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THE CASSINI MISSION

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This is an interim report on an assessment study of a Saturn-Orbiter plus Titan-probe mission. The study was jointly undertaken by the European Space Agency (ESA) and NASA in response to recommendations from a committee established by the European Science Foundation and the U. S. Space Science Board. This committee relied in part on earlier work by European and U.S. scientists.

The NASA Solar System Exploration Committee (SSEC) had recommended two separate missions to the Saturn system, in keeping with its charter to design low-cost, dedicated planetary missions. These were a Titan probe, to be carried by a small spacecraft that would include some type of radar mapping device, and a Saturn Orbiter that would be a more sophisticated spacecraft, to be launched separately. This proposal became part of the SSEC Core Program of missions planned to occur before the year 2000. A competitive plan, to fly a duplicate of the Galileo spacecraft (including a Saturn probe) to Saturn had floundered because of budgetary considerations. At about this time (fall of 1983), a group of European scientists led by D. Gautier and W.-H. Ip had proposed to ESA to combine a Saturn orbiter and a Titan probe in a single mission that would be carried out in collaboration with NASA. Each agency would assume responsibility for one of the major components. It is this proposal, called the Cassini Project, which was approved by NASA and ESA in January 1984 for an assessment study to be carried out over the next year and a half.

Obviously, to do better than Voyager did at Saturn, we must either get more specialized or more sophisticated, or both at once if we can possibly do it. Having recovered from the extreme conservatism that dominated mission planning in the early stages of the SSEC work, the Cassini Science Study Team perhaps went overboard in assembling a strawman payload. That meant adding instruments that Voyager didn't have, and taking instruments that Voyager did have and making them better, or more suited to the Saturn-Titan system. We certainly wanted to fly a radar in order to study the surface of Titan through the satellite's ubiquitous aerosol cover, and to do much better studies of the rings. We can get closer to the various components of the system by using an orbiter, and we can do so several times. Of course the probe of Titan's atmosphere is an enormous step forward. We can spend up to four years in a series of orbits around Saturn, exploring much more of the magnetosphere than Voyager could. This would include measurements from orbits at high inclination angles. Yet we must keep expenses down. This requires collaboration between at least two partners to divide up the cost of the mission.

The Cassini Project is easy to divide. NASA is taking on the commitment to build the orbiter, which will be one of the new Mariner Mark II spacecraft the agency is planning. The Europeans are building a new lightweight probe, especially configured for the atmosphere of Titan. Europeans and Americans will share in the experiments to be included in both the probe and the orbiter in various ways that have not yet been formally defined.

At the present time, the launch date is set for 1994, with a Delta-Vega trajectory that leads to arrival at Saturn in the year 2002. This puts a strain on most people's calendars, but that's the best we can do if everything goes exactly as planned at present. (Since this preview was presented in May 1985, the Assessment Study was completed on schedule in June. Copies may be obtained by writing to Mr. John Beckman at JPL. The formal evaluation of this study by the ESA review panels occurred in January 1986. The panel recommended initiation of a Phase A study in January of 1987.)

A list of the people involved in the Study is given in Table 1. In addition to these individuals, we have invited a number of other scientists to attend our meetings in Europe and in the U. S. The spacecraft configuration is still being changed in response to science and engineering requirements. A major driver for the orbiter is to achieve overall compatibility with other Mariner Mark II missions. The June 1985 version of the spacecraft is shown in Fig. 1.

Table 1

Participants in Cassini Assessment Study

ESA	NASA
G. Haskell	W. Piotrowski
D. Gautier	T. Owen
W.-H. Ip	M. Allison
S. Bauer	J. Cuzzi
M. Fulchigoni	D. Hunten
	T. Johnson
	H. Masursky
	R. Samuelson
	E. Sittler
	F. Scarf

Unlike the Jupiter system that Galileo is visiting, Saturn has only one large satellite, so the spacecraft repeatedly encounters Titan to "power" the orbital tours. We get over 20 encounters with Titan at about 1000 km, so we can actually use the orbiter as an upper atmosphere probe. Therefore, the aeronomy instruments will be on the orbiter rather than on the probe. We'll also get two close encounters with Iapetus and frequent close visits to the interesting inner satellites. Radar mapping of Titan is one of the key experiments being proposed for the orbiter. The level of sophistication of this device is still being studied. The magnetospheric scientists would like the orbiter to move up to a high inclination orbit toward the end of the nominal four-year mission.

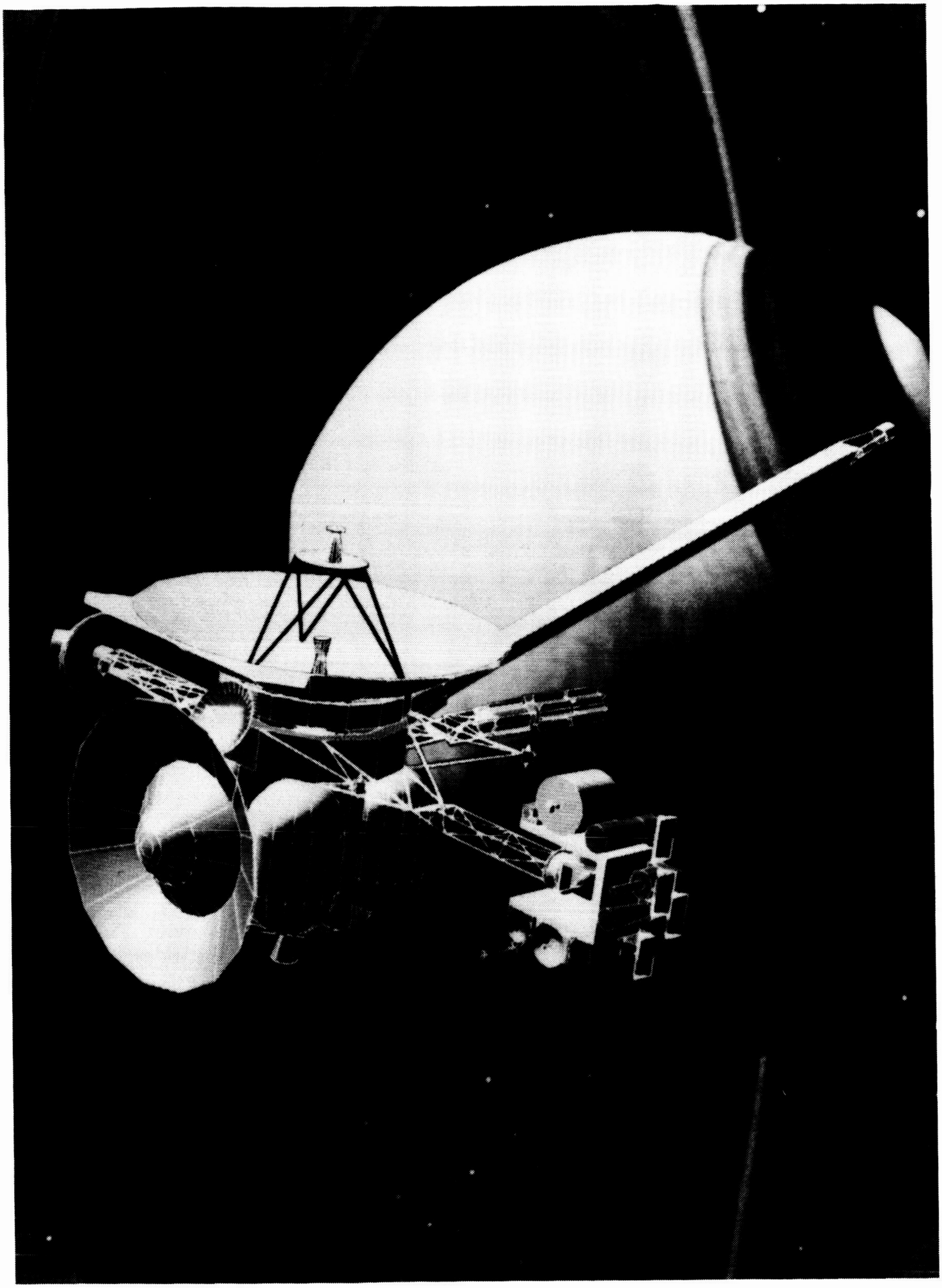

Figure 1. The configuration of the Cassini spacecraft as of December 1985.

DR. HUNTEN: I think planetary people would like a high inclination too.

DR. ALLISON: But not in the magnetotail.

DR. OWEN: The consensus of the group is remarkable as you can see. The Titan probe entry and descent is very different from the Galileo entry probe profile. We have nearly four hours of descent time through Titan's atmosphere, which means that one can capture samples and analyze them almost at leisure. There are proposals for imaging in the near infrared, and possibly with radar as well. The probe will land or splash-down at relatively low velocities, 3 to 4 meters per second. Byron Swenson, who has worked this out, says the impact is similar to a drop from a height of 18 inches on Earth. So if you can jump 18 inches, you'll find out what the impact on Titan will be like.

DR. HAPKE: Can the probe float?

DR. OWEN: The probe can indeed float. A quick study of the splash-down indicates that the probe would be completely submerged on impact, but would then bob up to the surface. However, immersion in this 94 K ocean poses a tough thermal problem, and no effort is being made to solve it. The guidelines we're working with are that surface science must not drive the mission, but if the probe can carry out some useful measurements after the landing with no extra effort, it will certainly do so.

Figure 2 provides an idea as to what the satellite encounters are like. It is based on a presentation by Walter Flury of ESOC for one of the orbital tours that has been studied. Voyager 1 and Voyager 2 miss distances are compared with Cassini. It is apparent that except in the case of the Voyager 1 encounter with Titan, we get much better satellite encounters than Voyager was able to achieve. And we get more of them. In place of Voyager's single, intensely interesting Titan encounter, Cassini will provide over 30 such visits.

Highlights of the proposed orbiter payload include the fact that we are insisting on both a long-focus and a short-focus camera in order to provide adequate resolution at various distances. The radar is very much under discussion, and there is a battery of infrared instruments which is also not yet well-defined. More detailed definition of these instruments will be a prime early task for the Phase A studies. What are the trade-offs between using a microwave radiometer to study Titan's surface, and using the radar instrument? What combination of infrared instruments gives the greatest amount of information about the atmospheres of Titan and Saturn? And so on.

Most of the instruments on the probe have been flown before. There is a proposal to try to combine a gas chromatograph and a mass spectrometer, but this requires careful evaluation. An aerosol collector should be included as one of the inlet systems for this instrument if its efficacy can be demonstrated. Imaging on the way down, perhaps combined with some new infrared capability is also under review. Just to give a feeling for what kind of "free" surface science can be done, note that a GCMS on a probe that lands in an ocean can do some pretty nice experiments just by having a suitably designed, heated inlet.

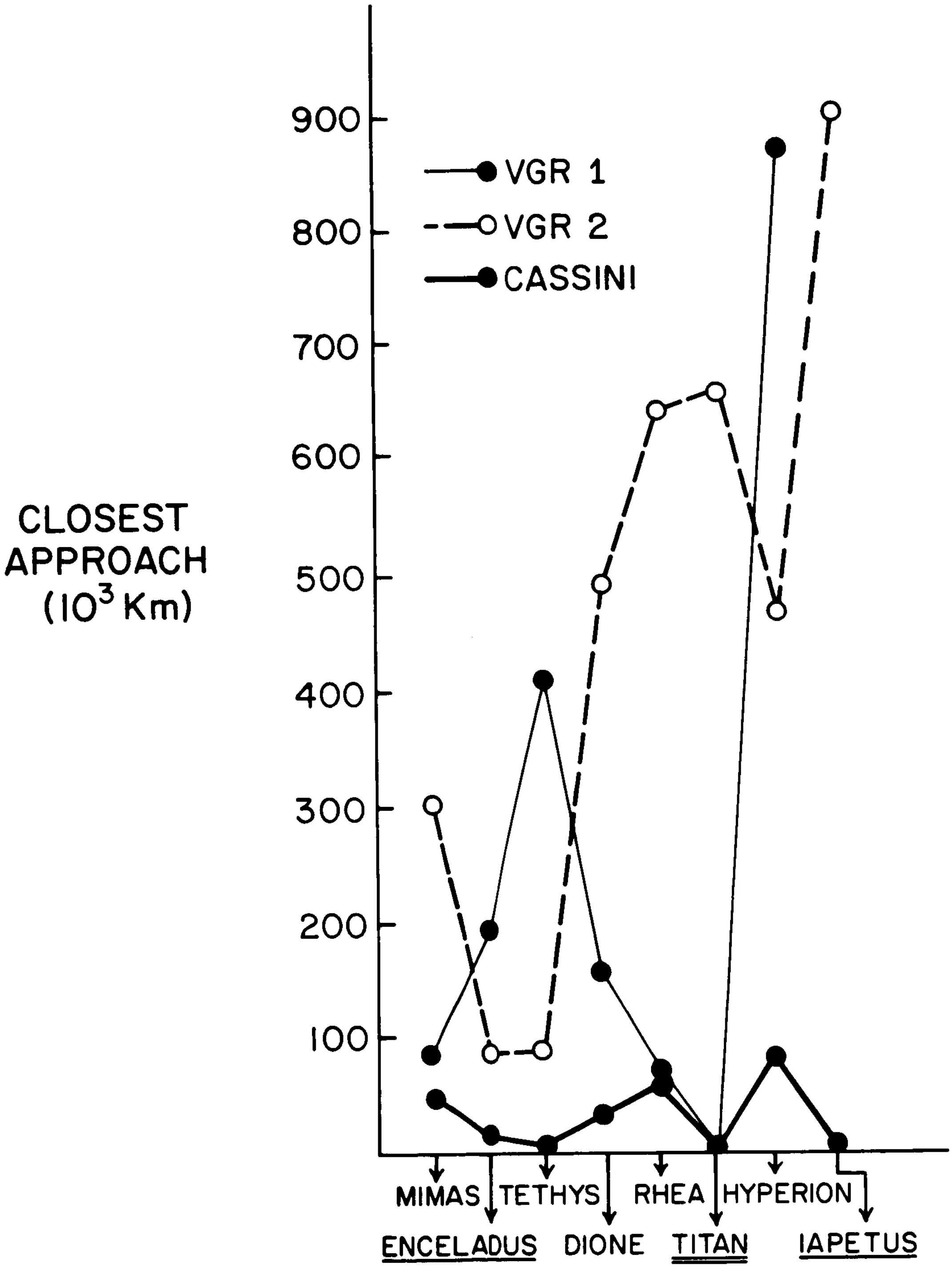

Figure 2. A comparison of flyby distances in the Saturn system for Voyagers 1 and 2 and the Cassini Orbiter.

The four-year lifetime of the orbiter mission means that there will be an opportunity to do quite a lot of surveying on various aspects of this system. We expect many new phenomena to be discovered, since the Voyager encounters were very brief. The details of the tour have not been worked out, but we are very, very early in the design of the mission and orbital tours are one of many aspects that will receive lots of additional study in the years ahead. I am sure that many readers of this short report will become participants in the future studies and in the mission itself, if it is approved. All suggestions for improving the science return from this exciting enterprise will be very welcome.

DR. ROSSOW: We have time for a few comments.

DR. HUNTEN: Let me make one comment about the prospects. A couple of weeks ago the meeting of the Space Science Board was attended by ESA top management--namely the Director General and the Scientific Director. They seemed to be taking it for granted that the Cassini study is going to go into Phase A. They don't even regard it as an issue.

DR. POLLACK: I'd like to make a couple of quick comments on something that's germane to Cassini as well as some other missions, and has to do with the possibility of gaining very significant meteorological information by measuring horizontal winds by Doppler tracking of the probes. Some of you may know that I've been working very hard in terms of examining the feasibility of this for the Galileo probe. The good news is that if we can do it for Jupiter, and I am optimistic that we can, then it's much easier to do so for the other planets including Saturn, Uranus and Neptune as well as for Titan. I just want to quickly give people a feeling for what the status of that is. First, why is measuring the horizontal winds as a function of altitude by Doppler tracking of the probe important? The point is that depending upon whether the winds are driven by deep convection as Andrew Ingersoll indicated, or driven by water condensation or solar energy deposition, you have distinctly different altitude profiles for the resulting zonal winds. Consequently, there is a significant amount of useful information to be gained for any outer planet or any satellite that has an appreciable atmosphere by Doppler tracking a probe. In the case of Galileo, the reason that this is such a tremendous challenge is that unless you know quite accurately what the longitude of the probe is (and 1 degree is really not good enough because of the large rotation), you may potentially have a serious problem in determining the wind profile. In the case of Saturn and even more so for Titan, it would be a somewhat easier situation. Even in the case of Galileo going into Jupiter, we are optimistic that we really can recover wind information. Work that I've done with David Atkinson at Ames indicates that given significant probe uncertainties in longitude for even a relatively difficult test case profile, we would in fact have been able to obtain a very good recovery on wind profile and the longitude of entry with a linear least squares technique. The bottom line is that we think Doppler tracking of probes has something very relevant to offer in terms of putting good constraints upon dynamical theories of Jupiter, Titan, Saturn and the rest of the outer planets.

DR. BELTON: I was very glad to see that you have two cameras, i.e., complimentary optical systems on Cassini. I hope that you will pursue this, and maintain this right through the whole exercise.

DR. OWEN: That was the voice of Galileo imaging, which was unfortunately denied the possibility of two cameras through budgetary constraints. It is certainly our intent to maintain this dual camera capability, if at all possible.