TELECOMMUNICATIONS FOR THE INTERNATIONAL SOLAR POLAR MISSION*

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ABSTRACT

The International Solar Polar Mission (ISPM) is a joint venture of the National Aeronautics and Space Administration (NASA) and the European Space Agency (ESA) for each to develop a single spacecraft to carry unique scientific experiment hardware packages. The hardware is designed to gather data for the scientific study of solar properties and interplanetary physics out of the ecliptic plane.

The NASA and ESA spacecrafts will be launched in tandem by the Shuttle and the three-stage Inertial Upper Stage (IUS) from earth in a ten-day launch window in early February, 1983. After separation from the IUS, the two spacecraft will proceed on parallel but independent trajectories very close to the ecliptic plane to Jupiter. There, the two spacecraft will make use of the large momentum transfer derived from the Jupiter swingby. The spacecraft targeted southwest of Jupiter will be swung to depart in a northward trajectory, highly inclined to the ecliptic plane, and the spacecraft targeted northwest of Jupiter will be swung to depart in a southward trajectory, also highly inclined to the ecliptic plane. The ISPM will be the first mission to send spacecraft in an orbit highly inclined to the ecliptic plane and the first to exploit any planet to maximize orbital inclination.

The journey to Jupiter from earth will take 475 to 500 days. The remaining 1700 days of the mission is spent in the inclined orbit. By the end of the mission, the two spacecraft will each have completed passage over both poles of the sun, one pole before and the other pole after crossing the ecliptic plane.

Telecommunication services are required from launch through the out of the ecliptic phases of the mission which correspond to ranges from near earth to 6.1 astronomical units

* TRW has been selected by the Jet Propulsion Laboratory (JPL) to negotiate the ISPM spacecraft contract.

(1AU = one earth-sun distance of 93,000,000 miles). Telecommunication services are provided by the following links: spacecraft/IUS/Shuttle to the Jet Propulsion Laboratory (JPL) Mission Control and Computer Center (MCCC) via the Tracking and Data Relay Satellite System (TDRSS); spacecraft/IUS to the JPL MCCC via the TDRSS; IUS third stage/NASA spacecraft/ESA spacecraft to the JPL MCCC via the TDRSS; and NASA and ESA Spacecraft to the JPL MCCC via the Deep Space Network (DSN).

Key features of the NASA spacecraft telecommunication system design:

- General Features
  - Signal and modulation formats completely compatible with the TDRSS and the JPL DSN
  - Configuration makes maximum use of space qualified, off-the-shelf hardware
  - Full equipment redundancy provides high confidence of mission success
  - Multiple downlink science and engineering data rates selectable by command
  - Science and engineering data link performance can be optimized by command selection of downlink modulation indices
  - Concatenated Reed Solomon/convolutional encoding and Viterbi/Reed Solomon decoding minimizes spacecraft EIRP

- Antenna Subsystem
  - High gain S/X-band antenna for receive and transmit functions with earth signal autotrack for spacecraft attitude control
  - Medium gain X-band antenna for emergency and large earth/spacecraft aspect angle (LAA) transmit functions
  - Broad coverage S-band antenna for earth signal acquisition, emergency, and LAA receive functions and for emergency and LAA transmit functions

- RF Subsystem
  - RF switches and hybrids for alternate receive and transmit signal paths
  - Transponders for S-band coherent carrier, command, and ranging signal detection and for S/X-band coherent or noncoherent carrier data and ranging modulation
  - X-band 22 watts TWTAs
  - S-band 5 watts solid state amplifiers

- Telemetry Modulation Subsystem
  - Reed Solomon and convolutional encoding
  - Multi-frequency suppress subcarrier modulation or bypass
  - Downlink data carrier modulation index control (32 programmable indices)

Design consideration, tradeoffs, implementation, and performance for the NASA spacecraft Telecommunication System are discussed.