Pioneer 10 and 11 Mission Support

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A general description is presented of the Pioneer 10 Jupiter Encounter objectives and the resulting operations plan.

I. Introduction

Pioneer 10 has been supported in cruise mode for over a year and a half and Pioneer 11 for six months. Cruise activities have included a solar conjunction by Pioneer 10, zodiacal light observations using the imaging photopolarimeter, Jupiter observations, various instrument calibrations and observations, and continuous measurements of the characteristics of a region of space no prior man-made spacecraft has seen. Pioneer 10 is fast approaching its encounter with Jupiter in December of this year. The Pioneer Project defines the encounter period as extending from November 4 to January 4 of 1974. Closest approach to the planet Jupiter occurs on the fourth of December around 0300 GMT. The Pioneer support article in the preceding issue of the *DSN Progress Report* (Ref. 1) described in great detail the manner in which a particular instrument, the imaging photopolarimeter, would be operated during the encounter sequence. As was described, that instrument dominates the encounter sequence activity and is the source of the most stringent requirements on Ground Data System reliability. This article describes in general terms the entire encounter sequence.

II. Pioneer 10 Encounter Objectives

The Pioneer 10 spacecraft carries eleven on-board experiments, and the mission includes two ground-based experiments that utilize the radio link. These experiments, which will be utilized in various combinations to attempt to meet the scientific objectives described herein, are listed as follows together with the cognizant experiment team facilities:

Magnetometer	Jet Propulsion Laboratory
Plasma analyzer	Ames Research Center
Charged particle detector	University of Chicago
Geiger tube telescope	University of Iowa
Cosmic ray telescope	Goddard Space Flight Center
Trapped radiation detector	University of California, San Diego
Ultraviolet photometer	University of Southern California
Imaging photopolarimeter	University of Arizona
Infrared radiometer	California Institute of Technology
Asteroid meteoroid detector	General Electric
Meteoroid detector	Lewis Research Center
S-band occultation	Jet Propulsion Laboratory
Celestial mechanics	Jet Propulsion Laboratory

It is expected that Jupiter will have a magnetic field anywhere from 3 to 30 times the strength of the magnetic field of Earth. The Pioneer 10 spacecraft will attempt to measure the strength of that field and map its characteristics along the flight path of the spacecraft. Because of the presence of a magnetic field, it is also expected that the planet Jupiter will have radiation belts similar to the Van Allen Belts of Earth. The presence and characteristics of these high-energy electron and proton radiation belts will be measured.

Various decimetric and decametric radio emissions have been observed on Earth from the planet Jupiter. It is hoped to find a basis for interpreting the source of these radio emissions from Jupiter by the measurements performed during the flyby.

The instruments will be used to detect and measure the bowshock and magnetospheric boundary and its interaction with the solar wind.

The objectives of the atmospheric measurements will be to investigate the thermal balance and temperature distribution of the outer atmosphere, to measure the hydrogen/helium ratio in the atmosphere, and to measure the structure of the ionosphere and upper atmosphere. In addition, the brightness, color, and polarization of reflected light from the upper atmosphere will be measured.

The last objective involving on-board experiments is the production of two-color visible light images of the disk of the planet.

The objectives of the ground-based experiments will be to increase the accuracy of the ephemeris and known mass properties of the planet Jupiter and its associated satellites and to measure atmospheric properties as the radio link passes through the atmosphere.

III. Major Pioneer 10 Jupiter Encounter Events

The far encounter starts on November 4. Beginning on that date there will be significant spacecraft activity approximately 8 hours per day. By November 12 the disk of Jupiter will extend across approximately 15 pixels (a pixel constitutes a picture element in the imaging system). By November 18 the planet will extend across 20 pixels and enlarge to 30 pixels by November 24. The region of 30 pixels is considered comparable to Earth-based resolution. It is at this time that the encounter sequence moves to 24-h/day operations. Even though the imaging prior to November 24 is below Earth-based resolution, it is considered valuable because it constitutes viewing of the planet Jupiter from phase angles impossible from Earth. Because Jupiter is so far from Earth, Earth observation is always of the full disk of the planet under flat light conditions. The Pioneer spacecraft will see the planet Jupiter over a wide range of phase angles, which will be important for possible shadowing of cloud layers to enable the atmosphere to be seen in greater detail, and the polarimetry measurements at these varying phase angles will contain valuable information about the particle size in the atmosphere. The imaging photopolarimetry resolution decreases symmetrically on the other side of closest approach.

Since estimates of the magnetic field strength of Jupiter vary over such a wide range, there is a large uncertainty as to the extent of the magnetosphere. It is therefore expected that the bowshock of the magnetosphere will be crossed somewhere between November 25 and December 1. Two instruments are important for measuring the fine structure of the bowshock: the plasma analyzer and the trapped radiation detector. Upon detecting that the spacecraft has crossed through the bowshock when approaching the planet Jupiter, the spacecraft must be commanded into a mode which replaces the imaging data in the telemetry with plasma analyzer measurements and gives the trapped radiation detector a higher service rate. Because of the large uncertainty as to when the bowshock crossing will occur, this event will have to be detected in real-time by observing the output of some of the on-board instruments, and the IPP sequence interrupted in order to send the commands to the plasma analyzer and trapped radiation detector.

The ultraviolet photometer will observe the planet between November 30 and December 2 and again on December 3. The infrared radiometer will observe the planet on December 4 during the periapsis passage. The spacecraft is expected to enter the radiation belt of Jupiter at about 2200 GMT on December 3 and to exit the radiation belt at about 0700 GMT on December 4. It is during the time period when the spacecraft is within the radiation belt that there is the most concern about damage occurring to the spacecraft. Charged-particle environments around planets are comprised of both protons, which constitute the plasma, and free electrons. Any charges that build up on a spacecraft due to the free electrons are usually bled off by the plasma. However, as has been discovered in the case of satellites orbiting the Earth, there are circumstances which arise in which the plasma can be pushed to a lower altitude than the free electrons, and it is in these circumstances that very large charges can build up on a spacecraft. Estimates of the potential charge buildup on the Pioneer spacecraft vary over a wide range. There are two possible impacts of a large charge buildup: (1) actual damage to electrical components in the spacecraft and (2) false commanding of the spacecraft because of electrical discharges taking place. The project has been developing contingency plans in the event that false commanding does occur.

Two Earth occultations will take place during the Jupiter encounter. The first will be an occultation of the satellite Io, which will occur at approximately 0243 GMT on December 4. The Io occultation will last from 60 to 90 seconds. It is hoped to get measurements of the atmosphere of Io as the radio link occults the satellite. The Jupiter–Earth occultation will occur at approximately 0340 GMT on December 4 and will last about 60 minutes. During the Jupiter occultation the spacecraft will be placed in a low data rate state and a limited amount of science data stored on board for readout after emergence from occultation.

The solar occultation will occur at approximately 0415 on December 4 and last approximately 50 min. The spacecraft will have to be placed in a spin averaging mode during this time period because of the loss of solar reference.

In order to maintain the capability to receive a maximum amount of telemetry at the required 1024-bit rate, it will be necessary to maintain the pointing of the spacecraft 9-ft-diameter high-gain antenna within 1 deg of Earth. This will necessitate several spacecraft precession maneuvers during the two-month encounter period. The last of the precession maneuvers prior to the periapsis pass will occur on about November 24.

Reference

1. Miller, R. B., "Pioneer 10 and 11 Mission Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. XVI, pp. 15–21, Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1973.