaluation of the potential environmental consequences as part of the Final Safety Analysis Report (FSAR). Monte Carlo simulations will be applied in the FSAR.

The Systems for Nuclear Auxiliary Power (SNAP)-9A RTG, which used plutonium (Pu-238) fuel in the metallic form, was designed for reentry burnup. Following the SNAP-9A reentry burnup, the particles associated with the plutonium (Pu-238) had a measured arithmetic mean particle size of 10 $\mu$m with a range of 5 to 58 $\mu$m. Contacts with Dr. Gofman through his organization have failed to yield any indication that he evaluated the SNAP-9A accident.

Response to Comment 1F:

The results of the accident analysis have been factually stated in the EIS in terms of 1) the total probability of release, 2) the radiological consequences of such a release, and 3) the risk. Appendix C discusses the environmental and health risks associated with plutonium (Pu-238) dioxide in greater detail. See also Johnston v. U.S., 597 F. Supp. 374, at 409-415 (U.S.D.C., D. Kan., 1984).

Response to Comment 1G:

Tables 4-10 and 4-11 of the EIS present the estimated area of land contamination from potential accidents where plutonium could be released. Section 4.1.6.2 deals with the radiological consequences to the land.

A Phase 5 accident occurring during the 8 seconds the instantaneous impact point is over Africa would lead to spacecraft breakup during reentry. Reentry heating would cause the RTG converter housing and release the individual aeroshell modules, which would then reenter separately. General purpose heat source (GPHS) modules are designed to remain intact
under these reentry conditions. Individual reentering GPHS modules impacting rock could lead to fueled clad failures and release of fuel (an average of 5.5 $\times 10^7$ Bq [1.5 curies]). No releases would be expected from soil or water impacts. The total probability for such a release is estimated to be around 5.0 $\times 10^4$ for the Proposed Action. Should such a release occur, the maximum individual dose is estimated to be 1.24 $\times 10^4$ Sv (1.24 $\times 10^2$ person-rem) and the collective dose is estimated to be 4.32 $\times 10^3$ Sv (4.32 $\times 10^1$ person-rem), resulting in 1.51 $\times 10^4$ health effects.

A review of Tables 4-10 and 4-11 of the EIS reveals that the estimated area of land contamination based upon a U.S. Environmental Protection Agency screening level of 7.4 $\times 10^3$ Bq/m$^2$ (0.2 $\mu$Ci/m$^2$) for a Phase 5 accident would be about 0.02 km$^2$ (0.008 mi$^2$) in the expectation source term case, and about 0.1 km$^2$ (0.04 mi$^2$) in the maximum source term case (Command Shutdown and Destruct Scenario). It should be noted that these estimates would apply to an accident occurring during the 8-second period of Phase 5 when the GPHS modules could impact the African continent. Even then, the modules would have to impact rock for a release to occur. The amount of land that would have to be remediated, if any, would be determined by an assessment of the impact location. For accidents occurring outside the United States or its territorial jurisdictions, the State Department and diplomatic channels would be employed in accordance with pre-arranged procedures and support elements would be dispatched as appropriate.

Response to Comment 1H:

NASA has followed the technical progress in power source technology worldwide for many years. Indeed, a substantial portion of the work in the area of solar arrays has been funded by NASA. While improvements have been made in solar technology, significant breakthroughs are still required to support a mission like Cassini. Recent international conferences on space power provided no reports of technical breakthroughs that would suggest changing the proposed approach to powering the Cassini spacecraft. The availability of the solar power option was discussed in response to Comment 1B.
Response to Comment 1:

NASA places the highest priority on assuring the safe use of radioactive materials in space. Thorough and detailed safety analyses are conducted prior to launching NASA spacecraft with RTGS, and many prudent steps are taken to reduce the risks involved in NASA missions using RTGS. In addition to NASA's extensive internal safety requirements and reviews, missions that carry nuclear material also undergo an additional safety review involving detailed verification testing and analyses.
We are presently running an international petition campaign calling for an end to the Cassini mission as long as nuclear power is used onboard.

We urge NASA to rethink its severe opposition to solar in deep space, especially when the Cassini mission partner ESA, now acknowledges that RTG's are not needed for deep space missions.

Our opposition to nuclear power in space will only deepen as NASA explores the use of such power for the Moon colony or the Mars exploration mission. As the public learns more about this issue as they have since Galileo they too will begin to pay a closer look at who is running the show down at NASA and DoE when it comes to making these decisions. And we can assure you that people are becoming less intimidated by the so-called science experts as they see technology fail time after time. The taxpayer is footing the bill and is being asked to assume the risk of contamination from missions that do not need to be a threat.

If NASA wants to do pure science they had better start getting out of bed with the nuclear industry that is in it for pure profit. We will continue to shine a light on this unholy alliance.

In peace,

Bruce K. Gagnon
State Coordinator

RESPONSES TO COMMENTS
Commentor No 1: Florida Coalition for Peace & Justice
(Bruce K. Gagnon)
(Continued)

Response to Comment 1J:

NASA's primary choice of space power for planetary missions has historically been solar. For example, the Mars Observer, Viking Orbiters, Mariners 4, 6, 7 and 9 were solar-powered Mars missions. NASA continues to use solar power for missions when such technology is applicable. Future missions to Mars such as Pathfinder and Mars Global Surveyor will be solar-powered, using the newest high efficiency GaAs/Ge cells. Mars Pathfinder lander and microrover represent the first use of photovoltaics on the Martian surface. However, NASA incorporates RTGs with spacecraft designs when solar power or other power technology is not feasible for the planned mission. The current state of the technology makes solar power infeasible for a mission like Cassini. See also response to Comment 1B.

Response to Comment 1K:

The availability of solar power technology for the Cassini mission has been addressed in response to Comment 1B. The total health effects mission risk to the public (considering all launch phases and the Earth-Gravity-Assist trajectory) for Cassini has been provided in Section 4.1.8 of the EIS, and is estimated to be small (about $1.8 \times 10^3$ health effects).
New solar cells with record efficiency

Under contract with ESA, European industry has recently developed high efficiency solar cells for use in future demanding deep-space missions such as the recently approved ROSETTA cometary mission. The new solar cells reach a 25% efficiency under deep space conditions. The efficiency is the ratio between the electrical energy produced by the cell and the incoming solar energy. The higher the efficiency, the "better" the solar cell.

Unlike telecommunications and Earth observation satellites which orbit near the Earth and are normally powered by solar cells arrays, spacecraft operating at very large distance from the Sun (typically deep-space probes) experience a solar intensity which is only about 5% or less of that near the Earth. This was the case for ESA's ULYSSES for instance which, before reaching the Sun's poles had first to travel to Jupiter at 780 million km from the Sun (Jupiter is five times farther away from the Sun than we are!). Moreover, the equilibrium temperature of solar arrays at those distances goes down to about -100 °C. Current solar cells used all over the space world are not generally made to operate at these low temperatures and solar intensities. They allow for 10- to 20% efficiencies in near-Earth orbits but show anomalous behaviour at deep space conditions.

For this demanding environment deep-space probes have to use power sources other than solar panels, because their electrical performance degrades too much at these low light intensities and low temperatures. Until now, deep space probes had to use thermoelectric power generators, like the so-called RTGs (Radioisotope Thermoelectric Generators).
As RTG's technology is not available in Europe, ESA therefore attempted to develop a power source based on very high-efficiency solar cells.

Under low-light low-intensity conditions, 25% efficiency has been achieved on 6x4 cm Silicon cells. The 25% mark represents the highest efficiency ever reached worldwide with Silicon cells without special optical concentration devices to increase the amount of sunlight collected to be converted into electricity. Another breakthrough had already been reached by ESA a little over one year ago with solar cells of a different technology, the Gallium Arsenide (GaAs) type, where 23% efficiency was reached on 2x4 cm cells.

This technology milestone in Silicon solar cells was reached by an industrial team led by DASA (Heilbronn, Germany) with CISE (Milano, Italy) as sub-contractor (CISE being also responsible for the development of high efficiency GaAs solar cells).

ESA expects that the new high performance Silicon solar cells could profitably be used in deep space missions for Europe and that this technology could also be of interest for near-Earth orbit space applications as well as for Earth based ones.
Plutonium Lab Safety Questioned

By John Fleck

Federal investigators have raised questions about safety procedures at Los Alamos National Laboratory's plutonium laboratory, where workers once will begin making new parts for NASA's 1997 Cassini mission to Jupiter.

Los Alamos and Department of Energy officials defended the lab's safety, and a NASA official said he doesn't think Cassini will be delayed.

The most serious dispute between investigators and the Department of Energy, which runs Los Alamos, is over whether a backup power generator used in power safety systems should be automatic or manually operated.

The investigation, done during the past year by the Defense Nuclear Facilities Safety Board, didn't find imminent threats to public or worker safety, according to board reports.

The board's staff did, however, find problems in procedures used to ensure safety at Los Alamos Technical Area 55, the laboratory's main plutonium handling complex.

The board has called a hearing March 7 in Washington, D.C., to look into the problems.

One of these problems, an allegedly inadequate backup power supply, could allow dangerous plutonium to escape the building if there was a plutonium leak inside the building at the same time the power went out, according to a report by board investigators.

DOE officials say they believe a manually operated power generator is sufficient to prevent leaks.

The report also cited a "high frequency" of radiation leaks inside the Los Alamos plutonium complex — 51 during a 19-month period in 1992 and 1993.

In addition, investigators found Los Alamos hasn't done the paperwork to demonstrate it complies with the DOE nuclear safety-regulated regulations. Officials at Los Alamos and the U.S. Department of Energy said Technical Area 55 is safe.

"If we thought that facility was unsafe, we would shut it down," said Jerry Belloso, manager of the department's Los Alamos Area Office.

Belloso acknowledged the problems, but said they involve compliance with bureaucratic regulations, not the actual safety of the plutonium complex.

Belloso attributed the number of reported radiation leaks to heightened safety scrutiny by workers, who now report more incidents that in the past might not have been mentioned.

Dana Christiansen, deputy chief of the Los Alamos division that runs the plutonium complex, pointed out that the laboratory has built plutonium parts for U.S. spacecraft for more than two decades without danger to public or worker health.

The Defense Nuclear Facilities Safety Board is an independent federal agency with the legal authority to investigate safety issues and make recommendations to the U.S. Secretary of Energy, said spokesman Carl Morgan.

It doesn't have the authority to shut anything down. Past investigations, however, have led to work delays at other U.S. nuclear facilities.

Plutonium is a radioactive metal used in nuclear reactors and not found in nature.

Dangerous if inhaled, plutonium is only handled in sealed containers with glove-box portables allowing workers to work with it remotely.

Los Alamos Technical Area 55 is the largest functioning plutonium-processing facility in the United States. NASA uses plutonium to power spacecraft used on deep-space missions. Los Alamos is preparing to begin manufacturing the plutonium parts for NASA's $1.4 billion Cassini spacecraft.

Ron Draper, deputy manager of the Cassini project for NASA, said in a telephone interview that he didn't expect the problems at Los Alamos to cause any delays in Cassini's launch.
RESPONSES TO COMMENTS
Commentor No. 2: Mr. & Mrs. Puchstein

Response to Comment 2A:

Radioisotope thermoelectric generators (RTGS) are the only suitable power technology available for the Cassini mission to Saturn. Furthermore, there is no new technology presently available or on the horizon to replace the RTGs for the Cassini mission.

The United States has an outstanding record of safety in using RTGs on 23 missions over the past three decades (See Table 2-2). While RTGs have never caused a spacecraft failure on any of these missions, they have been on board three missions which experienced malfunctions for other reasons. In all cases, the RTGs performed as designed.

More than 30 years have been invested in the engineering, safety analysis and testing of RTGS. Safety features, demonstrated through extensive testing, have been incorporated into the RTG's design. See Section 2.2.4.2 of the Environmental Impact Statement for more detailed information. There is about 32.4 kg (71.4 lb) of plutonium dioxide in the three RTGS. Table 2-3 provides the isotopic composition of the fuel form used for the Cassini mission.

Response to Comment 2B:

NASA places the highest priority on assuring the safe use of radioactive materials in space. Thorough and detailed safety analyses are conducted prior to launching NASA spacecraft with RTGS, and many prudent steps are taken to reduce the risks involved in NASA missions using RTGS. In addition to NASA's extensive internal safety requirements and reviews, missions that carry nuclear material also undergo an additional safety review involving detailed verification testing and analyses.
Response to Comment 3A:

Homeowners and other property owners would not be left with the financial responsibility for damages resulting from contamination as a result of an accidental release of plutonium associated with the Cassini mission. While it is true that individual homeowner insurance is generally not available for damages resulting from nuclear related activities, Congress has provided a mechanism for financial reimbursement for damages from a nuclear-related incident. The provisions of law that provide for this protection is known as the Price-Anderson Act. This Act is incorporated into the Atomic Energy Act.

The Price-Anderson Act, as amended, (42 U.S.C. Sec. 2210) governs liability and compensation in the event of a nuclear incident arising out of activities of the U.S. Department of Energy (DOE). A "nuclear incident" is defined under the Atomic Energy Act, "as any occurrence, including an extraordinary nuclear occurrence, within the United States causing, within or outside the United States, bodily injury, sickness, disease, or death, or loss of or damage to property, or loss of use of property, arising out of or resulting from the radioactive, toxic, explosive, or other hazardous properties of source, special nuclear or byproduct material..." (42 U.S.C. Sec. 2014(q)). In the case of the Cassini mission, DOE retains title to the radioactive power systems at all times. The radioisotope thermoelectric generators (RTGS) would, therefore, be subject to the Price-Anderson Act provisions. In the unlikely event that an accident were to occur resulting in release of plutonium, affected homeowners would be eligible for reimbursement for loss of property due to contamination.

Response to Comment 3B:

The fuel containment approach taken in the RTG design is one of Multiple barriers as described in Section 2.2.4.2 of the Environmental Impact Statement (EIS):

"Each general purpose heat source (GPHS) module consists of a graphite aeroshell, two carbon-bonded carbon fiber insulator sleeves, two graphite impact shells (GISs), and four [iridiumencapsulated] fueled clads. The... aeroshell... serves as the module's primary heat shield to protect the internal components from direct exposure to a reentry's thermal and aerodynamic environment.
The two GISs contained in the GPHS module provide the primary resistance to impact and mechanical loads. The iridium shell protects and immobilizes the fuel. The iridium alloy is compatible with the plutonium dioxide fuel material, resists oxidation in air, and melts at 2,425°C (4397°F)."

The three key features that make the iridium useful are: its high melting temperature, its material compatibility with the plutonium dioxide fuel, and its resistance to oxidation in air. These features coupled with the reentry heating and impact protection provided by the graphics of the GPHS module components limit the release potential for a wide range of accident environments.

A summary of the safety tests conducted to demonstrate the containment of fuel to a high degree of reliability under a range of accident environments is presented in Section 2.2.4.2 of the EIS.

The dimensions of all components of the GPHS-RTG assembly are given in the Reference Design Document, Volume I of the Ulysses Final Safety Analysis Report (FSAR) (U.S. Department of Energy, Final Safety Analysis Report for the Ulysses Mission, Volume I Reference Design Document ULS-FSAR-002, March 1990). The iridium clad is 0.56 mm (0.022 in) thick minimum. The plutonium fuel pellet is 27.56 mm (1.085 in) long and 27.53 mm (1.084 in) in diameter. The graphite impact shells have a minimum thickness of 4.24 mm (0.167 in). The graphite aeroshell has a minimum thickness of 4.70 mm (0.185 in).

Response to Comment 3C:

Aside from the multiple benefits being derived during mission planning, the Cassini mission to the Saturnian system would represent a rare opportunity to gain significant insights into major scientific questions about the formation of the solar system and the conditions that led to life on Earth, in addition to a host of questions specific to the Saturn system. See Section 1.4 of the EIS for further details.

Sections 4.1.6 and 4.2.6 of the EIS discuss the estimated consequences and potential impacts of radiological accidents that could occur during the Cassini mission. These sections provide analyses and information on the potential consequences and impacts on the Cape Canaveral Air Station (CCAS) regional area which is defined in Section 3 (Affected Environment) to
include the six-county region surrounding CCAS and Kennedy Space Center (KSC). As discussed in Section 4.1.8 of the EIS, the population which could be affected by a launch accident (near the launch pad) would be the population in the vicinity of CCAS, estimated on the order of 100,000 people.

Response to Comment 3D:

NASA has invested in research and development of solar power technology. Additionally, DOE, the European Space Agency, and other agencies and research centers around the world have been investing in and improving upon solar power technology over the last decade. A number of solar power designs were investigated for the Cassini mission that would utilize unproven yet promising technology (e.g., the Advanced Photovoltaic Solar Array).

NASA studied many different solar, battery, and other power alternatives, including long life fuel cells, available for Cassini and found none that would meet the mission requirements. A Cassini spacecraft equipped with the highest efficiency solar cells available, or fuel cells, or batteries, or combination of these would make the spacecraft too massive for launching to Saturn. Even if a heavy-lift booster were available that could launch the Cassini spacecraft with a massive solar array, such large solar arrays would introduce insurmountable complexity to the mission and would severely jeopardize the chances for mission success. For fuel cells, even assuming the highest currently available energy fuel-per-unit mass and 100 percent efficient conversion (an idealistic assumption since only 60-70 percent is currently feasible), the resulting dry mass (before adding propellants for the spacecraft engines needed for maneuvers in space) would be about 16,000 kg (17.6 tons). It would not be possible to launch Cassini and place it on a trajectory to Saturn if it were that massive, i.e., it would exceed the launch capability of the Titan IV (Solid Rocket Motor Upgrade [SRMU])/Centaur by more than a factor of 2.

Though NASA continues to invest in research and development of solar power technology, the current state of the technology makes solar power infeasible for the Cassini mission to Saturn. See also responses to Comments 1B and 2A.
As discussed in Section 2.2.8 of the EIS, the Range Safety program must ensure that the launch and flight of space vehicles presents no greater risk to the general public than that imposed by the overflight of conventional aircraft. In addition, safety clearance zones and procedures to protect the public on land, on the sea, and in the air are established and controlled for each launch and launch vehicle at the facilities on the Eastern Range (this would include both CCAS and KSC). Safety control zones are established to protect personnel and resources. Consistent with our Nation's policies for outer space missions such as Cassini, a U.S. launch site is used.
Clearly, year after year, as time passes, larger and larger nuclear missiles will attempted to be launched at KSC/AF. In each case the argument will be the same, "The previous nuclear launches succeeded." Soon or later, a catastrophic nuclear spill will occur. Its time that NASA build a population-safe nuclear launching site in the remote Pacific.

No place on earth is safe from the reentry of a failed nuclear missile. What if it lands on a population center such as New York, Chicago, Los Angeles, Paris, Rome, London? What will NASA say? How will they justify their benefit/risk calculation?

How many Titan IV/Centaur missiles have been flown to date? How many were successful? With this paucity of successful launches how can NASA arrive at a realistic estimate of the launch risk?

The present Florida ground level of plutonium contamination is 0.001 microcurie/sq meter. In case of nuclear contamination by the Cassini launch, NASA proposes that a level of plutonium contamination some 200 times higher than the present level is safe, and harmless to health, for which no de-contamination is required. NASA bases back on the EPA, for support that this level will do no harm. One should recognize the element of self-interest in such a pronouncement. The higher the level, the less money EPA has to spend to clean up the many nationwide sites that have already been contaminated by nuclear bomb tests, nuclear bomb manufacture, and nuclear power plants.

The health consequences of a plutonium spill are underestimated. In particular the risk to children is not even discussed. The sheltering of schoolchildren indoors. At the time of the last nuclear launch, Galileo, the local media suggested that children and adults hold handkerchiefs to their faces. What a cruel hoax? NASA said nothing, and did not even provide their workers at KSC with respiratory masks.

NASA mentioned, but is not deterred, from its own estimates of the following stated impacts, "Where areas of land cover used by man (e.g., buildings, roads, ornamental vegetation) are contaminated 'mitigation actions could prevent the immediate return of the population to their homes and workplaces. Cleanup actions could last from several days to several months". High range cost decontamination methods include, "removal and disposal of all vegetation, removal and destruction of topsoil, destruction of citrus and all other perennial growing stocks, banning of future agricultural land use, demolition of some or all structures, land use restrictions, permanent relocation of affected populations."

As of March 3, 1995, there had been three Successful Titan IV (SRM)/Centaur flights. The reliability data for the Titan IV/Centaur, expressed as initiating accident probabilities, are discussed in Section 4.1.5.3 of the EIS. The data were developed using peer-reviewed state-of-the-art assessment methodologies developed by a panel of technical experts in the aerospace industry. The methodologies involved the combination of analytical and failure rate predictions with actual flight history using Bayes Theorem. The theorem allows analytical evaluations to be mathematically combined with observed evidence to develop the probability of failure during a single launch.

The consequence and risk estimates reported in this EIS do not assume that cleanup of the contaminated lands occurs in the event of an accident with a release of plutonium. The reported doses, based on the expectation case, in
terms of individual doses and doses to the exposed population as a whole, indicate that the estimated radiological dose impacts are small. Mitigation activities described in Section 4.1.9 of the EIS would be employed, where applicable, to reduce radiological impacts even further.

Estimates of land areas potentially contaminated are based on plutonium deposition above a screening level established by the U.S. Environmental Protection Agency of $7.4 \times 10^3$ Bq/m$^2$ (0.2 µCi/m$^2$). This is a risk-based value at which cleanup actions would be evaluated. It is established independent of prevailing background levels.

Response to Comment 3I:

The radiological consequences of postulated accident source terms in the EIS have been calculated based on internal dose conversion factors presented in International Commission on Radiological Protection (ICRP) Publication 30. As such, these factors apply to adult members of the population. Particle size and age-dependent internal dose conversion factors are treated as part of a model presented in its recently released publications Human Respiratory Tract Model for Radiological Protection: ICRP Publication 66, 1995. ICRP-60 recommends a dose commitment period of 50 years for an adult, is in ICRP-30, and 70 years for children. These new internal dosimetry recommendations are being evaluated and will be implemented, as appropriate, in the radiological consequence analysis being performed for the Cassini FSAR.

Response to Comment 3J:

As discussed in Sections 4.1.9 and 4.2.9 of the EIS, a comprehensive radiological contingency plan would be developed, prior to the launch of the Cassini spacecraft, in accordance with the Federal Radiological Emergency Response Plan. Protective action guidelines and post-accident monitoring would be addressed as part of the contingency planning activities. This contingency plan would be developed through the combined efforts of NASA, DOE, EPA, Federal Emergency Management Agency, the State of Florida, and local organizations involved in emergency responses. Portions of the plan would be practiced to assure that the various organizations were prepared to support the launch.

As discussed in Section 4.1.6.3 of the EIS, an accident occurring in the, CCAS regional area could result in up to 1.43 km$^2$ (0.55 mi$^2$) of land
contaminated above the screening level of $7.4 \times 10^3$ Bq/m$^2$ (0.2 µCi/m$^2$). The appropriate decontamination or mitigation action would be taken upon further evaluation of the accident consequences.
RESPONSES TO COMMENTS
Commentor No. 3: Horst A. Poehler, Ph.D.
(Continued)

Response to Comment 3K:

NASA has estimated that the risk to the population near CCAS/KSC would be exceedingly low. The total health effects mission risk to the public (considering all launch phases and the Earth-Gravity-Assist trajectory) for Cassini is provided in Section 4.1.8 of the EIS, and is estimated to be small (about $1.8 \times 10^{-3}$ health effects).

The National Environmental Policy Act process has afforded the population in the area of the launch the opportunity to convey their concerns regarding possible risks to the public and the environment stemming from the proposed Cassini mission. NASA has given serious consideration to all public comments concerning the Cassini draft EIS.

Response to Comment 3L:

Using widely accepted methodologies and best available information, NASA has provided analyses of the consequences associated with a potential launch accident in EIS Sections 4.1.6 and 4.2.6. The analyses indicate that the estimated consequences would be very small.

Response to Comment 3M:

The risk assessment includes the allowance for contributions from human error in several ways. The estimations of the launch failure rates were based in part on historical experience with both the Titan and STS (Shuttle) launch vehicles and in part on estimates of failure sequences that could lead to a severe accident. Human error was an integral consideration in the development of the Titan IV failure probabilities, (i.e. the initiating accident probabilities described in Section 4.1.5.3 of the EIS).

The estimation of the probability of an inadvertent reentry during an Earth swingby also included human error. The estimates are based on historical failure experience with interplanetary spacecraft and their components and on failure sequences that could lead to loss of control of the spacecraft.
RESPONSES TO COMMENTS
Commentor No. 4: Dorothy Scott Smith

Response to Comment 4A:

See response to Comment 2A.

Response to Comment 4B:

The citation on Dr. Helen Caldicott's book, *Nuclear Madness*, reads:

"...it plutonium is so toxic that less than one-millionth of a gram (an invisible particle) is a carcinogenic dose.


As used in the Cassini mission, the fuel is a high-fired oxide, a stable and relatively insoluble ceramic material. Plutonium is radiologically toxic if deposited in sensitive tissues, such as the lungs. However, it must first be reduced to particle sizes small enough to deposit in the deep lung region. Typically, deep deposition of particles in the lungs requires particle sizes nominally 3 \( \mu m \) and less, equivalent to the 10 \( \mu m \) respirable particle of unit density used by ICRP (ICRP 1979). Larger inhaled particles are removed in the nasopharyngeal and tracheobronchial regions, and can never reach the lung.

The "invisible particle" of one-millionth gram of plutonium referred to by Dr Caldicott would be, in fact, a single 60 \( \mu m \) diameter plutonium dioxide particle and cannot reach the deep lung region. This "invisible" one-millionth gram actually represents a larger number of particles to inhale from the atmosphere if they are to reach the deep lung region. An independent analysis based on the amount of plutonium in human populations around the world resulting from the 6,350 kg (14,000 lb) of plutonium released to the atmosphere from weapons tests, estimated that only about 0.25 g (0.00055 lb) had deposited in the worldwide population (Richmond, Chester R., 1976, "Review of John W. Gofman's Reports on Health Hazards from Inhaled Plutonium," Oak Ridge National Laboratory, ORNL/TM-5257, February 1976). This estimate would be representative of plutonium or plutonium dioxide in a vapor-like state. From these data and a world population of 3 billion at the time, an average uptake factor of \( 1.3 \times 10^{-17} \) grams inhaled per gram of plutonium released to the atmosphere.
can be estimated from atmospheric weapons tests. To achieve a uniform distribution of one pound of plutonium in the world population, equivalent to one ten-millionth \((1 \times 10^{-7})\) not one-millionth \((1 \times 10^{-6})\) gram of plutonium, as stated in Dr. Caldicott's book requires almost 2,000 times the cumulative release of plutonium from all past nuclear weapons tests conducted in the atmosphere. To achieve Dr. Caldicott's one-millionth gram for each person on earth would require about 140,000,000 kg (154,320 tons) of plutonium being released to the atmosphere.

When larger particle sizes are considered, then, in principle, fewer plutonium particles deposited in the deep lung region are required to achieve Dr. Caldicott's one-millionth gram. For example, about 8,400 particles of 3\(\mu\)m diameter must be deposited in the deep lung region to cause a plutonium lung burden of one-millionth gram. Here again, nature conspires against Dr. Caldicott's assertion in two ways; first, radiological toxicity decreases from "hot particle" effects, and second, it is extremely difficult for a person to breathe and deposit one-millionth gram of plutonium in deep lung tissue. As stated by a leading expert in health physics and radiation biology: "There is no scientific evidence to support the allegation that one millionth of a gram of Pu in 'an invisible particle' will cause lung cancer. Theoretically, a single alpha particle could cause a cancer, but because of the random probabilistic nature of the carcinogenic process, the probability is too remote to calculate. Studies on 'hot particles' have shown them to be less carcinogenic than the same amount of radioactivity diffusely distributed in the tissue." (Declaration of Dr. Marvin Goldman, at paras. 6 and 12, October 5, 1989). The second point relates to the lung's physiology, which limits the fraction of inhaled particles that reach and become deposited in deep lung tissue as the size is increased. On the average only about one in twenty-five (0.04) inhaled 3\(\mu\)m particles reach and deposit in deep lung tissue (ICRP 1979).
Response to Comment 5A:

See response Comment 2A.

Response to Comment 5B:

The radioisotope thermoelectric generators (RTGS) and radioisotope heater units (RHUS) to be used on the Cassini spacecraft have been designed and safety tested to ensure containment of the plutonium (Pu-238) dioxide fuel under most accident environments. The ceramic plutonium (Pu-238) dioxide minimizes the generation of small respirable particles and exhibits a low potential for vaporization in thermal environments in the event some of the fuel is released during an accident. This ceramic fuel form also has a low solubility and is relatively immobile in the environment.

As part of the launch approval process, the Department of Energy (DOE) will be preparing a more in-depth evaluation of the potential radiological consequences as part of the Final Safety Analysis Report (FSAR). NASA will review the FSAR, when it becomes available, and will evaluate the information presented for differences, if any, in the estimation of the potential consequences.

Response to Comment 5C:

NASA is actively studying several future alternate space power sources, including solar cells, and power antennas. NASA has invested substantially in the research and development for such advanced power sources and is continuing to research more efficient technologies. Additionally, the DOE, the European Space Agency, and other agencies and research centers around the world have been investing in and improving upon solar power technology. Historically, NASA's primary choice of power source- for planetary missions has been solar, and it continues to use solar power for missions when such technology is applicable. However, the current state of the technology makes solar power infeasible for a deep space mission such as Cassini. See also response to Comment 1B and 1K.
Response to Comment 6A:

NASA has invested in research and development of solar power technology. Additionally, the U.S. Department of Energy, the European Space Agency, and other agencies and research centers around the world have been investing in and improving upon solar power technology over the last decade. A number of solar power designs were investigated for the Cassini mission, including designs that would utilize unproven yet promising technology (e.g., the Advanced Photovoltaic Solar Array).

NASA studied many different solar, battery, and other power alternatives, including long life fuel cells, available for Cassini and found none that would meet the mission requirements. A Cassini spacecraft equipped with the highest efficiency solar cells available, or fuel cells, or batteries, or combination of these would make the spacecraft too massive for launching to Saturn. Even if a heavy-lift booster were available that could launch the Cassini spacecraft with a massive solar array, such large solar arrays would introduce insurmountable complexity to the mission and would severely jeopardize the chances for mission success. For fuel cells, even assuming the highest currently available energy fuel-per-unit mass and 100 percent efficient conversion (an idealistic assumption since only 60-70 percent is currently feasible), the resulting dry mass (before adding propellants for the spacecraft engines needed for maneuvers in space) would be about 16,000 kg (17.6 tons). It would not be possible to launch Cassini and place it on a trajectory to Saturn if it were that massive, i.e., it would exceed the launch capability of the Titan IV (Solid Rocket Motor Upgrade [SRMU])/Centaur by more than a factor of 2.

Though NASA continues to invest in research and development of solar power technology, the current state of the technology makes solar power infeasible for the Cassini mission to Saturn. See response to Comment 1B.
RESPONSES TO COMMENTS
Commentor No. 6: Ronald J. Balogh
(Continued)

Response to Comment 6B:

NASA has followed the technical progress in power source technology worldwide for many years. Indeed, a substantial portion of the work in the research and development of solar arrays has been carried out under NASA funding. Historically, NASA's primary selection of a power source for planetary missions has been solar-based, and NASA has continued to use solar power when feasible. While improvements have been made in solar technology, significant breakthroughs are needed to support a mission such as Cassini. Recent international conferences on space power provided no reports of technical breakthroughs that would suggest changing the proposed approach to powering the Cassini spacecraft. The solar power options for Cassini has been extensively reviewed and rejected for this EIS because no U.S. launch vehicle exists with the required lift capacity to conduct a solar powered mission to Saturn using available solar power technologies.

Response to Comment 6C:

See response to Comment 2A

Response to Comment 6D:

NASA appreciates expression of your views and has considered your comment. If you have any new information or additional pertinent data, which would improve the analysis in the Environmental Impact Statement, please let us know.
Mr. Howard Wright  
CRAP/Cassini Program Manager,  
Office of Space Science & Applications  
Code SL, NASA  
Washington, D.C. 20546

Dear Mr. Wright,

I am writing to you to express my concerns over the use of plutonium as a fuel source for the CRAF/Cassini Mission and any future missions which would use plutonium as a fuel source.

I live in the City of Cocoa Beach, Florida, and have for the past 19 years. I consider the Kennedy Space Center to be my neighbor and as such would prefer a friendly peaceful coexistence with them.

Currently I find this proposition of peaceful coexistence to be impossible because NASA and the Department of Energy choose on their own accord, to subject my family and myself, my community and environment to a calculated risk of plutonium contamination. These same risks were placed on my community and myself during the Galileo and Ulysses Missions. I did not understand then nor do I now, how NASA has the right to put me or anyone else, man, animal, or natural environment under a calculated risk of the effects of PuO$_2$.

The simple truth to this matter is that NASA, The Dept. of Energy, or the Federal Government itself does not have this right. This is a great injustice to everyone and everything concerned. I cannot accept this action by NASA. It is arrogance of the highest degree.

The facts to support these calculated risk factors can be found in the Final Environment Impact Statement for the Ulysses Mission (Tier 2), Section 4-33. Section 4-33 (Urban Areas) states and I quote, "If mitigation actions were necessary, temporary relocation of the population from their homes and workplaces my be required." It also states the "Deposition could also have a long-term effect on future investigations at any archaeological site. Archaeological digs, by their very nature, disturb the soil surface with digging and shifting operations, which could expose workers and others to PuO$_2$." What about our own back yards, does this apply to gardening or planting flowers?
receive protection which supercedes any other water classifications and standards, and as such prohibits any activity which reduces water quality parameters below existing ambient water quality conditions. An ascent phase accident leading to a release could deposit sufficient amounts of PuO$_2$ to result in violation of this protection standard.” This is a prime example of NASA’s arrogance in its risk assessment. It knew full well that it might violate this protection and launched Ulysses anyway in light of what is in NASA’s own Environmental Impact Statement, it should be clear why I feel NASA is no longer a neighbor in good standing. They have violated my trust, they have elevated themselves to playing God with my life and where I live. Subjecting me and others to risks, however small, if actualized would be catastrophic.

NASA has argued that the solar option was no option, that the technology did not yet exist for these Deep Space Probes. While that in itself may be arguable the fact that NASA now has until 1995-96 to develop a solar alternative is not. I implore you to plan solar power as the fuel source for this and all future missions where plutonium RTG’s would be used.

Please remember that an individuals rights stop where they infringe on anothers, and this should be true for NASA too.

Sincerely,
Ron Balogh
442 Brightwaters Drive  
Cocoa Beach FL 32931  
December 14, 1994

Dr. Peter B. Ulrich  
Solar System Exploration Division  
Office of Space Science  
NASA Headquarters  
Washington, DC 20546

Dear Dr. Ulrich:

I request by way of this letter to extend my comment date to that of December 20, 1994.

Thank You,  
Very truly yours,

[Signature]

Ronald J. Balogh
Response to Comment 7A:
See response to Comment 2A.

Response to Comment 7B:
The total health effects mission risk to the public (considering all launch phases and the Earth-Gravity-Assist trajectory) for Cassini has been provided in Section 4.1.8 of the Environmental Impact Statement (EIS), and is estimated to be small (about 1.8 x 10^3 health effects). See Section 1.4 in the EIS for details on the multiple benefits being derived during mission planning. The Cassini mission to the Saturnian system would represent a rare opportunity to gain significant insights into major scientific questions about the formation of the solar system and the conditions that led to life on Earth, in addition to a host of questions specific to the Saturn system.

Response to Comment 7C:
See response to Comment 6A.
Your cooperation is essential.

Sincerely,

Mr. Arnold F. Welbei
RESPONSES TO COMMENTS
Commentor No. 8: Southern Rainbow Education Project (SREP)
(Gwendolyn M. Patton)

Dr. Peter Ulrich
Solar System Exploration Division
Office of Space Science
NASA HQ
Washington, D.C. 20546

December 15, 1994

Response to Comment 8A:
See response to Comment 2A.

Response to Comment 8B:
See response to Comment 4B.

Response to Comment 8C:

NASA and the Department of Energy take very seriously the possibility that an action that they take could potentially result in human fatalities or harm to the environment. Therefore, both agencies have gone to great lengths to reduce the potential for such events, both through design of the radioisotope thermoelectric generators and through design and operation of the spacecraft and its mission. As a result of these designs, the risks of fatalities or harm to the environment from the Proposed Action are considered to be very low. See Sections 4.1.5.2 and 4.2.5.1 of the Environmental Impact Statement for more details on launch phase accident scenarios.
Response to Comment 9A:

We appreciate your concern in taking the time to read and comment on the Draft Environmental Impact Statement (EIS). See response to Comment 2A.

Response to Comment 9B:

NASA and the Department of Energy take very seriously the possibility that an action that they take could potentially result in human fatalities or harm to the environment. Therefore, both agencies have gone to great lengths to reduce the potential for such events, both through design of the radioisotope thermoelectric generators and through design and operation of the spacecraft and its mission. As a result of these designs, the risks of fatalities or harm to the environment from the Proposed Action are considered to be very low. See Sections 4.15.2 and 4.2.5.1 of the EIS for more details on launch phase accident scenarios.
NASA and the Department of Energy take very seriously the possibility that an action they take could potentially result in human fatalities or harm to the environment. Therefore, both agencies have gone to great lengths to reduce the potential for such events, both through design of the radioisotope thermoelectric generators and through design and operation of the spacecraft and its mission. As a result of these designs, the risks of fatalities or harm to the environment from the Proposed Action are considered to be very low. See Sections 4.1.5.2 and 4.2.5.1 of the Environmental Impact Statement for more details on launch phase accident scenarios.

We appreciate your concern in taking the time to respond to the draft Environmental Impact Statement.
December 16, 1994

Dr. Peter Ulrich
Solar System Exploration Division
Office of Space Science
NASA HQ
Washington, DC 20546

Dear Dr. Ulrich,

In the minds of so many Americans, the cost of space programs is justified chiefly because of the spinoff of technologies that can help our nation and the world realize a better life.

Let us pose the question: which technology development would advance the quality of life—development of plutonium power systems for deep space probes or development of solar-powered systems for deep space probes?

Given that plutonium is fiendishly toxic and carcinogenic and given that solar-powered systems are well within technical reach for space probes and could spin off into sustainable energy technology that the earth is literally dying for want of, the answer to the question is obvious.

Why no serious commitment to solar power for the 1997 Cassini mission to Saturn? I can assure you that the 700 plus members statewide of the South Dakota Peace & Justice Center will be vigorously lobbying against funding for NASA projects, such as a plutonium-powered Cassini mission, which fly in the face of common sense at the least and may even be said to demonstrate a death wish for our culture and our living world.

Sincerely,

Jeanne Koster, staff


Response to Comment 11A:

NASA continues to invest in solar and other technologies for space applications. NASA's investment along with that of other Federal research and development programs has yielded advances in solar technologies that are in widespread use today. See also response to Comment 3D.

Response to Comment 11B:

NASA has estimated the risks from plutonium (Pu-238) dioxide onboard the Cassini spacecraft and has found the risks to the world population and our planet to be very low. The risks from the launch of Cassini would be lower than many of the risks that we face in our everyday lives (see Table 4-20 in the Environmental Impact Statement). A wide range of potential accident scenarios was evaluated. See also response to Comment 1K.
Response to Comment 12A:

NASA appreciates expression of your views. Please see response to Comment 7B for more information.

Response to Comment 12B:

See responses to Comments 3D.
Response to Comment 13A:

NASA considers the risk analysis presented in the Environmental Impact Statement (EIS) to be the best estimate based on the available information at the time. As part of the launch approval process, the Department of Energy will be preparing a more in-depth evaluation of the risks as part of the Final Safety Analysis Report (FSAR). NASA will review the FSAR, when it becomes available, and will evaluate the information presented for differences, if any, in the estimates of the potential radiological consequences and risks.

Response to Comment 13B:

See response to Comment 4B.

Response to Comment 13C:

The total health effects mission risk to the public (considering all launch phases and the Earth-Gravity-Assist trajectory) for Cassini has been provided in Section 4.1.8 of the EIS, and is estimated to be small (about $1.8 \times 10^3$ health effects).

Response to Comment 13D:

See response to Comment 3D.
RESPONSES TO COMMENTS
Commentor No. 14: Dr. Mary Ann Lawrence

Response to Comment 14A:

The inadvertent reentry accident during an Earth swingby is addressed in Section 4.1.5.4 and Appendix B of the Environmental Impact Statement (EIS). The analyses of this accident show that about one-third of the plutonium dioxide fuel will be released as particles at high altitudes. During the reentry of these particles, about 37 percent will be converted to vapor and small particle sizes, which remain and disperse in the atmosphere gradually reaching the ground over many years. The larger particles will reach the ground much faster under the influence of gravity. The unreleased two-thirds of the fuel is contained in GPHS heat source components that survive the atmospheric reentry. Intact modules will fail and release some fuel if they impact on hard rock and the graphite impact shells will fail and release some fuel if they impact land. Impacts on hard rock are expected to occur only 4 percent of the time and on land masses about 25 percent of the time. All these factors affecting the behavior of the RTGs in the unlikely event of an inadvertent reentry accident are considered in the information contained in the EIS.

Response to Comment 14B:

See response to Comment 4B.
December 19, 1994

Dr. Peter B. Ulrich
Solar System Exploration Div
Office of Space Science
NASA Headquarters
Washington, DC 20546

RE: Cassini Draft Environmental Impact Statement

Dear Mr. Ulrich:

I am writing in response to the draft environmental impact statement for the Cassini mission. Before providing my comments, however, I wish to note that the National Space Society commented on many topics raised by the Cassini draft EIS in an earlier proceeding. That was the notice of February 27, 1991, published at 56 Federal Register 8219. The Cassini Draft EIS makes no reference to those comments, and does not seem to take them into account. That is frustrating; we are often told that the voices of grassroots space interests should be heard more, only to discover that when we talk, people at NASA aren’t always listening. I am attaching a copy of the letter in question for your information.

Comments on the EIS

Our strongest complaint, echoing the comments that we made almost four years ago, is that the EIS understates the costs of a "no action" alternative. As has consistently been the problem with NASA Environmental Impact Statements for deep-space missions (see, for example, the Ulysses and Galileo Statements), the Cassini draft EIS fails to recognize the very significant adverse environmental effects of a no-action alternative. Instead, the costs of cancelling the mission are characterized strictly in terms of lost scientific opportunities.

Although we agree that there would be substantial costs in terms of lost scientific knowledge, we do not believe that these are the only costs involved. The rather artificial and truncated scope of most Environmental Impact Statements tends to overstate the importance of risks, and underestimate the importance of benefits, in evaluating whether to proceed. NSS believes that the long-term environmental benefits stemming from a better understanding of our solar system, and the material and energy resources available there, are significant and should be weighed against the short-term environmental risks involved in undertaking the missions.

Response to Comment 15A:


Response to Comment 15B:

See Section 4.4 of the EIS for a discussion of the No-Action alternative. NASA agrees that the potential long-term environmental benefits from understanding the solar system and the material resources there, would be significant. Missions such as Cassini are a significant part of the U.S. space exploration program and afford an opportunity to gather data from both planned and unplanned activities. As with other NASA missions, history suggests that the ultimate value of such deep space exploration may well be in something we cannot envision at the current time—the serendipitous potential that makes exploration so exciting and full of discovery. Solar system exploration improves our understanding of the chemical and physical conditions needed to foster the development of life. The benefit society reaps from this new understanding is difficult to quantify, but it is notable that the study and understanding of many terrestrial problems (e.g., global climate change) have benefitted from techniques and theories arising from space exploration.
RESPONSES TO COMMENTS
Commentor No. 15: National Space Society
(Glenn Harlan Reynolds)
(Continued)

In preparing Section 4.4 of the Draft EIS, NASA attempted to confine itself to the more quantifiable impacts of the No-Action alternative. In doing so, NASA tended to be somewhat conservative. NASA therefore has revised the text of Section 4.4 to emphasize the loss of potential benefits and knowledge that would be gained from the Cassini mission, such as our understanding of Earth's processes.

Response to Comment 15C:

Council on Environmental Quality (CEQ) regulations require that NASA evaluate the environmental impacts of the No-Action alternative along with those of the Proposed Action and other reasonable alternatives.

The Politics of RTGs

Our discussion of the Cassini EIS would be incomplete without mentioning that NASA has come under substantial political pressure from antinuclear activists regarding its use of radiisotopic thermoelectric generators in various deep-space probes such as Cassini.
Response to Comment 15D:

The design of the Cassini mission and the spacecraft will be based on engineering and environmental analyses taking into account scientific benefits, risk assessment and available resources.

Ulysses, or Galileo. In the case of the Ulysses mission, NSS participated as a friend-of-the-court in support of the mission, and we will likely do so with regard to Cassini if litigation ensues.

The opposition of antinuclear groups to RTG-powered deep space missions has more to do with publicity-seeking and direct mail fundraising than with any real concerns about the safety of RTGs. In addition, some of these groups fear (against all reason) that such programs are simply stalking-horses for some kinds of massive nuclear-powered antimissile battle stations that they expect the Department of Defense to construct. While NSS neither supports nor opposes military uses of space as such, we consider these fears to be both absurd and irrelevant to the question of whether missions such as Cassini are safe. We remain concerned, however, as we were in our 1991 letter, that fear of political opposition from antinuclear groups may cause NASA in the future to adopt mission architectures or strategies that are driven by political, rather than engineering concerns. We stress that any mission design should be based on sound scientific and engineering judgment, not on political concerns.

Conclusion

We consider the Cassini draft EIS to be an adequate statement (if occasionally an overstatement) of the risks involved in the mission. Its chief deficiency lies in a failure to address the very real environmental consequences of a no-action alternative. We urge the revision of the Cassini draft EIS to reflect this important concern.

Sincerely,

Glenn Harlan Reynolds
Executive Chairman, National Space Society

attachments:
Comments to Howard Wright, 4/12/1991
NSS Environmental Position Paper
NSS Comments, Ulysses Draft EIS, 4/6/1990
April 12, 1991

Mr. Howard Wright

CRAF/Cassini Program Manager
Office of Space Science and Applications
Code SL
National Aeronautics and Space Admin.
Washington, D.C. 20546

RE: Outer Solar System Exploration Program, 56 FR 8219

Dear Mr. Wright:

In response to your notice of February 27, 1991, published at 56 Federal Register 8219, here are the views of the National Space Society regarding environmental issues associated with new outer solar system exploration programs. The National Space Society is a grassroots public interest organization, with over 120 chapters and over 30,000 members, dedicated to the creation of a spacefaring civilization. That goal underlies the character of our response.

In your notice, you listed three primary issues to be addressed in the CRAF/Cassini Environmental Impact Statement. These issues involve the feasibility and desirability of the following alternatives to the baseline mission plan: (1) use of alternative (non-nuclear) power sources; (2) use of trajectories involving planets other than earth for fly-by assists (or, in a more accurate formulation, a ban on earth gravity assists); and (3) the "no action" alternative. NSS' views are as follow.

Alternative Power Sources

NSS takes no position on whether alternative power sources are feasible; we consider that to be an engineering question which is far more thoroughly within NASA's competence than within our own. However, we believe that this question should continue to be treated
as an engineering question. Notwithstanding political agitation by various antinuclear groups (whose real agenda seems more related to stopping the Strategic Defense Initiative than to improving civilian space mission planning), NSS believes that NASA should choose power sources based solely on engineering concerns: what configuration best assures that the mission will achieve maximum capability (including reliability) at minimum cost. NSS would strongly oppose the selection of an alternative nonnuclear power source purely for political reasons. We believe that if NASA were to do so, it would be violating its responsibility to taxpayers to produce the best mission at the least cost.

Having said this, we do believe that where solar power is just as suitable on an engineering basis as nuclear power, the safety concerns relating to the use of space nuclear power may appropriately serve as a tie-breaker. Although we consider the risks involved in using nuclear power onboard deep space probes to be minor, they are not zero, and are undoubtedly greater than those associated with the use of solar power.

Ban on Earth Flyby Architectures

NSS’ views on the use of earth flyby assists are very similar to those expressed above. We believe that the risks associated with such endeavors are low, and do not believe that mission capabilities should be sacrificed, or missions canceled, solely in order to avoid an earth flyby. Once again, we believe that decisions on whether to use an earth flyby should be made solely on the basis of sound engineering and astrodynamical judgment. Where the use of gravity assists involving planets other than earth is equally effective in terms of mission capabilities, we would favor avoiding an earth flyby, but again we regard the risk involved in such flybys to be so minor as to make it no more than a tie-breaker in deciding between other-wise comparable trajectories.

The "No Action" Alternative

NSS’ views are strongest in regard to the question of how the "no action" alternative should be evaluated. The rather artificial and truncated scope of most Environmental Impact Statements tends to overstate the importance of risks, and understate the importance of benefits, in evaluating whether to proceed. NSS believes that the long-term environmental benefits stemming from a better understanding of our solar system, and the material and energy resources available there,
We believe that missions such as Cassini -- and, much more significantly, CRAF--will play a vital role in helping us learn to identify resources that may later be exploited to the benefit of mankind. Over the long term, we believe that the entire solar system is a part of humankind's resource base, and that a key environmental goal is to move polluting industries -- including extractive ones -- off the earth's surface and out of its biosphere. In this way, the long term health of the earth’s environment is entirely consistent with -- and in tact assured by a vigorous program of space exploration and settlement. (See our position paper, "Outer Space and the Global Environment," a copy of which is attached, for more detail on this topic).

Such a program of space settlement has already been endorsed by President Bush - in his speech of July 20, 1989 -- and by Congress, in the Space Settlements Act of 1988, Pub. L. 100-685, 102 Stat. 4083 (1988). If we are to continue to lay the groundwork (so to speak) for later human expansion throughout the solar system, missions like CRAF and Cassini play an essential role --just as early exploration missions, like those of Lewis and Clark or Zebulon Pike, played a vital role in the opening up of the American West for settlement.

Abandoning -- or even substantially delaying -- these missions of exploration would have significant costs in terms of impeding progress toward this important national goal. We believe that NASA has the responsibility --- both statutory and moral -- to weigh this cost in the balance in assessing the "no action" alternative. Therefore, we believe that the "no action" alternative should be invoked only when the risks of a mission are unacceptable beyond any reasonable doubt.

Conclusion
  The space mission-planning process seems to have been politicized in the wake of the Ulysses and Galileo launch controversies. NSS believes that this politicization is unfortunate, and that those antinuclear groups who have opposed such launches do not reflect the public interest, and in fact are themselves not particularly interested in the launches and missions in question except as an opportunity to open an additional front in their ongoing campaign against the Strategic Defense Initiative. NSS, as a group favoring the expansion of civilization into outer space, takes no position on the Strategic Defense Initiative. However, we would not wish to see programs that we do support become the victims of "collateral damage" from someone else's war. For this reason, we urge

RESPONSES TO COMMENTS
Commentor No. 15: National Space Society
(Glenn Harlan Reynolds) (Continued)
again that NASA make its decisions on mission power and architecture solely on the basis of sound engineering judgment, and that it not allow itself to be swayed by the political campaigns of policy entrepreneurs.

Sincerely,

Glenn Harlan Reynolds
Chair, NSS Legislative Committee
and Member, Board of Directors

Attachment:
NSS Environmental Position Paper
I viewed my mother quite differently when I was in the womb than I did after birth. Afterward, I was able to take more responsibility for her.
-- Astronaut Russell Schweickart

Human activity in outer space has already had important ramifications for the Earth. As early as 1949, astronomer Fred Hoyle predicted that "Once a photograph of the Earth, taken from the outside, is available, a new idea as powerful as any in history will be let loose." And so it was, once Apollo astronauts brought back photographs of the Earth from hundreds of thousands of miles away. Among the ideas let loose was the concept of the Earth as a whole, as a system of interrelated parts in which national boundaries were of little importance. Our planet, seen as a small, fragile object amid a sea of blackness and emptiness, became widely known as (significantly enough) "spaceship Earth. It is no coincidence that the first Earth Day took place shortly after these photos became available, and used one of them as its symbol. The consequences of this change in attitudes continue to be played out.

That change would be colossally important even if it were the only impact of the space program on environmental matters. But it is not. On closer examination, it is clear that the creation of a spacefaring civilization and the preservation of Earth's environment are not only complementary, but are in many ways the same. In fact, over the long term, we believe that human expansion
into space is not only essential to the preservation of Earth's environment, but in fact will play an important role in promoting the spread of life throughout the solar system and beyond, something that we regard as perhaps humankind's most important role. Following are some examples, in both the near term and the longer term, of how space activity is part of a sound strategy for preserving and restoring environmental quality here on Earth. And following those examples is a larger view of why both environmental preservation and human expansion throughout the solar system are important.

**Near Term: Space as a Global Management Tool**

Short of killing off the human species altogether, preserving the Earth's environment requires that we understand the impact that our activities have on our planet, and adjust our activities to minimize the harm that we do. This kind of understanding is hard to come by, but many space-related projects play a part.

First, satellite observation of the Earth is vital. It was a NASA satellite, Nimbus 7, that first verified the Antarctic ozone hole - an observation that led to our understanding of how chlorofluorocarbons (CFCs) can lead to the depletion of stratospheric ozone, which in turn led to the beginning of efforts to bring CFC pollution under control.. Similarly, LANDSAT and SPOT photos have dramatized the extent of deforestation in the Amazon, of desertification in Africa and Asia, and of ocean pollution in
many areas. And, aside from spotting crisis situations, satellite imagery plays a vital part in the mundane-but-important process of managing farmland, forests, and public lands generally. The planned Earth observing System, better known as "Mission to Planet Earth," will drastically expand the amount of data available, and, with it, our ability to understand the Earth in order to save it.

Second, the understanding we gain from observing other parts of the solar system also serves to increase our understanding of the Earth. Studies of the Martian climate by the Mariner and Viking probes were instrumental in the development of climatic models that were later used in assessing threats like global warming and nuclear winter. Studies of the solar climate by probes like Ulysses will shed additional light on global warming and ozone depletion, and give us some sense of the extent to which Earthly climate change is driven by solar variation. And studies of other planets in general -- from Venus, with its runaway greenhouse effect, to Mars, with not enough of one -- underscore the fragility of climate, and the preciousness of our Earth. Good planets, as we have learned, are hard to find.
Longer Term: Space as Safety-Valve

There are many -- perhaps too many -- people on Earth. For several decades, at least, their numbers are likely to expand. This large population puts enormous, and growing, stress on the Earth's biosphere and resource base. Yet, paradoxically, it is not the creation of too much wealth, but the creation of too much poverty, that has produced most of the Earth's environmental problems.

Poverty is bad for the environment. Poor people burn wood for fuel -- leading to deforestation and aggravating the greenhouse effect. Poor people cut down rain forests for farmland, and mediocre farmland at that, with the same results. Poor people have many children, increasing the pressure on resources further, and making it harder to break the cycle of poverty.

But this does not mean that the industrial nations are less to blame. For they, too, are poor, except by comparison with those worse off. They burn oil and coal for fuel, creating acid rain and contributing to global warming. They remove large quantities of resources from the Earth's crust -- so large that the poorer countries could never equal their living standards, even in the absence of other barriers, because there is not enough to go around. And their economies pollute the Earth so much that elevating the poorer nations to their standards of living, if it were possible at all, would be ruinous to the Earth's ecosystem.
In both cases, though, the reason isn't malevolence, or immorality. "Rich" and poor nations alike do the damage that they do largely because they have no other way to live -- because they lark the resources and knowledge needed to do better. Space programs can change that. If we draw on space resources, then we are not limited to the resources, whether of materiel or energy, locked in the Earth's crust, resources that will run out within a few centuries no matter how stringently they are conserved. Within a century, and perhaps much sooner, it will be practical to obtain many minerals from the Moon and asteroids, meaning that destructive and unsightly mining and smelting on Earth will no longer be needed. Energy, too, can come from space: from orbital solar power plants, from similar facilities on the Moon, or even potentially from fusion plants powered by lunar Helium-3, eliminating the use of fossil fuels.

Over the long term (meaning perhaps two human lifetimes), it will be possible to move most polluting industries off the Earth, and into space. And the industries that remain can be made far less polluting through the use of clean, inexpensive energy derived from space. If this is done, Earth can be returned to a
level of environmental health not seen since the industrial revolution began -- and without the need to kill off humanity by the billions, or to condemn poor nations to poverty for eternity.

The Big Picture: Space and the Expansion of Life

The Earth is the cradle of humanity -- but one cannot remain in the cradle forever.

-- Konstantin Tsiolkovsky

For as long as anyone remembers, humans have been wondering about their place in the world. Why are we here? And what makes us different from the rest of life on this planet?

For the past several decades, there has been at least one major difference. We are the only species that has the ability to leave. Space activists have not fully considered the environmental implications of this fact -- but then, neither have environmentalists.

There are two possible ways to view the environmental movement. In its misanthropic form, it may be seen as based on a Romantic hostility to humanity and its works. Space has nothing to offer those who hold this negative view. But in a broader form, the environmental movement can be seen as dedicated to the flourishing of life, both in quantity and diversity, as a primary good. In a more positive formulation, the works of humanity
are good or bad depending on whether they contribute to the flourishing of life, or harm it.

The expansion of humanity into space has a lot to offer those who hold this view. As humanity settles space, it will carry parts of the Earth’s biosphere -- plants and animals -- along with it. Perhaps this is humanity's real role. If one believes in the so-called Gaia hypothesis, under which all life on Earth can be viewed in a sense as one meta-organism, perhaps our role is that of meta-gametes, carrying the seeds of life throughout the solar system, and eventually beyond, thus spreading life to places where it could not have evolved on its own, and which it could not have reached in other ways. And even if one does not adhere to the Gaia hypothesis, the spreading of life seems a good thing in itself.

This is a vital role for the space program, but not just for any space program. To support the "greening of the solar system," we must have a robust, vigorous space program that does more than merely send robotic probes to distant planets. We must have a space program capable of fostering a true spacefaring civilization, one in which travel throughout the solar system -- and eventually beyond it -- is routine, and comparatively affordable. That is NSS’ goal and it is, we think, one that is profoundly in accord with the true goals of the environmental movement.
April 6, 1990

Dr. Dudley G. McConnell
NASA Headquarters
Code EL
Washington, DC 20546
Via Express

RE: NSS Comments on Ulysses Draft EIS

Dear Dr. McConnell:

In response to NASA's request for public comments, 55 Fed. Reg. 6326 (February 22, 1990), the views of the National Space Society (NSS) follow. NSS is a nationwide grassroots organization dedicated to the exploration and development of outer space and to the creation of a spacefaring civilization. Formed by the merger of the National Space Institute and the L5 Society, NSS has tens of thousands of members nationwide, and affiliate organizations throughout the world. Furthermore, NSS' views generally represent those of the substantial majority of all Americans that strongly supports an expansive and ambitious space program.

Scope of Comments

Because NSS believes that NASA has examined the issues in more than adequate scope and detail, and because NASA possesses expertise and experience in dealing with missions of this kind that no private organization can possibly hope to equal, NSS will not engage in a detailed examination of the technical issues addressed in the Environmental Impact Statement, particularly as NSS would have little to add to NASA's already thorough treatment. Instead, NSS will stress items omitted from the EIS, or given inadequate treatment therein, that NSS believes should have an important impact on the decision whether to proceed with the mission. In short, NSS is of the opinion that the EIS takes inadequate cognizance of the importance of the Ulysses mission in terms of the benefits, as well as potential detriments, that the mission will involve for the earth environment.
The Ulysses Mission and Its Importance

The Ulysses mission is of vital importance for a variety of reasons, some connected with scientific information gathering in the abstract, others connected with more down-to-earth problems. Since Ulysses will gather information regarding previously unobserved solar regions (the poles), it is an essential part of gathering a meaningful understanding of how the Sun, and the solar climate, works. One would not, after all, expect to understand the earth's climate without understanding what goes on at the poles; indeed, most climatological theories today suggest that many important climatic processes take place only at the poles. Similarly, an understanding of what goes on at the Sun's poles is vital to understanding the solar climate, and Ulysses provides an essential first step.

Such understanding has importance from a purely scientific standpoint, of course. Solar scientists have a lot to learn, and the understanding that they achieve will also be of use in understanding other stars as well: the Sun, after all, is the only star we are currently able to observe at close range. In addition, understanding the solar climate will have important ramifications for our understanding of solar-driven events that spread throughout the solar system: the solar wind, various magnetic and plasma effects, solar flares, and so on.

It is worth stressing, however, that abstract scientific benefits are not the only ones likely from Ulysses. There are also many concrete benefits that will come from such knowledge, benefits with considerable down-to-earth importance. These include:

- **Better understanding of the earth's climate:** Since the Sun is the earth's primary source of heat, variations in solar output can have dramatic impact on the earth's climate. Existing climatological models are unable to take these into account in any significant way, because the mechanisms of solar variation are, to put it mildly, poorly understood. If we are to understand matters such as global warming and other forms of climatic change, we must have more information concerning the solar climate, of the sort that Ulysses can provide.

- **Better understanding of the space environment:**
key hazard to manned flight in outer space is excess solar radiation stemming from solar flares. Such flares also pose a hazard to some kinds of spacecraft, and when particularly severe even to earth-based radio communications. A better understanding of the solar climate may lead to an ability to predict solar flares, and to adapt operations to avoid the worst of them. This will be particularly important in the context of space station operations and long-duration manned flights such as the manned Mars mission planned by the President.

- Better understanding of the earth/space interface: The changing solar cycles interact substantially with the earth's magnetic field and with the highest reaches of the upper atmosphere, at an altitude of 100-300 miles, approximately. Expansion of the upper atmosphere during part of the cycle is an important mechanism for removing debris from low-earth orbits. Better understanding of this process will be important in determining ways of addressing the orbital debris problem, which as recent Congressional hearings made clear is of considerable importance already.

Of course, by stressing these concrete benefits NSS does not mean to suggest that abstract scientific knowledge is not important. Such "abstract" knowledge always turns out to have important concrete uses in the end, though often those uses are entirely unforeseeable at the time the knowledge is arrived at.

Adequacy of the Ulysses EIS

In General

Having reviewed the draft Ulysses Environmental Impact Statement, NSS is of the opinion that it is entirely adequate. NASA has reviewed and considered all relevant factors of importance, and in particular has examined the possibility of catastrophic failure resulting in release of radioactive material from the onboard Radiothermal Generators with considerable thoroughness.

Such examinations are of necessity imprecise and subject to dispute; if risks were entirely clear, and all possible modes of failure obvious, we would live in a very different world indeed. And any authoritative
determination is nonetheless open to dispute -- even judicial opinions fail to convince everyone. However, within the limits of the real world, NASA has done a more than adequate job, certainly no one else has the expertise or experience to do better, and the excellent safety record of radiothermal generators in practice suggests that NASA's estimates cannot be too far off base. Some imponderables remain, of course, but that is the nature of risk assessment and it is foolish to pretend otherwise. Given that radiothermal generators are far less risky than nuclear reactors (with which they are often confused by the public) and given the lack of alternatives, NSS believes that the level of risk is acceptable, and that the EIS identifies and correctly analyzes all significant factors which can be determined in advance.

NSS also agrees that there are no reasonable alternatives to the use of radiothermal generators for the Ulysses mission. As correctly noted in the EIS, available alternative power sources pose unacceptable costs or risks to the mission -- and, in general, simply would not work at the distance from the Sun (that of Jupiter) at which most of the mission's important phases will (and must) take place.

**Errors and Inadequacies in the EIS**

NSS would, however, like to take issue with NASA's statement (Draft EIS at pp. v, 4-30) that "[t]here are no environmental impacts associated with the no-action alternative." While this statement may be true from the rather artificial perspective that seems inevitable in the context of an Environmental Impact Statement, it is in fact false. Pursuing a "no-action" alternative -- that is, scrubbing the mission -- would in the real world have negative consequences for the environment that could in fact be quite severe, and that NASA should take into account in determining whether to proceed with the mission.

These consequences would stem from the failure to acquire the information regarding the solar climate, and its interaction with the earth's climate and the earth/space interface, that was described earlier. In the absence of such information, earthbound climatological models will inevitably suffer, understanding of the extent of the (already severe) orbital debris problem will be reduced, and efforts to ameliorate environmental problems on the earth will be
handicapped, perhaps severely. There are no planned missions duplicating (even in part) Ulysses' functions. Given the long lead-times present for Solar System Exploration, this means that a cancellation of Ulysses would result in a major and long-lasting gap in our knowledge of these important topics.

Furthermore, cancellation of Ulysses would result in a squandering of human and intellectual capital, and in very significant demoralization costs among the planetary science community. Leaving aside the specific benefits that Ulysses itself will provide, no one would disagree that space exploration and planetary science have been of enormous benefit to our understanding of the earth environment -- and, in fact, have been an enormous source of consciousness-raising regarding the importance of environmental issues in general. It is no accident that the first Earth Day took place shortly after the first pictures of the earth from the Moon became available (futurist Arthur C. Clarke predicted that such photos would have just such an impact as early as 1959), or that the environmental movement has adopted just those photos as an important symbol. Furthermore, knowledge gained by satellite observations -- both of the earth and of other planets -- has had dramatic impact on our understanding of specific problems such as the Antarctic ozone hole. Senator Albert Gore, Jr. recently discussed this issue, see Gore, Outer Space, the Global Environment, and International Law: Into the Next Century, 57 Tenn. L. Rev. 329 (1990), and a number of environmental commentators have made similar points. See, e.g., Hartmann, Space Exploration and Environmental Issues, 6 Environmental Ethics 227 (1984), and Beyond Spaceship Earth: Environmental Ethics and the Solar System (Sierra Club Press, 1986): G. Reynolds & R. Merges, Outer Space: Problems of Law and Policy 195-98 (1989).

Cancelling the Ulysses mission would have a chilling effect on such enterprises in the future, as scientists would be reluctant to invest years of their time in a mission that might be cancelled at the last moment for environmental reasons. Thus, the losses to the environment from cancelling Ulysses might go far beyond those specific benefits promised by Ulysses itself.

In addition to the loss of these concrete benefits, the abstract knowledge gained from Ulysses would be lost. That is not only a loss to the scientific community, but also a loss of other concrete benefits.
(currently unforeseeable but no less important for that) likely to be derived from that knowledge. NSS understands that the nature of EIS drafting, and the assumptions and pressures inherent in the risk assessment process generally tend to lead to a discounting of such unquantifiable benefits (a problem known in the risk-assessment trade as the "dwarfing of soft variables"), but urges that NASA resist these pressures and take account of the substantial potential losses, both immediate and long-term, of adopting a "no action" approach.

For this reason NSS also believes that Section 4.8.2 of the EIS (Draft EIS at P. 4-31) should be revised. That section currently states:

A potentially large benefit to be gained from successful completion of this project is a better understanding of Earth through exploration and study of the environments of other planets.

Obviously, NSS does not disagree with this statement. However, NSS believes that the importance of this aspect of the mission is drastically understated in the EIS and should be more fully reflected along the lines set out above.

Conclusion and Recommendations

Environmental Impact Statements, of course, do not make recommendations; their purpose is simply to set out costs and benefits. NSS has already explained why it believes that the Ulysses EIS is adequate in its statement of potential costs and risks, but inadequate in its treatment of the likely benefits of the mission. NSS recommends that the EIS be revised to take these benefits into account.

Regardless of the extent to which such revisions are made, NSS recommends as well that NASA take the benefits noted in these comments into account in making its decision whether to proceed with the Ulysses mission. It is not the function of an Environmental Impact Statement to determine whether a particular project is "too risky." Its function is solely to ensure that the agency to whom decisionmaking authority has been delegated (here NASA and, because radioactive materials are involved, the President) makes an informed decision after considering all relevant factors.
NSS believes that when all relevant factors are considered, the necessary conclusion is that the *Ulysses* mission is not only justified, but very important -- and that that importance stems not only from scientific factors, but from the very significant positive impact that *Ulysses* is likely to have on the earth's environment over the long term. For this reason, NSS supports a decision to go ahead with the *Ulysses* mission.

Sincerely,

Glenn Harlan Reynolds
Chairman, NSS Legislative Committee, For the
National Space Society
RESPONSES TO COMMENTS
Commentor No. 16: Committee to Bridge the Gap
(Daniel Hirsch)

Response to Comment 16A:

The Cassini Environmental Impact Statement (EIS) examines the range of mission alternatives available for accomplishing the Cassini mission objectives within a reasonable timeframe, as well as the No-Action alternative. A number of optional launch vehicles, mission trajectories to Saturn, and spacecraft power and heating sources were examined in detail.

Response to Comment 16B:

NASA has followed the technical progress in space power research and development worldwide for many years. NASA studied many different solar, battery, and other power alternatives, including long life fuel cells, available for Cassini and found none that would meet the mission requirements. A Cassini spacecraft equipped with the highest efficiency solar cells available, or fuel cells, or batteries, or combination of these would make the spacecraft too massive for launching on the Titan IV (Solid Rocket Motor Upgrade [SRMU])/Centaur to Saturn. Even if a heavy-lift booster were available that could launch the Cassini spacecraft with a massive solar array, such large solar arrays would introduce insurmountable complexity to the mission and would severely jeopardize the chances for mission success. For fuel cells, even assuming the highest currently available energy fuel-per-unit mass and 100 percent efficient conversion (an idealistic assumption since only 60-70 percent is currently feasible), the resulting dry mass (before adding propellants for the spacecraft engines needed for maneuvers in space) would be about 16,000 kg (17.6 tons). It would not be possible to launch Cassini and place it on a trajectory to Saturn if it were that massive, i.e., it would exceed the launch capability of the Titan IV [SRMU]/Centaur by more than a factor of 2.

NASA continues to invest in research and development of solar power technology. Indeed, a significant portion of the work in the area of solar arrays has been carried out under NASA funding. While improvements have been made in solar technology, significant breakthroughs are still required to support a mission such as Cassini (see response to Comment 1B). Recent international conferences on space power provided no reports of technical breakthroughs that would suggest changing the proposed approach to powering Cassini. Within the timeframe of the Proposed Action, no power...
source options other than radioisotope thermoelectric generators are capable of meeting mission requirements.

Response to Comment 16c:

As stated previously in response to Comment 16B, NASA continues its research and investment in electric power technology for space missions. Historically, NASA's primary choice of a power source for planetary missions has been solar power and it has continued to be used for missions when such technology is feasible. The solar power option for Cassini has been extensively reviewed and rejected for this EIS because no U.S. launch vehicle exists to conduct a solar powered mission to Saturn using available solar power technology (see response to Comment 1B). To wait for future development of solar power options suitable to meet the mission requirements would indefinitely delay the mission. NASA has proceeded as quickly as possible in providing a high quality and accurate EIS utilizing the best available information.

Response to Comment 16D:

See response to Comment 13A.
Response to Comment 16E:

The particle size distributions for the accident source terms used in the analysis are based on consideration of the plutonium (Pu-238) dioxide fuel form and its response to accident environments (explosion overpressure, fragment, fire, impact, and reentry) as determined by safety test data and analysis. The small fraction of respirable particles associated with a release particle size distribution reflects the ceramic nature of the fuel and its low potential for vaporization in thermal environments. Impact-related releases are expected to be largely non-respirable particles and chunks.

Response to Comment 16F:

The predicted health effects resulting from postulated accident source terms are presented both with and without the application of *de minimis* dose. The EIS takes no position relative to the appropriateness of applying a *de minimis* dose in the determination of the radiological consequences.
Response to Comment 17A:

NASA and the Department of Energy take very seriously the possibility that an action that they take could potentially result in human fatalities or harm to the environment. Therefore, both agencies have gone to great lengths to reduce the potential for such events, both through design of the radioisotope thermoelectric generators and through design and operation of the spacecraft and its mission. As a result of these designs, the risks of fatalities or harm to the environment from the Proposed Action are considered to be very low. See Sections 4.1.5.2 and 4.2.5.1 of the Environmental Impact Statement for more details on launch phase accident scenarios.

NASA appreciates your expressing your views and has considered your comment. Please see response to Comment 2A for further information on the use of plutonium dioxide for the Cassini mission.
Dec. 19, 1994

Dr. Peter Ulrich
Solar System Exploration Division
Office of Space Science
NASA HQ
Washington, D. C. 20546

Dear Dr. Ulrich:

We are writing to ask you to suspend plans to launch the Cassini space probe to Saturn as long as any plutonium is scheduled to be on board. The risk of an accident at launch or during its "sling shot fly-by" above the Earth is not worth the gamble.

We urge the use of alternative on-board power sources such as solar energy and the long life fuel cells for all future deep space missions.

Sincerely,

Jennie Baer
MARGARET MEAD CHAPTER-WILPF
Jennie Baer, Secretary

Response to Comment 18:
See response to Comment 2.

Response to Comment 18A:
See response to Comment 2A.

Response to Comment 18B:
See response to Comment 7B.

Response to Comment 18C:
See response to Comment 6A.
Response to Comment 19A:
See response to Comment 2A.

Response to Comment 19B:
See response to Comment 7B.

Response to Comment 19C:
See response to Comment 6A.

Response to Comment 19D:
The Department of Energy provides radioisotope thermoelectric generators (RTGS) to NASA as an electrical power source for missions to explore the outer solar system. Such interagency cooperation is not for the profit of any laboratory.
RESPONSES TO COMMENTS
Commentor No. 20: Florida Coalition for Peace & Justice
(Sylvia Torgan with 24 Additional Petitioners)

Response to Comment 20A:
See response to Comment 2A.

Response to Comment 20B:
See response to Comment 7B.

Response to Comment 20C:
See response to Comment 6A.
NASA appreciates expression of your views. Your comments are similar to those raised by earlier commentors.

Response to Comment 21A:
See response to Comment 2A.

Response to Comment 21B:
See response to Comment 7B.

Response to Comment 21C:
See response to Comment 6A.
Dr. Peter Ulrich  
Solar System Exploration Division  
Office of Space Science  
NASA HQ  
Washington, DC 20546

I wish to comment on the DEIS for the 1997 Saturn Cassini space mission. In particular, I am concerned about the utilization of plutonium-238 & 239 as fuels.

Specific concerns:

1) I am not at all convinced that the DEIS correctly estimates the potential risks in the event of possible catastrophe scenarios. As you know well, the carcinogenic risks from any exposure to plutonium are very high. Whether in the event of explosion or crash at relatively low altitude levels, or explosion (or leakage) in upper or super atmospheric levels, the risk potential to humans and other terrestrial life forms could be much higher than estimated—depending on circumstances.

2) Plutonium use at this point in history is going in the wrong direction. High efficiency solar cells, already developed in some other countries, are clearly the way to go. Not only will such cells cost less in dollar amounts (including externalized costs); they also eliminate the potential risk of plutonium exposure. The more plutonium-powered missions are launched, the greater the likelihood of accident resulting such exposure. We do not want to, nor do we need to go down that path.

I urge you to cancel planned use of plutonium in this and all other space missions.

Thank you for your attention to these concerns.

Sincerely yours,

Richard H. Hiers, Ph.D., J.D.

Response to Comment 22A:

NASA considers the risk analysis presented in the Environmental Impact Statement (EIS) to be the best estimation based on the available information at the time. The results of the accident analysis have been factually stated in the EIS in terms of (1) the total probability of release, (2) the radiological consequences of such a release, and (3) the risk. As part of the launch approval process, the Department of Energy will be preparing a more in-depth evaluation of the risks as part of the Final Safety Analysis Report (FSAR). NASA will review the FSAR, when it becomes available, and will evaluate the information presented for differences, if any, in the estimates of the potential radiological consequences and risks.

Response to Comment 22B:

See response to Comment 1B.

Response to Comment 22C:

Comment noted. Please refer to Sections 4.1.5.3 and 4.2.5.2 in the EIS for a discussion of initiating accident probabilities.

The total health effects mission risk to the public (considering all launch phases and the Earth-Gravity-Assist trajectory) for Cassini have been estimated and are small (about 1.8 x 10^-3 health effects). See Section 1.4 in the EIS for details on the multiple benefits already being derived from mission planning. The Cassini mission to the Saturnian system represents a rare opportunity to gain significant insights into major scientific questions about the formation of the solar system and the conditions that led to life on Earth, in addition to a host of questions specific to the Saturn system.

Response to Comment 22D:

See response to Comment 2A.
RESPONSES TO COMMENTS
Commentor No. 23: Mr. & Mrs. Harry Kernes

Response to Comment 23A:

The Cassini mission will use plutonium-238 dioxide in the radioisotope thermoelectric generators to generate onboard electrical power. The mission would commit human, material, economic and other resources (see Section 4.8 of Environmental Impact Statement [EIS]) to provide significant new scientific information to address some fundamental questions about the origins of life and our solar system. Significant technological benefits, as discussed in Section 1.4 of the EIS, have been achieved during the planning of the mission.
NASA has invested in research and development of solar power technology. Additionally, the U.S. Department of Energy, the European Space Agency, and other agencies and research centers around the world have been investing in and improving upon solar power technology over the last decade. A number of solar power designs were investigated for the Cassini mission that would utilize unproven yet promising technology (e.g., the Advanced Photovoltaic Solar Array).

NASA studied many different solar, battery, and other power alternatives, including long life fuel cells, available for Cassini and found none that would meet the mission requirements. A Cassini spacecraft equipped with the highest efficiency solar cells available, or fuel cells, or batteries, or combination of these would make the spacecraft too massive for launching to Saturn. Even if a heavy-lift booster were available that could launch the Cassini spacecraft with a massive solar array, such large solar arrays would introduce insurmountable complexity to the mission and would severely jeopardize the chances for mission success. For fuel cells, even assuming the highest currently available energy fuel-per-unit mass and 100 percent efficient conversion (an idealistic assumption since only 60-70 percent is currently feasible), the resulting dry mass (before adding propellants for the spacecraft engines needed for maneuvers in space) would be about 16,000 kg (17.6 tons). It would not be possible to launch Cassini and place it on a trajectory to Saturn if it were that massive, i.e., it would exceed the launch capability of the Titan IV (Solid Rocket Motor Upgrade [SRMU])/Centaur by more than a factor of 2.

Though NASA continues to invest in research and development of solar power technology, the current state of the technology makes solar power infeasible for the Cassini mission to Saturn. See response to Comment 1B.

The concerns of the Florida Coalition for Peace and Justice are addressed in response to Commentor No. 1.
Response to Comment 25A:

There is about 32.4 kg (71.4 lb) of plutonium dioxide in the three RTGs of which approximately 28 kg (62 lb) are plutonium isotopes. Table 2-3 provides the isotopic composition of the fuel form used for the Cassini mission. See also response to Comment 4B.

Response to Comment 25B:

See response to Comment 2B.

Response to Comment 25C:

See response to Comment 1B.
RESPONSES TO COMMENTS
Commentor No. 26: Arthur Draving

NASA appreciates your comments on the use of plutonium on the Cassini mission to Saturn. Your comments are similar to those raised by earlier commentors.

Response to Comment 26A:
See response to Comment 2A.

Response to Comment 26B:
See response to Comment 5B.

Response to Comment 26C:
See response to Comment 6A.
John P. Ferrell  
441 Madeira Avenue  
Coral Gables, FL 33134

Dr. Peter Ulrich  
Solar System Exploration Division  
Office of Space Science  
NASA HQ  
Washington, DC 20546

December 25, 1994

Dear Dr. Ulrich:

I am writing to express my vehement disapproval of your plan to allow 73 pounds of Plutonium to be launched from Florida. As a resident and voting citizen I urge you not to jeopardize the health of my family's state.

I hope you make decisions on such delicate matters in the future based on a short and long-term quality of life criteria instead of a short-term cost-benefit analysis. My daughter's quality of life cannot be described by numbers of dollars or "excess cancers." All cancers are excess and should be avoided.

Thank you for understanding and considering the concerns of your constituents and citizens in making your final decision on our quality of life.

Sincerely,

John P. Ferrell

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NASA appreciates Your comments regarding the launch of the Cassini spacecraft to Saturn. Your comments are similar to those raised by earlier commentors.

Response to Comment 27A:

See response to Comment 2A.

Response to Comment 27B:

See responses to Comments II and 8C.
RESPONSES TO COMMENTS
Commentor No. 28: Ingeborg F. Roberts

Response to Comment 28A:

Cassini is a peaceful scientific mission being designed and developed by civilian agencies of the U.S. government and those of Europe. The plutonium fuel form used in the radioisotope thermoelectric generators (RTGS) is not weapons-grade material, and is used to generate electricity for the spacecraft and its scientific instruments.

Response to Comment 28B:

See response to Comment 5B.

Response to Comment 28C:

NASA has estimated the risks from plutonium (Pu-238) dioxide onboard the Cassini spacecraft and has found the risks to the world population and our planet to be very low. The risks from the launch of Cassini would be lower than many of the risks that we face in our everyday lives (see Table 4-20 in the Environmental Impact Statement). A wide range of potential accident scenarios was evaluated.

Response to Comment 28D:

See responses to Comments 3D.
RESPONSES TO COMMENTS
Commentor No. 29: Geraldine Jenara Amato

Response to Comment 29A:

See response to Comment 2A.

Response to Comment 29B:

See response to Comment 6A.

Response to Comment 29C:

The Cassini mission is an international cooperative mission with the European Space Agency and the Italian Space Agency. There is no intent by NASA to generate excess profits for any organization.
Dec. 28, 94

Dear Dr. Ulrich:

Please cancel the Cassini plutonium mission. I support the campaign to stop nuclear power in space. 73 pounds of plutonium on a Titan rocket is a gamble you shouldn't take, and Americans shouldn't be subjected to. In April 94 the European Space Agency declared their industries have high-efficient solar cells available for deep-space missions. I only wish you and the DOE could be so thoughtful. Cassini is myopic, wasteful & dangerous. Cancel it!

Mary Sprunger-Froese
2350 15th, Fountain Blvd.
COLO SPRINGS, CO 80903

NASA appreciates your comments regarding the Cassini mission to Saturn. Your comments are similar to those raised by earlier commentors.

Response to Comment 30A:

See response to Comment 2A.

Response to Comment 30B:

See response to Comment 1B.

Response to Comment 30C:

See response to Comment 7B.
RESPONSES TO COMMENTS
Commentor No. 31: Harvey Wasserman

Response to Comment 31A:

Please see responses to Comments 2A, 2B, and 8C.
RESPONSES TO COMMENTS
Commentor No. 32: Edward Dierauf

Response to Comment 32A:

See response to Comment 3D.

Response to Comment 32B:

See response to Comment 7B. The dominant isotope of the fuel, plutonium-238, has a half-life of 87.75 years. Because of radioactive decay and accounting for all the plutonium isotopes in the original fuel, the amount of plutonium remaining (without any mitigation actions) after 100 years would be 45 percent, after 500 years would be 2 percent, after 1,000 years 0.13 percent, and after 5,000 years would be 0.08 percent.

553 15th Avenue
San Francisco, CA 94118
December 30, 1994

Dr. Peter Ulrich
Solar System Exploration Division
Office of Space Science
NASA Headquarters
Washington, D.C. 20546

Dear Dr. Ulrich:

Please consider solar alternatives for supplying energy to the 1997 Cassini spacecraft mission. It is wrong to press ahead upon a procedure using radioactive material that can impact upon man’s health for thousands of years if something goes wrong in the launch.

Yours very truly,
Edward Dierauf

Dierauf
NASA appreciates your comments on the Cassini mission to Saturn and your concern for the welfare of future generations. Your comments are similar to those raised by earlier commentors.

Response to Comment 33A:
See response to Comment 4B.

Response to Comment 33B:
See response to Comment 6A.

Response to Comment 33C:
See response to Comment 1C.

Response to Comment 33D:
See response to Comment 2A.

Response to Comment 33E:
See response to Comment 13A.
NASA appreciates your comments on the use of radioactive materials on Cassini mission. Your comments are similar to those raised by earlier commentors.

Response to Comment 34A:
See response to Comment 2A.

Response to Comment 34B:
See response to Comment 28A.

Response to Comment 34C:
See response to Comment 6A.
Dear Dr. Ulrich:

I write to protest the Cassini plutonium mission planned for 1997.

I am not convinced that the DEIS recently released has realistic figures that even come close to that of other experts such as Dr. Helen Endicott.

I think that the risks are much greater than NASA and the DOE would have us believe.

I urge you to reconsider this planned launch.

Sincerely yours,

Karen McFadyen

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Response to Comment 35A:

The results of the accident analysis have been factually stated in the EIS in terms of 1) the total probability of release, 2) the radiological consequences of such a release, and 3) the risk. Appendix C discusses the environmental and health risks associated with plutonium (Pu-238) dioxide in greater detail. See also response to Comment 4B.

Response to Comment 35B:

See response to Comment 13A.
RESPONSES TO COMMENTS
Commentor No. 36: Linda Bermann

Dr. Peter Urich
Solar System Exploration Division
Office of Space Science
MS # 2605–J
Washington, D.C. 20546

Dear Dr. Urich:

I am writing with deep concern for the safety of the earth and all of us on it.

I am writing to protest the CASSINI plutonium mission – a most dangerous project – at our expense!

Please do not allow nuclear power and weapons in space. We do not need this danger to our lives; the constant tension and worry in addition to our normal daily living.

Respectfully,

LINDA BERMANN
2550 DANA ST. # 7B
BERKELEY, CA 94704 - 2868

Response to Comment 36A:

Cassini is a peaceful scientific mission being designed and developed by civilian agencies of the U.S. government and those of Europe. The plutonium fuel form used in the radioisotope thermoelectric generators (RTGs) is not weapons-grade material, and is used to generate electricity for the spacecraft and its scientific instruments.

Response to Comment 36B:

NASA has estimated the risks from plutonium (Pu-238) dioxide onboard the Cassini spacecraft. The total health effects mission risk to the public (considering all launch phases and the Earth-Gravity-Assist trajectory) for Cassini is provided in Section 4.1.8 of the Environmental Impact Statement (EIS), and is estimated to be small (about 1.8 x 10^-3 health effects).

The risks from the launch of Cassini are lower than many of the risks we face in our everyday lives (see Table 4-20 in the EIS).
RESPONSES TO COMMENTS
Commentor No. 37: Merilyn Hiller

NASA appreciates your expression of views regarding the Cassini mission to Saturn. Your comments are similar to those raised by earlier commentors.

Response to Comment 37A:
See response to Comment 3D.

Response to Comment 37B:
See response to Comment 7B.

Response to Comment 37C:
See response to Comment 1B.

Dr. Peter Ulrich
Solar System Exploration Division
Office of Space Science
NASA HQ
Washington, DC 20546

January 2, 1995

Dear Dr. Ulrich:

The Cassini plutonium mission is a potentially deadly idea. Why must plutonium (aptly named after Pluto, lord of death) be used as an on-board power source when solar energy could be used instead?

I resent mightily that my taxes are being used for such a misguided and risky plan. Are there not enough cancers growing already in our people that you must dream up still another “risk factor” to be added to an ever-growing list? Stop this mission, re-think the use of plutonium, consider seriously using instead high efficiency solar cells recently developed in Europe.

Sincerely,
(Ms.) Marilyn Hiller

CC: Rep. Studds
Sen. Kennedy
Sen. Kerry
Pres. Clinton
RESPONSES TO COMMENTS
Commentor No. 38: Sidney and Olive Manuel

Response to Comment 38A:

NASA believes that the Cassini mission to Saturn will be of great benefit to all people. Your comments about the use of plutonium in this mission are addressed in response to Comment 7B.
Response to Comment 39A:

NASA places the highest priority on assuring the safe use of radioactive materials in space. Thorough and detailed safety analyses are conducted prior to launching NASA spacecraft with radioisotope thermoelectric generators (RTGs), and many prudent steps are taken to reduce the risks involved in NASA missions using RTGs. In addition to NASA’s extensive internal safety requirements and reviews, missions that carry nuclear material also undergo an additional safety review involving detailed verification testing and analyses.

The Department of Energy has designed the RTGs with a number of safety features. First, the fuel is in the heat-resistant, ceramic form of plutonium dioxide, which reduces its chance of vaporizing in fire or reentry environments. This ceramic-form fuel is also highly insoluble, has a low chemical reactivity, and primarily fractures into large, non-respirable particle and chunks in the unlikely event that the RTGs are in an accident resulting in some released material.

Second, the fuel is divided among 18 small, independent modular units, each with its own heat shield and impact shell. This design reduces the chances of fuel release in an accident because all modules would not be equally impacted in an accident.

Third, multiple layers of protective materials, including iridium capsules and high-strength graphite blocks, are used to protect the fuel and prevent its accidental release. Iridium is a metal that has a very high melting point and is strong, corrosion-resistant and chemically compatible with plutonium dioxide. These characteristics make iridium useful for protecting and containing each fuel pellet. Graphite is used because it is lightweight and highly heat-resistant. See also response to Comment 2A.

Response to Comment 39B:

The U.S. Department of Energy and the U.S. Nuclear Regulatory Commission are two separate governmental agencies that evolved from the Atomic Energy Commission.

NASA considers the risk analysis presented in the Environmental Impact Statement (EIS) to be the best estimation based on the available information at the time. As part of the launch approval process, the Department of
Energy will be preparing a more in-depth evaluation of risks as part of the Final Safety Analysis Report (FSAR). NASA will review the FSAR, when it becomes available, and will evaluate the information presented for differences, if any, in the estimates of the potential consequences and risks.

Response to Comment 39C:

See response to Comment 1B.

Response to Comment 39D:

While the launch is not aimed at or targeted to Africa, there are several reasons why launch vehicles are generally directed eastward from Cape Canaveral Air Station/Kennedy Space Center. There are no land masses or populations threatened in the event of an early ascent launch accident. An eastward launch from the Cape puts a spacecraft on the proper course to travel toward other solar system bodies within the ecliptic plate, such as Saturn. In addition, from the Cape's location at 28.5 degrees north longitude, launch vehicles receive an extra 1,400-kilometer per hour (900 mile per hour) boost due to Earth's rotational velocity. This means less fuel is required for the launch vehicle to reach its destination.

For the Proposed Action, the instantaneous impact point would be over Africa for a brief period of 8 seconds in Phase 5 (see Section 2.2.7). Should an accident occur during this period, NASA has estimated that the total probability of a plutonium release would be very small with statistically indistinguishable health effects (see Section 4.1.8 of the Environmental Impact Statement).

Response to Comment 39E:

See response to Comment 2A.
Historically, NASA used solar power for missions when such technology was applicable. For example, the Mars Observer, Viking Orbiters, Mariners 4, 6, 7 and 9 were solar-powered Mars missions. Future missions to Mars such as Pathfinder and Mars Global Surveyor will be solarpowered, using the newest high efficiency GaAs/Ge cells. Mars Pathfinder lander and microrover represent the first use of photovoltaics on the Martian surface. However, NASA incorporates radioisotope thermoelectric generators (RTGs) with spacecraft designs when solar power or other power technology is not feasible for the planned mission. The current state of the technology makes solar power infeasible for a mission like Cassini. See also response to Comment 6A.

Response to Comment 40B:

See responses to Comments 2A and 1K.

Response to Comment 40C:

The risk analysis presented in the Environmental Impact Statement is deterministic. Monte Carlo simulations were performed in the estimation of the launch phase initiating accident scenario probabilities and the Earth-GravityAssist inadvertent reentry probabilities. The Monte Carlo technique is appropriate when evaluating functional relationships involving probability distributions. As part of the flight approval process, the Department of Energy will be preparing a more in-depth evaluation of the potential environmental consequences as part of the Final Safety Analysis Report (FSAR). Monte Carlo simulations will be applied in the FSAR.

Response to Comment 40D:

See response to Comment 4B.

Response to Comment 40E:

See response to Comment 1B.
Response to Comment 40F:

Cassini is a peaceful scientific mission being designed and developed by civilian agencies of the U.S. government and those of Europe. The plutonium fuel form is not weapons-grade material, and is used to generate electricity for the spacecraft and its scientific instruments.

Response to Comment 40G:

NASA continues to invest in solar and other technologies for space applications. NASA’s investment along with that of other Federal research and development programs have yielded advances in solar technologies that are in widespread use today.
RESPONSES TO COMMENTS
Commentor No. 40: V. Lee Fuqua
(Continued)

The Casini mission
Thank you for your time.

Sincerely,
V. Lee Fuqua
V. Lee Fuqua
PO Box 1978
California, CA
92795

POMA BASKET

Woven in the coil technique, this large conical carrying basket's typical geometric design was either reddish brown or black on a light ground or white on a brown ground.
January 8, 1995

Dr. Peter Ulrich
Solar System Exploration Division
Office of Space Science
NASA HQ
Washington, DC 20546

Dear Dr. Ulrich,

I am writing to urge you, in the strongest terms, to delay the planned launch of the Cassini space mission to Saturn until its onboard energy system can be made non-nuclear. Doubtless it is easier and cheaper to proceed with the plan to use plutonium in RTU's, but the risks to human life of doing so are simply unacceptable--especially because solar and fuel-cell options are feasible.

As a life member of AAAS and the former director of a research center at NYU, I am a strong advocate of using public funds to advance basic science, and hope that it will not be necessary to cancel the mission altogether, though in these times of new demands for budgetary stringency I would much rather see the required billions used to protect Medicare and Medicaid from threatened cuts. The possible gains to knowledge from Cassini if everything goes well cannot in any way counterbalance the possible consequences of failure: damage to the health of countless thousands of human beings and death to many.

We have been lucky, so far, that there have not been worse disasters from the launching of so many space vehicles carrying radionuclides. It is high time to stop that risky practice altogether, surely not to try to launch the largest amount of plutonium ever sent into space. And using the notoriously unreliable Titan IV as the vehicle, to boot!

NASA has the opportunity to get some favorable publicity, for a change, if it is announced that the mission is being delayed because a way has been found to eliminate dangers to human life. Such a delay might also make it possible to redesign it more economically.

Sincerely yours,

Robert R. Holt, Ph.D.

Robert R. Holt
Professor of Psychology Emeritus
Box 1087 Truro, MA 02666-1087

Response to Comment 41A:
See response to Comment 2A.

Response to Comment 41B:
See responses to Comments 1K and 6A.

Response to Comment 41C:
The Titan family of launch vehicles has a flight history which spans more than three decades. They have been used for more than 320 launches including five launches of spacecraft with radioisotope thermoelectric generators and 10 launches carrying astronauts into space. See response Comment 3G. Refer to Section 4.1.5.3 of the Environmental Impact Statement for more details.

Response to Comment 41D:
See response to Comment 1H.
RESPONSES TO COMMENTS
Commentor No. 42: Bob Ellenberg

NASA appreciates your comments about the use of plutonium in the Cassini mission to Saturn. Your comments are similar to those raised by earlier commentors.

Response to Comment 42A:
See response to Comment 7B.

Response to Comment 42B:
See response to Comment 1B.

Response to Comment 42C:
See response to Comment 5B.

Response to Comment 42D:
NASA appreciates your expression of views.

January 16, 1995

Bob Ellenberg
1315 N.E. 9th St.
Gainesville, Fl. 32601
(904) 335-1856

Dr. Peter Ulrich
Solar System Exploration Division
Office of Space Science
NASA HQ
Washington, D.C. 20546

Dr. Ulrich:

It has brought to my attention that as part of the Cassini space mission to Saturn, NASA is planning on sending a Titan 4 rocket from Kennedy Space Center with 73 pounds of plutonium on board as fuel. If one citizens opinion is worth anything, you have mine as totally opposed to fueling this mission with plutonium. Too, too risky, too many lives are potentially in jeopardy if anything should happen to the space ship and it came down anywhere on the planet with the possibility of radiation escaping from its container. Zero is the only acceptable figure for the loss of life, or for more cancers. As a health professional, I know we have enough cancer without creating more.

I have read that the European space industry has been working with high efficiency solar cells that can send space ships into deep space. Let us not continue to depend on such a deadly source of energy as plutonium.

Please pay attention to the will of the people, our monies are paying for the project and we should have input.

Thanks for you time,

Bob Ellenberg
NASA appreciates your comments about the use of plutonium in the Cassini mission to Saturn. Your comments are similar to those raised by earlier commentors.

Response to Comment 43A:

See response to Comment 2A.

Response to Comment 43B:

See response to Comment 1B
February 12, 1975

Dear Dr. Ulrich,

Plutonium is so deadly, I do not understand why you want to use it in space. I think you should recheck your data and use a safer fuel — perhaps solar power with another tank. Sincerely,

Ruth Putz

197 Kendall

February 12, 1975

RESPONSES TO COMMENTS

Commentor No. 44: Ruth Putz

NASA appreciates expression of your views. Your comments are similar to those expressed by earlier commentors.

Response to Comment 44A:

See response to Comment 2A.

Response to Comment 44B:

See response to Comment 6A.
RESPONSES TO COMMENTS
Commentor No. 45: Carole and Frank Hyneman

NASA appreciates expression of your views. Your comments are similar to those expressed by earlier commentors.

We understand that the 1997 Cassini space mission to Saturn includes plans to use 73 lbs of plutonium. We are opposed to this because of the terribly toxic nature of plutonium. We urge you to consider using a safer power alternative. The European Space Agency, in 1994, released a statement saying that European industry has recently developed high-efficiency solar cells for use in future demanding deep-space missions.

Why would we rather use deadly plutonium when there is a safe alternative?

Sincerely yours,
Carole Hyneman

Response to Comment 45A:
See response to Comment 2A.

Response to Comment 45B:
See response to Comment 1B.
Fran Collier  
3187 Windrush Bourne  
Sarasota, FL 34235

Dr Peter Ulrich  
Solar System Exploration Division  
Office of Space Science  
NASA HQ  
Washington, DC 20546

Dear Sir:

This letter is to urge you to halt the Cassini plutonium mission and stop the use of nuclear power in space.

NASA and DOE give little consideration to the use of a solar-powered alternative on the Cassini mission. However, in April 1994 the European Space Agency released a statement saying that “European industry has recently developed high efficiency solar cells for use in future demanding deep-space missions.”

How unfortunate that the nuclear power industry and the DOE continue producing plutonium generation in the Savannah River Plant, Los Alamos Labs, Oak Ridge, Mound Labs and Martin Marietta. These sites were mainstays in producing nuclear weapons. Now nuclear power in space might keep them profitable.

Please use your influence to stop nuclear power in space and to develop solar energy for ALL purposes!

Sincerely,  
(Mrs) Fran Collier

RESPONSES TO COMMENTS  
Commentor No. 46 Mrs. Fran Collier

NASA appreciates expression of your views. Your comments are similar to those expressed by earlier commentors.

Response to Comment 46A:

See response to Comment 2A.

Response to Comment 46B:

See response to Comment 6A.

Response to Comment 46C:

See response to Comment 19D.
RESPONSES TO COMMENTS

Commentor No. 47: Religious Education for the Catholic Deaf & Blind
(Rev. René Robert)

February 27, 1995

Dr. Peter Ulrich
Solar System Exploration
Office of Space Science
NASA HQ
Washington, D.C. - 20546

Dear Dr. Ulrich:

Regarding the 1997 Cassini
Space launch to Saturn, I greatly
protest carrying plutonium on this
mission. The possibility of an
accident would endanger every
living being.

Again, I am against the
Cassini plutonium mission.

Thank you.

Very truly yours,

Rev. Rene Robert

Response to Comment 47A:
See response to Comment 2A.

Response to Comment 47B:

NASA has estimated the risks from plutonium (Pu238) dioxide onboard the
Cassini spacecraft and has found the risks to the world population and our planet to
be very low. The risks from the launch of Cassini would be lower than many of the
risks that we face in our everyday lives (see Table 4-20 in the Environmental Impact
Statement). A wide range of potential accident scenarios was evaluated.