Pioneer Venus 1978 Mission Support

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Significant aspects of the multiprobe portion of the Pioneer Venus Mission are described.

I. Introduction

The Pioneer Venus 1978 Project will consist of two missions: an orbiter mission and a multiprobe mission. Both missions will utilize an Atlas SLV-IIID Centaur D-1AR launch vehicle with about 160-km parking-orbit trajectory. The orbiter mission will launch in May 1978 using a type II trajectory and will have a Venus orbital design lifetime of at least 243 Earth days. The multiprobe mission will launch in August 1978 using a type I trajectory. Both missions will arrive at Venus in December 1978. The type I and type II trajectories are used in order to separate the launch dates of the two missions. The spacecraft will be constructed by the Hughes Aircraft Company under contract to Ames Research Center, which has project management responsibilities. This article will concentrate on describing some significant aspects of the multiprobe mission as it is currently understood. Note that much of this material is subject to further refinement and change.

II. Multiprobe Physical Characteristics

The multiprobe mission consists of a bus, one large probe, and three small probes, all five of which will enter the Venusian atmosphere. A schematic drawing of the spacecraft is shown in Fig. 1. The spacecraft will be spin-stabilized and have a launch weight, including the probes and all science instruments, of just over 816 kg (1800 lb). There will be a total of 60 kg (133 lb) of instruments, 18 kg (40 lb) of which will be on the bus.

The bus consists of a basic cylindrical structure, the surface of which is covered with solar cells. The large probe sits on top of the cylinder centered on the spin axis. The three small probes sit equally spaced around the circumference of the large probe. The probes are deployed from the bus by means of springs about 20 days before entering the Venusian atmosphere. The large probe will be deployed first and then the three small probes will be deployed simultaneously. The bus will then execute a maneuver to retard its time of flight so that the bus will enter the Venusian atmosphere after the probes have reached the surface of Venus. In this way, the bus will serve as a frequency reference for an interferometry experiment, which will be performed in order to determine wind velocities during the probe's descent.

Since the probes will be on battery power after release from the bus, there will be no RF signal from them until just prior to entry in order to conserve power. Commands will be sent to the bus while the probes are still attached to set the epoch for the coast timers in each of the probes. The probes will have an on-board sequence programmer which, together with the coast timer, will control the entry sequence. The RF signal from each of the probes will be turned on 22 min prior to entry, where entry is defined as 200 km above the surface of Venus, which is the approximate altitude at which maximum dynamic stress and blackout will occur.

All of the probes consist of a sphere pressurized with an inert gas and sitting in a high-drag aeroshell which also serves as a thermal shield for the entry. The aeroshell and afterbody heat shields of the large probe will be jettisoned at about 68 km altitude, at which point parachutes will be deployed to slow the descent through the lower atmosphere. The parachute will be jettisoned at an altitude of approximately 44 km. The total descent time for the large probe will be about 1½ hr. The small probes will not utilize a parachute nor will they jettison their heat shield; they will depend solely upon aerodynamic drag to slow their descent. The small probe descent will last on the order of 1 hr.

The entry sequence programmers on the small probes will be able to store on the order of 15 commands. The programmer on the large probe will store 64 commands. In addition, there will be spacecraft-detected events which will back up the stored sequence. For example, if the coast timer should fail to turn on the RF system 22 min prior to entry, an accelerometer on the probe will detect the occurrence of entry and initiate the entry sequence. In order to recover science data during the blackout region, the probes will have a storage capability. The large probe will be able to store on the order of 2500 bits of formatted data; the small probes will have a 1500-bit capacity. During the blackout, this storage will be filled with low-rate data, and these data will be transmitted interspersed with the real-time data during the remainder of the descent.

III. Science Payload

The large probe will be carrying on the order of 32 kg (70 lb) of instruments. Each small probe will carry about 2.3 kg (5 lb) of instruments, and the bus will carry approximately 18 kg (40 lb) of instruments. The instruments and chief scientists for the multiprobe mission have been officially designated and are listed below:

Large probe	Experimenter
Neutral mass spectrometer	J. Hoffman/University of Texas, Dallas
Gas chromatograph	V. Oyama/Ames Research Center
Atmosphere structure	A. Seiff/Ames Research Center
Solar radiometer	M. Tomasko/University of Arizona
Infrared radiometer	R. Boese/Ames Research Center
Cloud particle size spectrometer	R. Knollenberg/Particle Measurement Systems
Nephelometer	B. Ragent/Ames Research Center

Small probe	Experimenter
Atmosphere structure	A. Seiff/Ames Research Center
Nephelometer	B. Ragent/Ames Research Center
Net flux radiometer	V. Suomi/University of Wisconsin

Bus	Experimenter
Neutral mass spectrometer	U. Van Zahn/University of Bonn
Ion mass spectrometer	H. Taylor/Goddard Space Flight Center

In addition, the following Earth-based experiments have been approved:

Earth-based radio experiments	Experimenter
DVLBI	G. Pettengill/Massachusetts Institute of Technology
Tracking, turbulence	R. Woo/Jet Propulsion Laboratory
Tracking, propagation	T. Croft/Stanford University
Tracking, winds	A. Kliore/Jet Propulsion Laboratory

The individual experiments listed above will be described in more detail in subsequent *DSN Progress Report* articles on the Pioneer Venus 1978 Mission.

IV. Telecommunications

The signals from each of the probes will be received via a direct link with Earth rather than via a relay through the bus. This means that during the descent there will be a total of five signals, the bus plus four probes, which must be acquired and tracked simultaneously. This aspect of the mission, together with the current DSN plans for handling the five simultaneous signals, was described in a previous article (Ref. 1).

Current concepts call for the use of long-constraint-length sequential decoding (essentially identical to that used on Pioneers 10 and 11) for all the signals from the bus and the probes. The small probes will be in one-way, using on-board very stable oscillators as the frequency reference during their entire descent. The downlink signal from the small probes will turn on 22 min prior to entry, although the oscillators themselves may be turned on earlier to allow them to warm up.

The small probes will be using very low subcarrier frequencies, on the order of 4 kHz. In order to aid in the initial acquisition at 22 min prior to entry, the small probes may be programmed to transmit carrier-only for the first 5 min. This will provide a stronger carrier to look for and will reduce the chances of locking the closed-loop receivers onto a sideband.

On the large probe, an attempt will be made to acquire and maintain two-way lock (where the frequency transmitted by the probe is determined by a coherent multiple of a frequency received from Earth) during the entire descent. This will necessitate acquiring an uplink to the large probe at probe turn on 22 min prior to entry and reacquiring the uplink after exit from the blackout. Blackout will last on the order of 20 sec; however, a large doppler shift will have taken place during that period.

Both the large and small probes will have various telemetry format changes during the descent; however, each telemetry format will have the same frame length, so that it should not be necessary to reconfigure the station portion of the ground system with each telemetry format change. The probes will change to a lower telemetry bit rate for a few minutes surrounding the expected blackout, and the small probes will switch to a lower bit rate for the lower 30 km of the descent. These bit rate changes will require reinitialization in real-time of the station portion of the Ground Data System, which will result in a few minutes of lost real-time data which will have to be recovered from the open-loop telemetry recordings which will be made.

Current planning calls for the transmitter power of the large probe to be 40 watts and for the small probes to be 10 watts each, utilizing solid-state amplifiers. The antennas on the large and small probes will be identical. During the final stages of descent, the probes will be descending essentially perpendicular to the local surface of the planet. This, coupled with the plan to disperse the probes over widely different latitudes and longitudes on the planet, means that the communication angle from the spin-stabilized probes will be as great as 60 to 65 deg. The antennas carried on the probes will therefore be required to have a fairly wide beamwidth and corresponding relatively low gain. Current antenna design is an approximately 10-cm (4-in.) diam plastic hemisphere with a turnstile-shaped conductive strip on its surface.

Obtaining sufficient telemetry margin to achieve the desired bit rates with the constraints of antenna size and transmitter power is one of the principal design challenges of this mission. How soon the RF systems can be turned on prior to entry and the total transmitter power are highly constrained by the battery size which, in turn, is highly constrained by weight limitations. The DSN will have less than 20 min to acquire all four of these signals, signals which have not been seen since launch. It will be possible to do a telemetry check on all of the probes one at a time while they are still attached to the bus via a hardwire connection with the bus telemetry subsystem. However, it will not be possible to do a direct or indirect RF check with the probes after launch until the RF turnon 20 min prior to entry.

Reference

1. Miller, R. B., "Pioneer-Venus 1978 Mission Support," in *The Deep Space Network Progress Report 42-20*, pp. 17–19, Jet Propulsion Laboratory, Pasadena, California, Apr. 15, 1974.

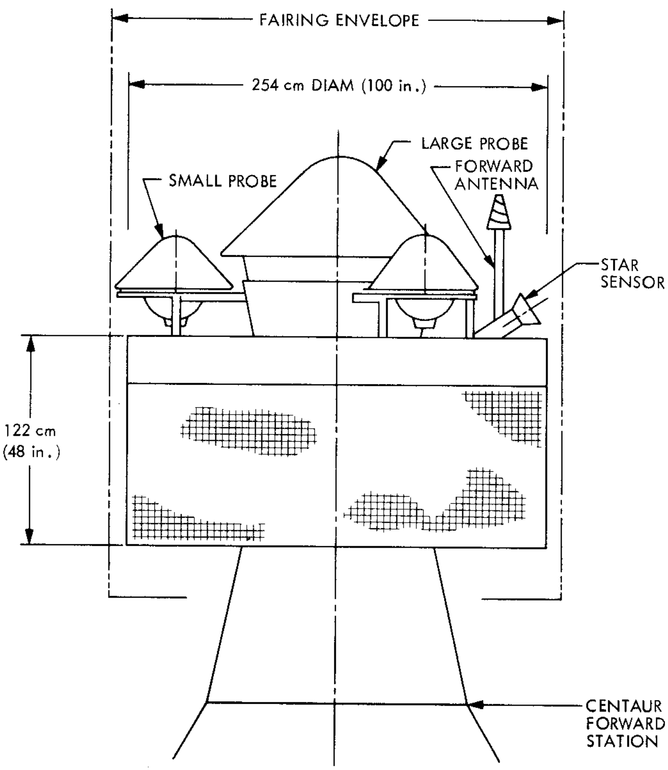

Fig. 1. Pioneer Venus 1978 multiprobe spacecraft