



On the Restructured Cassini Mission: Letter Report

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"On the Restructured Cassini Mission"

On October 19, 1992, Dr. Louis J. Lanzerotti, chair of the Space Studies Board, and Dr. Joseph A. Burns, chair of the Committee on Planetary and Lunar Exploration, sent the following letter to Dr. Lennard A. Fisk, associate administrator for NASA's Office of Space Science and Applications.

At its meeting on July 16 and 17, 1992, a panel of the Space Studies Board's Committee on Planetary and Lunar Exploration (COMPLEX), chaired by Professor Reta Beebe of New Mexico State University, carried out a review of the restructured Cassini mission. A previous letter, dated March 30, 1992, conveyed to you the results of an earlier review of the CRAF and the pre-restructured Cassini missions. The current COMPLEX report was subsequently discussed at a meeting of the Space Studies Board on August 29, 1992. This letter and attached assessment by COMPLEX present the views of the Board and COMPLEX on the Cassini mission as it is now defined.

Please note that the information supplied to the Board and COMPLEX was insufficient to allow the Board to evaluate either the realism or accuracy of the budget profile projected for the restructured mission. The Board notes, however, that past experience shows that deferring needed expenditures in order to flatten a program's yearly funding profile can raise the overall cost of a mission.

While recognizing the loss of some science content as a result of the restructuring, COMPLEX has concluded that the new Cassini mission remains responsive to the committee's highest priority for outer planet exploration, the intensive study of the Saturn system. The restoration of the cruise science, however, is strongly urged for both operational and scientific reasons.

COMMITTEE ON PLANETARY AND LUNAR EXPLORATION SCIENTIFIC ASSESSMENT OF THE RESTRUCTURED CASSINI MISSION

October 19, 1992

At its meeting in Irvine, California, on July 16 and 17, 1992, a panel of the Space Studies Board's Committee on Planetary and Lunar Exploration (COMPLEX), chaired by Professor Reta Beebe of New Mexico State University, carried out a

review of the reconfigured Cassini mission. The committee had previously issued a series of letter reports on the CRAF and Cassini missions. [1,2,3,4](#) Since the most recent review in March 1992, [5](#) the mission has been restructured in order to decrease cost, increase mission resiliency and design margins, and eliminate the dependence on the Titan solid rocket motor upgrade. Because this restructuring affects the science capability of the spacecraft and the instrument complement, COMPLEX has assessed the mission in terms of the scientific impact of the revisions. A detailed examination of the budgetary and management revisions was outside the scope of the committee's advisory role, however, and COMPLEX therefore has chosen to evaluate the restructured mission in terms of its potential contribution to post-Voyager knowledge of the saturnian system. Ronald F. Draper (deputy project manager), Richard L. Stoller (spacecraft system engineer), William M. Fawcett (science instruments manager), and Ellis D. Miner (science manager) of the Jet Propulsion Laboratory (JPL) represented the Cassini project in this review.

The Voyager 1 and 2 flybys of the giant planets, including Saturn, were very successful and returned a wealth of scientific information. Nevertheless, high-resolution data were obtained for only a few days for each of the planetary systems. Accordingly, the Cassini mission has been designed to carry out the second phase of the exploration of Saturn, that of extending the spatial and temporal resolution of observations in order to better characterize the planet and its physical environment. The mission utilizes a Venus-Venus-Earth-Jupiter trajectory with a launch in late 1997. For two years after launch the spacecraft will orbit within two astronomical units of the Sun, gaining energy using gravitational assists from Venus flybys in April 1998 and June 1999 and then returning back past Earth in August 1999. Cassini will receive an additional boost during a near pass of Jupiter in January 2001 and will continue on to Saturn, arriving in late 2004. The spacecraft will investigate the saturnian system for four years, providing an opportunity to make detailed observations with sophisticated instruments for an extended time.

COMPLEX's previous reviews concerned a baseline Cassini mission, which utilized an orbiting spacecraft equipped with an articulated platform containing instrumentation capable of imaging the planet, rings, and satellites in visible and near-infrared light. A second, spinning platform housed instruments for determining the spatial and temporal variations of the magnetosphere and its charged-particle population. This orbiting spacecraft also carried a radar system for mapping Titan's cloud-shrouded surface and the Huygens probe (supplied by the European Space Agency) for characterizing Titan's atmosphere and surface in situ. This combination of instruments was judged to be highly responsive to the goals for the exploration of the outer solar system as previously defined by COMPLEX. [6](#)

The major differences between the restructured Cassini mission and the baseline mission are the substitution of body-fixed instruments for the attached platforms, deferment of the development of the ground system and flight software to post-launch, and the cancellation of all cruise science. A modest reduction of instrument

capability also occurred.

The following limitations have been imposed on the mission:

- The restructured mission has reduced remote sensing capability. The necessity of pointing the entire spacecraft, rather than just a scan platform, means that observations take longer. In addition, rapidly moving targets, such as the inner moons, are difficult to view. The continually changing spacecraft orientation may also make it more difficult to accurately reconstruct the magnetic field configuration.
- All remote sensing data must be recorded for later transmission because the antenna cannot stay pointed at Earth while the instruments are in use.
- It will be more difficult to infer the full three-dimensional distribution of charged particles because the body-fixed instruments will sample at an angular rate of only 0.25°/second (accomplished by spinning the spacecraft about its major axis), or perhaps 1.0°/second if motors are attached to individual instruments. Originally the turntable rotated at 18°/second.
- Spacecraft stability has been reduced. The currently estimated stability will produce narrow-angle images of quality similar to that of the Saturn images obtained by Voyager 1 and 2. The extent to which this can be achieved will be known by December 1992.

On the other hand, the restructured mission also provides the following desirable characteristics:

Approximately 20% cost savings are projected.

- No saturnian science objectives are lost. The main impact is the reduction of observing time available to each investigating team. Nevertheless, even though fewer data will be taken per orbit, any set of observations needed to address a particular scientific question can be planned.
- Previously, the power supplied by aging radioisotope thermoelectric generators would have been insufficient for alternate mission scenarios with longer flight times. Power requirements on the restructured mission have been reduced to a level that makes all backup missions viable.
- The reduction in mass allows the mission to be flown with the Titan launcher's standard solid rocket motor and does not require the proposed upgraded version, the solid rocket motor upgrade. COMPLEX believes that the minimization of impact on the science is a result of the close cooperation between JPL personnel and the science teams, including the foreign partners in the mission.

The instrument capabilities of the Cassini mission are still considerably greater than those of its Voyager predecessors, and its four years in orbit around Saturn

will allow unprecedented studies of the planet's magnetosphere, rings, atmosphere, and satellites. Cassini thus responds to a past COMPLEX recommendation [7](#) that reconnaissance missions, such as Voyager, be followed by missions of intensive study. The Cassini orbital mission, with its extended duration and deployment of the Titan atmospheric probe (Huygens), is still the most sophisticated mission to be flown to the outer planets. It will allow achievement of the following measurement objectives that are necessary to attain the goals listed in COMPLEX's strategy for the exploration of the outer planets. [8](#) These measurement goals are to:

- Increase the spatial resolution of satellite coverage by repeated close flybys to allow geological assessment of the surface morphology of the icy satellites;
- Obtain long-term temporal sampling of the saturnian atmosphere to better understand its dynamical properties;
- Obtain higher-resolution sequential observations of ring structures to study wave phenomena and other ring aspects;
- Map the magnetosphere and understand its interactions with the rings, icy satellites, Titan, and the solar wind; and
- Measure the composition, structure, and circulation of Titan's atmosphere and characterize the physical properties and geographic variability of its surface.

The planned instruments and orbital sequences will allow synergistic observations of Saturn and will gather spatially and temporally dependent data adequate to fulfill many of the criteria delineated in the published Space Studies Board documents. [9](#)

With respect to deletion of cruise science in the restructured mission plan, COMPLEX notes that Jupiter and Saturn are similar objects. If observations of the jovian system were obtained with Cassini's instruments, then both the saturnian data set from Cassini and the jovian data set from Voyager/Galileo could be directly intercompared and, thus, the scientific return of each greatly enhanced. Therefore, COMPLEX recommends that the decision to delete all cruise science be revisited. An effort should be made to obtain a significant jovian data set, acquired one-half of a jovian year after the completion of the Galileo mission. COMPLEX recommends that NASA carefully assess the incremental cost of this part of the mission in relation to the scientific value of the jovian data and the increased engineering reliability that would be gained by early operation of the Cassini system.

Although the Cassini spacecraft has undergone considerable revision, it is COMPLEX's overall opinion that the restructured Cassini mission remains responsive to the scientific priorities set out in its report, *A Strategy for Exploration of the Outer Planets: 1986-1996*. [10](#) Significant though these changes are with respect to legitimate individual science objectives, the recommended modifications do not substantially compromise the primary mission objectives, which include the intensive study of the saturnian system as a whole.

COMPLEX reiterates its statement of March 30, 1992, [11](#) that, with current technology, any intensive study mission beyond the asteroid belt must be more than a Discovery-class mission. Although intermediate-size missions (larger than Discovery class, but smaller than Cassini) could undoubtedly achieve some of COMPLEX's objectives for comprehensive study of the saturnian system, they could not achieve many others.

REFERENCES

1. Space Science Board letter to [Dr. Geoffrey Briggs, May 31, 1985](#).
2. Space Science Board letter to [Dr. Geoffrey Briggs, May 27, 1987](#).
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4. Space Studies Board letter to [Dr. Lennard Fisk, August 10, 1990](#).
5. Space Studies Board letter report, ["Scientific Assessment of the Craf and Cassini Missions,"](#) March 30, 1992.
6. Space Science Board, A Strategy for Exploration of the Outer Planets: 1986-1996, National Academy Press, Washington, D.C., 1986.
7. See reference 6.
8. See reference 6.
9. See reference 6.
10. See reference 6.
11. See reference 5.