International Solar Polar Mission Support

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This article provides an introduction to the International Solar Polar Mission, which is now scheduled for a late March to early May 1985 launch.

I. Introduction

The International Solar Polar Mission (ISPM) is a joint project between the European Space Agency (ESA) and the National Aeronautics and Space Administration (NASA). The primary objective of the mission is to investigate solar and interplanetary phenomena as a function of the solar latitude. The mission is to be accomplished by using a gravity assist at the planet Jupiter to send two spacecraft out of the ecliptic plane. One spacecraft will be built by ESA and the other will be NASA's responsibility. Both spacecraft will carry complementary science and include experiments from both the United States and Europe. NASA is also responsible for providing the launch vehicle in addition to the tracking and data acquisition support for the mission.

ISPM will be only the second interplanetary mission since Pioneer Venus in 1978 and will follow the launch of the Galileo spacecraft by one year. Current plans call for two shuttle launches using a three-stage inertial upper stage (IUS) separated by at least 20 days between March 27 and May 5 of 1985.

II. Trajectory

Trajectory information at the time of writing was very preliminary because of the recent two-year delay in the mission. The actual spread of launch dates, Jupiter encounter, and high heliographic latitude phases were not known at the time of writing.

The mission trajectory is portrayed schematically in Fig. 1 which is an oblique view of the ecliptic plane. Following the launch and early midcourses, both spacecraft would enter the Earth-to-Jupiter cruise phase of the mission. It is a secondary mission objective to gather continuous fields and particles and daily coronagraph data while in transit to Jupiter. The Jupiter encounter will be in June or July of 1986 depending upon the launch date and available energy. One spacecraft will be targeted over the north pole of Jupiter to throw it out of the ecliptic plane in the southern direction, while the other spacecraft will be targeted over the south pole of Jupiter to be thrown into the northern hemisphere. Fields and particle measurements within the Jupiter environment are also a secondary mission objective. Targeting constraints in the basic mission plan call for the perihelion distance to be equal to or greater than one astronomical unit and for the time above heliographic latitudes greater than $|70|^\circ$ (absolute value) to be maximized. It is also required that during the high heliographic latitude phase of the mission, the heliocentric distance be equal to or less than two astronomical units. The first high heliographic latitude phase of the mission will extend over the last half of calendar 1988. The two spacecraft will then cross the ecliptic plane and reverse positions in a second high heliographic latitude phase of the mission, where the time above $|70|^\circ$ heliographic latitude will occur in the second and third quarters of calendar 1989. The end of the prime mission is defined as when both spacecraft have crossed to a latitude below $|70|^\circ$ for the second time which will occur in or near August of 1989.

The nature of the ISPM trajectories will place unique requirements on the Deep Space Network coverage. During the high latitude phases of the mission, one of the spacecraft will be visible only in the southern hemisphere of the earth, while the other spacecraft will be visible only in the northern hemisphere. During brief periods of the missions at the highest latitude phases, the spacecraft will become circumpolar as viewed from the Deep Space Stations. (For example, the spacecraft in the southern hemisphere will reach a point where it never falls below the horizon in Australia.) The hour angle declination construction of the typical DSN 34-meter-diameter antenna will restrict antenna view periods to periods on the order of 12 hours; however, the azimuth-elevation 64-meter-diameter antennas could, in principle, track the spacecraft continuously except for periodically unwrapping its cables.

During the Earth-to-Jupiter phase of the mission, both spacecraft will have a southern declination which unfortunately results in very short view periods from Madrid and Goldstone.

III. Science Objectives

As previously mentioned, both spacecraft will carry a complement of European and U.S. experiments. NASA funds the U.S. experiments on the ESA spacecraft, and ESA funds the European experimenters on the NASA spacecraft. A list of the experiments on both spacecraft, the principal investigators and their affiliations follows:

ESA Spacecraft

ESA spacecraft	Principal investigator	Affiliation	Code
Magnetic Field	P. C. Hedgecock	Imperial College, London	HED
Solar Wind Plasma	S. J. Bame	LASL, Los Alamos	BAM
Solar Wind Ion Composition	G. Gloeckler G. Geiss	Univ. of Maryland Univ. of Berne	GLG
Low Energy Charged Particles	L. Lanzerotti	Bell Lab Murray Hill	LAN
Low Energy Ion Composition	E. Keppler	MPI, Lindau	KEP
Cosmic Ray and Solar Charged Particles	J. A. Simpson	Univ. of Chicago	SIM
Solar Flare X-Ray and Cosmic Gamma Bursts	K. Hurley M. Sommer	CESR, Toulouse MPI, Garching	HUS
Radio and Plasma Waves	R. G. Stone	NASA/GSFC	STO
Cosmic Dust	E. Gruen	MPI, Heidelberg	GRU

NASA Spacecraft

NASA spacecraft	Principal investigator	Affiliation	Code
White Light Coronagraph X-Ray XUV	R. M. MacQueen	High altitude	CXX
Solar Flare X-Ray and Cosmic Gamma-Ray	T. L. Cline	GSFC	SXR
Comprehensive Particle Analysis	E. C. Stone	Cal Tech	CPA
Solar Wind Experiment	H. Rosenbauer	Max Planck Institute, Germany	SWE
Magnetic Field Experiment	M. H. Acuna	GSFC	MAG
Radio Astronomy Experiment	R. G. Stone	GSFC	RAP
Neutral Gas Measurement	H. Rosenbauer	Max Planck Institute, Germany	GAS
Zodiacal Light Experiment	R. H. Giese	Ruhr-Univ., Bochum, Germany	ZLE
Radio Science	P. Esposito	JPL	RSI

An additional experiment under consideration is a gravity wave experiment. The acceptance of this experiment on the NASA mission is tied to the addition of an experimental X-band receive capability on the spacecraft and X-band transmission capability in the DSN. If this experiment is accepted, the principal investigator will be H. Wahlquist, of the Jet Propulsion Laboratory. An S-band experiment on the ESA portion of the mission has been proposed by Professor B. Bertotti of the Instituto di Fisica Teorica of the University of Pavia in Italy.

Descriptions of some of these experiments and, in particular, the radio science and gravity wave experiments will be provided in future articles on the ISPM mission.

IV. Key Spacecraft Characteristics

The individual ESA and NASA spacecraft will be described in more detail in future articles. The following will serve as a basic introduction to their key characteristics. Both spacecraft will be spin-stabilized and powered by a single radio isotope thermal electric generator (RTG). The NASA spacecraft will be on the order of 450 kilograms, while the ESA spacecraft will be on the order of 350 kilograms. Each spacecraft's principal communication link to the ground will be via a parabolic high-gain antenna which is rigidly mounted parallel to the spin axis of the spacecraft. Therefore, Earth pointing will have to be maintained by periodic positioning of the spacecraft's spin axis as the apparent position of the Earth moves. The ESA high-gain antenna will be about 1.6 meters in diameter and located essentially on the spin axis. The NASA high-gain antenna will be 1.98 meters in diameter, located significantly offset from the spin axis in order to accommodate a coronagraph instrument. The coronagraph will be despun in order to maintain Sun pointing and will be located on the spin axis. S-band uplink for commanding and X-band downlink with telemetry will be the primary communication channels for both spacecraft. An S-band downlink will be provided on both spacecraft in order to provide for Tracking Data Relay Satellite System compatibility in the near-Earth phase. The S-band downlink will also be used to provide wider beam width antenna coverage during certain maneuvers and to support certain navigation and radio science requirements. The most common mode expected during the flight will be a "split coherency" mode where the downlink S-band is derived in the spacecraft phase coherent with the received uplink S-band signal while the X-band is noncoherently derived from an onboard oscillator. This split mode is in order to enable collection of extensive amounts of doppler data while not suffering the turnaround loss for the X-band telemetry performance. Both spacecraft will include ranging capability using S- and/or X-band downlink(s). Note that in DSN jargon, uplink refers to the radio transmission from the ground to the spacecraft while downlink indicates the spacecraft to ground.

As currently understood, the command, telemetry, and general telecommunications design of both spacecraft is compatible with the multimission capabilities of the Deep Space Network. Although at the detailed level, certain aspects of the ESA telemetry and command design violate the NASA Planetary Standards, the spacecraft is expected to be fully compatible with the Deep Space Network. This means that the only implementation required to support the ISPM will be a minor amount of software in order to initialize the DSN systems for the specific spacecraft identification numbers and telemetry formats. The only exception currently under study is the addition of an experimental X-band uplink capability as an engineering development exercise and in order to support the gravity wave experiment on the NASA spacecraft. The current plan would result in a Supporting Research and Technology X-band uplink capability from DSS 13 (the Goldstone R & D site) and an operational X-band uplink from DSS 42 (Australian 34-meter site).

The principal data rates for the life of the ESA mission will be 4,096 and 8,192 bits per second although a lower rate may be required for a few months around the maximum range portion of the mission. The data rates for the NASA mission are not yet determined, but they may extend from 2 to as high as 48 kilobits per second principally due to the higher rates required to support the images from the coronagraph. Continuous return of instrument measurements for the life of the mission is a requirement for both spacecraft. To meet this objective, the basic coverage requirement for the ISPM is an eight-hour 34-meter track per day per spacecraft. Each spacecraft will have a tape recorder in order to record the 16 hours of data during the nontracking period. It is clear that this coverage requirement cannot always be met because the ISPM lifetime extends through the Galileo Mars flyby, the Uranus encounter of Voyager, and the Jupiter orbital operational phase and probe entry of the Galileo Mission. In addition, eight other extended mission spacecraft are expected to still be alive during the mission and require coverage. The basic coverage problem and interaction with other mission support will also be a topic of future Progress Report articles.

V. The Two-Year Launch Delay

A short time before this article was written, the ISPM was officially delayed from a February 1983 launch to the 1985 Jupiter window. The reason for the delay was a major budget cut that NASA had to accommodate to help the President achieve the objective of a balanced FY81 U.S. budget. The 1985 opportunity is less favorable than 1983 from a trajectory performance standpoint, with an effect of about 40 kg less payload capability. For this reason, the basic plan for 1985 is a split (two-shuttle) launch whereas the basic 1983 plan was to launch both the ESA and NASA in a tandem single shuttle launch. To accommodate the two-year stretch out, the NASA strategy is to slow down the program and serialize some activities that would have been in parallel. The ESA side of the mission plans to stretch work out only one year and to store the completed spacecraft and instruments for one year.

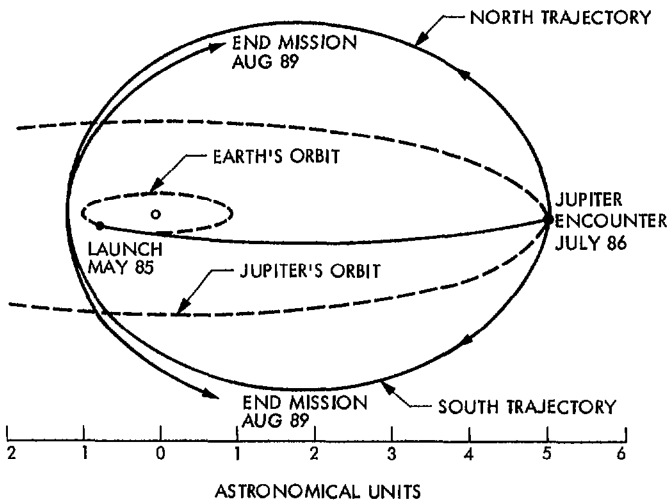

Fig. 1. Trajectory overview