Why the Cassini Mission Cannot Use Solar Arrays

INTRODUCTION

NASA's primary choice of space power for planetary missions has historically been solar power. Mars Observer, the Viking Orbiters, and Mariners 4, 6, 7, and 9 were all solar-powered Mars missions. Missions to Mars such as Pathfinder and Mars Global Surveyor use solar power featuring the newest high-efficiency gallium-arsenide (GaAs) cells. Indeed, the Pathfinder lander and microrover will represent the first use of photovoltaics on the Martian surface.

NASA continues to use solar power for missions when such technology is applicable. In cases where solar power or other power technologies are not feasible, NASA uses radioisotope thermoelectric generators, or RTGs, which create electricity from the heat generated by small amounts of decaying plutonium. RTGs made possible NASA’s celebrated Voyager explorations of Jupiter, Saturn, Uranus and Neptune, the Pioneer missions to Jupiter and Saturn the Galileo mission to Jupiter, and the Ulysses mission studying the Sun’s polar regions. NASA has determined that RTGs are required for the Cassini spacecraft to accomplish its mission objectives. The purpose of this fact sheet is to explain why solar technology cannot be used successfully for the Cassini mission.

CASSINI POWER AND FUEL DEMAND AT SATURN

In order for the Cassini spacecraft to complete the mission's science objectives, it must carry enough fuel (about 6,000 lbs) to travel to Saturn, to brake and insert itself into orbit around the planet, and to continue in orbit for four years. This amount of fuel is very heavy. Thus, in order to be light enough to launch, travel to Saturn, and accomplish the science objectives of the mission, it is critical to keep the rest of the spacecraft as light as possible.

Another limiting factor in meeting the mission science objectives is spacecraft electrical power. While orbiting Saturn and its moons, Cassini will use a variety of science instruments and combinations of instruments to collect many different types of data. Since the spacecraft has a limited amount of fuel and a limited amount of time in which to collect data at Saturn (four years), its power system will need to supply electricity to multiple science instruments at any given time, plus continuously run the spacecraft itself. Thus, a lightweight and highly efficient method of providing electrical power becomes doubly important.

THEORETICAL CASSINI SOLAR ARRAYS

NASA has found that even with solar arrays containing the latest high-efficiency solar cells developed by the European Space Agency (ESA) it would not be possible to conduct the Cassini mission using solar power. Why? The simplest and most immediate answer is that the arrays, in order to meet Cassini's electrical power requirements, would have to be so large that the spacecraft as a whole would be too massive to launch.

ESA has produced, under laboratory conditions (i.e., not manufacturing conditions), highly efficient solar cells that have been tested successfully under simulated space environments. These environments approximated the sunlight and temperature conditions at about 805 million kilometers (500 million miles) from the Sun, or about the same distance as Jupiter's orbit.

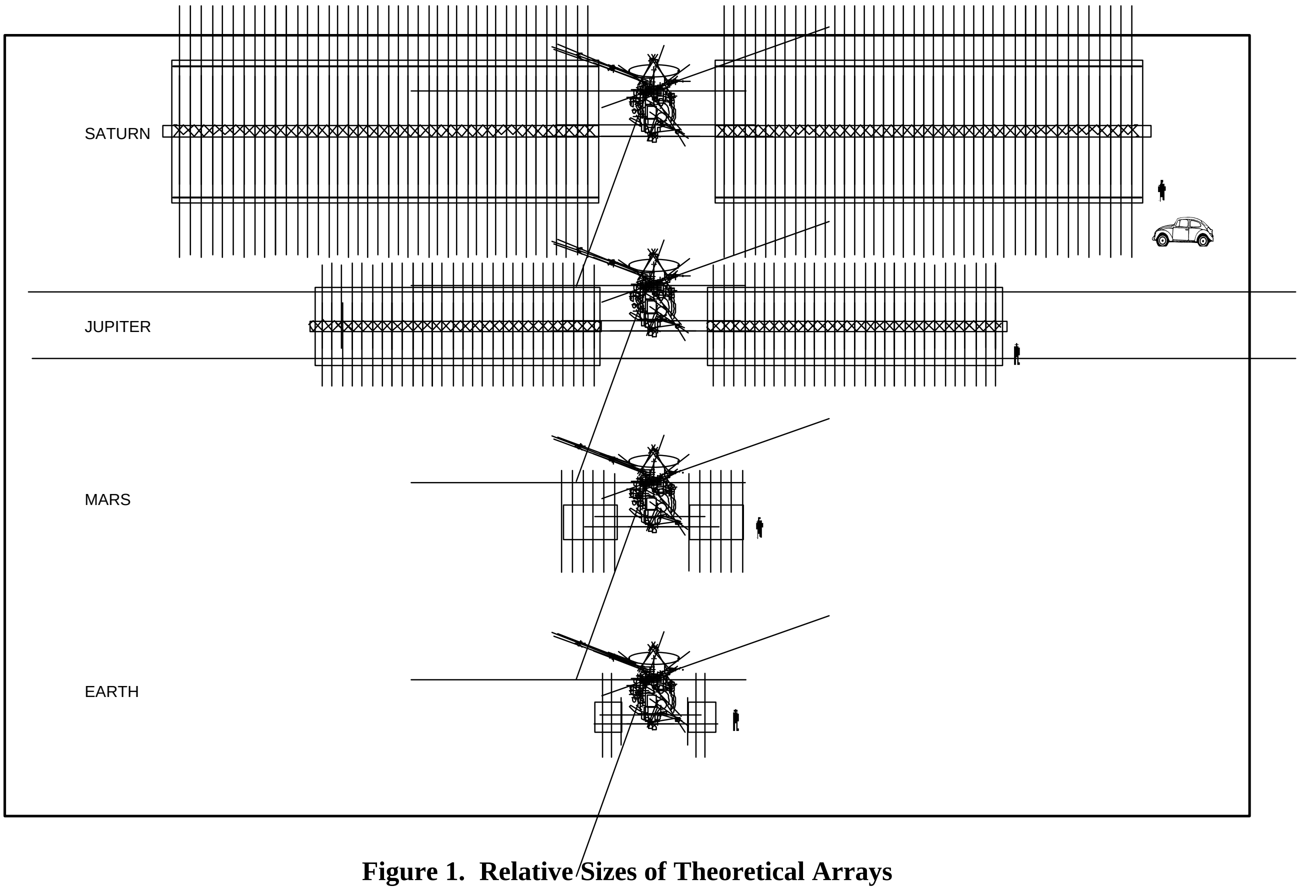

Figure 1. Relative Sizes of Theoretical Arrays

These solar cells do not exhibit the typical low-intensity, low-temperature (called "LILT") degradation that considerably reduces efficiencies for currently available commercial cells. But it is important to note that the cells could be less efficient at Saturn, which is almost twice as far from the Sun as Jupiter. Figure 1 depicts the relative sizes of theoretical arrays that would be required if a solar Cassini mission were possible.
Other limitations of the ESA solar cell technology include:

- Actual production efficiencies of advanced solar cells have historically been somewhat lower than research and development findings.

- The ESA GaAs devices are relatively thick and heavy compared to conventional solar cells.

- Considering theoretical analysis and published data, these advanced cells would be radiation sensitive. This would lower their efficiency if used on Cassini, due to the radiation environment through which the spacecraft will travel on its way to Saturn.

- If an array were to be made with the ESA cells (or any solar cells, for that matter), special diodes would have to be added to the array to compensate for cell fracturing that would be expected to occur from time to time. These diodes would add even more mass and complexity to the array.

Furthermore, the researchers who developed the ESA solar cells evaluated the JPL solar study and concluded that “LILT solar cells (including those developed by ESA) are not a viable power source alternative for the presently defined Cassini mission of NASA.”

PROBLEMS WITH LARGE ARRAYS

Taking the previous data into consideration, NASA's Jet Propulsion Laboratory (JPL) has estimated that solar arrays built for the Cassini mission would require a total area greater than 500 square meters (5,380 square feet) and that the spacecraft would require two arrays, each 9 meters (30 feet) wide and 32 meters (105 feet) long. There would also have to be supporting structures for the solar cells.

Attaching two such huge solar arrays to the Cassini spacecraft would severely impact the design, mass, and operation of the spacecraft.

One significant factor would be the array itself, which is a mechanical structure that ties the many solar cells together. This structure would have to be deployable, which means that it would have to be stowed for launch so that it could fit inside the Titan IV payload fairing, and then unfold once the spacecraft was on its way to Saturn. This, in turn, would require mechanical components to fold and unfold the arrays and support the long array arms when extended. Such components and support structures would increase the size and mass of the spacecraft considerably. The long and unwieldy solar arrays would also severely complicate spacecraft maneuvering and turning for scientific observations and data transmission back to Earth. Therefore, special devices would have to be added to enable the spacecraft to turn, again adding significantly to the mass. Finally, in order to properly regulate electrical power on board the spacecraft, special regulators and batteries would be required. This, too, would increase the overall mass.

Even if it were possible to launch a solar-powered Cassini the adjustments necessary to accommodate solar power would have substantial negative effects on the mission. First, they would make spacecraft maneuvering so slow and difficult that the mission would run out of time for scientific data collection, causing some crucial observations to be lost. Second, the addition of so many moving parts susceptible to mechanical failure would add considerably to the overall risk to mission success.

Finally, even if there were a rocket available and powerful enough to launch such a heavy spacecraft, the solar design itself would place the mission at great risk. If one of the very long arrays failed to completely deploy after launch, the mission would be lost.

SUMMARY

The Cassini spacecraft and science instruments need 600–700 watts of power at Saturn in order to operate the science instruments and transmit their data back to Earth. Finally, the spacecraft power system must be able to produce power reliably for 11 or more years at a distance of approximately a billion miles (1.6 billion kilometers) from the Sun.

The spacecraft's electrical power requirements for the science instruments and telecommunications, the launch mass, and the mission lifetime are all of critical concern in choosing the electrical power source. To determine how best to achieve the Cassini electrical power requirements, NASA has conducted in-depth studies of many different solar, battery, long-life fuel cell, and hybrid systems available. RTGs are the only feasible power system for the Cassini mission.

For more information on the Cassini mission, please contact:

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