BACKGROUND OF THE SOP²* MISSION

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ABSTRACT

This paper covers two areas of interest, providing an overview of:

1. Saturn mission design history.
2. Saturn's place in NASA's program plans.

The first area provides a view of how changing concepts and techniques can affect mission design and science return. The second puts Saturn in perspective with regard to its role in NASA's overall planetary program.

SATURN MISSION DESIGN HISTORY

Saturn mission design can be broken into two pieces. The first piece relates to how you reach Saturn from Earth, the second with what you do when you arrive there. The first Table shows a development history for Saturn missions covering the period from 1964 to the present. Throughout this time period, technology and the timely development of interplanetary trajectory techniques have made missions to Saturn more science effective by allowing delivery of larger and larger payloads. The first item in Table 1 shows the requirements of sending a package to Saturn if we do it the same way we did for the Ranger lunar, Mariner 1962 Venus, and Mariner 1964 Mars missions. These were first attempts to scope the outer planet exploration problem. Mission analysts found that direct ballistic trajectories to Saturn were very expensive, quite a bit more so than trajectories to Jupiter.

*SOP² is an abbreviation for Saturn Orbiter Dual Probe—a Saturn bound spacecraft combining three major systems: an orbiter, a Saturn probe, and a Titan probe.

Table 1. Saturn Missions – Development History

Study	Dates	Conclusion
• Specification of ballistic trajectory requirements	1964-65	Energy requirements very high
• Jupiter gravity-assist trajectory discovered	1966-67	Energy requirements comparable to Jupiter mission requirements
• Pioneer/Voyager mission designs	1968-74	Excellent reconnaissance missions to Jupiter and Saturn feasible
• Jupiter Orbiter studies	1969-77	Jupiter Orbiter missions very attractive and feasible; satellite tour techniques defined; outer planet probes studied in detail
• VEGA and ΔVEGA techniques discovered	1974-75	Energy requirements reduced; flight times increased
• Saturn Orbiter/Satellite Tour Study	1975	JOP techniques applied to Saturn; considered VEGA/ΔVEGA
• Titan mission studies	1975-76	Titan lander/probe missions conceptualized; scientifically rewarding missions described
• Ion Drive techniques applied to Saturn mission	1976-78	Energy requirements and flight times reduced
• 1977 SOP^2 study	1977	SOP^2 mission feasible in variety of ways; science priorities required for further mission design

In 1966 Gary Flandro discovered a family of Jupiter gravity-assist trajectories which now brought Saturn into the same launch vehicle range as Jupiter missions. The Pioneer and Voyager missions were designed on the basis of these earlier trajectory analyses, and our first outer planet reconnaissance missions were born. The Voyager mission design aided the solution to the problem of satellite encounter design, developing techniques in timing the launch and providing maneuvers which would maximize satellite science return consistent with planetary science desires.

With the Pioneer and Voyager mission designs underway, interest developed in an exploratory mission to Jupiter which would allow longer times to investigate the

extensive Jupiter system. The Jupiter Orbiter Probe (now Galileo) mission design developed satellite gravity-assist techniques which allowed satellite tours while in orbit around the parent body.

While the Jupiter orbiter design was being developed, a new interplanetary trajectory technique was found which allowed delivery of greater payloads to the outer planets. The technique calls for a trajectory which is first directed in towards the Sun with a possible Venus close flyby and/or deep space propulsion manuever, and then return to Earth for an Earth gravity-assist as the trajectory carries the spacecraft out to the outer planets (VEGA and Δ VEGA trajectories). Not only are the payloads larger, but the opportunities for such missions are available over a greater period of years than the direct Jupiter gravity-assist missions to Saturn. The drawback, and it is a major one, is that launch to arrival times are increased over the already long flight times required by the previously defined techniques.

In 1975, with interest increasing in the Jupiter orbiter mission, analysis of a Saturn orbiter applied the techniques of the Jupiter orbiter mission as well as the new VEGA and ΔVEGA techniques, and found such a mission concept to be feasible enough to warrant further study.

In the last few years technology has been advancing to the point where a new low thrust propulsive technique will be available to NASA which will allow realization of difficult, but scientifically exciting missions. The major problem with Saturn mission designs up through the 1970's was the restriction to relatively low payloads associated with long flight times. Ion drive techniques use a low thrust, continuously operating device acting over a period of years. Combining the ion drive techniques with the Earth gravity-assist techniques discovered earlier provides the possibility of delivering a highly interesting science package to the Saturn system.

Studies conducted last year at JPL and scheduled studies this year are focused on a Saturn Orbiter Dual Probe (SOP^2) mission design. One of the major reasons for holding the Saturn Workshop is to provide science recommendations for an intelligent design of such a mission. What kind of science return should the mission designers focus their study on?

SOP^2 AND NASA's PLANETARY PROGRAM

The timing for this workshop is appropriate. The Pioneer and Voyager missions will be returning important data between 1979 and 1981, in time to focus the SOP^2 design for a launch after 1985. Ion drive and trajectory software development

will be available for launches in the mid-1980's and beyond. Mission concept and feasibility design is now required so that later systems definition and design can take place and dovetail with the technology development and science base. Science recommendations are key to this continuing design process.

Table 2 shows the current 1979-83 planetary exploration five-year plan. This plan is the end result of consultations with the scientific community, mission planners in NASA, Congress, and the Office of Management and Budget.

Several plans were considered. It should be noted that SOP^2 was part of all of them. The SOP^2 mission is considered a high priority mission by NASA.

Table 2. Planetary New Starts – FY 1979-83

Mission	New Start/Launch	Mission Type
Venus Orbital Imaging Radar (VOIR)	1980/1984	Exploratory
Halley/Tempel-2 Rendezvous	1981/1985	Reconnaissance
Saturn Orbiter Dual Probe (SOP^2)	1983/1987	Exploratory
Mars Program Technology Development	1982/-	Intensive Science

DISCUSSION

D. HERMAN: Let me comment on the degree of commitment by NASA to an SOP^2 Mission. First of all, in the Fiscal 1979 Budget, recently submitted to the Congress, there is a separate five million dollar line item for the development of ion drive. The first intended use of that system is to effect a comet rendezvous, probably with comet Tempel 2. The second intended use of that system would be for SOP^2.

At the FY 1979 Budget Press Conference, Dr. Frosch stated that it's time to take ion drive out of being a laboratory curiosity and to develop it towards a flight propulsion system; that's NASA's intent.

With respect to the five-year plan, we were given budget guidelines by the Office of Management and Budget to plan the missions that we want to do in the next five years. We are obliged every fiscal year to submit a revised five-year plan that is consistent with the budget. Our own input to that five-year plan was to show the SOP^2 mission as a Fiscal 1982 new start with a 1986 launch. The Administrator, in reviewing the five-year plan, adjusted the timetable to shift the SOP^2 new start to FY 1983, and that is where it now stands. But we must still plan as if the SOP^2 Mission could indeed be a Fiscal 1982 New Start and a 1986 launch because something could happen to the Mars program to cause us to revert to the original timetable. Our assessment is that the SOP^2 Mission will go either as Fiscal 1982 or a Fiscal 1983 New Start with a launch either in 1986 or 1987.