

Tools for Cassini Response
[Inside NSS, September 1997]

Responding to Concerns That Might Be Raised
NUCLEAR RTGs & CASSINI MISSION TO SATURN
What you Should Know and What You Can Do

As of this writing, on October 6, NASA will launch the Cassini spacecraft on its way to Saturn. A small group of individuals is opposing the launch due to its use of a type of plutonium as a power source.

The NSS, in conjunction with the Metro Orlando Space Society, is preparing a number of strategies to aid in responding to the statements of this group. There has been some media coverage to date; things are expected to step up as September moves on.

Included with this article is an NSS Summary Statement approved by the NSS Policy Committee which lays out an interesting, environmentally-based argument against the opposition. Information from this Statement will be drafted into a series of shorter documents which will be distributed to Congress, the media and to our website for chapter downloading. All chapter regional organizers will also receive this information.

Also included with the Statement are a series of brief Q&A's on key Cassini issues, as well as a preliminary list of websites containing Cassini information. A number of these sites will be linked to a Cassini section of the NSS website, content for which is under development.

Cassini: Small Risks, Giant Benefits

The Mission

In October of 1997, a Titan IVB rocket will rise from Cape Canaveral, lifting the Cassini robotic spacecraft on the first leg of a nearly seven-year journey to the planet Saturn, 1.42 billion kilometers (882 million miles) away. The launch will be the culmination of more than eight years of preparatory work and billions of dollars of investment by an international team consisting of NASA, the European Space Agency, and the Italian Space Agency. Once released from the launch vehicle, Cassini will go through a series of "swingby" maneuvers, flying close by Venus (twice), then Earth, then Jupiter. With each swingby, Cassini will get a "gravity assist", and these successive energy boosts will send the 5,824-kilogram spacecraft onward to Saturn.

In July, 2004, Cassini will reach Saturn. For the next four years, while orbiting the planet, its payload of scientific instruments will carry out a series of detailed studies of Saturn's atmosphere, its numerous moons, its magnetosphere, and its fabled ring system. Cassini carries with it the 343-kilogram Huygens probe, designed to explore the Saturnian moon Titan.

After detaching from Cassini, the Huygens probe will parachute down into the orange, hazy atmosphere of Titan, which features a complex array of carbon-based molecules. For 2.5 hours, the probe will drop down toward the

frigid surface of Titan, a region which may contain lakes of liquid ethane over a thin layer of frozen methane and ammonia. Cassini/Huygens is humanity's first tentative step into this otherworldly place.

The Opposition

A relatively small but very outspoken group of activists is organizing a campaign to stop the Cassini mission. They object to the mission because they fear the potential consequences of an accident during the launch or during the Earth flyby phase (when the craft will swing within about 496 miles of Earth). Specifically, they fear the possibility that the plutonium carried onboard Cassini as a power source could be released into the atmosphere, radioactively contaminating the Earth environment.

These activists are coordinating a variety of protest activities, including circulation of anti-Cassini articles in the press and on the Internet, protest rallies and around-the-clock vigils in Florida and elsewhere, radio-show call-in campaigns, displays of anti-Cassini flyers, letter-writing and telegram campaigns, and distribution of thousands of postcards around the world to be mailed to President Clinton asking him to stop Cassini.

Some of the activists trying to ground Cassini are from the same groups which unsuccessfully opposed the Galileo probe to Jupiter in 1989, and the Ulysses probe to the polar regions of the Sun in 1990. Aided by the responsiveness of the Internet, they are gathering their forces and preparing to try again.

The Risks

There are 72 pounds of plutonium dioxide on board Cassini, enclosed within three Radioisotope Thermoelectric Generators (RTGs) and up to 130 Radioisotope Heater Units (RHUs). The RTGs use the heat of the natural radioactive decay of plutonium-dioxide to generate electric power for the craft and its instruments. The RHUs exploit the same process to provide heat to keep spacecraft systems at operating temperature.

With currently available technology, RTGs are the only realistic option for sending probes great distances from the Sun. They have been developed and tested over a 30-year period, and have been used on 24 prior spacecraft. To minimize risk of radioactive contamination of the Earth environment (space contamination is not a concern, given that the space environment is already a region of high natural radioactivity), the plutonium is put in insoluble, non-reactive ceramic form, and encased in a series of durable containers. In addition, flight trajectories have been designed so as to minimize the interval of time during Earth flyby when an accident could potentially release plutonium into the Earth environment. Despite these and other precautions, finite risks remain.

Cassini mission planners have extensively analyzed these residual risks, as they are legally required to do, beginning with the Final Environmental Impact Statement released to the public in July 1995. Also available: (i) as of April, 1997, a 90-page summary of the most recent Cassini nuclear safety analysis results prepared for the U.S. Department of Energy by Halliburton NUS Corporation, and (ii) as of July, 1997, a comprehensive Supplemental Environmental Impact Statement (SEIS) prepared by NASA's Office of Space Science. (Copies of the SEIS are available to the public. For further information, please contact NASA's Office of Public Affairs, Attn: Douglas Isbell, Tel. 202-358-1753.) The SEIS provides a detailed analysis which distributes risk over four main segments: pre-launch, early launch, late launch, and Earth gravity assist (flyby). Although the SEIS resists easy summation, and we strongly advise the reader to examine its assumptions and methodology, certain overall results emerge:

The total probability of a pre-launch phase accident that results in a release of plutonium is about 1 in 24,400, could result in 0.07 health effects (latent cancer fatalities over a 50-year period within the population potentially exposed), and could contaminate 0.58 square miles of land above an EPA guideline level.

For the early launch phase, the corresponding figures are: 1 in 1,590 chance of a release, 0.2 possible health effects, and 0.73 square miles.

For the late launch phase, the corresponding figures are: 1 in 450 chance of a release, 0.044 possible health effects, and 0.02 square miles.

For the Earth flyby phase, the figures are: less than 1 in 1 million chance of release, 120 possible health effects, and 3.05 square miles.

The SEIS estimates that the overall probability of an accident that releases plutonium is less than 1 in 345, and that if the one in 345 chance does occur, it could result in 0.11 health effects. The overall mission risk is 0.00032 health effects worldwide, i.e., 0.00032 latent cancer deaths over a 50-year period, beyond those normally expected to occur, within the exposed population. It has been estimated that the expected radiation dose a person might receive from a Cassini accident is about 1 millirem. To put this into perspective, we receive an average of more than 350 millirems each year just by living on Earth. Statistically, we are in less danger from Cassini than we are from dental X-rays.

The Benefits

The debate about Cassini often focuses on the potential risks. But as with any technology, ranging from the automobiles we use everyday to the X-ray machines we use as seldom as possible, the risks must be balanced against the benefits.

The Cassini mission is humanity's first extensive monitoring of the second-largest and second-most massive planet in the solar system, and the one with the largest, most visible and dynamic ring structure of all the planets.

The Cassini spacecraft will tour the Saturnian environment for four years, its twelve scientific instruments sending back to Earth a steady stream of information about Saturn's atmosphere, its 18 known moons, its magnetosphere, and its fantastic ring system. The mission includes more than 30 close Titan flybys, 4 close flybys of selected icy satellites, and 29 more distant satellite encounters. The Cassini mission is an important part of NASA's program for exploration of the solar system, the overall goal of which is nothing less than to understand the solar system's birth and evolution. The Huygens probe's descent by parachute toward the surface of the moon Titan may provide some particularly suggestive data. The nitrogen and methane molecules in Titan's hazy atmosphere are bombarded by high-energy particles and ultraviolet light, creating organic molecules that clump together and rain down on Titan's surface. The chemical processes occurring on Titan today may resemble the organic chemistry of early Earth.

The Cassini mission is classic "comparative planetology", to use a phrase coined by the great spaceflight pioneer Robert Goddard. The enormous potential benefit of such comparative study has been proved by what we learned from Venus: Measurements of the fluorine and chlorine chemistry of the atmosphere of Venus helped make and confirm the discovery that chlorofluorocarbons (CFCs) posed a threat to Earth's ozone layer.

Cassini is one of the great exploratory probes of the late 20th century, and the dawn of the next century. At nearly 13,000 pounds and two stories tall, it is among the largest, heaviest and most complex interplanetary spacecraft ever built. Its 7-year voyage to Saturn is in itself a magnificent feat of engineering. The wealth of scientific data Cassini sends back will be the most immediate benefit, but one must not forget the immense value of cumulative experience with (and refinement of) the propulsion, navigation, and data transmission

technologies that allow a spacecraft to reach a world 882 million miles away.

Long-Term Benefits: Toward a Solar Environmentalism

Space exploration and environmentalism are the twin progeny of 20th century technological advance. Nearly three decades ago, the famous Apollo photograph of the whole Earth floating in space helped launch the international environmental movement. Since then, both space exploration and environmentalism have developed considerably, both nourished by our increasingly sophisticated ability to measure and monitor the physical universe.

Regrettably, some environmentalists act as if they believe the Earth environment ends abruptly at the margins of that famous Apollo photograph. It does not. By now, it should be plain as day that Earth's environment is the solar system. It should be plain as day that Earth is dynamically interrelated with a wide variety of solar system physical processes—ranging from those as ordinary as photosynthesis to those as extraordinary as cometary impacts. The fate of our Earthly ecosystem is hitched to the fate of our star system, and to pretend otherwise is to be a spiritual descendent of those who clung to a Ptolemaic geocentrism long after the Copernican revolution.

In the nearly three decades since that whole-Earth image flashed into our cultural consciousness, we have learned a great deal about the solar environment. We have learned much recently about the shooting gallery of crisscrossing asteroids and comets which we now know regularly add moisture to Earth's atmosphere.

From solar probes we have learned about the solar winds, flares, and other phenomena which can potentially affect Earth's upper atmosphere, climate, and even our communications infrastructure. We have learned that there may be a rain of small comets depositing water and perhaps organic molecules into the upper reaches of the Earth's atmosphere. We have learned that some of the meteorites which fall onto Earth from Mars conceivably contain fossils of microbial Martian life. We have gathered some evidence that the solar system itself may be moving toward a region of interstellar gas and dust of a density that could eventually have dramatic effects on the inner solar system, including Earth's atmosphere and climate. We have even begun to catalog exoplanets, planets orbiting other stars, an exercise that sheds great comparative insight on our own solar system. And we have learned these things, many of which have crucial implications for understanding our Earthly ecosystem and its long-term prospects, precisely because we have made the effort to look and explore beyond the Earth.

Environmentalists whose vision is still confined within the frame of that Apollo photograph, no matter how sincere their expressed concern for Earth, will remain intellectually confined to an earthbound environmentalism. It is worth noting that many of the major environmental organizations are not protesting Cassini, evidence that their environmental vision is a more capacious and progressive one. But the anti-Cassini groups, in large part, are thoroughly earthbound environmentalists.

The National Space Society's environmental vision, in sharp contrast, looks toward the stars, starting with our own. If we can learn to draw on space resources, beginning with the moon and asteroids, then we will not be limited to

the non-renewable resources locked in Earth's crust. If we can build orbiting solar power plants, or perhaps fusion plants on the Moon powered by lunar Helium-3, then we will have eliminated the use of fossil fuels. And if, in the long run, we are able to create a spacefaring civilization that can carry ourselves and other elements of our ecosystem beyond Earth, we will have participated in a "greening of the solar system" quite congenial to those who see the flourishing of life, both in quantity and diversity, as a primary good.

The National Space Society's Conclusion

We have examined the risk analyses in the final and supplemental Environmental Impact Statements, considered the arguments of a variety of anti-Cassini groups, and contemplated the probable benefits of the mission.

We conclude that the Cassini mission poses definite but small risks that are vastly outweighed by enormous potential benefits. If the mission were to be canceled now, after years of international preparation and investment, it would be a great loss not only for space science and space exploration, but for the cause of farsighted environmentalism as well.

Decide for Yourself

You must ultimately decide the merits of this issue for yourself. You may be subject to a barrage of information from anti-Cassini groups between now and October, both in the print media and on the Internet. Some reflects legitimate concern, but some reflects uninformed fear-mongering or publicity-seeking by single-issue groups. For a thorough analysis of risks, we advise you to consult the Supplemental Environmental Impact Statement (SEIS) (see contact information above). In evaluating the soundness of anti-Cassini messages you may hear, we urge you to consider the following guidelines:

Does the anti-Cassini message show as much detailed awareness of the various categories of potential risk as does the SEIS itself?

Have those presenting the anti-Cassini view studied the SEIS, and if so are they able to explain which of the assumptions or methods of the SEIS analysis they find unsound, and why?

Do they indulge in unfair tactics such as (i) taking NASA to task for admitting a risk "even NASA admits...") when such admission is precisely what responsible risk-assessment requires, or (ii) using the past success of RTGs against RTGs, i.e. by arguing the historical record provides no real evidence of what would happen, or (iii) seizing on alarming statistics, e.g. that a single pound of plutonium, if pulverized and suitably dispersed, could kill everyone on Earth, without explaining how such a fantastically difficult and unlikely dispersal could be engineered?

Most importantly, does the anti-Cassini message merely obsess on the risks, or does it also fully consider the benefits, and show a willingness to

balance risks against benefits?

When anti-Cassini spokespeople claim to be motivated by concern for the environment, is it an earthbound environmentalism, or a more progressive and farsighted environmentalism?

The Cassini Mission: A Few Questions

1. *Isn't the Cassini spacecraft nuclear-powered?*

The Cassini spacecraft and its scientific instruments are powered by Radioisotope Thermoelectric Generators, or RTGs. These RTGs are not nuclear reactors and have no moving parts. They use neither fusion nor fission processes and could never explode under any imaginable accident scenario. RTGs produce power through the natural radioactive decay of plutonium (mostly Pu-238). The heat from the natural decay process is converted into electricity.

2. *But isn't plutonium one of the most dangerous substances known? I've heard that one pound of plutonium could kill everyone on Earth.*

Plutonium is without question a toxic substance, and becomes a health hazard when it is deposited in the body. If one were to inhale plutonium particles of a sufficiently small size to be deposited and retained in living lung tissue, alpha radiation could alter or kill nearby cells and over years result in cancerous tumors. The idea that one pound could kill every one of us is a theoretical notion that does not take into account the actualities of dispersal of the plutonium in the real world.

3. *But if there is an accident, couldn't the plutonium be released into the environment?*

To minimize risks, the Cassini plutonium is in a heat-resistant, ceramic form of plutonium dioxide that is highly insoluble, has a low chemical reactivity, and primarily fractures into large, non-respirable particles and chunks. It is encased in multiple layers of protective materials including iridium capsules and high-strength graphite.

More than 30 years have been invested in the engineering, testing, and safety analysis of RTGs, and they have been used on 24 different space exploration missions, including the Galileo and Ulysses probes. They have been on three missions which experienced malfunctions for other reasons, but the RTGs have never caused a spacecraft failure.

4. *Why not avoid the risks entirely by using a non-nuclear source of power, such as solar power?*

Cassini mission planners considered fuel cells or spacecraft batteries, but concluded that neither would last long enough for a mission of more than ten years. Moreover, the mass of batteries needed would be too heavy for present

launch capabilities.

Solar power is advancing, but is still not practical for a mission like Cassini, which will go vast distances from the Sun. The solar arrays needed, using available technology, would be about one quarter the area of a football field. They would be tremendously heavy to lift from Earth, would make spacecraft turns and maneuvers extremely difficult, and would interfere with the fields of view of many of the science instruments and navigation sensors.

5. *The Cassini spacecraft will follow a flight trajectory that will bring it close to Earth in 1999. Doesn't this pose additional dangers?*

To gain the energy needed to fly all the way (882 million miles) to Saturn, Cassini will get "gravity-assists" by flying close to Venus, Earth, and Jupiter. Such flybys have been used successfully since 1973. The Galileo spacecraft, for example, which was also RTG-powered, executed a 600-mile Earth swingby in 1990, and a 186-mile Earth swingby in 1992.

Cassini will come within 496 miles of Earth on its swingby in 1999. The trajectory has been designed to minimize the interval during which an accidental Earth-entry is even conceivable. Given the unlikely series of events and failures which would have to occur for such an Earth-entry to take place, the mission planners estimate the chances of such an occurrence at less than one in a million.

6. *But when all is said and done, isn't there a risk from the plutonium?*

Yes, despite all the precautions, a small residual risk remains. NASA has prepared and made available to the public (as of July, 1997) a Supplemental Environmental Impact Statement which analyzes and statistically quantifies the risks of plutonium contamination of Earth at various stages of the mission.

7. *If there's even a small risk, is it worth it?*

Much of our technology, ranging from automobiles to X-ray machines, brings with it risks, whether it's the automobile or the X-ray. Risks must be balanced against benefits. In the considered opinion of the National Space Society, the benefits far outweigh the risks, so it is definitely worth it.

CASSINI WEBSITES OF INTEREST

<http://www.nss.org/cassini>: Under Construction!

<http://www.jpl.nasa.gov/cassini/>
"Cassini: Voyage to Saturn"

The official JPL mission homepage with answers to just about every question: mission profile, spacecraft statistics, scientific objectives, flight operations, why to go to Saturn, images, launch countdown, new and live information, navigation, extended mission, kids page, links, links, links.

<http://newproducts.jpl.nasa.gov/calendar/cassini.html>
"Cassini Mission to Saturn"

Abbreviated version of the project home page: statistics, mission profile, Saturn science, the rings, moons, spacecraft, Huygens, Titan probe, experiments, international team, some good artwork and diagrams.

<http://albert.astro.williams.edu/j/chapter13.html>

“Chapter 13: Saturn”

JPL's archive on the status of the Cassini spacecraft: updated every month; Cassini advances in hardware, power systems, propulsion, other subsystems; newly discovered moon.

<http://condor.lpl.arizona.edu/>

“Cassini Imaging Science System WWW Server”

Cassini News (numerous press releases from Jan. 13, 1995 through April 21, 1997), people, software in use.

<http://nssdc.gsfc.nasa.gov/planetary/cassini.html>

National Space Science Data Center index for related topics, specific instruments, other planets, Cassini status.

<http://star-www.rl.ac.uk/ssd/cassini/cassini.html>

“CASSINI/HUYGENS-Remote sensing probe to Saturn”

Descriptions of the science instruments aboard with British involvement: CIRS, MAG, CDA, CAPS, RPWS, CISS, TRM, SSP, HASI.

<http://www.jpl.nasa.gov/cassini/MoreInfo/rtginfo/>

Nuclear Safety Issues and Answers: why not solar arrays? Fact and fiction about the mission, launch issues, Cassini power, swingby (gravity assist).

There are also web sites against Cassini. Here are two examples which demonstrate the tone of voice and reasons against the mission given by those in opposition:

<http://www.animatedsoftware.com/cassini/cassini.htm>

“Stop Cassini: The Plutonium Probe”

Newsletters addressing RTG controversy, encouraging people to stop Cassini, RTG info with diagrams from NASA, part of the 1995 Final Environmental Impact Statement (NASA).

<http://www.afn.org/~fcjp/space/cassini/>

“Stop the Cassini Mission”

The Florida Coalition for Peace and Justice shares its concerns.