RECORD OF DECISION

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Cassini Mission
Supplemental Environmental Impact Statement (SEIS)

A. Background

NASA completed development of the Cassini mission Environmental Impact Statement with distribution of the Final Cassini EIS (hereinafter the 1995 Cassini EIS) to the public and other interested parties in July 1995. The Record of Decision (hereinafter the 1995 ROD) was rendered in October 1995. While the 1995 Cassini EIS analyses used the best information available at that time, it was noted that NASA and the U.S. Department of Energy (DOE) were continuing to analyze and evaluate additional accident scenarios specific to the Cassini spacecraft and its launch vehicle and trajectory. In both the 1995 Cassini EIS and the 1995 ROD, NASA made the commitment that, should significant differences arise between the results of the ongoing analyses and the 1995 Cassini EIS, NASA would evaluate the information and make a determination regarding the need for additional environmental documentation, including supplementing the 1995 Cassini EIS. Updates of the safety analyses in support of the 1995 Cassini EIS were made available to NASA during the spring of 1997. In anticipation of this updated information, NASA determined that the purposes of the National Environmental Policy Act of 1969 (NEPA), as amended (U.S.C. 4321, *et seq.*), would be furthered by preparation of a Supplemental EIS (SEIS) for the Cassini mission.

The proposed action and preferred alternative consist of completing preparation of the Cassini mission for launch in the October 1997 opportunity, or either the secondary or backup opportunities, and operating the mission. The Cassini spacecraft, consisting of the Cassini Orbiter and the detachable Huygens Probe, incorporates three Radioisotope Thermoelectric Generators (RTGs) to provide onboard electric power and 117 Radioisotope Heater Units (RHUs) [1] to regulate spacecraft temperature.

B. Introduction to the SEIS

This SEIS was developed to address information that became available, subsequent to public release of the 1995 Cassini EIS and NASA's rendering of the 1995 ROD, from updated mission nuclear launch safety analyses. This information is pertinent to the consequence and nuclear risk analyses of potential accidents during the launch and cruise phases of the mission that were addressed in the 1995 Cassini EIS.

[1] Even though the SEIS states that the inventory of RHUs would be up to 129, the Cassini spacecraft will use 117.

The Draft SEIS was made available to the public in April 1997. Sixteen comment letters were received. These comments dealt with a range of issues, including, but not necessarily limited to, the use of solar technology for the Cassini mission, the properties of plutonium (*e.g.*, toxicity), the ability of the RTGs to survive reentry, emergency response plans, and availability of baseline assumptions and analyses.

The Final SEIS was made available on July 3, 1997, and the waiting period expired on August 4, 1997. Five comment letters were received, one from the U.S. Environmental Protection Agency (EPA) and four from private citizens. The EPA letter recommended use of an updated guidance for contamination cleanup; the four private citizens neither raised new issues nor provided any additional data or information relevant to the adequacy of the SEIS, but in part reiterated views previously asserted against the use of space nuclear power sources.

Alternatives Considered

The alternatives[2] addressed in the SEIS were:

1. Completion of preparations for and operating the Cassini mission to Saturn, with a launch during either the primary (October-mid November 1997), secondary (late November 1997-January 1998), or backup (March-April 1999) opportunities. The primary opportunity uses a Venus-Venus-Earth-Jupiter-Gravity-Assist (VVEJGA) trajectory; the secondary and backup opportunities use a Venus-Earth-Earth-Gravity-Assist (VEEGA) trajectory. This alternative would utilize the Titan IV (Solid Rocket Motor Upgrade [SRMU])/Centaur launch vehicle.

2. Completion of preparations for and operating the Cassini mission to Saturn, with a launch during either the March 2001 opportunity or the backup opportunity in May 2002. The primary opportunity uses a Venus-Venus-Venus-Gravity-Assist (VVVGA) trajectory; the backup opportunity uses a VEEGA trajectory. This alternative would utilize the Titan IV (SRMU)/Centaur launch vehicle.

3. Adoption of the no-action alternative, resulting in termination of preparations for launching and operating the Cassini mission.

Mission Components Evaluated

The key components associated with potential environmental concerns of the Cassini mission are the launch vehicle, the interplanetary trajectory, and the power system for the spacecraft's electrical requirements. These must function together to satisfy the requirements of the mission.

Key components were evaluated in the 1995 Cassini EIS in terms of technical feasibility, ability to satisfy the science objectives of the mission, and potential for reducing the postulated environmental impacts associated with the October 1997 baseline mission design. To be considered

[2] Since the 1995 Cassini EIS, the Solid Rocket Motor (SRM)-equipped Titan IV/Centaur launch vehicle option is no longer available and the 1999 Mission Alternative utilizing a dual shuttle launch is no longer a reasonable alternative.

technically feasible, a component must have been tested for space-flight applications or must be in the development stages on a timetable consistent with satisfying Cassini's science objectives. The requirement for components to satisfy the science objectives is essential because the mission must provide useful information in a timely manner.

The evaluation of mission components led to the following determinations: (1) the Titan IV (SRMU)/Centaur is the most capable U.S. launch system available and most closely matches the requirements of the Cassini mission; (2) the Cassini mission to Saturn requires planetary gravity-assist trajectories; and (3) the spacecraft requires the use of three mainly plutonium-238 dioxide-fueled RTGs and the potential for up to 157 RHUs (see, however, footnotes 1 and 6) to satisfy the mission electrical and thermal requirements. The total plutonium dioxide inventory will be around 400,000 curies at time of launch. The Jet Propulsion Laboratory conducted an in-depth analysis of the available electrical power systems, including many different solar, battery, and long-life fuel cell power sources and hybrid systems to identify the most appropriate power source for the Cassini mission. None of these were found to be technically feasible for Cassini. For example, a Cassini spacecraft equipped with the highest efficiency solar cells available[3] would make the spacecraft too massive for launching to Saturn. The spectrum of available launch vehicles was also analyzed, and it was determined that there is no available launch vehicle which could avoid planetary gravity assist trajectories.

Environmental Consequences of the Alternatives

For the 1995 Cassini EIS, in evaluating the potential impacts associated with accidents, NASA and its cooperating agency, DOE, using the best information available at that time, developed an array of four representative launch accident scenarios and the resulting accident environments. Accident scenarios and associated environments were also evaluated for an inadvertent reentry of the spacecraft into the atmosphere during an Earth swingby. NASA and DOE analyzed these accident scenarios with respect to the consequences and risks to human health (termed health effects, defined as excess latent cancer fatalities over a 50-year period, beyond those normally expected to occur within the exposed population) and to the environment.

Results from the 1997 updated analyses are more refined and comprehensive than those presented in the 1995 Cassini EIS. Refined probabilistic risk assessment techniques, similar to those used for the Galileo and Ulysses missions, were used to assess the full range of accident scenarios and environments that could occur during launch of the spacecraft, as well as an inadvertent reentry during Earth swingby. The refined techniques used in the updated analyses specifically estimate the response of the Cassini RTGs and RHUs to the environments associated with each accident case[4] for the Cassini mission.

[3] See Section 2.1.4, page 2-6, of the SEIS for an explanation of why solar arrays using the new European Space Agency solar cells are not feasible for the Cassini mission.

[4] The updated analyses determined that there were 19 accident cases that threaten the RTGs or RHUs with a potential for release of plutonium dioxide. See Table 4-1, page 4-5, of the SEIS for descriptions.

The Final SEIS provides the results of the updated analyses. While the overall best estimate of risk has not changed appreciably for the mission, the estimates of mission segment[5] risk and variability in the updated analyses were higher for the launch phase accident cases and lower for the Earth swingby case compared to those reported in the 1995 Cassini EIS.

The radiological consequences are reported in the SEIS in terms of mean, 5-, 50-, 95-, and 99-percentile estimates of health effects for accidents involving the RTGs and RHUs[6] separately and combined. The mean consequence reported for a given accident is the mean of the best estimate results from the updated analyses. In addition to the best estimate analysis, the updated analyses included an uncertainty analysis (*i.e.*, a study of the underlying test data and model input parameters used to estimate accident consequences and risks). The results of the uncertainty analysis are reported in the SEIS in terms of 5-, 50, and 95-percent confidence levels about the mean estimates of mission risk (for accidents involving the RTGs only).

C. Assessment of the Analyses

The results of the analyses show that for most accidents occuring during any launch segment (Pre-Launch, Early Launch, and Late Launch) there would be no release of nuclear material. In the event of a release during a launch segment accident, the mean of the best estimate analysis indicates that there would be no health effects. The 99-th percentile of the best estimate indicates that from 1 to 1.5 health effects could occur during a Pre- or Early Launch segment accident.

The mission's design ensures that the expected probability of an inadvertent reentry during the Earth swingby is less than one in one million. A postulated inadvertent reentry accident during the Earth swingby could result in a mean release of 6% of the plutonium dioxide inventory with a probability of one in 1.25 million. If such an accident were to occur, the mean of the best estimate analysis predicts that there could be approximately 120 health effects worldwide over a 50-year period.

Finally, the overall mean mission risk resulting from the updated analyses and reported in the SEIS is approximately one order of magnitude lower than the overall mission risk previously estimated for the 1995 Cassini EIS.

D. Additional Information

I have been fully briefed on the results of the safety analyses and independent evaluation. While there are some differences in mission segment risk estimates, the differences are not significant and do not change the overall nuclear launch safety mission risk, but reasonably bound that risk.

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[5]The potential accidents were aggregated into four mission segments: Pre-Launch, Early Launch, Late Launch, and EGA (Earth swingby) Reentry. See table 4-1 of the SEIS.

[6]It should be noted that although the Cassini spacecraft will use 117 RHUs, the updated analyses were based on an inventory of 157 RHUs.

E. Mitigation

The only expected or immediate environmental impacts of the Cassini mission are the same as those for every Titan IV launch, and mitigation will accordingly be the same. This SEIS primarily addresses possible radiological consequences of mission accidents. Regarding such possible radiological impacts, NASA, with expert technical assistance from DOE, the Department of Defense, the EPA, and other Federal agencies, and in cooperation with state and local authorities, has developed radiological emergency response plans. Key elements of monitoring and data analysis equipment will be predeployed to enable rapid response in the event of a launch contingency. The plans, documented elsewhere, address both monitoring and mitigation activities associated with the launch. In particular, post-accident mitigation activities, if required, will be based on detailed monitoring and assessment at that time. The plans cover the rôles of the agencies involved. NASA will be the Lead Federal Agency coordinating the Federal response for accidents occurring within U.S. jurisdiction, and would coordinate with the Department of State and other cognizant agencies, as appropriate, in the implementation of other responses.

In addition, two mission maneuvers have been altered to keep the chances of an inadvertent Earth swingby reentry below one in one million. First, the swingby altitude for the Earth gravity assist has been increased from 500 km (310 miles) to 800 km (500 miles) or higher. Second, the last trajectory correction before the Earth swingby has been delayed from ten days prior to the swingby to seven days prior to the swingby. This delay in the maneuver increases the biasing of the trajectory away from Earth during the period before the Earth swingby.

F. Choice of Alternatives

In view of the small risks associated with the Cassini mission, it is my intention to choose the proposed action, Alternative 1 (above, page 2), based on programmatic grounds as follows:

Alternative 1, completing preparations for and operating the Cassini mission, including its launch on a Titan IV SRMU/Centaur in October 1997, the secondary opportunity beginning in late November 1997, or the backup opportunity beginning in March 1999, enables the earliest and best return of scientific information, makes most effective use of fiscal, human and material resources, and avoids disruption of our Nation's program for solar system exploration.

The no-action alternative, while presenting the minimum environmental risk, would, however, jeopardize our Nation's unique Outer Solar System Exploration Program, deprive society of the invaluable scientific knowledge which should result from this mission, and could seriously disrupt and strain the international partnerships the U.S. has formed to undertake space activities for peaceful purposes, such as the Cassini mission.

The choice to complete preparations for and to operate the mission is fully consistent with the mandate of the National Aeronautics and Space Act to contribute materially, among other things, to the expansion of human knowledge of phenomena in space.

Decision

Based upon all of the foregoing, it is my decision to complete preparation of the Cassini mission for launch in the October 1997 opportunity, or either the secondary or backup opportunities, and to operate the mission.

Wesley T. Huntress, Jr.
Associate Administrator for
Space Science

Aug 12, 1997
Date