Pioneer Venus 1978 Mission Support

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TDA Mission Support

The Tracking and Data Acquisition portion of the Ground Data System, which will support the Differential Long Baseline Interferometry Wind Measurement Experiment, is described.

I. Introduction

The Pioneer Venus Multiprobe Mission includes a Differential Long Baseline Interferometry (DLBI) Experiment, which will attempt to measure the wind velocities in the atmosphere of Venus as four probes descend through the atmosphere. The fundamentals of the experiment are described in Ref. 1. The experiment will be using interferometry techniques to measure the components of the wind velocity perpendicular to the line-of-sight (Earth–spacecraft direction), and established doppler techniques to measure the velocity components along the line-of-sight. Each pair of stations which comprise the interferometer resolve only one component of the velocity. In order to resolve both components of the wind velocity perpendicular to the line-of-sight and to provide some measure of redundancy, four stations will be equipped to support this experiment. The 64-meter DSN stations located at Goldstone, California, and Canberra, Australia, will be utilized, along with the 9-meter Space Flight Tracking and Data Network (STDN) stations located at Guam and Santiago, Chile.

The end product at each tracking station is a wideband-width digital recording covering the entire bandwidth of interest, which includes five spacecraft signals. Plans to summer 1976 had assumed that the deliverable to the experimenter, located at the Massachusetts Institute of Technology (MIT), would be the actual wideband recordings produced at these tracking stations. This plan involved the Project procuring for the experimenter recorders capable of playing back these wideband recordings, and required that the experimenter implement and operate a system to convert the wideband recordings into a useable computer-compatible form. Estimates by MIT of the resources required to implement and operate this conversion process turned out to be a very significant portion of the total processing costs at MIT for the experiment. This problem, coupled with a similar expensive processing cost for the initial bandwidth reduction of the Pioneer Venus Orbiter occultation radio science data, led the DSN to form a special team in May 1976 to see what the DSN might be capable of doing to help solve both of these problems for the Project. This activity culminated in a functional design and estimated resources required, which were approved by both the Project and the Office of Tracking and Data Acquisition in June 1976. The result will be a new occultation subsystem to be implemented in the 64-meter subnet (which will be described in a subsequent Pioneer Venus Progress Report article), and the agreement of the DSN to provide (with Project financial assistance) equipment in Compatibility Test Area 21 (CTA 21) at JPL, Pasadena, necessary for reducing the bandwidth of the wideband digital recordings to produce standard computer-compatible recordings which will be the deliverable to the experimenter.

The total Ground Data System to support the DLBI Wind Measurement Experiment, therefore, now comprises four tracking stations located around the Pacific Basin in Australia, Guam, Chile, and California, a tape conversion facility located at JPL, Pasadena, and, finally, the actual science data processing to be performed at the Massachusetts Institute of Technology. The remainder of this article will describe the TDA-provided portions of this system: the tracking station configurations and the tape conversion facility at CTA 21.

II. Tracking Station DLBI Configuration

The key requirements for the tracking stations to support the DLBI experiment are described in Ref. 1. The details of the requirements had been conveyed in written material to the DSN through the flight project. In November 1975, a meeting was held at JPL with the experimenters and representatives of DSN Engineering and STDN Engineering for the purpose of clarifying the requirements face-to-face with the experimenters. After this meeting, the DSN then proceeded to produce a first cut at a functional design for the DSN stations. This functional design at a block diagram level was presented to the experimenter in mid-April 1976 in a teleconference. This teleconference and other informal exchanges between DSN Engineering and the experimenter then resulted in a final design for the DSN configuration which was formally reviewed and accepted by the experimenter on 22 June 1976 in a meeting at JPL. The resulting DSN design is shown at a functional level in the top part of Fig. 1. (A more detailed description of the receiver and calibrator design will be provided in a subsequent Progress Report article.) A key decision which was made in the design process was that the requirements for the DLBI experiment were sufficiently stringent and unique to warrant the DLBI requirement being met by a separate receiver dedicated to the experiment. The original concept had involved one of the open-loop receivers which will be provided for precarrier detection telemetry recovery including a second port 2 MHz wide to support the DLBI experiment. The final design involves a separate DLBI receiver which brings the total complement of open-loop receivers at Goldstone (DSS 14) and Australia (DSS 43) up to five per station for the Multiprobe entry.

The configuration involves a calibration tone generator which produces two tones, one above and one below the five spacecraft signals. The DSN configuration includes a switching capability to insert the calibration tones either before or after the low-noise amplifier. The tones will be inserted before the low-noise amplifier for testing purposes and for pre-pass checkout, but will have to be inserted after the low-noise amplifier to avoid possible interference with the recovery of the telemetry data from the probes during the actual entry event. The tones are also fed to a monitoring system which will strip the tones off the output of the receiver and compare them against the tones direct from the tone generator.

One of the most difficult parts of the actual receiver is the final mixer which must be flat from essentially dc to 1.8 MHz and have the images down at least 10 dB at the 1.8-MHz point. In order to meet the stringent relative phase stability requirements of the experiment, certain critical modules will be contained in temperature-stabilizing ovens. In addition, the cables carrying the tones from the control room up to the antenna will be actively stabilized as well as the cable carrying the reference frequency into the first mixer of the receiver. Redundant widebandwidth digital recorders will be provided at each station. For this experiment, the recorders will be operated at a 12-megabit per second rate operating at 76 cm (30 inches) per second.

It has been planned from the beginning that the STDN design would be derived by STDN Engineering based on whatever was the finalized design, for the DSN stations. With the finalization of the DSN design on 22 June, STDN Engineering proceeded with the detailed design for the STDN stations, which culminated in a formal review of the STDN design on 16 September at Goddard wherein the experimenter did concur in the STDN design.

Notice in Fig. 1 that the functional design of the STDN stations is essentially identical to the DSN except that it is not required to have the calibration tones switchable between the input and output of the low-noise amplifier, since there will be no telemetry recovery from the STDN stations. STDN Engineering was able to take advantage of the functional commonality and produce a detailed design, which involves use of many common modules with the DSN configuration. The calibration tone generator will be a common design using common modules as well as the critical last mixer mentioned above. The plan is to have the DSN procure, with Goddard funding, the common modules for the STDN stations. The STDN receiver involves using the first local oscillator (first mixer) in the standard STDN operational receiver, the multiplefrequency receiver. The analog-to-digital converter and recorder will be loaned to the STDN by the DSN as originally planned. The DSN is responsible for providing the necessary interface electronics to hook the recording subsystem up to the STDN Frequency and Timing Subsystem and power equipment. The interface of the STDN receiver to the recorder was to be a Goddard responsibility, but this engineering interface problem has been eliminated by STDN use of the same final mixer as in the DSN configuration.

III. Station Performance Validation

There will be several means of validating the proper performance of elements of the station configuration for testing purposes and for pre-pass checkout as well as during the actual event. The calibration tone monitor, comparing the tones as they go up to the input or output of the low-noise amplifier against the tones coming out of the rear-end of the receiver, will enable detection of several possible problems in the receiver chain. The recorders themselves are 18-track and have three indicator lights per track which are capable of detecting catastrophic failures in a particular track as well as the capability to do a bit error computation on a single track at a time. The micro controller on the recorder will be able to switch the bit error computation every 15 seconds from one track to another. This monitoring is possible on only one recorder at a time; however, the monitoring can be switched between the recorders without affecting the recording process during the period of interest.

For a total end-to-end system check at the DSN stations, it is planned at the current time to provide a spectrum analyzer type of device to operate on a full read-after-write output from the recorder in real-time. This will enable the detection of all signals of interest, or at least a single signal of interest, to show that the total end-to-end system is configured properly and that actual data are going to the recorder. The possibility of employing a similar process at the STDN stations has been discussed, and it appears feasible to provide a commercially available spectrum analyzer capable of detecting the bus signal using a digital-to-analog converter after the full read-after-write on the recorder. The advantage of this kind of approach for the STDN stations is that it would also be assuring that the station was actually on point. This is known automatically at the 64-meter stations because of the capability of detecting the telemetry in real-time. Other alternatives are being discussed for the STDN stations, such as the feasibility of tracking the Orbiter spacecraft using a regular closed-loop receiver just for the purpose of validating that the station is indeed on point. These monitor alternatives are still being evaluated by the STDN.

IV. The DLBI Tape Conversion Facility

The bottom part of Fig. 1 portrays the functional elements in the tape conversion facility to be provided at the Compatibility Test Area (CTA 21) at JPL, Pasadena. The process involves recovering one spacecraft signal at a time from the wideband recording by digitally mixing an estimate of that particular spacecraft signal with the output of the wideband tape recording and then digitally filtering the product so that the output is of sufficiently narrow bandwidth to be accommodated on a standard 9-track computer-compatible tape recording. The digital bandwidth reduction mixer and filter is envisioned to be a piece of special-purpose hardware (involving firmware), while the controller and formatter will be software written for a standard DSN minicomputer already available in CTA 21. The planned resulting bandwidth will be on the order of 1 kHz. Each of the five spacecraft signals (four probes and the bus) and the two calibration tones will each be independently processed. It will be Project responsibility to provide the DSN with the estimate of the frequency history of each of the five spacecraft signals.

V. DLBI Ground Data System Integration Plan

Figure 2 shows the overall major milestone schedule for the DLBI Wind Measurement Experiment of Pioneer Venus. For integrating the DSN and STDN elements, it is planned to do a trial installation in an STDN station located at Goldstone of all equipment required for the STDN configuration in mid-November 1977. This should enable solving any final integration and interface problems utilizing local engineering support. For interfacing with the experimenter, it is planned to provide on 1 October 1977 a computer-compatible tape that is correct in format, followed on 1 January 1978 by a computer-compatible tape which contains actual tones which have passed through the entire TDA portion of the Ground Data System. It is anticipated that the first computer-compatible recording containing actual signals (from the ALSEP or some other suitable spacecraft signal) will be available for the experimenter at the end of the first week of February 1978. At least two of the four stations should be ready in mid-February 1978 to start supporting some end-to-end system checkouts, with all four stations ready by mid-March 1978. It is planned to be fully operational by 1 April 1978, and to start supporting regular interferometry observations (currently envisioned as ALSEP tracking) from that time until the actual entry event the first of December 1978. This will give at least eight months to shake out any remaining problems in the total system, including the equipment and software at MIT.

Reference

1. Miller, R. B., "Pioneer Venus 1978 Mission Support," in *The Deep Space Network Progress Report 42-31*, pp. 11–14, Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1976.

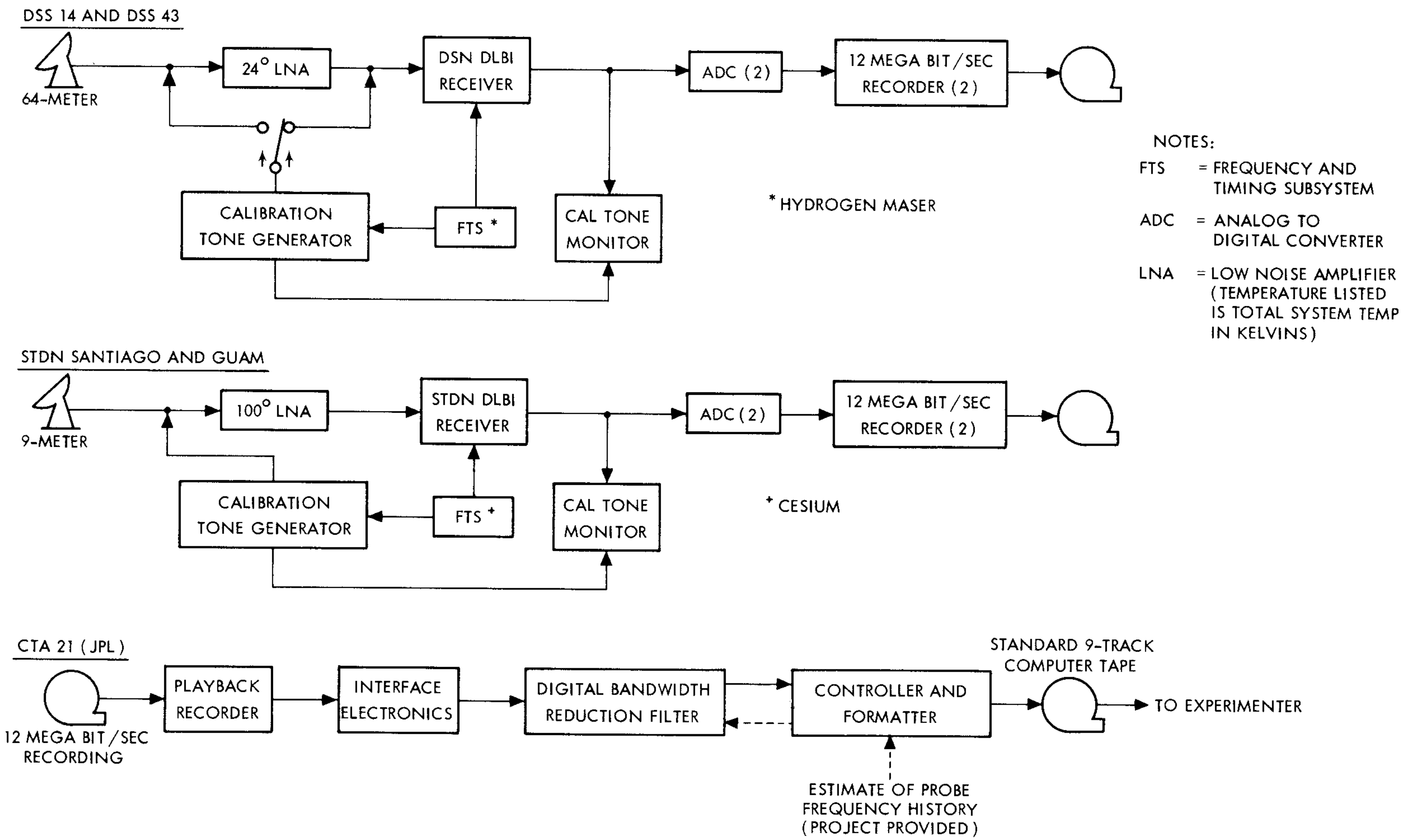

Fig. 1. Configuration for support of Pioneer Venus 1978 DLBI Wind Measurement Experiment

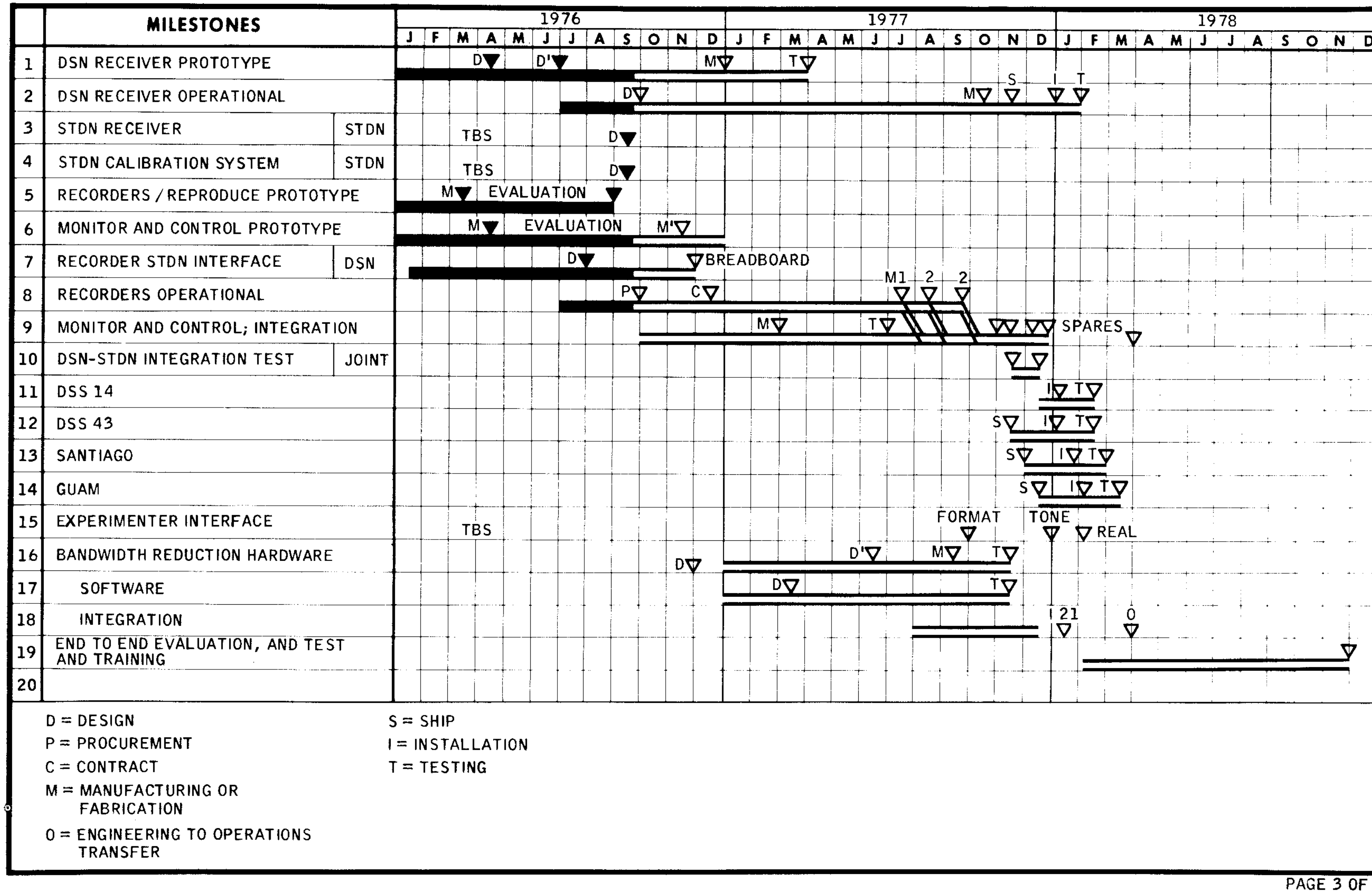

Fig. 2. Pioneer Venus 1978 major milestone schedule for DLBI Wind Measurement Experiment