Reports

Pioneer 10 and Pioneer 11

A year after the historic encounter of Jupiter by its sister spacecraft Pioneer 10 (*1*), Pioneer 11 passed by Jupiter on 3 December 1974, at a distance within 42,000 km of its cloud tops. After the Jupiter encounter, Pioneer 11 then headed for an encounter with Saturn in September 1979.

The prime scientific objectives of the Pioneer 11 mission are identical to those of Pioneer 10, that is: (i) the exploration of interplanetary phenomena, (ii) the study of the asteroid belt, and (iii) the in situ measurement of the Jupiter environment. To accomplish these scientific objectives, Pioneer 11 carries a payload of 12 instruments weighing 30.4 kg and using 25 watts of electrical power. This payload, listed in Table 1 along with the institutions and principal investigators providing the instruments, is identical to that of Pioneer 10 except for the addition of the flux-gate magnetometer on Pioneer 11. This instrument can measure fields about seven times larger than the helium vector magnetometer and was added to Pioneer 11 after some speculation that the close approach to Jupiter by Pioneer 11 and the strength of the Jovian magnetic field (Pioneer 10 had not at that time reached Jupiter) might give rise to a situation in which the magnetic field at Pioneer 11 exceeded the range of the helium vector magnetometer.

In addition to the on-board instruments, the S-band telecommunication signal of the spacecraft is being used by Dr. A. J. Kliore of the Jet Propulsion Laboratory to study the ionosphere of Jupiter and by Dr. J. D. Anderson of the Jet Propulsion Laboratory to measure the masses of Jupiter and its satellites by means of precision tracking of the spacecraft.

A sketch of Pioneer 11 is shown in Fig. 1. The spacecraft, including instruments, weighs 258 kg, and the diameter of the high-gain antenna reflector is 2.74 m. The spacecraft spins about an axis parallel to the axis of the reflector at 4.8 rev/min. Small thrusters using hydrazine and located at the edge of the reflector are used for making in-flight velocity adjustments, altering the spin rate, and changing the direction of the spacecraft so that the reflector points toward Earth and maintains high communication data rates. Throughout most of the month before and after encounter, the bit rate was 2048 bits per second. Electrical power is supplied by four radioisotope thermoelectric generators located at the end of two trusses extending from the body of the spacecraft. A long boom extending from the scientific instrument compartment supports the magnetometer sensor.

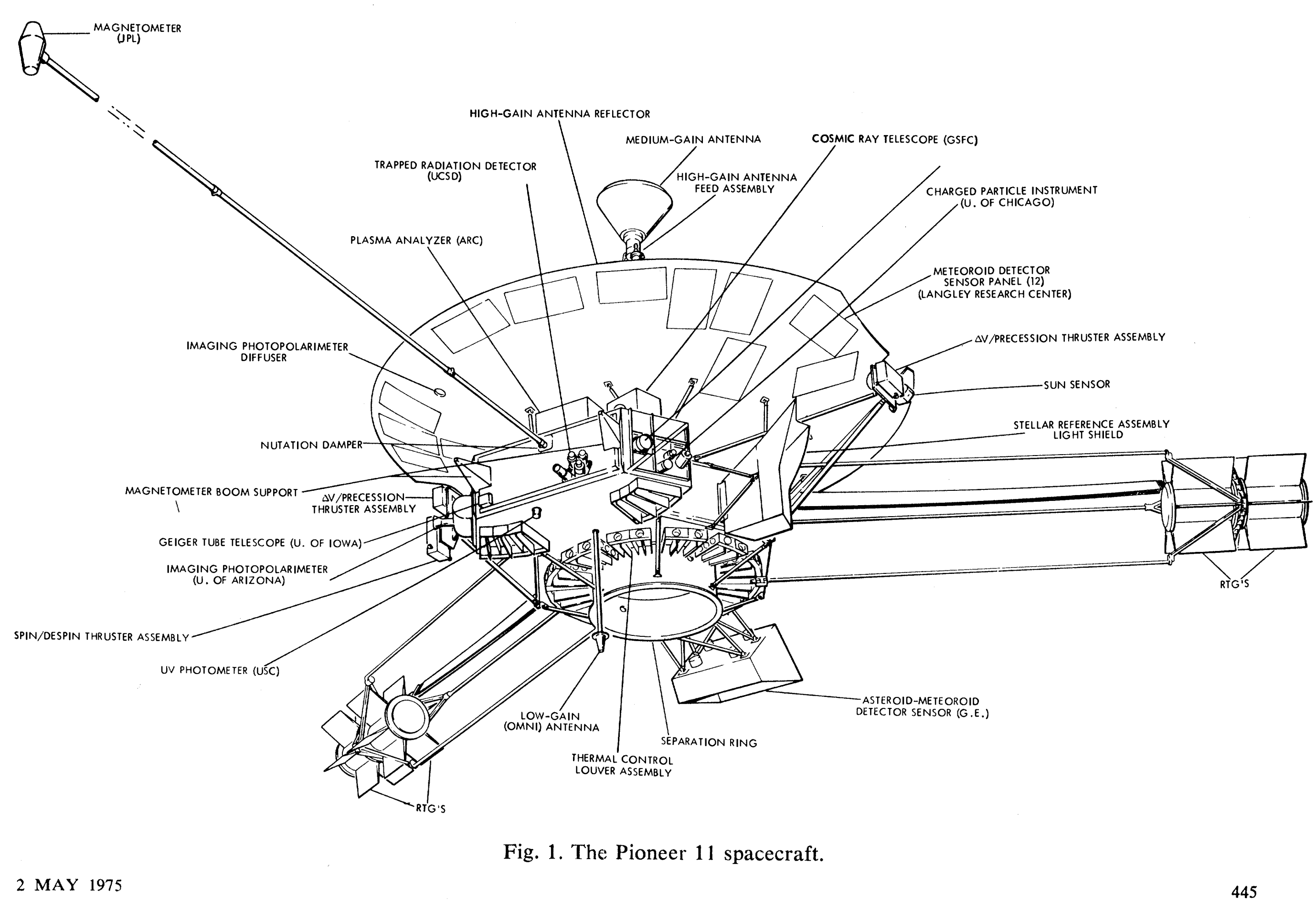
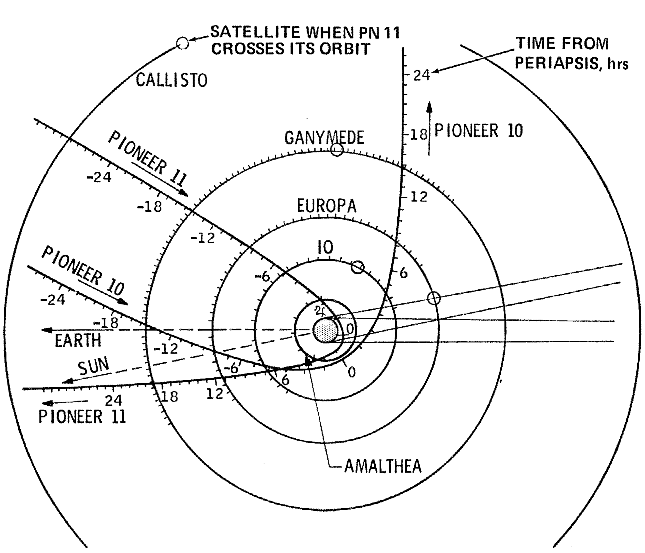


Fig. 1. The Pioneer 11 spacecraft.



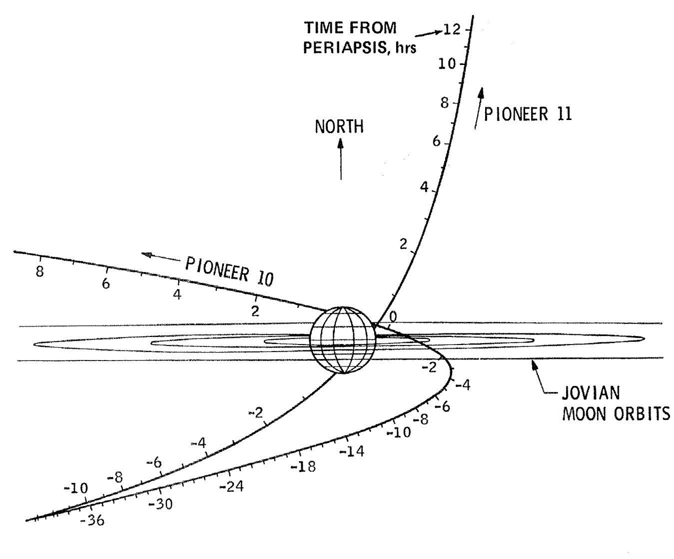


Fig. 2 (left). The Pioneer 10 and Pioneer 11 trajectories referenced to Jupiter and projected into a plane parallel to the ecliptic plane. Fig. 3 (right). The Pioneer 10 and Pioneer 11 trajectories referenced to Jupiter as seen from Earth.

Table 1. Instrumentation on Pioneer 11.

Instrument	Institution	Principal investigator
Helium vector magnetometer	Jet Propulsion Laboratory (JPL)	E. J. Smith
Flux-gate magnetometer	Goddard Space Flight Center (GSFC)	M. Acuna
Plasma analyzer	Ames Research Center (ARC)	J. H. Wolfe
Charged-particle detector	University of Chicago	J. A. Simpson
Geiger-tube telescope	University of Iowa	J. A. Van Allen
Cosmic-ray telescope	Goddard Space Flight Center (GSFC)	F. B. McDonald
Trapped radiation detector	University of California, San Diego (UCSD)	R. W. Fillius
Ultraviolet photometer	University of Southern California (USC)	D. L. Judge
Imaging photopolarimeter	University of Arizona	T. Gehrels
Infrared radiometer	California Institute of Technology	G. Münch
Asteroid-meteoroid detector	General Electric Company (G.E.)	R. K. Soberman
Meteoroid detector	Langley Research Center	W. H. Kinard

The Pioneer 10 and Pioneer 11 trajectories referenced to Jupiter and projected into a plane parallel to the ecliptic and passing through the center of Jupiter are shown in Fig. 2. Figure 3 shows the trajectories as viewed from Earth. In addition to passing much closer to the Jovian cloud tops (42,000 km, Pioneer 11; 132,000 km, Pioneer 10), the Pioneer 11 trajectory differed from that for Pioneer 10 in several other significant aspects. The Pioneer 10 trajectory was inclined about 14° to the Jovian equator, whereas that for Pioneer 11 was inclined about 50°. Thus, when closer to Jupiter than about 10 Jupiter radii (R_J), Pioneer 10 was at a magnetic latitude less than 20° and near the region of intense radiation, whereas Pioneer 11 was at a magnetic latitude of 40° or greater, except for the 1 hour before and after periapsis, and in a region of less intense radiation. Also, Pioneer 10 circled Jupiter in the direction of its rotation, whereas Pioneer 11 circled in the opposite direction. Thus, during the 6 hours before and after periapsis, the Pioneer 10 subsatellite point changed only about 180° in Jovian longitude, whereas for Pioneer 11 the change was about 720°.

The electron and proton radiation intensities experienced by Pioneer 11 during the encounter were larger than those for Pioneer 10 because of the closer approach of Pioneer 11. The integrated dose received by Pioneer 11 was considerably less than that for Pioneer 10, however, because of the high latitude of the Pioneer 11 trajectory. As a result, none of the spacecraft equipment suffered any damage. Two instruments suffered some degradation of portions of their electronic circuits. However, about 10 hours before periapsis and during the hour before periapsis, the spacecraft and several of the instruments experienced a number of uncommanded mode changes. The early changes are believed to have been caused by spurious pulses within the spacecraft or instrument electronics due to static charge buildup on the spacecraft; the changes near periapsis are believed to have been caused by the high radiation intensities.

When one realizes that it took almost 1½ hours for a command to travel from Earth to Pioneer 11 and then for the confirmation message to travel from the spacecraft back to Earth, it is easy to imagine the hectic moments, tenseness, and apprehension within the Pioneer 11 Mission Control area during the time that these anomalies were occurring on the spacecraft.

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References

1. *Science* **183**, 301–324 (1974).