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N70-34726

Technical Memorandum 33-426

Volume III

*Tracking and Data System Support
for the Pioneer Project*

Pioneer VIII. Prelaunch through May 1968

N. A. Renzetti

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

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Prepared Under Contract No. NAS 7-100
National Aeronautics and Space Administration

Preface

The work described in this report was performed by the Tracking and Data Acquisition organizations of the Jet Propulsion Laboratory, Air Force Eastern Test Range, and the Manned Space Flight Network and NASA Communications Network, both managed by the Goddard Space Flight Center. This volume, the third in a series documenting the *Pioneer* Project, covers the Tracking and Data System support for the *Pioneer VIII* mission from November 1967 – the start of the prelaunch phase (spacecraft arrival at Cape Kennedy, Florida) – through pass 171 on May 31, 1968. Some information is also included on planning activities and Project background.

Volumes I and II of this series presented similar information relative to the *Pioneer VI* and *VII* missions from prelaunch to the end of nominal mission. For those flights, nominal mission ended when the spacecraft telemetry data transmission via the Deep Space Network 85-ft.-diameter antenna stations exceeded a bit error rate of 1 in 100. However, in the case of *Pioneer VIII*, continued improvements in the operational performance of the DSN continue to extend the so-called nominal mission as defined above; therefore, this report was arbitrarily cut off at May 1968.

Acknowledgment

The author acknowledges the considerable assistance of E. R. Allen, R. H. Grace, R. E. Purdue, A. J. Siegmeth, A. D'Amore, W. J. Ross, and J. W. Thatcher. The report was based on material generated by the Operations staffs of AFETR, MSFN, NASCOM, and DSN. The material relating to the Goddard Space Flight Center *Delta* launch vehicle was abstracted from GSFC reports. The material relating to the mission and spacecraft was abstracted from Ames Research Center reports. The author is indebted to the support of A. C. Belcher and M. E. Binkley of the Office of Tracking and Data Acquisition, NASA Headquarters.

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Abstract

The *Pioneer VIII* mission (outward trajectory and heliocentric orbit) employed seven scientific instruments to accumulate information relative to interplanetary high-energy particles, solar phenomena, and plasma. The spacecraft also served as a celestial mechanics experiment reference point, and carried aloft a “piggy-back” satellite, called the *Test and Training Satellite*, to be used for *Apollo* ground station crew training and mission simulation. The Tracking and Data System (comprising the Air Force Eastern Test Range, Deep Space Network, Manned Space Flight Network, and NASA Communications Network) tracked the spacecraft from launch through the near-earth and deep space phases of the mission. For near-earth tracking, all Tracking and Data System facilities responded to mission, launch-vehicle, and range requirements. For deep space tracking, the Deep Space Network responded to tracking, telemetry, command, monitoring, simulation, and operations control requirements.

Tracking and Data System Support for the *Pioneer* Project

Pioneer VIII. Prelaunch Through May 1968

I. Introduction

This document provides a record of the tracking and data acquisition (TDA) activities of the Air Force Eastern Test Range (AFETR), the Goddard Space Flight Center (GSFC), and the Deep Space Network (DSN) in support of the *Pioneer* Project. Included in this report are descriptions of the TDA requirements, details of mission preparation on the part of the participating agencies, a comprehensive account of tracking operations, and a Tracking and Data System (TDS) performance evaluation summary. Brief descriptions of the TDS, the Spacecraft System, Launch Vehicle System, and mission objectives are also provided.

A. Purpose

The primary purpose of the *Pioneer VIII* mission is to accumulate scientific information from deep space. The time required for the analysis of such data is considerable. This is attributable to the fact that the gathered data encompass a variety of technical disciplines; moreover, the responsibility of preparing the analyses rests with the individual scientific experimenters having instruments aboard the spacecraft.

Pioneer VIII was the third spacecraft launched in this *Pioneer* generation; hence, this report is the third description of the TDS activities in the Project. To aid in understanding the information presented, the spacecraft, scientific instruments, and a portion of the related ground equipment are described in subsequent sections of this volume.

A listing is provided of major events and their time of occurrence during the *Pioneer VIII* flight, from the review before shipment to Cape Kennedy through pass 171. The test program and other activities are discussed in Section IV. In addition, the discussion of the review before shipment includes information pertaining to the test program conducted on the spacecraft and scientific instruments.

The performance during the mission of various elements of the *Pioneer* Project is discussed in Section V. Included is a description of the trajectory from launch and a discussion of the engineering performance of the spacecraft subsystems indicated by the telemetry data. The performance of the groups responsible for telemetry data retrieval and processing is also discussed.

A TDS performance evaluation of the mission is summarized in Section VI.

B. Objectives

Scientific observations of the characteristics of magnetic fields, plasma, and high-energy particles in interplanetary space beyond the influence of the earth can provide a better understanding of the mechanism related to the propagation through space of solar disturbances, terrestrial phenomena related to such disturbances, and the relationship between solar and galactic fields. These characteristics are influenced by solar phenomena, and vary both temporally and spatially. It is believed that, on a large time scale, they are influenced by the magnitude of solar disturbances that vary periodically over an 11-yr cycle. Because such disturbances are generally localized on the surface of the sun, and because the sun rotates, the spatial variation is surmised.

The objectives of the *Pioneer* Project are to conduct the aforementioned scientific observations and to determine the temporal and spatial variation of the interplanetary phenomena. To implement these objectives, the plan called for five flights—*Pioneer VI* was the first—to be launched at intervals of 8 to 12 mo so as to cover the period from near-minimum solar activity to maximum solar activity. Spatial effects were to be determined by launching two spacecraft to move ahead of the earth with increasing time and three spacecraft to move behind the earth with increasing time. *Pioneer VI* is of the former category; *Pioneers VII* and *VIII* are of the latter.

C. Pioneer Project Development

The *Pioneer* Project began in the latter part of 1961 when a number of discussions between NASA Headquarters and Ames Research Center (ARC) personnel about the scientific value and technical feasibility of the missions culminated in the decision to have industry conduct a mission feasibility study. The study was concluded in April 1962 and became the basis of the technical information presented in a briefing to the NASA associate administrator in June 1962. The *Pioneer* Project effort was approved on November 9, 1962.

After a period of Project planning and specification preparation, industry was solicited for proposals pertaining to the spacecraft and related equipment on January 29, 1963. The period of proposal evaluation, precontract discussions with industry, and explorations by NASA of the type of contract to be awarded ended

in the selection of TRW, Inc.—known at the time of selection as *Space Technology Laboratories, Inc.*, a subsidiary of *Thompson Ramo Wooldridge, Inc.*—as the contractor for the spacecraft and mission-dependent ground operational equipment. The selection date was June 7, 1963. A letter contract was signed on August 4, 1963, and the contract was defined on July 30, 1964. The fixed-price-incentive contract was the first of that type awarded by NASA for the development of a spacecraft.

The period of studies and Project definition, in which the planning and performance of predesign activities were accomplished, culminated with the first coordination meeting on August 26 and 27, 1963. The meeting was attended by all experimenters and by personnel from ARC and TRW. Approximately 5 yr and 1 mo elapsed from the start of the Project until *Pioneer VIII* was launched on December 13, 1967.

The number of organizations contributing to the success of *Pioneer VIII* is several hundred or more when account is taken of the many subcontractors supplying components and subsystems. To list all such organizations is beyond the scope or intent of this report. However, a number of organizations have played particularly significant roles in the Project; these are by necessity cited frequently throughout the report. Such organizations, together with their responsibilities and relations to other groups within the Project, are described in Table 1.

D. Tracking and Data System

The TDS provides the tracking and communications link between the space vehicle and mission operations. For *Pioneer* missions, the TDS uses the facilities of: (1) the AFETR for tracking and telemetry of the spacecraft and vehicle during the launch and near-earth phases; (2) the DSN for precision tracking commands, telemetry, communications, data transmission, processing, and computing; and (3) the Manned Space Flight Network (MSFN) and the NASA Communications Network (NASCOM), both of which are operated by Goddard Space Flight Center.

1. Near-earth phase. The AFETR extends from the eastern United States mainland through the south Atlantic area eastward into the Indian Ocean. It includes all stations, sites, ocean areas, and air space necessary to conduct missile and space vehicle test, development, and flight support. Administrative and management activities are largely concentrated at Patrick Air Force

Table 1. Principal elements of Pioneer Project

Organization	Responsibility	Organization	Responsibility
Program		McDonnell Douglas Corp.	Design and fabrication of second stage of <i>Delta</i>
Physics and Astronomy Program Office within OSSA ^a	Pioneer Project direction at NASA Headquarters	United Technology Center	Design and fabrication of third stage of <i>Delta</i>
Ames Research Center	Project management	Thiokol	Design and fabrication of first stage strap-on-solid-propellant motors
Spacecraft, mission-dependent ground operational equipment		Launch activities	
Ames Research Center	Spacecraft and GOE ^b system management; installation and checkout	Unmanned Launch Operations, Kennedy Space Center	Direction of launch operations
TRW	Design, development, and fabrication of spacecraft and GOE; integration and testing of spacecraft and instruments at TRW and Cape Kennedy Air Force Station	Air Force Eastern Test Range	Tracking and telemetry data acquisition during powered flight (NASA/DOD ^d agreement)
Scientific instruments		Ames Research Center	Launch operations coordination and spacecraft-launch vehicle interface
Ames Research Center	Assurance that overall scientific objectives are met Instrumentation systems management	Flight operations	
Principal investigators	Provision of scientific instrument; reduction, analysis, and reporting of data from instrument	Ames Research Center	Planning, direction, and control of mission
Goddard Space Flight Center	Magnetometer Cosmic dust detector	Jet Propulsion Laboratory	Management of Deep Space Network
Ames Research Center	Plasma detector	Deep Space Network	Tracking, telemetry data acquisition, and command transmission during free-flight trajectory
University of Minnesota	Cosmic ray detector	NASA Communications Network (JPL)	Communications between the various stations conducting flight operations
Graduate Research Center of the Southwest ^c	Cosmic ray detector	Data processing and analysis	
Stanford University	Radio propagation experiment	Ames Research Center	Management of preliminary data-reduction activities; dissemination of telemetry data to users; analyses of spacecraft and instrument engineering measurements
TRW	Electric field detector	Computer Sciences Corporation	Design, development, and operation of telemetry-data tape-processing station
Jet Propulsion Laboratory	Performance of celestial-mechanics investigation using Pioneer tracking data	TRW	Support for analysis of spacecraft engineering measurements
Launch vehicle			
Goddard Space Flight Center	Management of launch vehicle procurement		
McDonnell Douglas Corp.	Design and fabrication of Thor booster (first stage of <i>Delta</i> launch vehicle); integration and testing of <i>Delta</i> at Cape Kennedy Air Force Station		

^aOSSA = Office of Space Science and Applications (NASA).

^bGOE = ground operational equipment.

^cNow Southwest Center for Advanced Studies.

^dDOD = Department of Defense.

Base, and actual missile launches and flight tests are conducted at Cape Kennedy Air Force Station and over the downrange areas.

The AFETR uses major instrumentation systems to support projects, programs, and organizations that use the AFETR launch facilities.

As a part of the TDS, the AFETR performs TDA functions for *Pioneer* missions during the countdown and launch phases of each flight. To meet the tracking and telemetry commitments for *Pioneer* missions, the AFETR has at its disposal: (1) land-based instrumentation sites, (2) range instrumentation ships, and (3) range telemetry aircraft.

The MSFN is under the direction of the Goddard Space Flight Center, Greenbelt, Md. The MSFN is part of a worldwide network designed for supporting the manned space flight effort.

From the MSFN facilities, launch, first tracking, and launch mark event activities are monitored. By use of the signaling, conferencing, and monitoring arranging (SCAMA), voice operations and control are linked to all MSFN tracking stations committed to support *Pioneer* missions.

2. Deep space phase. The DSN, established by the NASA Office of Tracking and Data Acquisition, is under

the system management and technical direction of JPL. The DSN is responsible for two-way communications with unmanned spacecraft traveling from approximately 10,000 mi from earth to interplanetary distances. Present ground facilities permit simultaneous control of a newly launched spacecraft and a second one already in flight. In preparation for the increased number of U.S. activities in space, a capability is being developed for simultaneous control of either two newly launched spacecraft plus two in flight, or four spacecraft in flight. Advanced communications techniques are being implemented to make possible the acquisition of data and the ground tracking of spacecraft on outer-planet missions.

The DSN is distinct from other NASA networks, such as the Space Tracking and Data Acquisition Network (STADAN), which tracks earth-orbiting scientific and communication satellites, and the MSFN, which is used for tracking the manned *Gemini* and *Apollo* spacecraft. The DSN is composed of (1) the Deep Space Instrumentation Facility (DSIF), (2) the Space Flight Operations Facility (SFOF), and (3) the Ground Communications System (GCS).

The deep space tracking stations are situated in such a manner that three prime stations may be selected approximately 120 deg apart in longitude so that a spacecraft in or near the ecliptic plane is always within the field of view of at least one of the selected ground antennas. The Deep Space Stations (DSSs) and their respective locations are shown in Table 2.

Table 2. Deep Space Station designations and locations

Location	DSS No.	Geodetic latitude	Geodetic longitude	Height above mean sea level, m	Geocentric latitude	Geocentric longitude	Geocentric radius, km
Goldstone, Calif. (<i>Pioneer</i>)	11	35.38950°N	243.15175°E	1037.5	35.20805°N	243.15080°E	6372.0341
Goldstone, Calif. (<i>Echo</i>)	12	35.29986°N	243.19539°E	989.5	35.11861°N	243.19445°E	6372.0176
Goldstone, Calif. (<i>Venus</i>)	13	35.24772°N	243.20599°E	1213.5	35.06662°N	243.20507°E	6372.2599
Goldstone, Calif. (<i>Mars</i>)	14	35.42528°N	243.12222°E	1160	35.24376°N	243.12127°E	6372.1341
Woomera, Australia	41	31.38314°S	136.88614°E	144.8	31.21236°S	136.88614°E	6372.5317
Canberra, Australia	42	35.40111°S	148.98027°E	654	35.21962°S	148.98027°E	6371.6686
Johannesburg, S. Africa	51	25.88921°S	27.68570°E	1398.1	25.73876°S	27.68558°E	6375.5415
Madrid, Spain (Robledo)	61	40.429°N	355.751°E	800	40.238°N	355.751°E	6370.0868
Cerebros, Spain	62	—	—	—	—	—	—
Cape Kennedy, Fla.	71	28.48713°N	279.42315°E	4.0	28.32648°N	279.42315°E	6373.2913
Ascension Island	72	7.95474°S	345.67242°E	526.7	7.89991°S	345.67362°E	6378.2386

The acquisition of a spacecraft signal by one of the Deep Space Stations may involve six different functions: (1) pointing the antenna at the spacecraft, (2) tuning and locking receivers to the spacecraft transmitted frequency, (3) tuning and locking the ground transmitter to the spacecraft receiver frequency, (4) establishing range lock (where applicable), (5) synchronizing the telemetry system, and, in some cases, (6) providing for immediate command transmission to the spacecraft. Selected stations of the DSIF are equipped with special wide-field antennas mounted on the 85-ft-diam antennas to assist in the acquisition process. These acquisition-aid antennas have beamwidths of approximately 16 deg and are accurately boresighted with the 85-ft-diam antennas. They have angle-error outputs that are connected to a separate angle-channel receiver. By observing the angle errors generated simultaneously by both wide- and narrow-beamwidth antennas, a smooth change from tracking with the acquisition-aid antenna to tracking with the 85-ft-diam antenna can be effected.

The SFOF is located at JPL in Pasadena, Calif. Before launch, direction and status monitoring of the DSN, analysis of spacecraft and scientific instrument performance, and calculation of predictions for spacecraft acquisition by the DSN are performed at the SFOF. Within minutes after a launch, mission control is transferred to this facility, where tasks associated with the mission and its control are performed. Several weeks after the *Pioneer VIII* launch, mission control became the responsibility of ARC; at this time, the mission analysis teams were transferred to ARC.

The DSN, managed by JPL, provided all tracking, data acquisition, and command capability for the free-flight phase of *Pioneer VIII*. The Deep Space Stations within the network that have supported *Pioneer VIII*, their designations, and their locations are listed below:

Station Designation	Location
DSS 11	<i>Pioneer</i> Station, Goldstone, Calif.
DSS 12	<i>Echo</i> Station, Goldstone, Calif.
DSS 14	Mars Station, Goldstone, Calif.
DSS 41	Woomera, Australia
DSS 42	Tidbinbilla, Australia
DSS 51	Johannesburg, South Africa
DSS 61	Robledo, Madrid, Spain

Deep Space Stations 12, 41, and 62 provided the principal support during this report period of the *Pioneer VIII* mission because they were the only tracking stations with mission-dependent GOE. (Deep Space Station 71, also supplied with GOE, was used only for prelaunch check-out and did not track the spacecraft during the deep space phase.) A microwave system connecting DSS 12 with DSSs 11 and 14 provided the capability for using the GOE at DSS 12 in combination with the mission-independent equipment at DSSs 11 and 14.

With the exception of DSS 14, all of the designated stations are equipped with 85-ft-diam antennas. A typical Deep Space Station equipped with an 85-ft-diam antenna is shown in Fig. 1. These antennas are parabolic reflectors of cassegrainian construction that operate without radomes and use polar mounts at S-band frequencies. To enhance the signal-sensing capability, a low-noise pre-amplifier is mounted in the cassegrainian cone assembly. (Table 3 gives the characteristics for such S-band tracking systems.) The gain of the antenna is approximately 53 dB when receiving and 51 dB when transmitting. The beamwidth is 0.35 deg. Acquisition-aid antennas are also mounted on the reflectors at DSSs 41, 42, and 51. These waveguide horn antennas have a gain of approximately 21 dB when receiving and 20 dB when transmitting, and have a beamwidth of 16 deg. This broad width eases the problems associated with initial acquisition of the spacecraft following launch.

The Goldstone Mars Station (DSS 14) is equipped with a 210-ft-diam parabolic antenna that uses an azimuth-elevation mount. The gain is approximately 62 dB when receiving and 60 dB when transmitting. The beamwidth is 0.1 deg. The antenna was dedicated on April 29, 1966. *Pioneer VIII* will not require the use of DSS 14 until the summer of 1970, when it will be beyond the range of the 85-ft-diam antennas.

Transmitters at the Deep Space Stations operate with an output power between 0.2 and 10 kW. The maximum power is sufficient to transmit to the spacecraft whenever reception from the spacecraft is possible. The lower power can be used when the spacecraft is near the earth.

The Deep Space Stations are equipped with a paramp and a helium-cooled traveling-wave maser (TWM) system. At 2.295 GHz, the system noise temperature of the paramp is $270 \pm 50^\circ\text{K}$; that of the TWM is between 35 and 50°K . All station receivers employ a phase-lock loop and are tuned to the S-band frequency. These

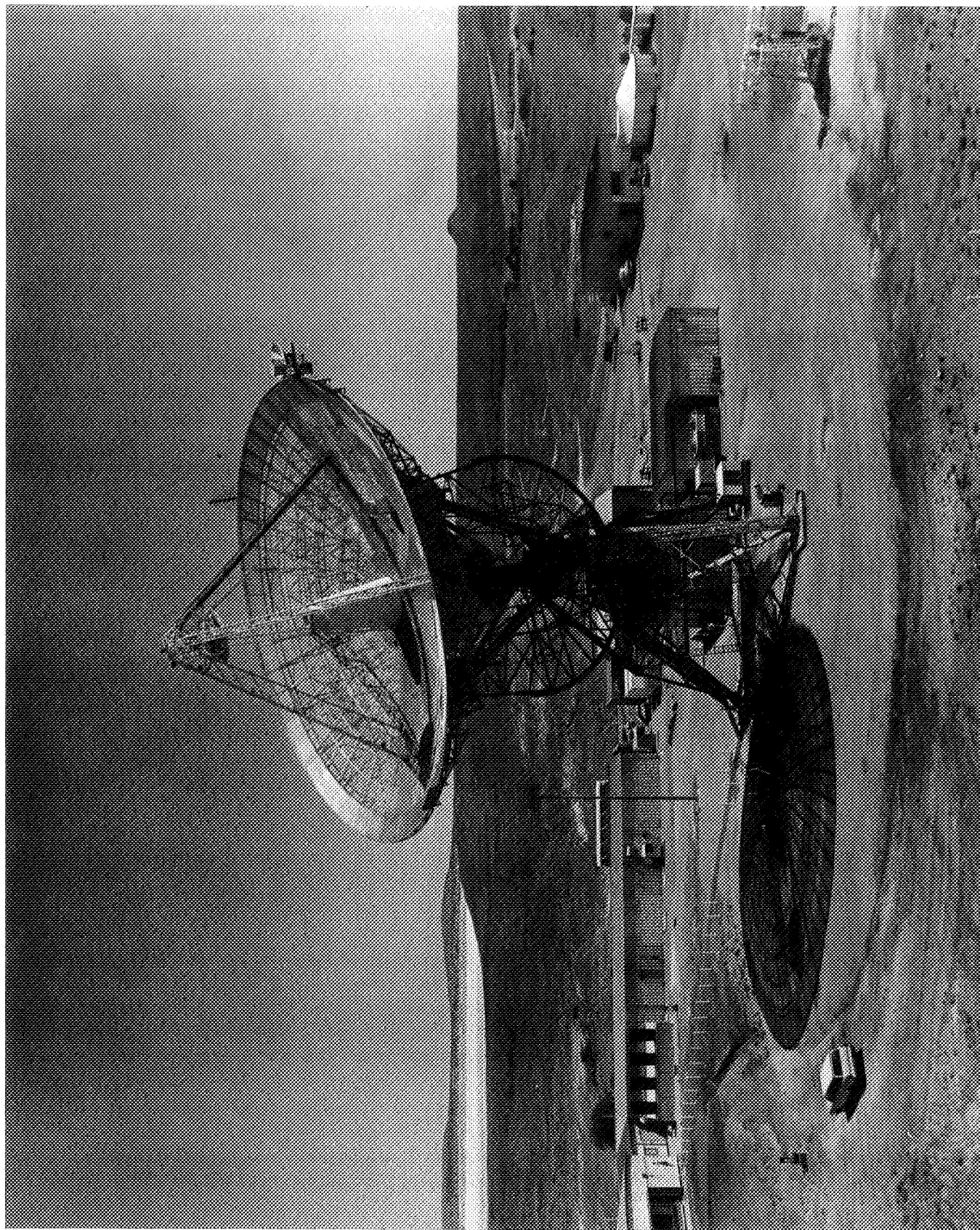


Fig. 1. Typical Deep Space Station with 85-ft-diam antenna

Table 3. Characteristics for S-band tracking systems

Equipment	Characteristic	Equipment	Characteristic
Antenna, tracking		Frequency (nominal)	2295 Hz
Type	85-ft-diam parabolic	Frequency channel	14a
Mount	Polar (HA-dec) ^a	Transmitter	
Beamwidth ± 3 dB	~ 0.4 deg	Frequency (nominal)	2113 Hz
Gain, receiving	53.0 dB, ± 1.0 , -0.5	Frequency channel	14b
Gain, transmitting	51.0 dB, ± 1.0 , -0.5	Power	10 kW, max
Feed	Cassegrainian	Tuning range	± 100 kHz
Polarization	LH ^b or RH circular	Modulator	
Max angle tracking rate ^c	51 deg/min ± 0.85 deg/s	Phase input impedance	$\geq 50 \Omega$
Max angular acceleration	5.0 deg/s/s	Input voltage	≤ 2.5 -V peak
Tracking accuracy (1 σ)	0.14 deg	Frequency response (3 dB)	dc to 100 kHz
Antenna, acquisition-aid		Sensitivity at carrier output frequency	1.0 rad peak/V peak
Type	2 $\times$ 2-ft horn	Peak deviation	2.5 rad peak
Gain, receiving	21.0 dB ± 1.0	Modulation deviation stability	$\pm 5\%$
Gain, transmitting	20.0 dB ± 2.0	Frequency, standard	Rubidium
Beamwidth ± 3 dB	~ 16 deg	Stability, short-term (1 σ)	1×10^{-11}
Polarization	RH circular	Stability, long-term (1 σ)	5×10^{-11}
Receiver	S-band	Doppler accuracy at F_{r_0} (1 σ)	0.2 Hz ± 0.03 m/s
Typical system temperature		Data transmission	TTY and HSDL ^d
With paramp	270 $\pm 50^\circ$ K		
With maser	55 $\pm 10^\circ$ K		
Loop noise bandwidth	12, 48, or 152 Hz		
Threshold (2B _{L0})	± 0 , -10%		
Strong signal (2B _{L0})	120, 255, or 550 Hz		
	± 0 , -10%		

^aHA = hour angle; dec = declination.
^bGoldstone only.
^cBoth axes.
^dHSDL = high-speed data line.

receivers lock to the carrier, detect the subcarrier signal, and supply the signal to the mission-dependent equipment for demodulation and further processing.

Each Deep Space Station is also equipped with two FR-1400 tape recorders and two SDS 910 or 920 computers for use by the flight projects. The tape units are used to record (1) telemetry data directly from the receivers and from the mission-dependent equipment and (2) other information from instruments at the ground station. The ground instrumentation is used in the *Pioneer* system to perform such functions associated with telemetry and command as the following:

- (1) Monitoring of spacecraft telemetry data and generation of alarms for out-of-tolerance performance.

- (2) Selective editing of telemetry data and preparation for their teletype transmission to the mission operation areas.

- (3) Verification of commands preceding actual transmission to the spacecraft.

E. Pioneer Spacecraft

The *Pioneer VIII* spacecraft was launched by a *Delta* DSV-3E launch vehicle from complex 17-B at the Cape Kennedy Air Force Station, Fla., at 0908:00 EST (1408:00 GMT) on December 13, 1967. The countdown proceeded smoothly, with no anomalies encountered. The launch vehicle system performance of all three stages was nominal. The boost trajectory appeared normal, and a

nominal heliocentric orbit was obtained. Data acquisition from the DSN occurred as planned.

Pioneers VI and VII—carrying six scientific instruments to investigate the characteristics of magnetic fields, plasma, and cosmic rays in interplanetary space—were launched from Cape Kennedy Air Force Station on December 16, 1965, and August 17, 1966, respectively.

All scientific instruments and equipment on the three spacecraft have continued to operate normally since launch. No malfunctions or anomalous performances have occurred to affect the objectives of the missions. In addition, a mass of information presenting the measurements made by the scientific instruments and the performance of the spacecraft subsystems has been telemetered from the spacecraft and received on the ground since their launch. A number of organizations performing a variety of tasks have contributed to this success.

These spacecraft were specially designed and fabricated to provide the means for exploring interplanetary particle and field phenomena at great distances from earth and to meet the constraints imposed by interfacing systems. The general requirements were to:

- (1) Provide a stable platform on which to mount scientific instruments to measure interplanetary phenomena at distances up to 7.5×10^7 km from earth.
- (2) Provide a capability for the instruments to scan 360 deg in the plane of the ecliptic.
- (3) Provide a magnetically clean spacecraft with a field strength of $< 1 \gamma$ at the magnetometer.
- (4) Operate in space for at least 6 mo.
- (5) Weigh less than 150 lb (including scientific instruments).
- (6) Provide a thermal environment favorable to the operation of on-board equipment.
- (7) Provide a data system to sample readings from the instrumentation and transmit the information to earth.
- (8) Provide a command system to permit changes in operating modes of on-board equipment by ground command.

The weight limitation and the requirements for flight in interplanetary space were compatible with the performance of the *Delta* launch vehicle. The spacecraft

size and overall profile were also compatible with the fairing of the launch vehicle. Finally, the structure met the strength and rigidity requirements to withstand the vibration and acceleration loads of the launch vehicle.

The telemetry and command communication subsystems are compatible with the requirements of the DSN and the need for communication at long distances. The communication subsystem operates at S-band frequencies. When the subsystem operates in a coherent mode, the spacecraft transmits a signal whose frequency is a fixed ratio of that received by the spacecraft; as a result, accurate doppler measurements can be made so that the spacecraft velocity relative to earth—and, hence, the trajectory—can be determined. The telemetry communication subsystem also operates at a frequency governed by an on-board oscillator to provide for occasions when the ground stations are not transmitting to the spacecraft or when doppler measurements are not required.

The *Pioneer VIII* spacecraft is a cylinder 35.14 in. high and 37.30 in. in diameter with a weight of 143 lb, including experiments. It was designed and built by TRW, and managed by ARC. The spacecraft contains five basic subsystems: thermal control, orientation control, communications, data handling, and power supply. Table 4 lists the *Pioneer VIII* spacecraft gross properties; Fig. 2 shows an exploded view of *Pioneer VIII*.

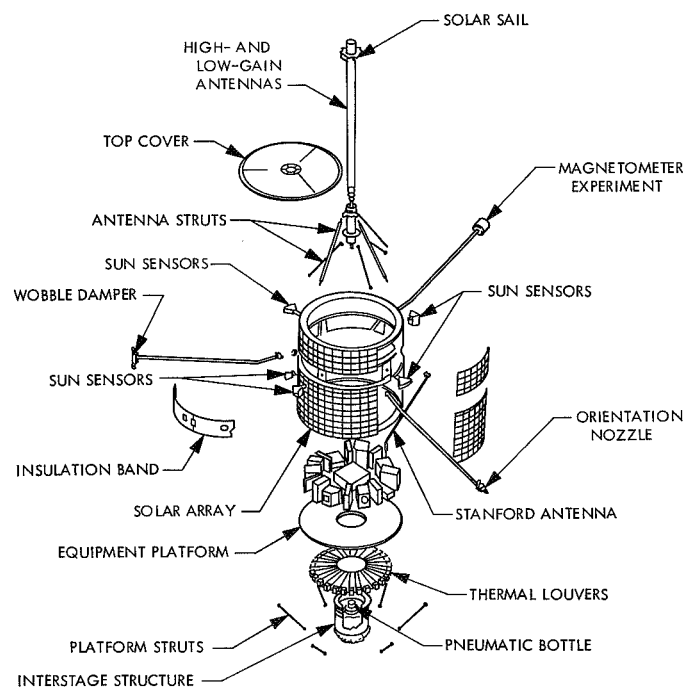


Fig. 2. Exploded view of *Pioneer VIII* spacecraft

Table 4. Pioneer VIII spacecraft gross properties

Property	Specification	Flight 1	Flight 2	Flight 3
Weight, lb				
Spacecraft	111.2	102.7	103.26	105.8
Experiments	—	34.3	35.09	38.0
Total		137.0	138.35	143.8
Moments (deployed), lb/in. ²				
Roll	—	43,509	43,509	45,500
Pitch (max)	—	32,115	32,115	33,000
Ratio (roll/pitch)	—	1.32	1.32	1.37
Electrical loads, W				
Spacecraft	—	43.4	43.6	43.1
Experiments (average)	7.4	9.2	8.2	12.3
Total	—	52.6	51.8	55.4
Solar array capacity, W				
0.8 AU	Spacecraft loads	102.5	97.8	96.5
1.0 AU	plus 7.4 W for	81.0	80.6	79.5
1.2 AU	experiments	60.2	60.8	60.0
Magnetic properties (with experiments), γ				
As received	—	0.17	0.239	0.20
Magnetized	16	1.68	1.46	1.7
Demagnetized	1.0	0.051 ^a	0.23	0.12
Stray field	0.5	0.120	0.337	0.25
Experiment mounting temperature, °F				
0.8 AU	30–90	75–80	83	84 ^b
Temperature, °F				
1.0 AU ^c	30–90	62	62	54
1.2 AU ^c	30–90	41	38	41
RF power to antenna, dBm				
Low gain	36	37	36.7	37.4
High gain	36	38	37.5	38.0
Radiating antenna gain, dB				
Low gain	—	−0.5	0.3	−0.4
High gain	—	10.9	10.7	11.1
Receiver sensitivity at antenna, dBm				
Low gain	−135	−143	−142.5	−141.1
High gain	−135	−144	−144.2	−140.3
Receiving antenna gain, dB				
Low gain	—	−0.7	−1.7	−1.3
High gain	—	10.9	11.1	11.8
^a Based on readings at 50 in. extrapolated to 80 in. ^b University of Minnesota cosmic ray detector. ^c Platform 3 temperature.				

Electrical power is provided by a solar array consisting of 10,368 n-p type solar cells mounted on the outer surface of the cylindrical spacecraft body. A narrow circular band divides the solar array and contains apertures for experiment viewing and orientation of the sun sensors.

A battery is used to provide power during the launch and initial orientation phases, and is also used throughout the remainder of the mission to provide peak power requirements for the instruments and equipment. Figure 3 is a simplified block diagram of the *Pioneer* spacecraft.

Projecting probe-like from the center of one end of the cylinder is a high-gain antenna, the upper portion of which contains two low-gain antennas. Extending from the opposite end of the cylinder is a whip antenna, designed to receive transmitted signals for the radio propagation detector (a scientific experiment).

The spacecraft has three radial booms, an antenna mast on the cylinder axis at the forward end of the spacecraft, and an antenna system at the aft end of the spacecraft for use in one of the scientific experiments (Stanford). Except for a small viewing band provided for the scientific instruments, the curved surface of the cylinder is covered with solar cells to supply the on-board power. Within the cylinder is a single platform on which all of the electronic equipment for the spacecraft and scientific instruments is located. Thermal louvers aft of the equipment platform cover a portion of the platform area and control the amount of heat radiated from that surface. These components are also shown in Fig. 2.

The three booms are capable of being folded against the antenna mast, and the Stanford antenna can be withdrawn against the cylinder, as illustrated in the sketch of Fig. 4. This arrangement allowed the spacecraft to fit within the launch-vehicle fairing. After separation from the third stage, the booms and Stanford antenna are automatically deployed. The three booms augment the spacecraft moment of inertia about the spin axis to achieve the gyroscopic stabilization required for the mission.

One boom has a nozzle that, as part of the nitrogen gas jet system, provides the torque for attitude control of the spacecraft. The second boom, included for stability, is equipped with a wobble-damping mechanism.

A magnetometer, used for one of the scientific experiments, is incorporated onto the third boom. The magnetometer is deployed at the far end of its boom to provide as much isolation as possible from the on-board instrumentation (and its inherent radiation).

The spacecraft is spin-stabilized. Thus, the stability requirements can be met within the overall weight and lifetime constraints, since the necessity for attitude correction is minimized and the on-board orientation subsystem is small, lightweight, and reliable. Alignment of the spin axis perpendicular to the plane of the ecliptic for the major portion of the mission provides the required scan capabilities.

To provide the required communication capabilities within the constraints imposed by the electrical power subsystem, the antenna mast is a high-gain antenna having a disk-like pattern that is axially symmetric with respect to and perpendicular to the spin axis. Because the spin axis is perpendicular to the ecliptic plane, and the earth and spacecraft are in the ecliptic plane, such a pattern assures that the earth will be within the radiation plane of the spacecraft.

The magnetic-cleanness requirement is eased somewhat by placing the magnetometer sensor at the end of the boom rather than on the equipment platform. Nevertheless, careful selection of materials and components throughout the spacecraft, and use of magnetic-compensation design techniques, were necessary to fully achieve this requirement.

The *Pioneer VIII* spacecraft is of the Block II type, which is somewhat different from the earlier Block I type of spacecraft. Table 5 gives a comprehensive summary of changes between Block I and Block II spacecraft.

F. Launch Vehicle

The launch vehicle for *Pioneer VIII* was the thrust-augmented improved *Delta* (DSV-3E). The prime contractor for the vehicle was the McDonnell Douglas Corporation. The vehicle had three basic stages, but it also had three solid-propellant motors that were included to augment the first-stage thrust. These components and their principal dimensions are shown in Fig. 5. The *Pioneer VI* launch was the first in which a *Delta* vehicle (*Delta 35*) placed a payload in an escape-from-earth trajectory.

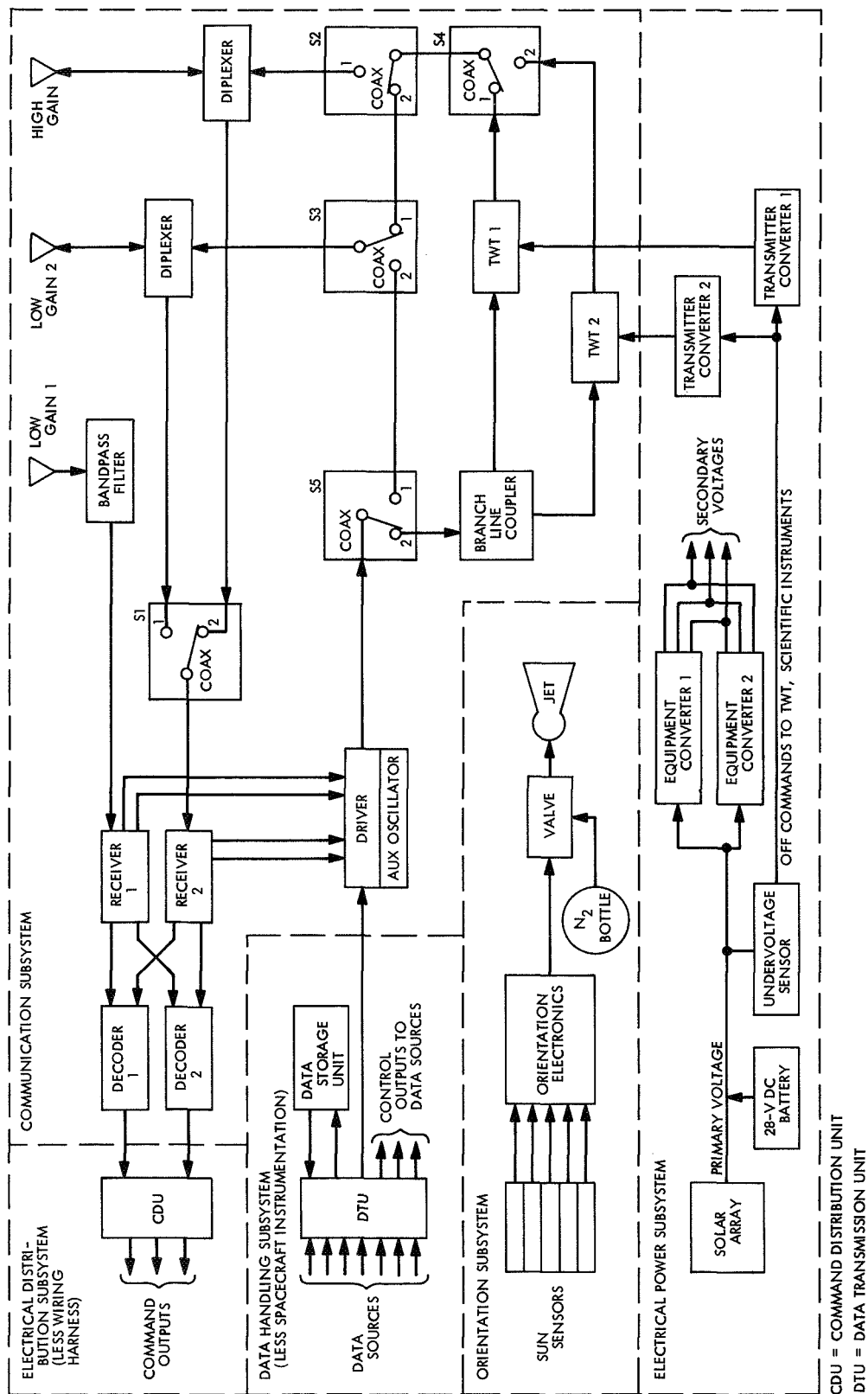


Fig. 3. Simplified functional block diagram of Pioneer spacecraft

Table 5. Summary of spacecraft changes between Block I and Block II (and IIA)

Block II change	Purpose of change	Affected spacecraft equipment	Remarks
Incorporate seven Block II experiments in lieu of six Block I experiments	Increase types of scientific interplanetary data that can be obtained from Pioneer spacecraft	Equipment platform, viewing band, DTU, ^a CDU, ^b harness, programming	Block IIA experiments: University of Minnesota cosmic ray detector GSFC magnetometer (substituted for ARC magnetometer) GRCSW ^c cosmic ray detector Stanford University radio propagation GSFC cosmic dust detector ARC plasma detector Stanford/TRW electric field detector
Increased experiment power requirements	Accommodate new experiments, including University of Minnesota cosmic ray detector	CDU	Installation of two jumper wires between inputs and outputs of two medium-current amplifiers in CDU
New boom flanges for ARC magnetometer experiment	Accommodate ARC magnetometer	Magnetometer boom assembly	
Substitution of GSFC for ARC magnetometer	Replace ARC magnetometer with GSFC magnetometer	DTU, harness, GSFC cable sets, EGSE ^d programming, mounting brackets, magnetometer boom assembly	DTU modification to process GSFC data while retaining capability to return to ARC configuration Harness: Add four wires between magnetometer and DTU New cable set from GSFC electronics to magnetometer boom
Modify signal conditioner	To accommodate changes in temperature ranges of receivers and transmitter driver	Signal conditioner	Resistor-driver networks in signal conditioner were changed
Modification of sun sensor cover glass specification	To increase sun-sensor resistance to solar radiation damage	Sun sensor cover glass	Increased sun sensor cover glass thickness from 20 to 100 mils
Modify platform layout	Accommodate larger battery and new experiment interface	Equipment platform	New platform layout, cable routing and insert pattern
Modify viewing band	Accommodate new experiment sensor apertures and permit easy access to experiments	Viewing band	
Modify data formats	Provide two redundant scientific formats that provide six scientific data inputs	DTU, cable harness	Rewired interconnections in DTU between scientific digital format gates and digital gate driver modules Wired both format gate modules for redundancy
Increase battery capacity	To permit greater flexibility in launch trajectory	Battery	1.25-lb increase over Block I battery Increased capacity from 1 to 2 A-h
Relocate converter fuses	Permit ready removal and testing of fuses without removing assembly covers	Equipment and TWT converters, CDU, fuse connector	Remove fuses from equipment and TWT converters and replace with jumper wires Separate converter fuse connector on CDU

^aDTU = data transmission unit.

^bCDU = command distribution unit.

^cGRCSW = Graduate Research Center of the Southwest.

^dEGSE = electrical ground support equipment.

Table 5 (contd)

Block II change	Purpose of change	Affected spacecraft equipment	Remarks
Additional commands	Add eight commands to provide spacecraft and experiments with no less than 36 command pulses	CDU	Add two pulse-command modules (CDU was originally designed to accommodate modules A40 and A41)
Modify cable harness	Accommodate experiment requirements, including addition of Stanford and TRW experiments	Harness	Electrical and mechanical changes Electrical changes for experiment interface connectors and in CDU and DTU interface connectors Change word assignments for University of Minnesota experiment Add wiring for four new University of Minnesota experiment commands and new receiver 2 temperature-sensor channel

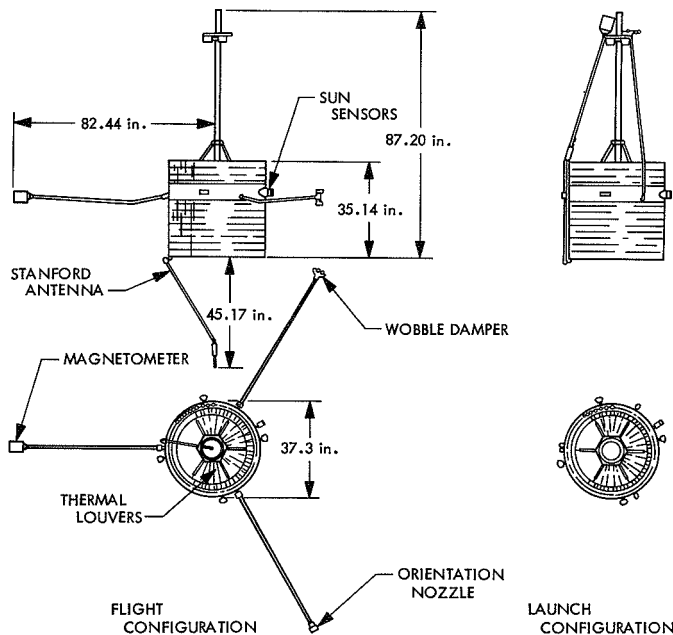


Fig. 4. Pioneer VIII spacecraft configuration

The first stage of the vehicle was a modified *Thor* powered by a Rocketdyne MB-3 (Block III) engine and augmented by three Thiokol solid-propellant rockets. The liftoff weight was approximately 150,000 lb; the lift-off thrust was 325,000 lbf, of which 175,600 lbf was supplied by the *Thor*. The fuel was RP-1 kerosene, and liquid oxygen was the oxidizer for the *Thor* stage. The main engine burned for 148 s. The three Thiokol solid-propellant rockets were started at the time of main engine start and burned for 40 s. Approximately 70 s after liftoff, the solid-rocket cases were ejected. During first-stage burn, the pitch and yaw control was effected by gimbaling the main engine in response to signals from

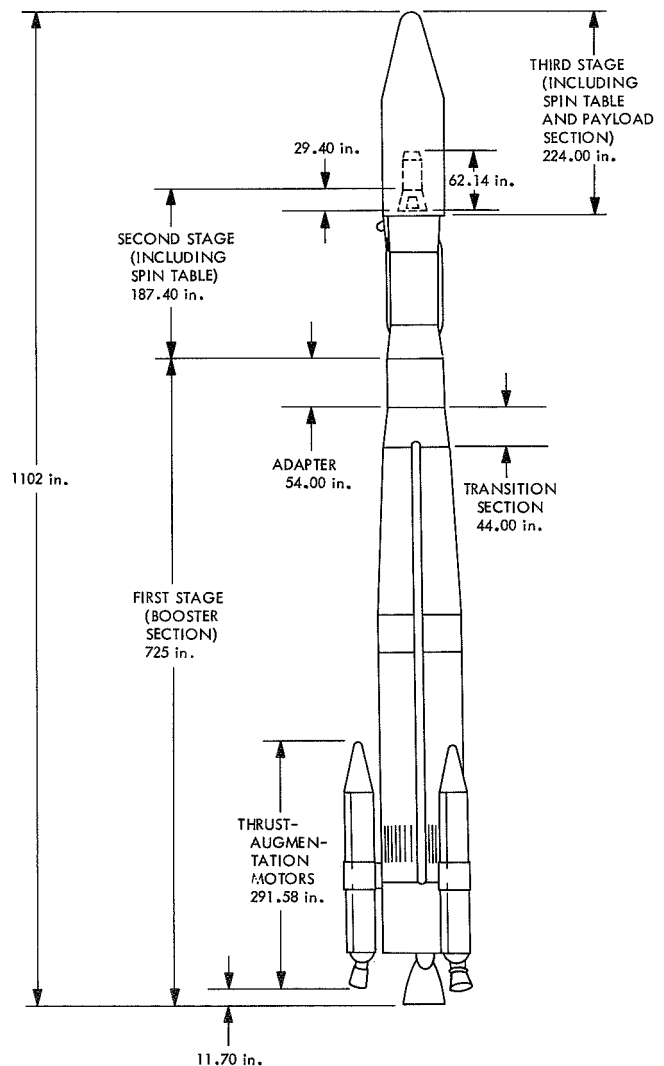


Fig. 5. Thrust-augmented improved Delta (DSV-3E) launch vehicle

an inertial reference package, which also maintained roll control by positioning the gimballed vernier engines. A radio guidance system in the second stage also provided corrective steering signals for the first stage.

Second-stage thrust was supplied by a pressure-fed Aerojet General Corporation AJ10-118E liquid-propellant propulsion system. The approximate weight at ignition was 14,000 lb; the thrust was about 7400 lbf. The fuel was unsymmetrical dimethyl hydrazine and the oxidizer was inhibited red fuming nitric acid. The motor burned for about 6.5 min. During the power portion of the second-stage flight, the main engine was gimballed to control pitch and yaw. Roll was controlled by four on-off cold gas jets, two of which reacted in a cw direction and two of which reacted in a ccw direction. Both pitch and yaw control systems responded to commands from the second-stage programmer as well as from the radio guidance system and inertial reference package. A velocity cutoff system was also incorporated in the second-stage guidance compartment.

The launch vehicle could delay third-stage ignition until 1800 s after second-stage cutoff. During this coasting phase, an on-off nitrogen gas jet used four solenoid-operated jets radially mounted on the aft end of the second stage for pitch and yaw control plus the four gas jets used during second-stage powered flight for roll control. The nitrogen gas was that previously used to pressurize the fuel tanks.

The third-stage propulsion for *Pioneer VIII* was the ABL X-258 rocket engine. The weight at ignition was about 735 lb, including the spacecraft, and the thrust was about 6200 lbf. Attitude control for the third stage was maintained by spin-stabilizing the third stage (and spacecraft) before separation from the second stage. The third stage was quite large in relation to the spacecraft itself. The *Pioneer VIII* spacecraft was mounted on an X-258 motor. The aerodynamic fairing for the third-stage-spacecraft combination was the standard fairing of the improved *Delta*.

The information necessary to assess the performance of the launch vehicle was telemetered from the first and second stages. The telemetry frequency for both the first stage and the second stage was approximately 230 MHz. Modulation was PDM/FM/FM (a complex signal form using pulse-duration modulation of a frequency-modulated signal on a frequency-modulated carrier). The second stage was also provided with a C-band radar

transponder system that was capable of transmitting a signal at a peak power of 500 W.

G. Scientific Experiments

The seven scientific instruments that make up the scientific payload for *Pioneer VIII* are as follows: two cosmic ray detectors, two plasma detectors, a magnetometer, and a radio propagation instrument; one additional experiment requires no special instruments aboard the spacecraft. The payload accounts for approximately 25% of the total *Pioneer VIII* weight. The power consumption for the instruments (with one plasma detector operating in its low-power mode) is 9 W. This level doubles when the plasma detector operates in the high-power mode, bringing the overall power consumption of the instruments to 35% of the total spacecraft requirement.

The payload covers approximately 280 in.² of platform. Approximately 72% of the telemetry data is allocated directly to the scientific payload for telemetering in the scientific data transmission mode. Except on rare occasions, this mode has been used throughout the mission. Approximately 33% of the command capability is allocated directly to the payload for controlling the operating conditions of the instruments.

Power to the scientific instruments is supplied directly from the spacecraft primary bus; each instrument, therefore, is provided with its own converter. Power to all instruments is shut down by a single ground command, but each instrument is capable of being activated by individual commands.

The scientific instruments met the weight and structural integrity constraints imposed by the launch vehicle performance, acceleration, and vibration parameters. They also met stringent requirements for magnetic "cleanness." As with the spacecraft, materials and components were selected carefully, and the use of magnetic minimization (or compensation) design techniques was necessary. The requirement for long lifetime was also met by careful selection of parts and by thorough parts screening.

Brief descriptions of the experiments and their related instruments are given in the paragraphs that follow to indicate the type of scientific information being gathered by *Pioneer VIII*. As stated previously, the reporting of the scientific results is the responsibility of the individual experimenters and is beyond the scope of this report except where mentioned for the sake of clarity.

Seven scientific instruments are aboard *Pioneer VIII*, weighing a total of approximately 35 lb. These instruments include the following:

- (1) Single-axis magnetometer, managed by Goddard Space Flight Center; Dr. Norman Ness, principal investigator.
- (2) Quadrispherical plasma analyzer, managed by Ames Research Center; Dr. John W. Wolfe, principal investigator.
- (3) Radio propagation detector, managed by Stanford University; Dr. Von Eshleman, principal investigator.
- (4) Cosmic ray anisotropy detector, managed by the Graduate Research Center of the Southwest; Dr. Kenneth McCracken, principal investigator.
- (5) Cosmic ray gradient experiment, managed by the University of Minnesota; Dr. Webber, principal investigator.
- (6) Cosmic dust detector, managed by Goddard Space Flight Center; Mr. Otto Berg, principal investigator.
- (7) Electric field detector, managed by Stanford University; Dr. Fred Scarf, TRW, principal investigator.

An eighth experiment having no on-board scientific instrumentation completes the *Pioneer VIII* experiment contingent. This experiment is a celestial mechanics investigation using the two-way doppler tracking information as its source of data. Dr. John Anderson of JPL is the principal investigator.

In addition to the above experiments, the *Pioneer VIII* launch vehicle included a "piggyback" satellite called the *Test and Training Satellite* (TETR-2). The mission objective of the TETR was to produce an active S-band doppler source to simulate an *Apollo* spacecraft, which thereby allowed for ground station crew training and mission simulation in general. The TETR gave active characteristics of an *Apollo* spacecraft and provided a common reference target for all stations. The TETR was mounted to the launch vehicle second stage, and was separated in an earth orbit after the *Pioneer VIII* spacecraft and third stage separated.

The objective of the *Pioneer VIII* mission is to obtain data on solar phenomena in the plane of the ecliptic that will increase scientific knowledge and understanding of the interplanetary environment. Also, the

Pioneer VIII flight mission joins *Pioneers VI* and *VII* to fulfill the requirements of the *Pioneer* space weather monitoring mission.

In addition to the objectives described above, *Pioneer VIII* has as specific objectives those described in the paragraphs that follow.

1. Magnetosheath and bow shock definition. To perform this investigation, the *Pioneer VIII* plasma and magnetometer on-board instruments had to be operating, and the resultant scientific data received by launch plus 3 to 3.5 h (or 8 to 10 earth radii altitude). *Pioneer VIII* performed analysis of the magnetosheath of the earth through December 15, 1967.

2. Geomagnetospheric tail analysis. To perform this investigation, the *Pioneer VIII* flight mission required 24-h continuous tracking coverage from syzygy minus 5 days to syzygy plus 15 days. *Pioneer VIII* successfully completed this investigation on February 2, 1968.

3. Solar event analysis. When a solar event of high scientific value (i.e., solar flare, Class III or above) occurs, dependent upon location and characteristics of the specific event, *Pioneer VIII* shares in its coverage. The Project requirement is continuous tracking coverage from 30 to 50 h following the event.

II. *Pioneer VIII* Tracking and Data System Requirements

A. Near-Earth Phase Support

The TDS near-earth phase support for the *Pioneer VIII* mission consisted of the committed facilities of the AFETR, the GSFC, and portions of the DSN.

The tracking and data acquisition coverage requirements placed upon the AFETR and GSFC are described in the paragraphs that follow. The requirement categories are as follows: (1) *Pioneer VIII* mission requirements, (2) launch vehicle requirements, and (3) range safety requirements.

As a result of the importance of the AFETR acquisition support to the DSN, the tracking requirement imposed upon the AFETR involved in this support has been classified as Class I, Class II, and Class III.

During the launch phase of any space mission—i.e., that period extending from launch to the initial Deep Space Station acquisition—several events occur that have a major influence upon the success of the mission. For example, all of the powered-flight and separation events occur that lead to the injection of the spacecraft into its deep space trajectory and the subsequent final separation of the spacecraft from the third stage of the launch vehicle. The information gathered from tracking and telemetry during this period is used to continually evaluate and update the status of the flight.

As explained, the acquisition support by the AFETR was important for the successful initial acquisition by the first-viewing, committed Deep Space Station. This AFETR acquisition support was primarily directed toward evaluating the performance of the launch vehicle, including the third-stage burn (initial DSN acquisition occurs subsequent to third-stage burn). In addition to being vital to the acquisition effort, near-real-time evaluation of launch-vehicle performance was of concern to spacecraft monitor personnel. For example, should the launch-vehicle performance have been nonstandard during any portion of powered flight, and if an indication of the degree of abnormality of the flight could be obtained soon enough, there would have existed an opportunity to change the command sequence of the spacecraft events so as to maximize the likelihood of meeting the flight test objectives.

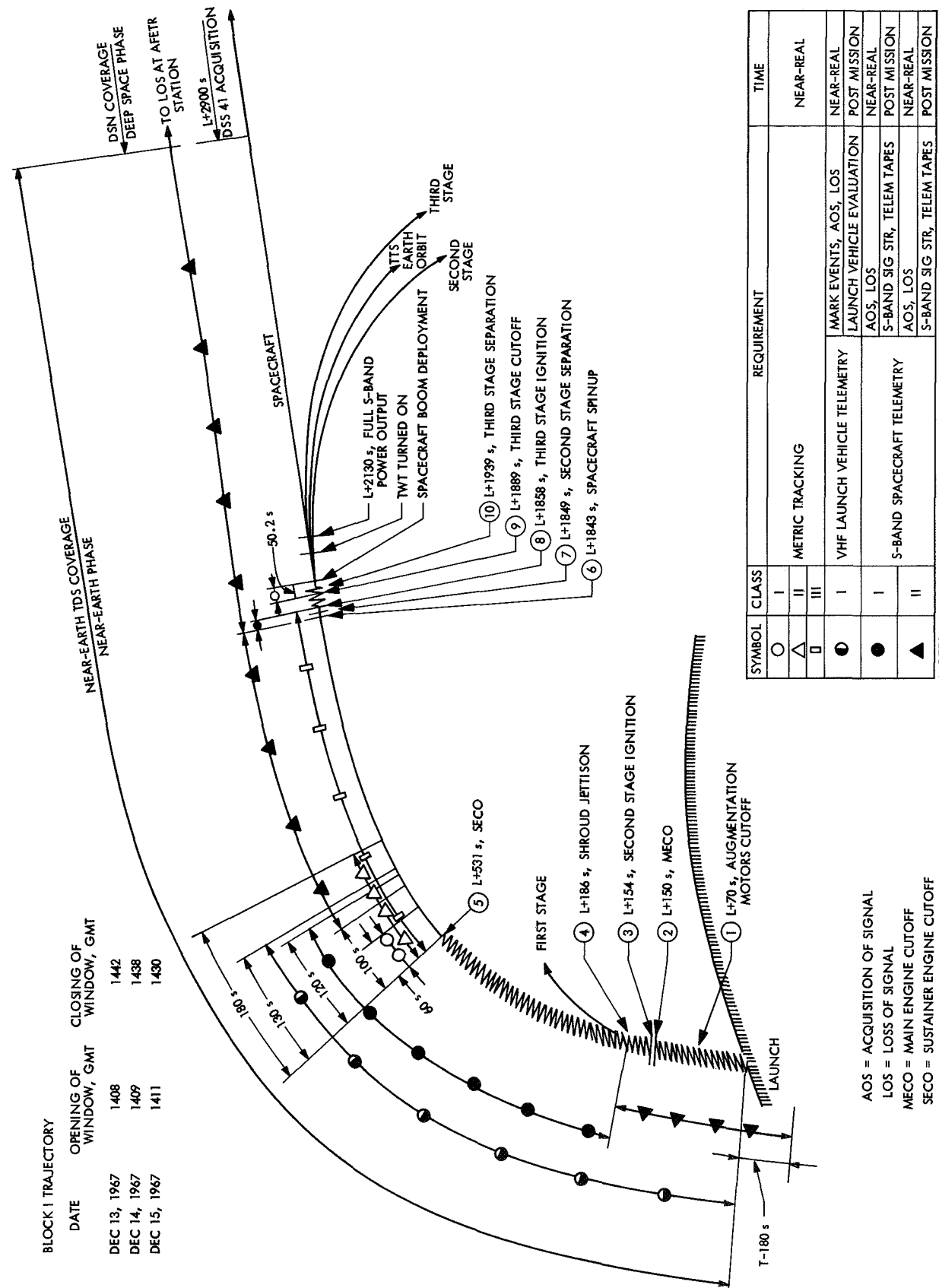
There are two general methods of evaluating the launch-vehicle performance in near-real time. One method involves comparing the actual mark times of the significant launch vehicle events from telemetry with the predetermined norms and analyzing the differences. This method includes the general evaluation of all available telemetry. The other method requires tracking data to calculate the resultant trajectory subsequent to the first- and second-stage burns (*Thor/Delta*). A comparison of the actual trajectory with the anticipated norm gives an evaluation of the launch vehicle performance. By employing both of these methods, one can be used to determine the validity of the conclusions derived from the other.

The actual launch-vehicle mark times for the *Pioneer* launches were determined by the AFETR from telemetry data received at individual sites and reported by the supervisor of range operations over the AFETR communications network. In the launch vehicle telemetry laboratory, the telemetry data were analyzed and the

mark times validated. The mission analyst also provided current reports to JPL regarding launch-vehicle performance based on all information available to him in real-time, including mark times.

The accuracy to which the vehicle stages injected the combination third-stage-spacecraft into the parking orbit was evaluated by tracking the *Delta* C-band beacon from AFETR and MSFN. Trajectory calculations by the AFETR performed at the Real Time Computing Facility (RTCF) based on these tracking data were made to establish the degree of normality of the parking orbit. This evaluation was done by the flight-path analysis group at the SFOF after receiving the parking-orbit elements and injection conditions from the RTCF. Determining the performance of the third stage by the AFETR in near-real-time was more difficult because this stage was not equipped with a radar tracking beacon. Two methods were conceived, however, that provided some indication of third-stage ignition and burn duration. One method involved examination of the doppler data in the RF signal on the carrier of the spacecraft S-band telemetry. The other method was dependent upon receiving a signal from the beacon installed on the third stage and retransmitting this signal to the telemetry laboratory for display and analysis of the doppler frequencies.

1. AFETR acquisition support. The first major event accomplished by the DSN during the flight was initial acquisition of the spacecraft by a Deep Space Station. To accomplish this, the acquiring station had to know the approximate spacecraft trajectory in terms of station predicts before the spacecraft came into view. Predicts, which included declination, hour angle, and doppler-detector output frequencies correlated with time, were furnished to all Deep Space Stations before launch. These predicts were based upon *anticipated* launch-vehicle performance; however, predicts based upon *actual* launch-vehicle performance could have proved to be very useful during the initial acquisition by the DSN, particularly if the performance had been substantially different from the stated norm. Because of the time required to receive the tracking data by the AFETR, calculate the predicts, and transmit them to the SFOF for retransmission to the Deep Space Stations, the most timely predicts were those based upon tracking data taken after injection into the parking orbit and a normal third-stage burn. Only the AFETR could supply these real-time predicts (by calculating the trajectory using radar tracking data). Because the trajectory of the mission was normal, DSSs 51 and 41 had no trouble acquiring. (Figure 6 illustrates the *Pioneer VIII* near-earth



AOS = ACQUISITION OF SIGNAL
LOS = LOSS OF SIGNAL
MECO = MAIN ENGINE CUTOFF
SECO = SUSTAINER ENGINE CUTOFF
MMW = DENOTES LAUNCH VEHICLE BURNS

SYMBOL	CLASS	REQUIREMENT	TIME
○	I	METRIC TRACKING	NEAR-REAL
△	II		NEAR-REAL
□	III		POST MISSION
●	I	VHF LAUNCH VEHICLE TELEMETRY	NEAR-REAL
●	I	MARK EVENTS, AOS, LOS	NEAR-REAL
●	I	LAUNCH VEHICLE EVALUATION	POST MISSION
●	I	AOS, LOS	NEAR-REAL
●	I	S-BAND SPACECRAFT TELEMETRY	POST MISSION
●	I	S-BAND SIG STR, TELEM TAPES	NEAR-REAL
●	I	AOS, LOS	NEAR-REAL
●	I	S-BAND SIG STR, TELEM TAPES	POST MISSION

NOTES:

- ALL EVENT TIMES ARE TYPICAL.
- EVENT TIMES AFTER SECO ARE ALTERED IF COAST TIME IS CHANGED DUE TO TRAJECTORY CONSIDERATIONS. NEW EVENT TIMES ARE SUPPLIED AFTER A DETAILED TRAJECTORY ANALYSIS HAS BEEN PERFORMED.
- ENCIRCLED NUMBERS INDICATE MARK EVENTS.

Fig. 6. Pioneer VIII near-earth tracking and telemetry requirements

phase tracking and telemetry requirements; Fig. 7 gives the projected near-earth phase station coverages and tracking time.) However, had the spacecraft been injected into a nonstandard trajectory, real-time AFETR predicts would have been critical for both stations.

2. Near-earth requirements classification. Requirements of the Project for tracking and telemetry support are divided into classes by the Project Office in accordance with their importance to the successful accomplishment of the mission. These classes are defined as follows:

- (1) Class I: requirements that reflect the minimum essentials to ensure accomplishment of primary test objectives. These are mandatory and—if not met—may result in a decision not to launch.
- (2) Class II: requirements that reflect that which is needed to accomplish all stated test objectives.
- (3) Class III: requirements that reflect the ultimate in desired support. Such support would provide the capability to achieve the test objectives earlier in the test program.

A great deal of data is required to meet the specified requirements. Some of these data are provided herein in Tables 6-16 and Figs. 8-14.

3. AFETR Class I tracking. The stated minimum requirement for tracking coverage is from SECO to SECO+60 s. Because SECO was the injection point into the parking orbit, this tracking coverage constituted 60 s of the parking orbit.

a. Class I overall coverage. The Class I C-band, VHF, and S-band tracking coverage requirements during the *Pioneer VIII* mission near-earth phase are listed in Table 17.

Table 6. Launch dates and launch windows for Pioneer VIII (Block I)

Date (1967)	Opening of window, GMT	Closing of window, GMT
Dec 13	1408	1442
Dec 14	1409	1438
Dec 15	1411	1430

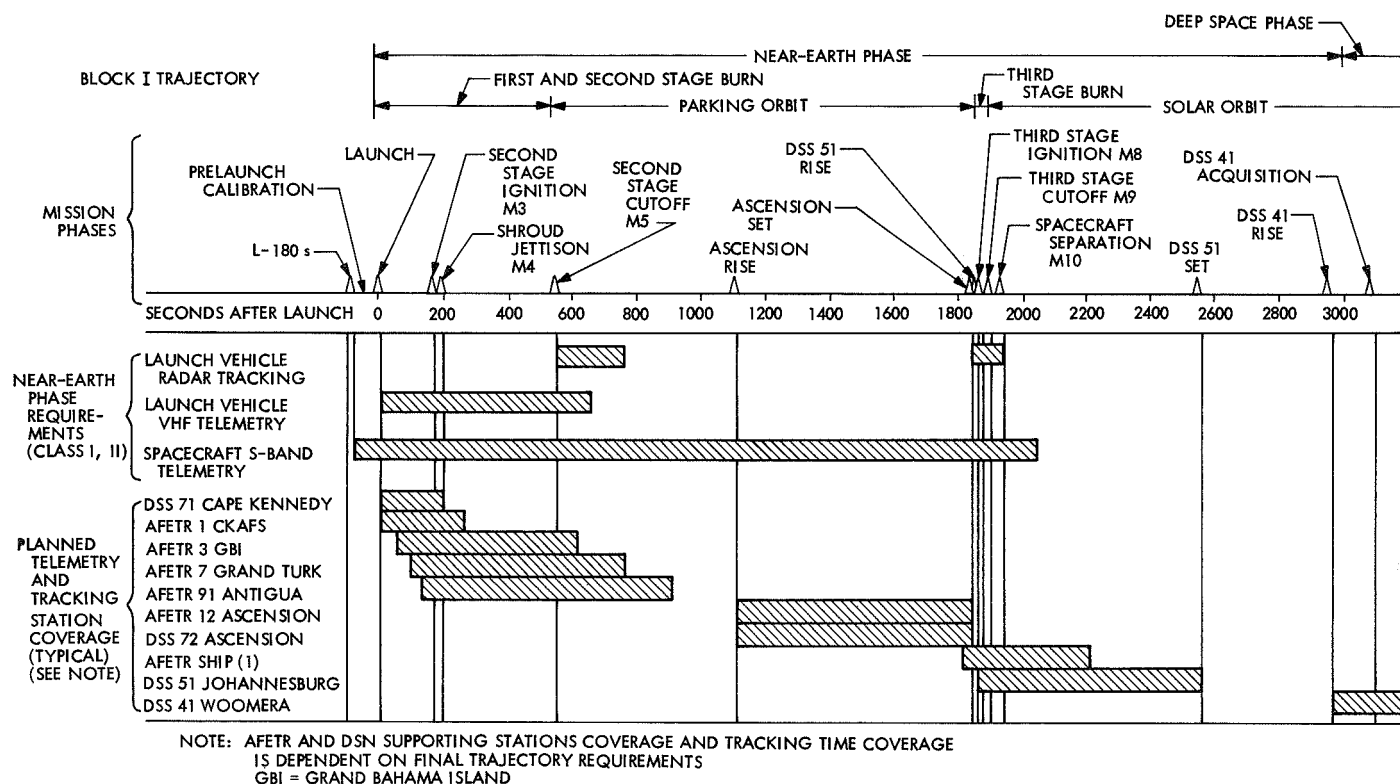


Fig. 7. Pioneer VIII projected near-earth station coverages and tracking time

Table 7. Launch-vehicle and spacecraft event times for Pioneer VIII (Block I)

Mark	Event	Time from liftoff, s
0	Nominal liftoff	0.000
1	Solid motor jettison	70.000
2	Main engine cutoff	149.521
3	Sustainer engine ignition	154.571
4	Shroud jettison	185.521
5	Sustainer engine cutoff	531.761
6	Third-stage spinup	1848.521
7	Second-/third-stage separation	1850.521
8	Third-stage ignition	1863.521
9	Third-stage burnout (injection)	1894.321
10	Third-stage/spacecraft separation	1959.521
11	Spacecraft boom deployment complete	1961.421
	Spacecraft TWT amplifier on	1961.421
	Step 1 orientation initiated	1961.421
	Nominal one-way acquisition	
	Nominal two-way lock	

Table 8. Earth-fixed spherical SECO conditions (zero thrust)

Condition	Parameter
Geocentric radius, km	6758.1347
Geocentric latitude, deg	21.371997
Longitude, deg	297.26885
Earth-relative velocity, km/s	7.2836474
Geocentric path angle of earth-relative velocity, deg	0.9430656
Azimuth angle of earth-relative velocity, deg	117.20589

Table 9. Parking orbit coast time and earth-fixed spherical third-stage ignition conditions

Condition	Parameter
Parking orbit coast time, s	1081.0590
Geocentric radius, km	6869.7345
Geocentric latitude, deg	-14.365844
Longitude, deg	353.23750
Earth-relative velocity, km/s	7.1533305
Geocentric path angle of earth-relative velocity, deg	0.4884320
Azimuth angle of earth-relative velocity, deg	121.88372

Table 10. Launch conditions and third-stage burn data^a

Condition	Parameter
Launch azimuth, deg	108
Location of pad 17-B	
Geocentric radius, km	6373.3390
Geocentric latitude, deg	28.286
Geodetic latitude, deg	28.447
Longitude, deg	279.435
Thrust, lbf	5612.4
Burn time, s	30.80
Propellant weight at ignition, lb	611.9
Total weight at ignition, lb	889.6
Propellant flow rate, lb/s	19.866883
Pitch angle χ , deg	-92.844599
Yaw angle τ , deg	0

^aThe launch conditions define the orientation of the launch plane in which χ and τ are defined.

Table 11. Earth-fixed spherical injection conditions

Condition	Parameter
Geocentric radius, km	6948.6261
Geocentric latitude, deg	-22.503767
Longitude, deg	8.5380811
Earth-relative velocity, km/s	10.301941
Geocentric path angle of earth-relative velocity, deg	0.0026785
Azimuth angle of earth-relative velocity, deg	115.64116

Table 12. Parking orbit elements

Element	Parameter
C_3^a (km/s) ²	-58.34
Semimajor axis, km	6831.8
Eccentricity	0.02147
Inclination to terrestrial equator, deg	32.9
Right ascension of ascending node, deg	90.2
Argument of perifocus, deg	75.4
True anomaly at SECO, deg	62.6
Radius of closest approach, km	6685.2
Period, min/s	93/40

^a C_3 = twice total energy per unit mass.

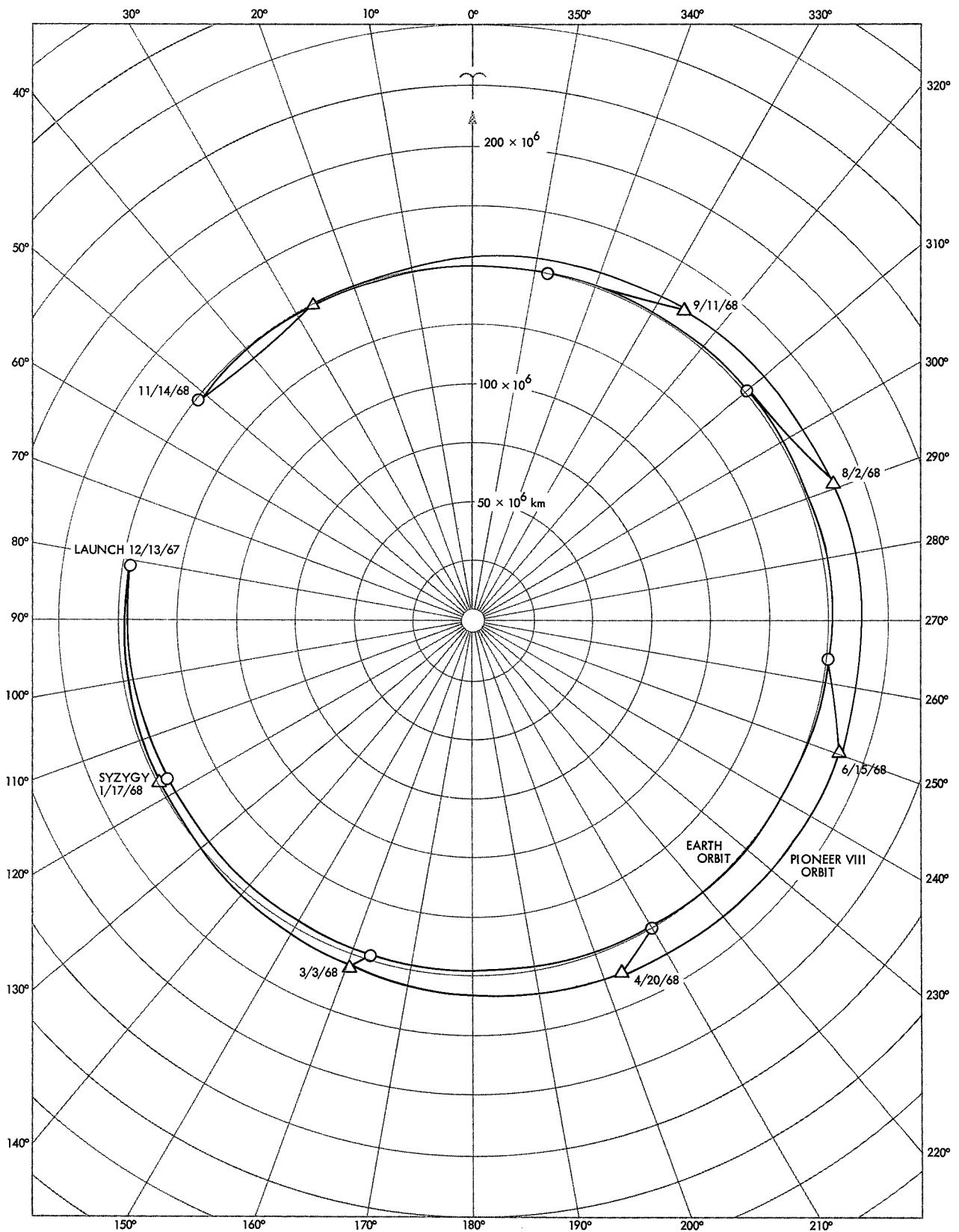


Fig. 8. Ecliptic-plane view of Pioneer VIII and earth

Table 13. Elements of escape hyperbola

Element	Parameter
C_3^a (km/s) ²	0.3164
Semimajor axis, km	-1,260,000
Eccentricity	1.0055
Inclination to terrestrial equator, deg	32.8
Right ascension of ascending node, deg	90.08
Argument of perifocus, deg	224.9
True anomaly at injection, deg	0
Radius of closest approach, km	6948.6

^a C_3 = twice total energy per unit mass.

Table 14. Elements of heliocentric orbit

Element	Parameter
C_3^a (km/s) ²	-849.3
Semimajor axis, km	156,256,000
Eccentricity	0.056
Inclination, deg	0.028
Longitude of perihelion ($\Omega + \omega$), deg	183.6
Epoch of perihelion passage	Dec 19, 1967
Epoch of aphelion passage	July 1, 1968
Period, days	389.9
Perihelion distance, km	147,400,000
Aphelion distance, km	165,100,000

^a C_3 = twice total energy per unit mass.

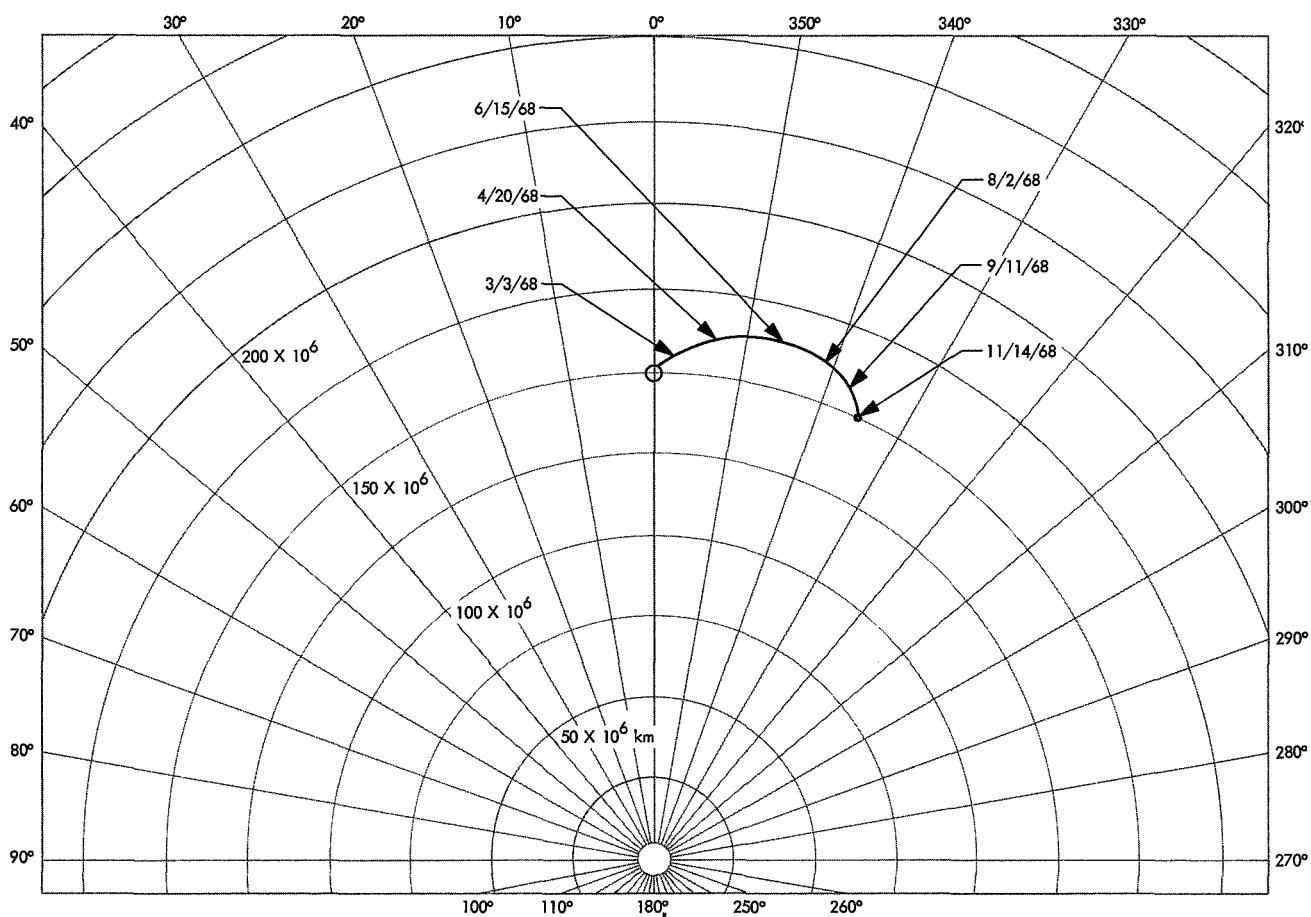


Fig. 9. Pioneer VIII sun-earth line plot

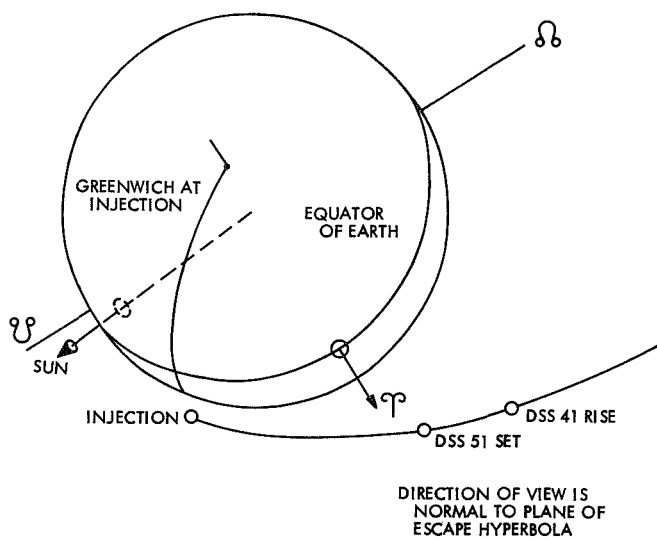


Fig. 10. Near-earth view of escape hyperbola

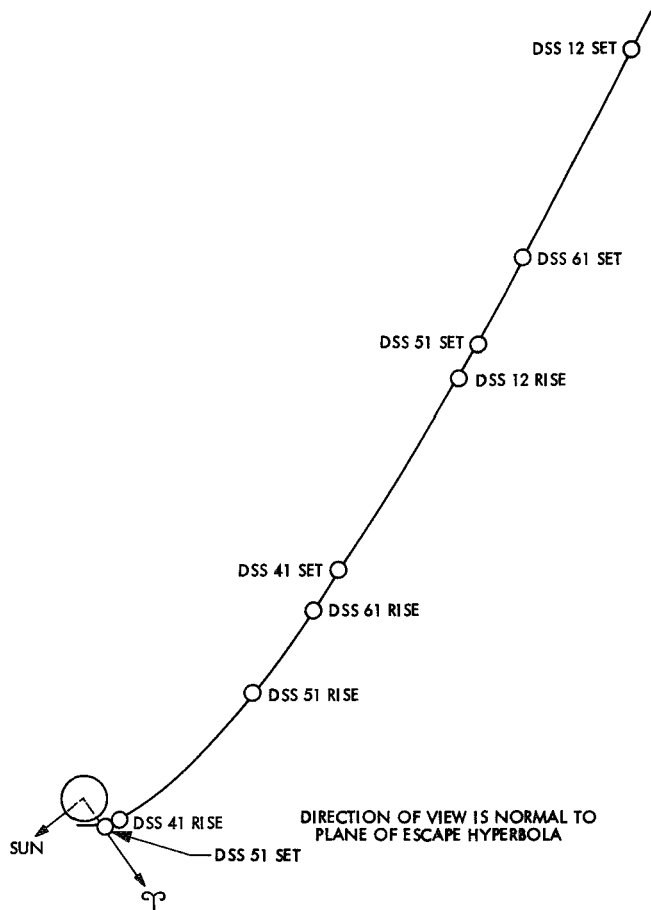


Fig. 11. Escape hyperbola for first day

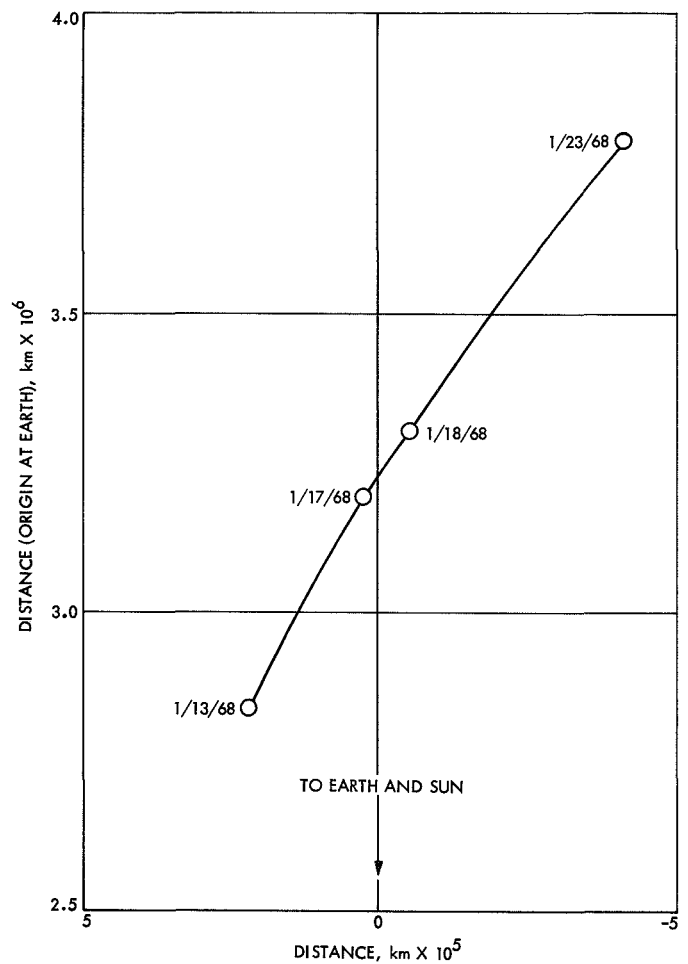


Fig. 12. Sun-earth plot through syzygy

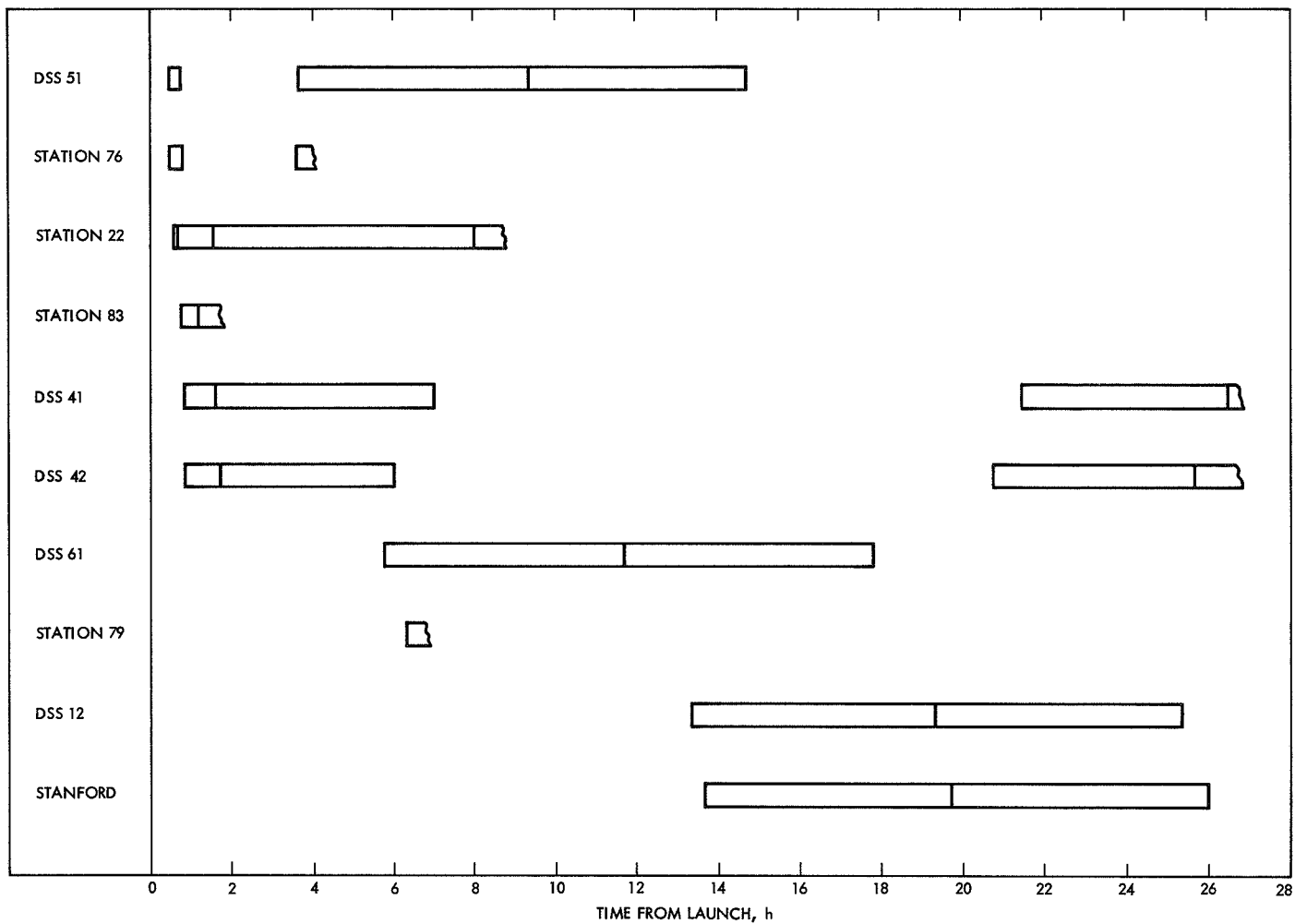


Fig. 13. View-period bar chart for parking-orbit escape trajectories

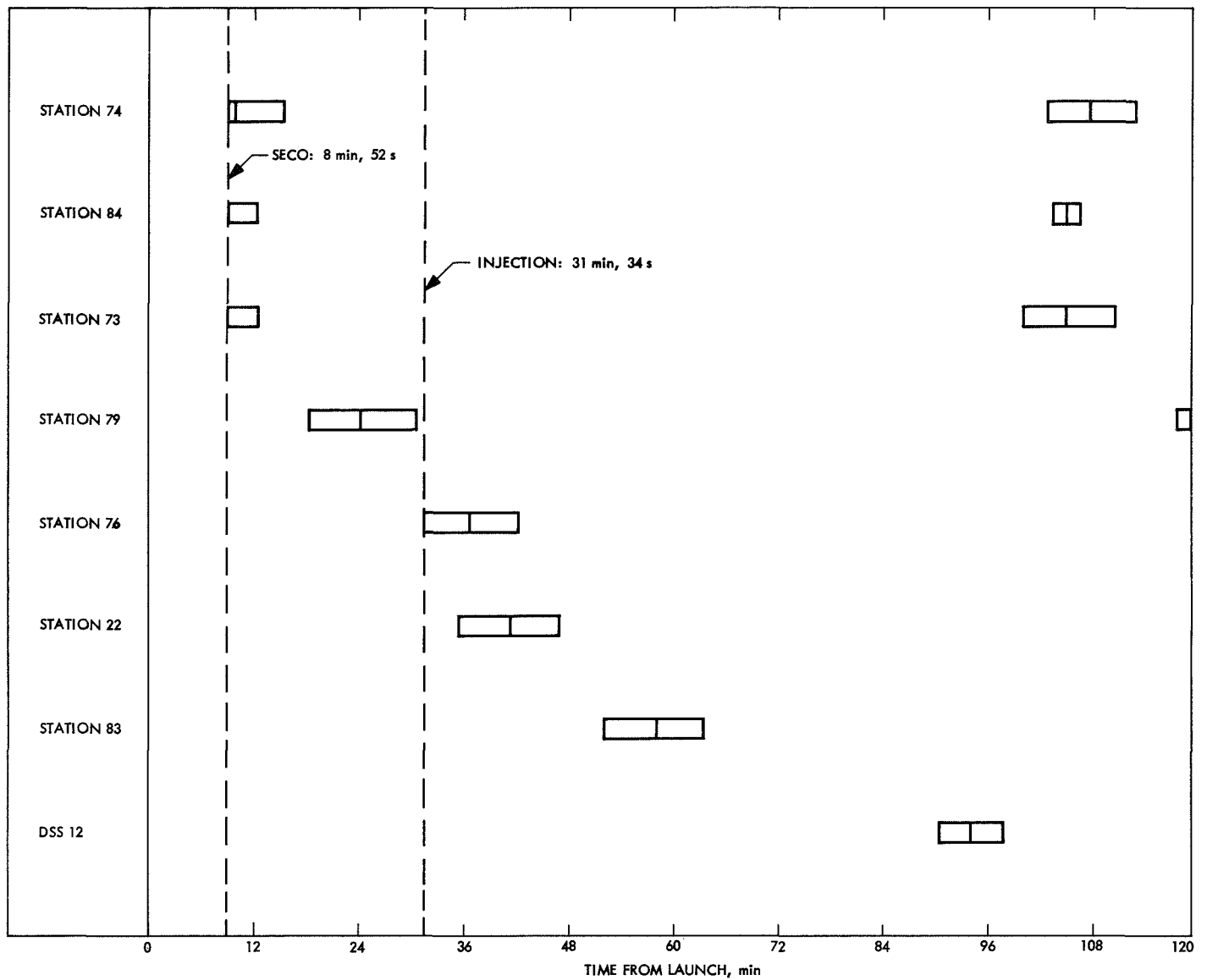


Fig. 14. View-period bar chart for parking orbit and extended parking orbit trajectories

Table 15. Events along parking orbit and escape trajectories

Event number	Station name	Station number	Event	Time from launch		
				h	min	s
①	—	—	SECO	0	08	52
②	Bermuda	84	Set	0	12	02
③	Grand Turk	73	Set	0	12	20
④	Antigua	74	Set	0	15	11
⑤	Ascension	79	Rise	0	18	13
⑥	Ascension	79	Set	0	30	47
⑦	Johannesburg	51	Rise	0	31	18
⑧	Pretoria	76	Rise	0	31	30
⑨	—	—	Injection	0	31	34
⑩	Tananarive	22	Rise	0	34	56
⑪	Johannesburg	51	Set	0	44	00
⑫	Carnarvon	83	Rise	0	44	19
⑬	Pretoria	76	Set	0	48	05
⑭	Woomera	41	Rise	0	49	25
⑮	Canberra	42	Rise	0	52	06
⑯	Pretoria	76	Rise	3	36	05
⑰	Johannesburg	51	Rise	3	39	40
⑱	Madrid	61	Rise	5	47	41
⑲	Canberra	42	Set	6	02	12
⑳	Ascension	79	Rise	6	22	11
㉑	Woomera	41	Set	7	01	13
㉒	Goldstone	12	Rise	13	25	33
㉓	Stanford	—	Rise	13	44	33
㉔	Johannesburg	51	Set	14	47	49
㉕	Madrid	61	Set	17	58	28
㉖	Canberra	42	Rise	20	55	57
㉗	Woomera	41	Rise	21	38	23
㉘	Goldstone	12	Set	25	27	53
㉙	Stanford	—	Set	26	02	08

Table 16. Events along parking orbit and extended parking orbit trajectories

Event number	Station name	Station number	Event	Time from launch		
				h	min	s
①	—	—	SECO	0	08	52
②	Bermuda	84	Set	0	12	02
③	Grand Turk	73	Set	0	12	20
④	Antigua	74	Set	0	15	11
⑤	Ascension	79	Rise	0	18	13
⑥	Ascension	79	Set	0	30	47
⑦	Johannesburg	51	Rise	0	31	18
⑧	Pretoria	76	Rise	0	31	30
⑨	—	—	Injection	0	31	34
10	Tananarive	22	Rise	0	35	49
11	Pretoria	76	Set	0	42	17
12	Tananarive	22	Set	0	47	05
13	Carnarvon	83	Rise	0	52	02
14	Carnarvon	83	Set	1	03	42
15	Goldstone	12	Rise	1	31	00
16	Goldstone	12	Set	1	38	03
17	Grand Turk	73	Rise	1	40	51
18	Antigua	74	Rise	1	43	28
19	Bermuda	84	Rise	1	44	03
20	Bermuda	84	Set	1	47	09
21	Grand Turk	73	Set	1	51	08
22	Antigua	74	Set	1	53	51
23	Ascension	79	Rise	1	58	13

b. *C-band tracking.* The C-band tracking coverage requirements in support of the *Pioneer VIII* mission are presented, along with the VHF and S-band telemetry requirements, in Table 17. The parking and transfer-orbit coverages are shown in Fig. 15.

c. *VHF telemetry.* The VHF telemetry coverage requirements in support of the *Pioneer VIII* mission are listed, along with the C-band radar and S-band telemetry requirements, in Table 17. The parking and transfer-orbit coverages are shown in Fig. 16.

d. *S-band telemetry.* The S-band telemetry coverage requirements in support of the *Pioneer VIII* mission are presented, along with the C-band radar and VHF telemetry requirements, in Table 17.

e. *Computed data.* The overall tracking coverage data provided to the RTCF at the AFETR (see Table 17) was intended to provide the following:

- (1) Parking-orbit elements and injection conditions and interrange vector (IRV) based on actual parking orbit C-band radar tracking data.

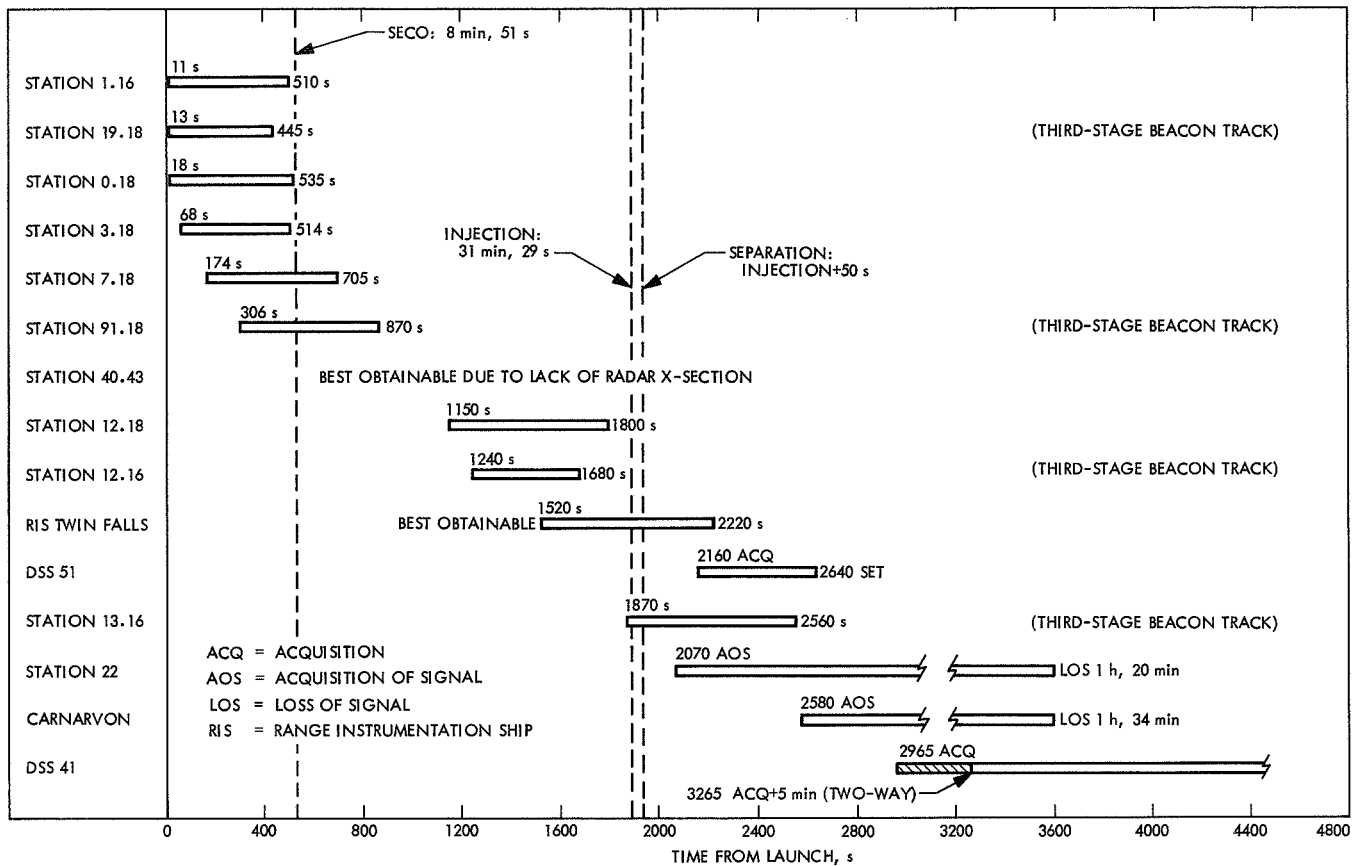


Fig. 15. Parking and transfer-orbit coverages, Block I—C-band radar

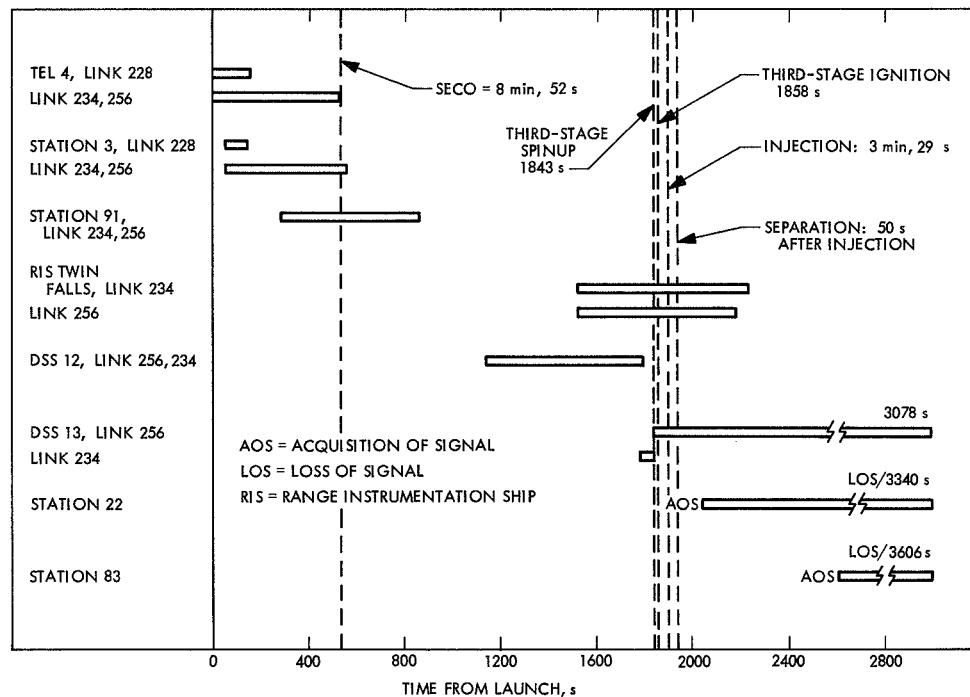


Fig. 16. Parking and transfer-orbit coverages, Block I—VHF telemetry

Table 17. Class I tracking requirements

Data type	Coverage interval
C-band radar	SECO to SECO + 60 s ^a Third-stage ignition through third-stage burn-out Third-stage burnout to third-stage-spacecraft separation ^a
VHF telemetry	Second stage Launch — 2 min to SECO Third-stage spinup through third-stage separation Third stage Spinup — 30 s through spacecraft separation
S-band telemetry	Shroud separation to second-stage cutoff + 120 s Third-stage spinup to third-stage-spacecraft separation
^a Data to be transmitted to JPL/AFETR within 30 min.	

- (2) Theoretical solar-orbit elements and injection conditions and IRV based on parking-orbit and nominal third-stage performance.
- (3) Deep Space Station predicts for DSSs 51 and 41 based on parking-orbit and nominal third-stage performance.
- (4) Actual solar-orbit elements and injection conditions and IRV based on postsolar-orbit-injection C-band radar tracking data.
- (5) Deep Space Station predicts for DSS 41 based on actual solar orbit.
- (6) Actual solar-orbit elements and injection conditions and IRV based on Deep Space Station tracking data.
- (7) Deep Space Station predicts for any Deep Space Station (and possibly Stanford) based on actual solar orbit, if required.
- (8) I-matrix for use as inputs for Type II orientation-maneuver computation at ARC, if required.

4. AFETR station support. The minimum facilities that must have a *go* status for the TDS to meet Project requirements are listed below.

a. Tracking.

- (1) Antigua or Grand Turk radar.

- (2) RIS *Pretoria* or *Twin Falls* radar.¹
- (3) Tracking data link (from radar support to RTCF).
- (4) RTCF or flight-path analysis and command (FPAC) and RTCF reformat capability.

b. Communications.

- (1) One voice and TTY from RTCF to JPL (Building AO, Cape Kennedy, Fla.).
- (2) One voice and TTY to SFOF from each of the following:
 - (a) JPL (Building AO).
 - (b) DSS 71.
 - (c) DSS 41.
 - (d) DSS 51 or 62.
 - (e) DSS 12 or 11 (required in case of spacecraft-earth orbit).

c. Deep Space Network.

- (1) DSS 41 in a *go* status.
- (2) DSS 51 or 62 in a *go* status.
- (3) DSS 12 or 11 in a *go* status.
- (4) DSS 71 spacecraft frequency reports: at least one frequency measurement before $L - 30$ min on launch day.

d. Telemetry.

- (1) S-band: Grand Bahama Island and Antigua or Tel 4 and Grand Bahama Island.
- (2) RIS *Twin Falls* or *Pretoria*.
- (3) VHF: RIS *Twin Falls* or *Pretoria*.

e. Tracking data. The *Pioneer* Project requirements for tracking data during the near-earth phase are for data to establish the orbit and the normalcy of spacecraft solar injection in real-time, as well as for launch-vehicle evaluation. These requirements are satisfied by tracking the third stage. Because the separation velocity is small, tracking of the third stage, both before and after separation, is very valuable in determining an early spacecraft orbit.

¹These postsolar orbit-injection tracking data would allow the DSN to commit to acquiring the *Pioneer VIII* spacecraft on any trajectory. If not available, the DSN would commit *only* to a nominal trajectory.

Different elements of the TDS also require tracking data to prepare acquisition and prediction data for their tracking stations. Prediction data, based upon normal launch-vehicle performance, are furnished to all stations prior to launch. However, prediction data based upon actual launch-vehicle performance are used during initial acquisition by all stations, particularly if the trajectory is substantially different from nominal.

The tracking data supplied by the uprange AFETR and MSFN radars are processed by the RTCF at the AFETR. Station predicts are generated in real-time for the AFETR, MSFN, and Deep Space Stations farther downrange. In addition, the AFETR forwards the tracking data directly to GSFC for use in generating prediction data for the MSFN stations. These data are also relayed to the SFOF for use with DSN data in calculating the spacecraft orbit.

f. Retransmission. The MSFN was to transmit Carnarvon tracking data to the AFETR. The AFETR was to retransmit its own raw tracking data, along with those of the MSFN stations, to the SFOF at Pasadena in near-real-time.

g. Coverage. The Project requirements for tracking the launch vehicle during the near-earth phase are summarized in Tables 18 and 19.

Table 18. Pioneer VIII Project requirements for launch-vehicle tracking

Class I	Class II
From SECO to SECO + 60 s	From SECO to SECO + 180 s
Third-stage burnout to third-stage-spacecraft separation	
Delivery requirements	
Data transmitted to JPL/AFETR within 30 min	Data transmitted in real-time

Table 19. GSFC requirements for launch-vehicle tracking

Class I	Class II
Third-stage ignition through third-stage burnout	After SECO until third-stage ignition, when redundant radar track is available

h. Telemetry data.

Data requirements. Requirements have been placed upon various elements of the TDS to receive and record spacecraft and launch-vehicle telemetry during the near-earth phase.

Retransmission. Launch-vehicle telemetry, received by downrange AFETR and MSFN stations, is required to be retransmitted during the third-stage burn.

Coverage. Table 20 lists the launch-vehicle and spacecraft telemetry coverage requirements.

Mark events. The Deep Space Network requires mark event time reports from the AFETR and the MSFN.

i. Support. The ability to satisfy the near-earth phase tracking and telemetry requirements is strongly dependent upon the characteristics of the trajectory and the capabilities of the TDS facilities during this phase. The most dominant trajectory characteristic is the change of location of the transfer-orbit injection as the mission moves from Block I to Block II for launch. Had the launch been deferred to later Blocks, the injection location would have moved uprange slightly. This would result in the inability of either Pretoria or Ascension to provide good injection tracking data for Blocks II, III, and IV.

5. Real Time Computing Facility. The requirements of the RTCF are as follows:

- (1) At least single-station raw C-band radar tracking data from SECO (parking-orbit injection) to SECO + 60 s in decimal-data format.²
- (2) Raw C-band radar tracking data from third-stage burnout (solar-orbit injection) to third-stage-spacecraft separation in decimal-data format.²

²Minimum requirement for the SFOF to back up the RTCF during the Pioneer VIII launch.

Table 20. GSFC coverage requirements for launch-vehicle telemetry

Class I	Class II
Prelaunch calibrations	Launch — 2 min through spacecraft separation
From launch — 2 min to SECO	

- (3) Parking-orbit elements and injection conditions and IRV based on actual parking-orbit C-band radar tracking data.
- (4) Theoretical solar-orbit elements and injection conditions and IRV based on parking orbit and on nominal third-stage performance.
- (5) Deep Space Station predicts for DSSs 51 and 41 based on parking orbit and on nominal third-stage performance.
- (6) Actual solar-orbit elements and injection conditions and IRV based on postsolar-orbit-injection C-band radar tracking data.
- (7) Deep Space Station predicts for DSS 41 based on actual solar orbit.
- (8) Actual solar-orbit elements and injection conditions and IRV based on Deep Space Station tracking data.
- (9) Deep Space Station predicts for any Deep Space Station (and possibly Stanford) based on actual solar orbit, if required by FPAC director.³
- (10) I-matrix for use as inputs for Type II orientation-maneuver computation done at ARC, if required by FPAC director.³

The RTCF was able to complete all of the above support requirements by $L+4$ h.

6. Data processing support. It was mandatory that the CDC 3600 computers at the RTCF be operational to enable the AFETR to prepare Deep Space Station predicts. These computers processed the raw tracking data and computed the parking-orbit elements, the solar-orbit elements (based on a normal third-stage burn), and the predicts.

The purpose of the CDC 3100 computer for JPL support was the conversion of octal raw tracking data into a decimal format before data transmittal to JPL. This enabled FPAC personnel at JPL to visually evaluate the data in real-time. Because this was a recent improvement in the AFETR-JPL interface, JPL still had the capability to receive and process octal data; consequently, it was not considered mandatory that the CDC 3100 computer be available to support the launch.

³Required only if the DSN FPAC team were to encounter major problems.

7. Near-earth phase trajectory characteristics. Real-time flight analysis of the near-earth phase of the flight, as well as during the prelaunch countdown, was facilitated by the ready access to data pertaining to the launch window and trajectory.

To present a clear composite picture of the near-earth phase of the station coverages in relation to flight events and coverage requirements, an earth track of the trajectory up to about the first 26 h from launch is plotted in Fig. 17; see Table 15 for events denoted by circled numbers. An elevation constraint of 0 deg was established for the AFETR stations and 5 deg for the Deep Space Stations.

8. MSFN station support.

a. C-band tracking. The C-band radars at Tananarive, Carnarvon, and Hawaii were required to beacon-track the second and third stages. Tananarive was committed on a "best-obtainable" basis. All stations were to provide real-time data, magnetic tape recordings of high-speed data, and verbal confirmation of the Greenwich Mean Time of acquisition of signal (AOS) and loss of signal (LOS) to the MSFN controller.

Tananarive.

- (1) During revolution 1, beacon tracking of third stage on a best-obtainable basis from AOS to LOS.
- (2) Real-time transmission of low-speed data in standard 38-character radar data format to RTCF at AFETR.
- (3) Verbal confirmation in real-time of GMT of AOS and LOS to MSFN controller.
- (4) Magnetic tape recordings, strip-chart recordings, and postlaunch instrumentation message (PLIM) data sheets.

Carnarvon.

- (1) During revolution 1, beacon tracking of third stage on a best-obtainable basis from AOS until directed to switch track to second stage.
- (2) When directed, switch and beacon-track second stage to LOS.
- (3) Real-time transmission of low-speed data to GSFC for reformatting and retransmission to RTCF at AFETR.

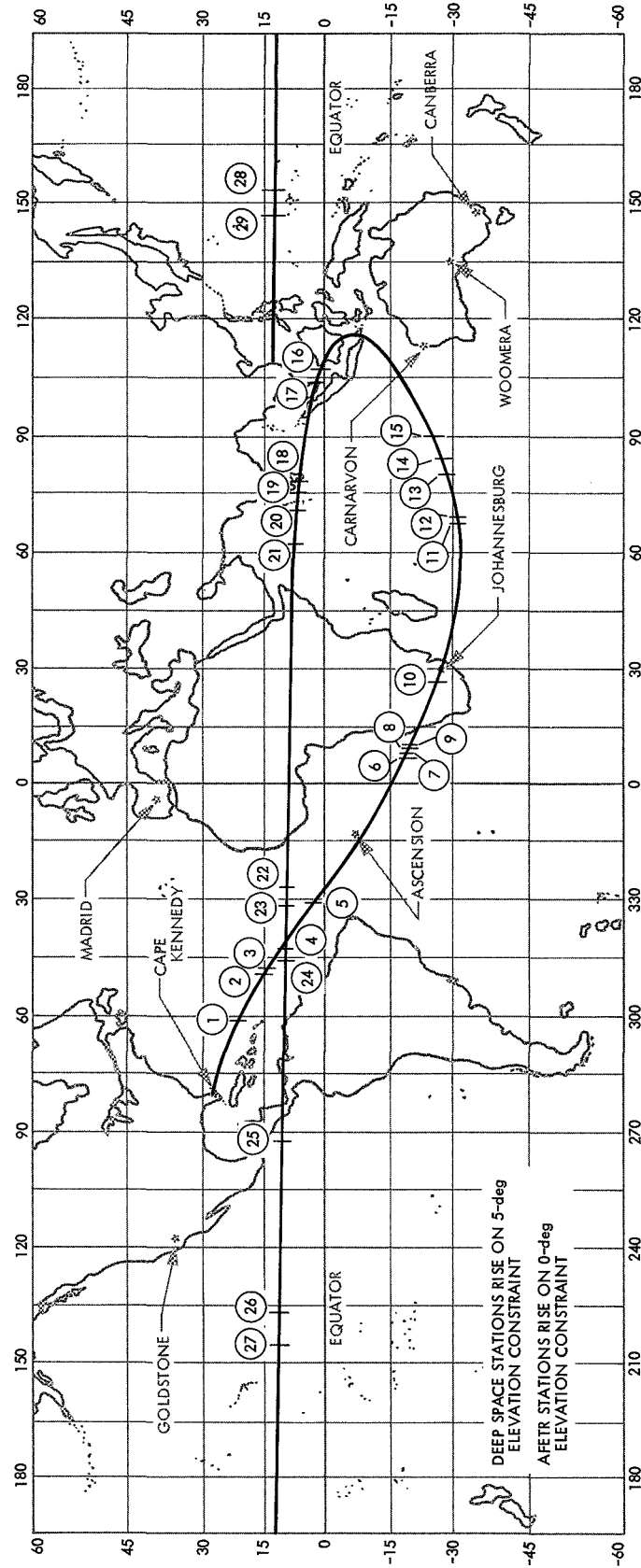


Fig. 17. Earth track of powered-flight trajectory, parking orbit, and escape orbit (Block I)

- (4) Verbal confirmation in real-time of GMT of AOS and LOS to MSFN controller.
- (5) Magnetic tape recordings, strip-chart recordings, and PLIM data sheets.

Hawaii.

- (1) During revolution 1, beacon tracking of second stage from AOS to LOS.
- (2) Real-time transmission of low-speed data in standard 38-character radar data format to RTCF at AFETR.
- (3) Verbal confirmation in real-time of GMT of AOS and LOS to MSFN controller.
- (4) Magnetic tape recordings, strip-chart recordings, and PLIM data sheets.

b. VHF telemetry. The MSFN stations at Bermuda, Tananarive, Carnarvon, Guam, Hawaii, and Guaymas, as well as portions of NASCOM and the GSFC-AFETR interface at Cape Kennedy, were to support the *Pioneer VIII* mission.

Coverage of the second-stage 234.0-MHz link for receiving, decommutating, and recording was required of all stations. Tananarive was to provide support on a best-obtainable basis during revolution 1. In addition, Bermuda was to provide a real-time readout of mark event 5 (SECO).

All stations were to provide verbal confirmation in real-time of the GMT of AOS and LOS to the MSFN controller. Retransmission of telemetry data was required of Tananarive and Carnarvon during the third-stage burn.

Bermuda.

- (1) Receive, decommutate, and record second-stage 234.0-MHz link from AOS to LOS during revolution 1.
- (2) Receive and record third-stage 256.2-MHz link from AOS to LOS on revolution 1.
- (3) Provide real-time readout of mark event 5 (SECO).
- (4) Teletype confirmation of mark event 5 time of occurrence in GMT.
- (5) Verbal confirmation in real-time of GMT of AOS and LOS to MSFN controller.

- (6) Magnetic tape recordings, strip-chart recordings, and PLIM data sheets.

Tananarive.

- (1) Receive and record second-stage 234.0-MHz link from AOS to LOS during revolution 1 on a best-obtainable basis.
- (2) Receive and record second-stage 234.0-MHz link from AOS to LOS during revolution 2.
- (3) Receive, demodulate, and record third-stage 256.2-MHz link from AOS to LOS during revolution 1 on a best-obtainable basis.
- (4) Retransmit specified telemetry data to Building AE at AFETR.
- (5) Verbal confirmation in real-time of GMT of AOS and LOS to MSFN controller.
- (6) Magnetic tape recordings, strip-chart recordings, and PLIM data sheets.

Carnarvon.

- (1) Receive, demodulate, and record second-stage 234.0-MHz link from AOS to LOS during revolution 1.
- (2) Receive and record third-stage 256.2-MHz link from AOS to LOS during revolution 1 on a best-obtainable basis.
- (3) Retransmit specified telemetry data to Building AE at AFETR.
- (4) Verbal confirmation in real-time of GMT of AOS and LOS to MSFN controller.
- (5) Magnetic tape recordings, strip-chart recordings, and PLIM data sheets.

Guam.

- (1) Receive and record second-stage 234.0-MHz link from AOS to LOS during revolution 1.
- (2) Verbal confirmation in real-time of GMT of AOS and LOS to MSFN controller.
- (3) Magnetic tape recordings and PLIM data sheets.

Hawaii.

- (1) Receive and record second-stage 234.0-MHz link from AOS to LOS during revolution 1.

- (2) Verbal confirmation in real-time of GMT of AOS to MSFN controller.
- (3) Magnetic tape recordings and PLIM data sheets.

Guaymas.

- (1) Receive and record second-stage 234.0-MHz link from AOS to LOS during revolution 1.
- (2) Verbal confirmation in real-time of GMT of AOS and LOS to MSFN controller.
- (3) Magnetic tape recordings and PLIM data sheets.

c. Computer support. The requirements levied on GSFC with respect to computer support were as follows:

- (1) Provide pointing data printouts to be used for mission planning and for committing MSFN station coverage.
- (2) Generate and transmit nominal pointing data to participating MSFN stations.
- (3) Receive launch-trajectory data from AFETR via Launch Trajectory Data System.
- (4) Generate radar-simulation tapes for Tananarive, Carnarvon, and Hawaii.
- (5) Use launch-trajectory data to drive displays at GSFC operations control center.
- (6) Generate and transmit real-time acquisition messages to participating MSFN stations based on second- and third-stage data.
- (7) Reformat Carnarvon radar data to standard 38-character radar data format for transmission to RTCF at AFETR.

9. JPL/AFETR operational support. The JPL/AFETR field station located at Cape Kennedy was to support the launch operations of *Pioneer VIII* by providing the necessary operational interfaces between the DSN and SFOF in Pasadena and the AFETR and other Project elements at the AFETR. This operational interface comprised the following activities:

- (1) Monitoring and keeping the DSN Project engineer informed of the status of AFETR stations, ships, and equipment; progress through the countdown; and the occurrence and time of in-flight events.
- (2) Providing liaison between the FPAC group and AFETR Real Time Computing Facility through the JPL data coordinator.

- (3) Receiving and retransmitting (to the SFOF) AFETR metric data and computed data, including injection conditions, orbital elements, and DSIF acquisition information.
- (4) Relaying spacecraft telemetry data from DSS 71 to the SFOF and to Building AM.
- (5) Receiving from the SFOF, and retransmitting to Building AM, spacecraft telemetry data from DSS 51.

In addition to the launch-phase operations, the field station participated in the prelaunch integration tests and operational readiness tests. These tests essentially duplicated the launch-phase activity, with operations simulated where necessary.

10. Deep Space Network. The nominal DSIF acquisition procedure consists of pointing the S-band acquisition-aid (SAA) antenna 10 deg above the horizontal in the direction of the nominal trajectory (called point A). If the spacecraft is not acquired by the time the spacecraft should be at point A, a search pattern is initiated, which causes the SAA antenna to move in turn to points B, C, D, and E, and finally back to the nominal trajectory (point F). This search pattern is illustrated in Fig. 18; angles and times are listed in Table 21.

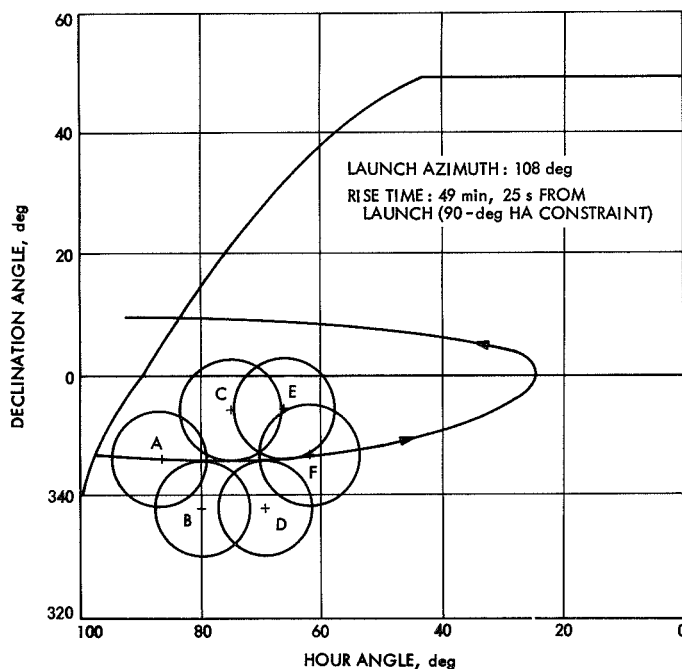


Fig. 18. Pioneer VIII Block I trajectory nominal DSS 41 acquisition search pattern

Table 21. Pioneer VIII Block I trajectory nominal DSS 41 acquisition search pattern

Point	Hour angle, deg	Declination, deg	Time to leave, min:s
A	86.9	345.9	50:13
B	79.6	337.6	52:13
C	74.8	353.6	53:43
D	69.5	337.8	55:13
E	66.1	354.1	56:43
F	62.1	346.5	58:13
"G"	24.1	000.1	120:00

The 3σ dispersions provided by the *Pioneer* Project Office were used to perturb the nominal trajectory $\pm 3\sigma$ for all six injection parameters, providing 13 separate predict cases (1 nominal and 12 perturbed cases).

Worst cases were also obtained by selecting the ± 1 , 2, or 3 dispersions in radius, latitude, longitude, inertial velocity, inertial path angle, and inertial azimuth angle that would provide the worst combined effect upon the rise azimuth and rise time at DSS 41.

The acquisition study consisted of determining whether the twelve 3σ dispersions and the four worst-case dispersions all fell within the DSS 41 SAA antenna 8-deg half-beamwidth when the antenna was pointed at points A, B, C, D, E, and F, respectively. All sixteen dispersed cases (twelve 3σ cases and four worst cases) fell within the 8-deg SAA antenna beamwidth when the antenna was pointed at points A and F. Since points B, C, D, and E were selected along the nominal trajectory, at 8-deg beamwidth off the nominal trajectory, the nominal and none of the 16 dispersed cases were within the beams at these times, as shown in Fig. 19.

It should not necessarily be concluded, however, that these points should be changed because the dispersed cases are within the nominal (although very improbable) performance of a launch vehicle. Points B, C, D, and E would, therefore, be able to intercept some of the off-nominal (outside the 3σ) dispersions that could occur in case of a launch-vehicle malfunction.

Another point "G" was selected at the "turning point" in the trajectory, where the spacecraft motion changes

from easterly to westerly motion in reference to the earth. The "dwell time" of the spacecraft is considerable; if the spacecraft had not been acquired by launch+75 min, the SAA antenna would have been pointed at point "G" (a point at 120 min from launch at 24.1 deg HA and 000.1 deg dec).

The nominal trajectory would spend 100 min within 8-deg half-beamwidth of the SAA antenna. All of the 3σ dispersions spend about 90 min in the SAA antenna beam at point "G," and even the worst cases spend an hour in this region.

11. DSN requirements vs constraints. This subsection details the DSN requirements and constraints for each facility supporting the *Pioneer VIII* launch. Table 22 lists the DSN launch requirements and constraints.

a. Near-earth trajectory.

DSN Class II requirements:

- (1) Sixty seconds of posttransfer (solar) orbit-injection tracking data.⁴
- (2) RTCF in a *go* status.
- (3) FPAC team in a *go* status, as outlined in FPAC checklist.

DSN constraints:

- (1) Sixty seconds of postparking orbit-injection tracking data.
- (2) RTCF or FPAC team in a *go* status.

b. Communications. The DSN near-earth phase launch communications requirements are shown in Fig. 20.

B. Pioneer VIII Deep Space Phase Requirements

Since the requirements placed upon the DSN systems are in support of the DSN commitments to the *Pioneer* Project, it is appropriate to list and describe these basic

⁴Sixty seconds of posttransfer (solar) orbit-injection tracking data would allow the DSN to commit to acquiring the *Pioneer VIII* spacecraft on any trajectory. If the 60 s of data were not available, the DSN would be able to commit only to acquiring the spacecraft on a nominal trajectory. This is defined as any trajectory within the launch-vehicle 3σ injection dispersion ellipses provided by the *Pioneer* Project Office.

Table 22. DSN launch requirements and constraints

Class I requirements	Class II requirements	Launch constraints
DSS 71 spacecraft frequency reports: daily from L-8 to L-1 day and at L-90, L-30, and L-5 min	DSS 71 spacecraft frequency reports (see facility checklist): daily from L-8 to L-1 day and at L-90, L-30, and L-5 min on launch day	DSS 71 spacecraft frequency reports (see facility checklist): at least four frequency measurements between L-8 and L-1 day and at least one frequency measurement before L-30 min on launch day
DSS 41 able to provide tracking, telemetry, and command support during initial acquisition and subsequent passes	DSS 41 in a go status (see facility checklist)	DSS 41 in a go status (see facility checklist)
DSS 51 or 62 able to provide tracking, telemetry, and command support	DSSs 51 and 62 in a go status (see facility checklist)	DSS 51 or 62 in a go status (see facility checklist)
DSS 12 or 11, with microwave communications from DSS 11 to Pioneer GOE ^a at DSS 12, able to provide tracking, telemetry, and command support	DSSs 12 and 11 in a go status ^b (see facility checklist)	DSS 12 or 11 in a go status ^c (see facility checklist)

^aGOE = ground operational equipment.

^bDSS 11 has an acquisition-aid antenna (SAA) and DSS 12 does not; therefore, DSS 11 should have a better chance to sequence a spacecraft in an earth orbit.

^cRequired in case spacecraft should remain in earth orbit.

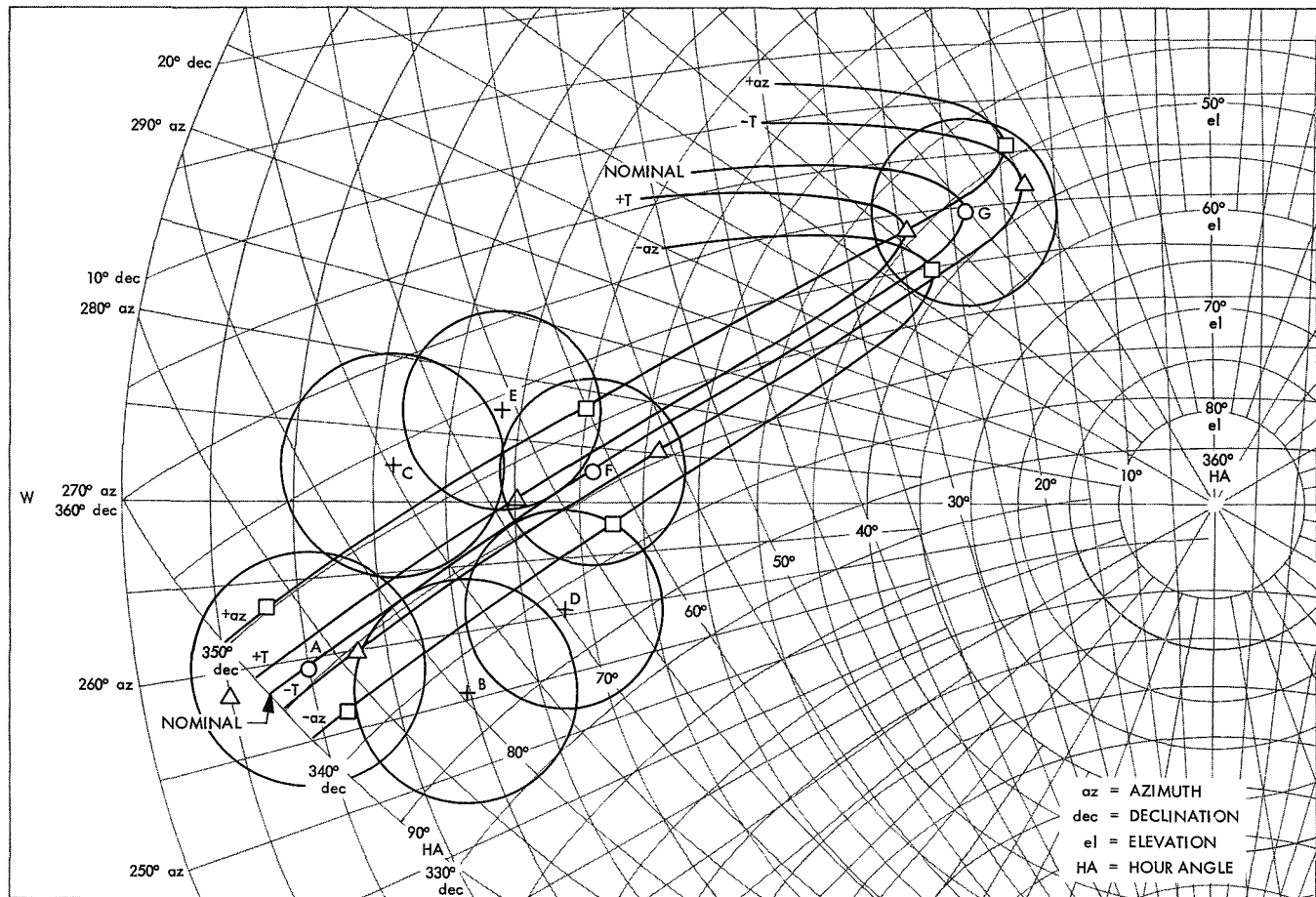


Fig. 19. Pioneer VIII Block I trajectory nominal and worst-case dispersions

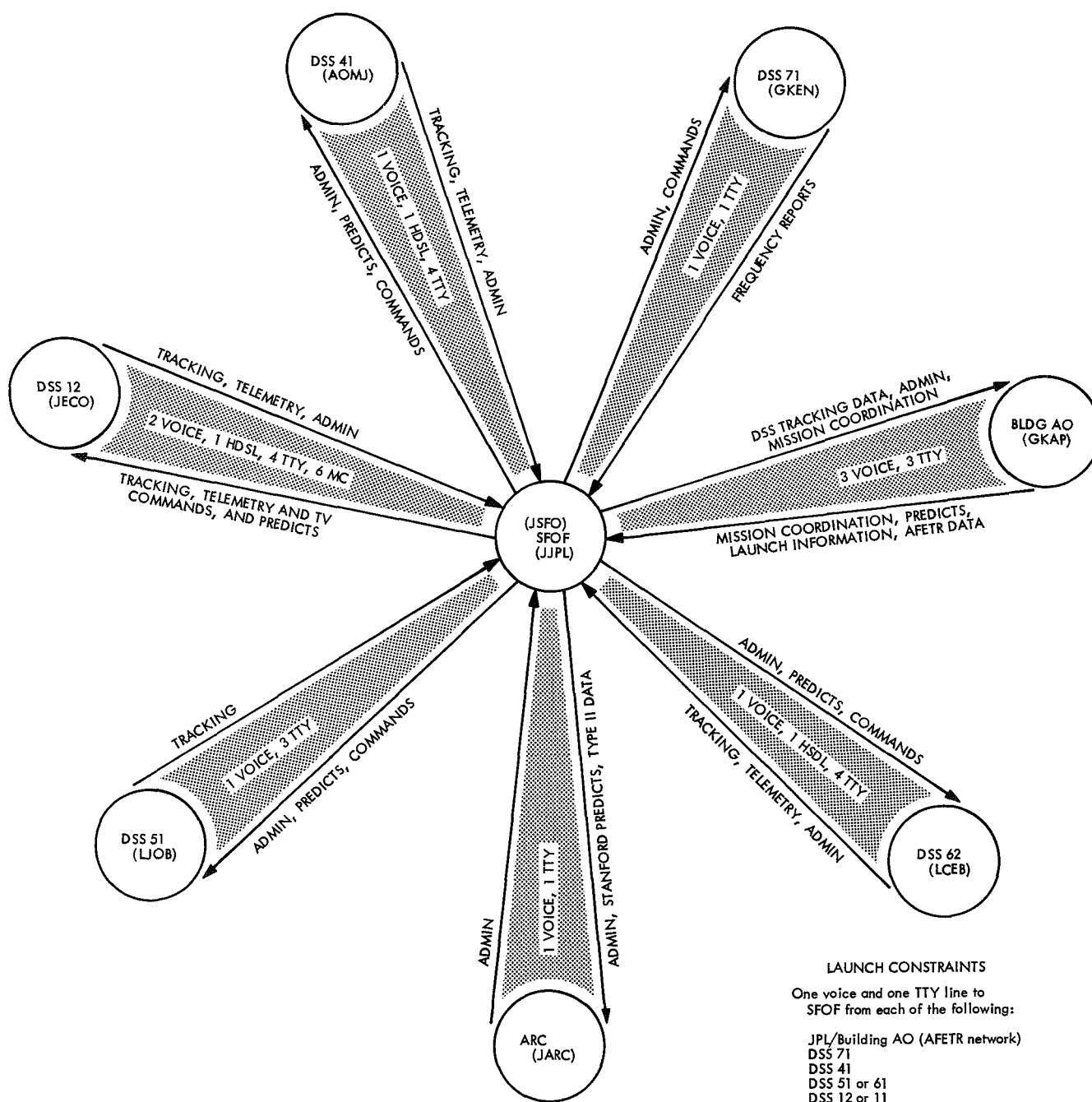


Fig. 20. Launch communications requirements

commitments. The DSN stations assigned for the *Pioneer VIII* mission are as follows:

Station	Location
DSS 12	<i>Echo</i> Station, Goldstone, Calif.
DSS 62	Cerebros, Spain
DSS 41	Woomera, Australia
DSS 51	Johannesburg, South Africa (when available)
DSS 71	Cape Kennedy, Fla.

The DSN sites that supported the *Pioneer VIII* mission are DSSs 12, 41, and 62 (also DSS 51, as available). Full coverage was scheduled for the first 50 days of the mission. This met the requirements for full coverage during the first 30 days and for full coverage from -5 to $+15$ days at *syzygy* (expected at $L+35$ days).

The trajectory was such that, during the initial pass over DSS 51, the tracking rates were too high for the station to lock on to the spacecraft (except for possibly the last 5 or 6 min of the view period). Therefore, DSS 41 was to be the prime acquisition station. It was expected that DSS 42 would act as a backup for DSS 41. Project requested DSS 41 not to go into two-way lock until approval had been received from the Space Flight Operations Director (SFOD), which would occur approximately 5 min after initial acquisition. Thus, the coverage plan was as listed in Table 23.

1. DSN launch requirements.

- (1) DSS 71 spacecraft frequency reports: daily from $L-8$ to $L-1$ day and at $L-90$, $L-30$, and $L-5$ min.
- (2) Woomera (DSS 41) able to provide tracking, telemetry, and command support during initial acquisition and subsequent passes.
- (3) Johannesburg (DSS 51) or Cerebros (DSS 62) able to provide tracking, telemetry, and command support.
- (4) Goldstone *Echo* (DSS 12) or *Pioneer* (DSS 11), with microwave communications from DSS 11 to the *Pioneer* GOE at DSS 12, able to provide tracking, telemetry, and command support.

Table 23. Station coverage plan

Station	Pass	Metric data
DSS 51	0	No two-way data
DSS 41	1	One-way to rise $+5$ min; two-way from rise $+5$ min on
DSS 42	1	One-way only (backup to DSS 41)
DSS 51	1	Two-way
DSS 62	1	Three-way if DSS 51 tracking (two-way if DSS 51 not tracking)

a. Class I.

- (1) DSS 71 spacecraft frequency reports: at least four frequency measurements between $L-8$ and $L-1$ day and at least one frequency measurement before $L-30$ min on launch day.
- (2) DSS 41 in a *go* status (see DSS 41 checklist).
- (3) DSS 51 or 62 in a *go* status.
- (4) DSS 12 or 11 in a *go* status.

b. Class II.

- (1) DSS 71 spacecraft frequency reports: daily from $L-8$ to $L-1$ day and at $L-90$, $L-30$, and $L-5$ min on launch day.
- (2) DSS 41 in a *go* status (see DSS 41 checklist).
- (3) DSSs 51 and 62 in a *go* status.
- (4) DSSs 12 and 11 in a *go* status.

2. Deep Space Instrumentation Facility.

a. *Equipment.* The following equipment was operational at the committed Deep Space Stations:

- (1) Project-dependent equipment, consisting of command encoder, demodulator-synchronizer, and computer buffer.
- (2) Exciter.
- (3) Transmitter.
- (4) Receiver.
- (5) Modulator.
- (6) Diplexer.
- (7) SAA antenna system.

- (8) S-band cassegrainian monopulse (SCM) antenna system.
- (9) Maser.
- (10) FR-1400 tape recorders.
- (11) SDS-910 computer.
- (12) Frequency and timing system.

b. Data validation. The functions of the Deep Space Stations in support of space missions are listed in Table 24.

c. Quality control of data.

Metric data. Metric data monitoring for the *Pioneer* Project was conducted in the following three phases:

- (1) Phase 1: L to $L+3$ days.
- (2) Phase 2: $L+3$ to $L+30$ days.
- (3) Phase 3: $L+30$ days to end of nominal mission.

Data monitoring was performed during each of these phases as outlined in Table 25.

Tracking data were monitored continuously in near-real-time at the Goldstone computer facility during Phase 1 only. Data were monitored for high-frequency noise and compared with predicted data using the Goldstone prediction and monitor programs. The orbit determination program was used to validate tracking data for the Project within the SFOF during all phases.

The purpose of near-real-time readouts at the Goldstone computer facility was to monitor the metric data and provide near-real-time performance feedback to the DSN stations during critical periods.

Telemetry data. Telemetry data monitoring, on a random basis, was to be performed by the operator at the DSN station as diagrammed in Fig. 21. The nonreturn-to-zero computer (NRZ-C) data and sync status from both the *Pioneer* GOE and the reproduce head of the FR-1400 tape recorder were to be recorded on the Consolidated Electrodynamics Corporation (CEC) oscillograph. In addition, a dual-beam oscilloscope was to be connected to both the FR-1400 input and reproduce output of the 2.048-kHz telemetry data stream.

The CEC oscillographic data provided a record of the DSN station receiver in- and out-of-lock history and FR-1400 recording history. The real-time analysis of the FR-1400 recording performance was to be made by a

visual comparison of the telemetry data stream from the DSN station receiver with that recorded on the FR-1400.

Summary reports concerning telemetry recovery have been published weekly during the mission. The reports

Table 24. Data requirements in support of Pioneer VIII mission

Type of data	Specific requirements
Pre-mission statistical data from Deep Space Stations	Predictions (consisting of antenna angles, transmit and receive VCO ^a frequencies, doppler frequency vs time for a probable mission, AFETR and CCF ^b launch predicts, etc.) Telemetry test tapes Tracking data test tapes Command tapes Telemetry calibration book Command System modulation index
Pre-mission calibration data from Deep Space Stations	Calibration data sheets containing: Measured system noise temperature Optical boresight angle readouts RF boresight shift vs polarization RF boresight vs signal strength (-100 , -110 , -120 , -130 , and -140 dBm) Receiver threshold sensitivity at various bandwidths Telemetry channel threshold sensitivity (75% in-lock signal level) Serial number of test transponder used in tests Loss from test transponder output connector to low-noise-amplifier input connector Signal level vs AGC ^c and channel 6 VCO frequency from -90 dBm to threshold in 5-dB increments Star tracking data Measured antenna gain Measured maser gain Measured paramp gain Loss from feedhorn output connector to low-noise-amplifier input connector Antenna radiation and polarization patterns Feedhorn ellipticity
Log data (other than magnetic recordings)	Station identification Time (GMT) of start and finish of record Date record was made Record identification Mission designator
Station calibration and checkout sheets	Station identification Date of record Purpose of data (pretrack or posttrack calibration, etc.) Time (GMT) of record Name of operator Mission designator
^a VCO = voltage-controlled oscillator. ^b CCF = Central Computing Facility. ^c AGC = automatic gain control.	

Table 25. Pioneer data monitoring

Phase	Period	Monitor frequency
1	L to L+3 days	Continuous Every 4 h (L to L+20 h) Every 8 h (L+20 to L+72 h)
2	L+3 to L+30 days	Within 12 h of a 2-way pass
3	L+30 days to end of nominal mission	Within 72 h of a 2-way pass

cover telemetry demodulator in-lock times for each pass, and contain such data as a tabulation of the percentages of gross coverage by station and network. Percentages were derived by abstracting receiver in- and out-of-lock times and demodulator in-lock times from the posttrack reports of the DSN stations. These times are added and then divided by the scheduled tracking period of each station for each pass to give overall percentage coverage.

Telemetry data validation. The Deep Space Station would play back a random 10-min sample of each FR-1400 tape to verify that the *Pioneer* GOE could lock up to the recorded 2.048-kHz telemetry stream.

A summary of the tape-playback performance was included in the data package forwarded to Operational Document Control in the SFOF.

DSN station logs. The Deep Space Stations employed a comprehensive logkeeping and reporting system to provide a complete record of system performance.

Any equipment outages or suspected malfunctions causing loss of data or spacecraft signal were to be immediately reported by voice to the network control area and documented by teletype reports and station logs. The station pretrack reports, tracking reports, and posttrack reports reflect all equipment anomalies plus such station parameters as prepass calibration and post-pass calibration of a Deep Space Station. These reports spell out the DSN performance in support of the assigned mission before, during, and after all tracking passes. Station logs and network control logs further reflect (in hours, minutes, and seconds) all equipment failures or loss of data encountered during any tracking pass. In addition, the operational voice circuits to the Deep Space Stations from the network control area are recorded by the JPL communication center.

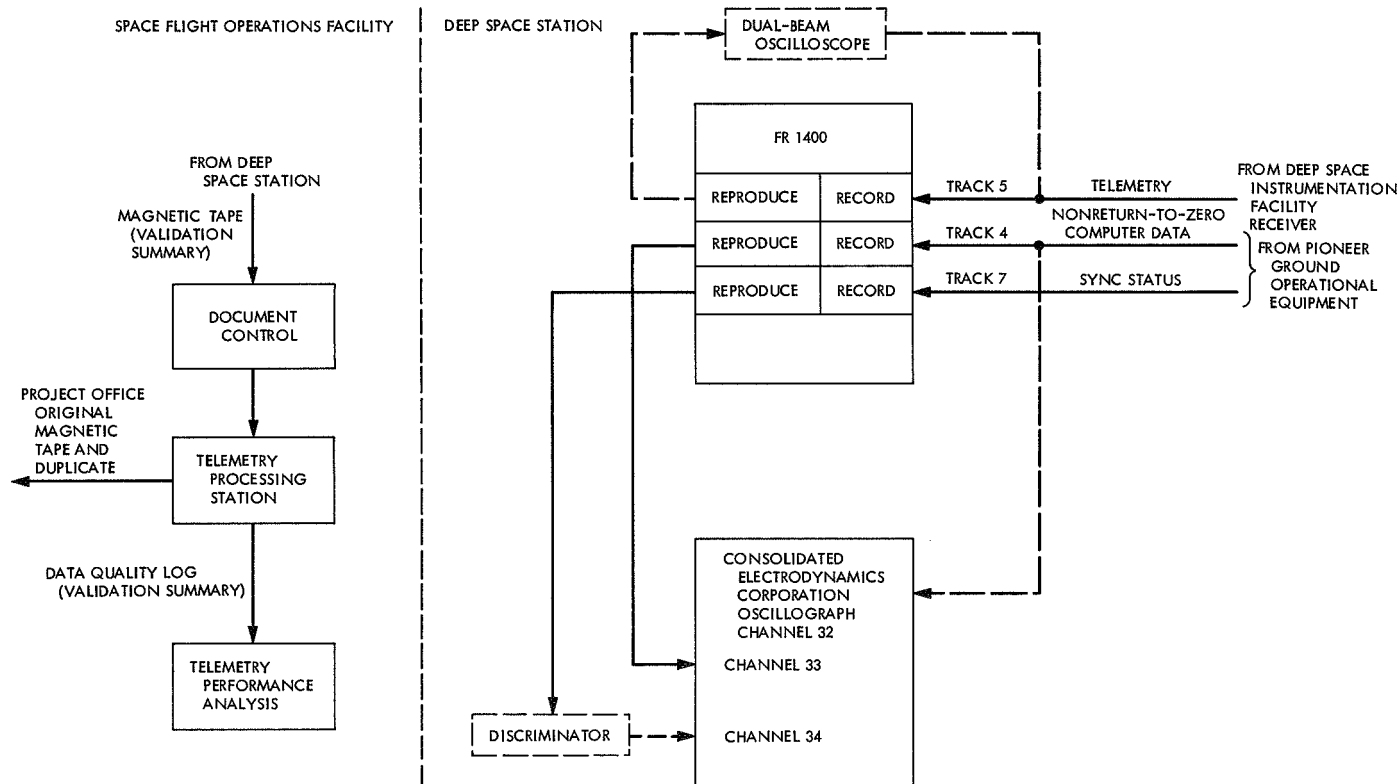


Fig. 21. Pioneer telemetry data monitor

Initial acquisition of spacecraft by DSN. In addition to preflight standard trajectory information and spacecraft telecommunication system design parameters, the *Pioneer* Project provided to the DSN an indication of the normality of spacecraft injection in real-time to assist the initial acquisition of the spacecraft by the DSN. The DSN furnished to the *Pioneer* Project a medium-accuracy orbit based on tracking data received from the Deep Space Stations. The accuracy of this orbit was to be as follows:

- (1) Injection: 10 km and 2-Hz two-way doppler.
- (2) Injection+10 days: 200 km and 5-Hz two-way doppler.
- (3) Injection+180 days: 1000 km and 5-Hz two-way doppler.

An orbit was to be furnished as soon as possible after launch, and updated at least monthly.

The equipment that was required to be operational at the Deep Space Stations to qualify each initial-acquisition station in a *go* status at launch is listed in Table 26.

3. Ground Communications Facility. Figure 22 is a schematic diagram of the planned communication lines, as described. As indicated in this diagram, the DSN internal communication requirements included communication lines between the committed DSN stations and the SFOF. A minimum requirement was that there be at least two teletype and one voice circuit operational between each DSN station and the SFOF.

Communication circuits committed to support the *Pioneer* Project consist of NASCOM circuits to the overseas stations and AFETR area, and DSN circuits to Goldstone utilizing the JPL/Goldstone microwave link.

a. NASCOM circuits. Technical control of all NASCOM circuits is the responsibility of GSFC. This is defined as the continuous function of maintaining the continuity

Table 26. Deep Space Station support requirements

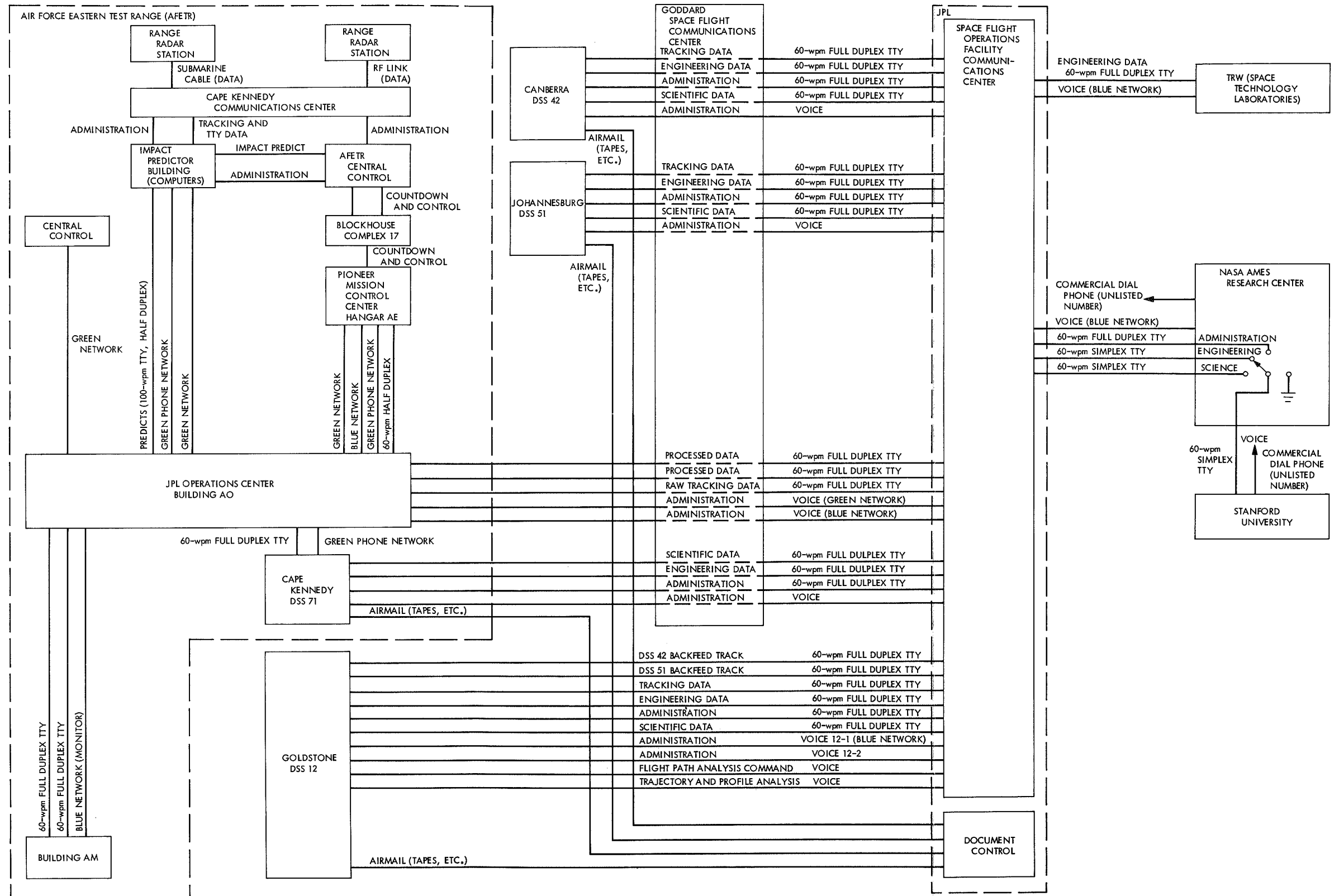
Equipment	Station				
	DSS 11	DSS 12	DSS 41	DSS 51	DSS 62
Paramp	X	X	X	X	X
Receiver (1 or 2)	X	X	X	X	X
SAA ^a and microwave			X	X	
SCM ^b and microwave	X	X	X	X	X
Exciter	X	X	X	X	X
Transmitter	X	X	X	X	X
Servo	X	X	X	X	X
Tracking data handling	X	X	X	X	X
Doppler	X	X	X	X	X
Frequency and timing	X	X	X	X	X
FR-1400 magnetic tape recorder (two)	X	X	X	X	X
DIS ^c (alpha)	X	X	X	X	X
DIS (beta)	X	X	X	X	X
SDS-910 computer	X	X	X	X	X
Power	X	X	X	X	X
Equipment air conditioner	X	X	X	X	X
<i>Pioneer</i> GOE ^d		X	X	X	X
Microwave link to DSS 12	X				

^aSAA = S-band acquisition aid (antenna system).

^bSCM = S-band cassegrainian monopulse (antenna system).

^cDIS = digital instrumentation system.

^dGOE = ground operational equipment.



and integrity of the communication circuits. The major policies and procedures used in accomplishing this responsibility are as follows:

- (1) Provide and maintain sufficient order wire facilities to remote facility control points; commercial and overseas carriers' toll test centers and primary routing points; JPL Communications Control for circuit and facilities coordination, trouble reporting, and fault location.
- (2) Establish backup circuits and prepare diverse routing plans.
- (3) Establish working relationships with the various communications carriers and establish mutual service-restoral plans.
- (4) Provide for the technical and administrative supervision of technical control centers at the primary switching and subswitching centers.

b. Mission operations control. In conjunction with technical control, JPL Communications Control had the responsibility for mission operational control of all communication circuits used to support the *Pioneer* Project. This included the control of the entire DSN ground communications facility as an entity, including the communication centers at the remote stations and the communication facilities linking them with the Mission Control Center.

JPL Communications Control was to make sure that no marginal circuit was taken out of service for corrective action or for any other reason without prior approval of the SFOD or his authorized representative. All technical control tests and routine maintenance tasks were to be performed on a noninterference basis with respect to mission simulations and flight operations. JPL Communications Control was also to see that all mission and mission-related traffic had absolute priority on communications facilities devoted to mission support.

As part of the concomitant responsibility, Communications Control was to provide facilities and personnel to perform circuit quality monitoring, testing, and analysis of circuit performance. This was accomplished by using the following:

- (1) Signal quality monitoring devices that serve as alarms and indicate when distortion levels of incoming data on teletype circuits exceed certain

predetermined levels (normally 20 to 25% distortion).

- (2) A Stelma analyzer (DAC-5) that provides distortion and bias readings as either average, peak, or individual (marking or spacing bias); scope presentation of an incoming or outgoing teletype signal for visual analysis; and test patterns or individual letter tests at various speeds and desired amounts of distortion.
- (3) A comprehensive method of recording circuit outages using trouble tickets and communication logs.

Communications Control established uniform and efficient DSN communications-related operating procedures and disciplines, requested and confirmed special or critical coverage from cognizant agencies during critical periods of the *Pioneer VIII* mission, conducted circuit optimization testing on all circuits before release for mission support, and conducted periodic circuit assurance tests on all idle circuits during mission support periods.

c. JPL/Goldstone circuits. The procedures and policies used in maintaining the quality of circuits to Goldstone (DSS 12) are identical, where applicable, to those described for NASCOM circuits. In addition, microwave alarms were available that indicated loss of pilot tone or any other type of microwave outages on either a group or a microwave channel.

It was anticipated that use of the prepared policies, procedures, and hardware, along with the addition of the signal quality monitoring devices and microwave alarms, would result in optimum communications support of the *Pioneer VIII* data-validation effort.

d. Launch-support requirements:

- (1) Between JPL Operations Center at AFETR (Building AO) and SFOF: three voice networks (AFETR, status, and mission director) and three duplex teletype circuits (one for raw and two for computed data).
- (2) Between DSS 71 and SFOF: one voice network and one teletype circuit (for frequency reports).
- (3) Between DSS 41 and SFOF: one voice network and one duplex teletype circuit (for predicts and tracking data).

- (4) Between DSS 51 and SFOF: one voice network and one duplex teletype circuit (for predicts and tracking data).
- (5) Between DSS 62 and SFOF: one voice network and one duplex teletype circuit (for predicts and tracking data).
- (6) Between DSS 12 and SFOF: one voice network and one duplex teletype circuit (for predicts and tracking data).
- (7) Between DSS 11 and SFOF: one voice network and one duplex teletype circuit (for predicts and tracking data).
- (8) Between SFOF and ARC: one voice network and one duplex teletype circuit (for Stanford predicts and Type II maneuver data).

e. Launch constraints. The Class II launch constraints were the same as the DSN launch requirements. Class I launch constraints were as follows:

- (1) Between JPL Operations Center at AFETR and SFOF: one voice network (AFETR network) and one teletype circuit.
- (2) Between DSS 71 and SFOF: one voice network and one teletype circuit.
- (3) Between DSS 41 and SFOF: one voice network and one teletype circuit.
- (4) Between DSS 51 or 61 and SFOF: one voice network and one teletype circuit.
- (5) Between DSS 12 or 11 and SFOF: one voice network and one teletype circuit.

4. Receiving and processing mission data tapes. This subsection briefly describes the requirements pertaining to the receiving and processing of *Pioneer VIII* mission data tapes for quality control and validation that took place in the SFOF.

a. Operational Data Control. Control of data coming into the SFOF from the Deep Space Stations was maintained to ensure proper handling and distribution. This control was performed in accordance with specified SFOF procedures.

Received tracking data were forwarded to distribution in the flight-path analysis area (FPAA) and to the SFOD and his assistant for purposes of trajectory computations

in accordance with the commitment document. Validation was performed by FPAC personnel.

Science data were separated from the engineering data subcommutator at the Deep Space Stations by computers and recorded on magnetic tapes. The tapes were mailed to the SFOF, then forwarded to ARC.

Magnetic tapes of recorded data received from the Deep Space Stations were forwarded by SFOF personnel to the TPS for duplicating and processing. After processing, the original tapes were returned, along with the duplicate and one copy of the data log, for shipment to the *Pioneer* Project Office at ARC.

b. Telemetry processing station. The TPS complex in the SFOF provided one duplicate magnetic tape of each original Deep Space Station magnetic recording received. During the duplicating process, TPS personnel were required to ascertain that the recording technique was correct and that telemetry data, as well as station performance information, were available. Further validation included the following:

Monitoring and verification of recording levels. The quality of a recording was determined by applying quality control devices such as spectrum analyzers and bit-error detectors. Verification was also made that information was recorded in the proper standard being used by the Deep Space Stations.

Inspecting recorded data for continuity. A data-time correlation was performed to determine that data drop-out was not excessive and that data rates did not exceed the limitations of processing equipment.

All data validation was done on the duplicated tapes.

Copies of TPS validation reports were returned to the Deep Space Station for inclusion in the station performance summary report.

c. Computer. At least one of the two computer strings in Mode 2 was required to be operational. A computer string in Mode 2 consists of an IBM 7044 computer and an IBM 7094 computer with a 1301 disk storage unit connected in tandem. This computer string was used by the FPAC team to compute acquisition prediction information for use by the Deep Space Stations and the Stanford tracking station, and to determine the best estimate of the actual spacecraft orbit so that accurate

trajectory information would be available to *Pioneer* Project personnel.

d. Data flow and processing. *Pioneer* mission operations are concerned with real-time, quick-look, and non-real-time telemetry data requirements. Table 27 lists the mission data requirements.

Real-time data. These data were to be received in real-time via hardline or radio communication link. They were then to be displayed on-line in the user areas as rapidly as operational priorities would permit. Data are classified as real-time if they are received at the SFOF within 5-10 min after receipt by the Deep Space Stations (see Table 27).

Quick-look data. These are selected data extracted on-site by the SDS-910 computer and transmitted in real-time to the SFOF upon request by the SFOD. These data are monitored in the *Pioneer* mission support area and simultaneously transmitted to the ARC data processing center and TRW.

Non-real-time data. These are data received at the SFOF either in the form of magnetic tape recordings or of delayed transmission from a communications link more than 30 min after receipt of data at the Deep Space Station (see Table 27).

The flow from the SFOF includes acquisition and tracking information and commands for the DSIF, general status information, and spacecraft performance data. All Deep Space Station flight data are forwarded within 48 h to SFOF document control at JPL.

The incoming data circuits are routed through the communications center to the teletype machines and closed-circuit TV in the user areas.

e. Launch support requirements.

Class I:

- (1) Either RTCF or FPAC team and data processing system in a *go* status.
- (2) Track area in a *go* status.
- (3) Essential internal SFOF communications to operate in a nonstandard mode.

Class II:

- (1) Communication processor in a *go* status.

Table 27. Classification of mission data requirements

Function	Real-time ^a	Non-real-time ^b
Data demodulation ^c	X	
Data decommutation ^c	X	
Analog-to-digital conversion		
Data formatting ^c	X	
Data logging	X	
Engineering units conversion	X ^d	
Alarm monitoring	X ^d	
Orbit determination		X
Trajectory computation		X
Spacecraft orientation ^e	X	
Command generation ^f	X	
Command verification ^c	X	
Scientific data calibration	X	
Engineering data analysis	X ^d	X
Scientific data analysis	X ^d	X
Premission tests and training	X	X
Tape dubbing at ARC		X

^aReal-time = 5 to 10 min after acquisition by DSN.
^bNon-real-time = magnetic tape via airmail after acquisition by DSN.
^cTo be done at Deep Space Stations.
^dSelected data.
^eTo be done at Goldstone.
^fTo be initiated at the SFOF but generated at Deep Space Stations.

- (2) Communication area support in a *go* status.
- (3) Data processing system in a *go* status.
- (4) Data chief area in a *go* status.
- (5) Data control area in a *go* status.
- (6) FPAC team in a *go* status.
- (7) Track area support in a *go* status.
- (8) Internal SFOF communications in a *go* status.
- (9) Television monitors in a *go* status.
- (10) Simulation Data Conversion Center (SDCC) support from L-5 to L-3 h.

The frequency reports transmitted from DSS 71 to the SFOF between L-8 and L-1 day and at L-90, L-30, and L-5 min on launch day included the following:

- (1) Spacecraft transmitter one-way frequency measurement.

- (2) Spacecraft auxiliary oscillator temperature (in degrees Fahrenheit) measured coincident with item (1).
- (3) Time (GMT) of measurement of items (1) and (2).
- (4) Spacecraft receiver best-lock frequency.
- (5) Spacecraft transmitter two-way frequency corresponding to spacecraft receiver best-lock frequency.
- (6) Spacecraft receiver temperature at time of item (5) measurement.
- (7) Spacecraft receiver static phase error, in volts, corresponding to spacecraft receiver best-lock frequency.
- (8) Spacecraft receiver serial number.
- (9) Auxiliary oscillator driver serial number.

III. Pioneer VIII Tracking and Data System Configuration

A. Near-Earth Phase Configuration

For near-earth support, the TDS was composed of selected resources of the AFETR, MSFN, NASCOM, and DSN. Within each agency, specific supporting stations were as listed in Table 28.

Based on trajectory data and requirements, the TDS agencies selected the appropriate metric and telemetry data-acquisition instrumentation from resources available at the sites listed in Table 28. Particular attention was paid to Class I intervals to assure a high probability of providing the required coverage. The specific resources allocated to support the near-earth phase of *Pioneer VIII* are provided in Table 29.

1. Metric data. The AFETR was the primary agency responsible for meeting metric requirements during the launch and earth-orbital mission phases. The addition of MSFN radar instrumentation to that of the AFETR provided the required coverage with a reasonable degree of redundancy. Radars listed in Table 28 tracked the *Agenda* C-band beacon in meeting both launch-vehicle and spacecraft metric requirements. In addition, the AFETR optical tracking instruments provided accurate metric data from liftoff to 5000 ft.

Figure 23 illustrates the configuration of the metric system and data flow that supported the early launch phase. Optical instruments as well as C-band radars are shown.

Table 28. Near-earth phase facilities

Agency	Station and location
Air Force Eastern Test Range	Station 1—Cape Kennedy/Patrick AFB, ^a Fla. Station 3—Grand Bahama Island Station 7—Grand Turk Island Station 9.1—Antigua Island Station 12—Ascension Island Station 13—Pretoria, South Africa RIS ^b <i>Twin Falls</i> —South Atlantic RIS <i>Coastal Crusader</i> —South Atlantic
Manned Space Flight Network	Bermuda Island station MSFN/USB ^c site—Ascension Island Tananarive site—Malagasy Carnarvon site—Australia Goddard Space Flight Center, Md. Guam Island—Marianas Islands Hawaii—Hawaiian Islands
NASCOM	Worldwide facilities of NASCOM provided communications between supporting agencies
JPL facility at AFETR	Building AO at Cape Kennedy, Fla.
Deep Space Network	DSS 71—Cape Kennedy, Fla. DSS 72—Ascension Island DSS 51—Johannesburg, South Africa SFOF—Pasadena, Calif.

^aAFB = Air Force Base.
^bRIS = Range Instrumentation Ship.
^cUSB = unified S-band.

As shown in Fig. 23, it was planned that the AFETR radars aboard RIS *Twin Falls* and at Grand Turk, Antigua, Ascension, and Pretoria would provide real-time parking-orbit and solar-orbit metric tracking data to JPL for relay to the SFOF. Radar data from the MSFN radars at Bermuda, Tananarive, or Carnarvon were also to be used.

In addition to relaying these data to JPL, the AFETR Real Time Computing Facility was to use the data to compute orbital elements and injection conditions (parking orbit and theoretical and actual solar orbits), which would be transmitted to JPL in the following formats:

- (1) Standard JPL orbital message format.
- (2) AFETR interrange vector.
- (3) AFETR standard orbital parameter message (SOPM).

The DSN and MSFN acquisition information, based on the parking orbit plus theoretical second-burn and actual

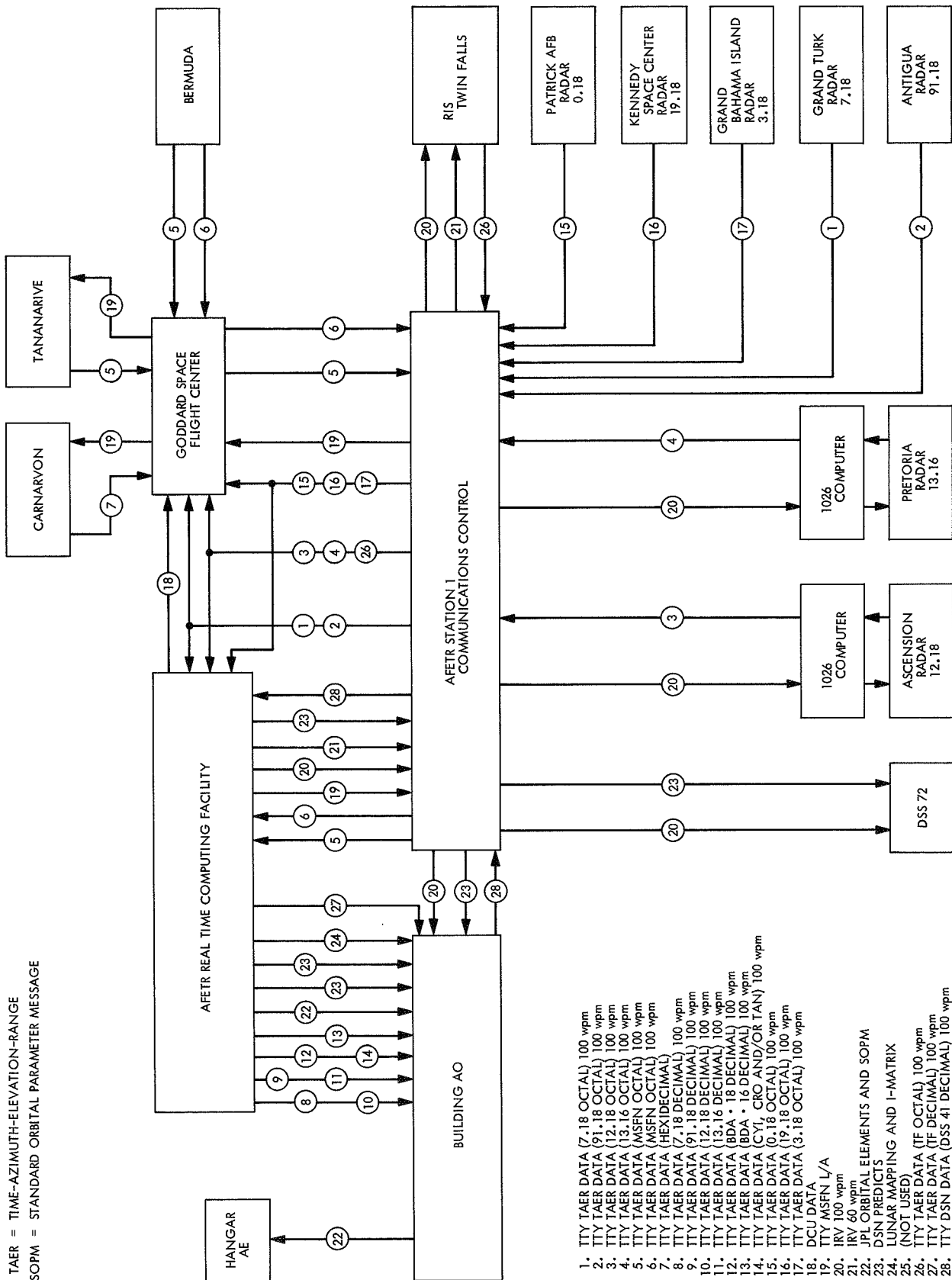


Fig. 23. Near-earth phase metric data flow

Table 29. AFETR and MSFN station facilities

Station	Tracking capability (radar type)	Telemetry capability
AFETR stations		
Cape Kennedy area	C-band	VHF and S-band
Patrick AFB	0.18 (FPQ-6)	(Tel-4)
Cape Kennedy	1.16 (FPS-16)	
Kennedy Space Center	19.18 (TPQ-18)	
Grand Bahama	C-band	VHF
	3.16 (FPS-16)	
	3.18 (TPQ-18)	
Grand Turk	C-band	VHF
	7.18 (TPQ-18)	
Antigua	C-band 91.18 (FPQ-6)	VHF and S-band
Ascension	C-band	VHF and S-band
	12.16 (FPS-16)	
	12.18 (TPQ-18)	
RIS Pretoria	C-band 13.16 (MPS-25)	VHF and S-band ^a
MSFN stations		
Bermuda	C-band (FPS-16 and FPQ-6)	VHF
Tananarive, Malagasy	C-band (Capri)	VHF
Carnarvon, Australia	C-band (FPQ-6)	VHF
AFETR ships		
RIS Twin Falls (15-knot cruising speed)	C-band (FPS-16)	VHF and S-band
^a 3-ft-diam antenna only.		

solar-orbit computations, would be prepared and forwarded by the RTCF. In addition, the AFETR was to transmit interrange-vector messages and DSS 72 predicts directly to DSS-72, where solar-mapping messages would be prepared. After the single-station solutions had been found, the RTCF was to compute (and transmit to JPL) recursive accumulative solutions of the actual solar orbit. An I-matrix and a solar-mapping message based on each solution were to be included.

It was expected that the AFETR would have no difficulty in satisfying the requirement for 60 s of tracking immediately following parking-orbit injection. However, problems were anticipated in providing the 60 s of tracking coverage required during the transfer orbit at injection.

A tracking ship in the South Atlantic enhanced the probability of injection tracking. However, the ship and *Pretoria* were both supporting on a best-obtainable basis

because of the late delivery of third-stage antenna patterns. Carnarvon was to be used to provide backup to these stations for third-stage tracking.

2. Telemetry. The first- and second-stage vehicle was to radiate one PDM/FM/FM telemetry link. The frequency of the first-stage link was 228.2 ± 0.125 MHz. The frequency of the second-stage link was 234.0 ± 0.125 MHz. The subcarrier configuration of each link is shown in Table 30. During the minus count, and until LOS at approximately $L+5$ min, DSS 71 was to transmit spacecraft science and engineering data to Building AO for routing to the SFOF and Building AM. Following this, and until approximately $L+48$ h, spacecraft telemetry data from each Deep Space Station tracking the spacecraft were to be transmitted to Building AO for routing to Building AM. Figure 24 shows the communication routing configuration to support this portion of the *Pioneer VIII* mission.

The uprange AFETR and MSFN stations were to be used to meet the VHF telemetry requirements from launch through transfer-orbit injection. It was expected that these requirements would be satisfied by the combined support of the MSFN stations and AFETR stations and tracking ships.

The Class I intervals for S-band telemetry coverage (spacecraft telemetry) were specified as follows: from shroud separation to second-stage cutoff plus 120 s, and from third-stage spinup to spacecraft separation. These were to be covered by the AFETR stations. No figure outlining coverage intervals was available, as coverage was on a best-obtainable basis only.

Table 30. Subcarrier link data

Signal, kHz	Application	Characteristics
0.40	Continuous	—
2.30	Continuous—link	228.2 MHz only
3.00	Continuous—link	228.2 MHz only
3.90	Continuous	—
5.40	Continuous	—
7.35	Continuous	—
10.50	Continuous	—
14.50	Continuous	—
22.00	$\pm 15\%$ continuous	—
40.00	$\pm 15\%$ continuous	—
70.00	$\pm 15\%$ commutated	45×20 , PDM

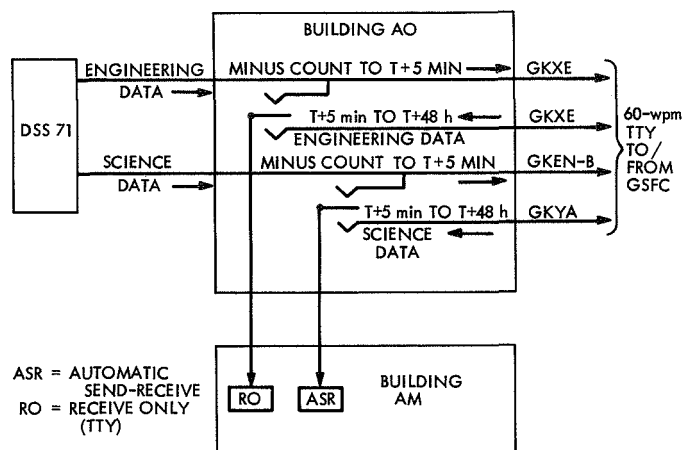


Fig. 24. Spacecraft telemetry data transmission (engineering and science)

3. Real Time Computing Facility. The AFETR Real Time Computing Facility at Cape Kennedy, using CDC 3600 computers, processed metric data received from the AFETR and MSFN sites. An important function during the near-earth phase was the computation and transmission of acquisition information to the various TDS sites supporting the mission.

The RTCF used metric data for orbital computations and planetary mapping to meet trajectory-definition requirements. Various computer runs were made, based on actual parking-orbit conditions, estimated and actual transfer-orbit conditions, and actual postposigrade conditions.

The RTCF retransmitted teletype data from all radars to GSFC in octal format, and converted AFETR radar teletype data to decimal format for transmission to the JPL/AFETR operations center at Cape Kennedy via 100-wpm teletype circuits. Another function of the RTCF was to receive high-density data from Bermuda and Carnarvon radars, convert them to decimal format, and transmit the information to Building AO. The JPL personnel at Building AO selected appropriate metric data for retransmission to the SFOF via teletype as required.

4. Data dissemination.

a. Countdown phase. During the countdown phase (Fig. 25), the status coordinator received status information from the TDS coordinator and JPL, and by monitoring appropriate launch-vehicle and spacecraft mission operations paging systems (MOPS) channels.

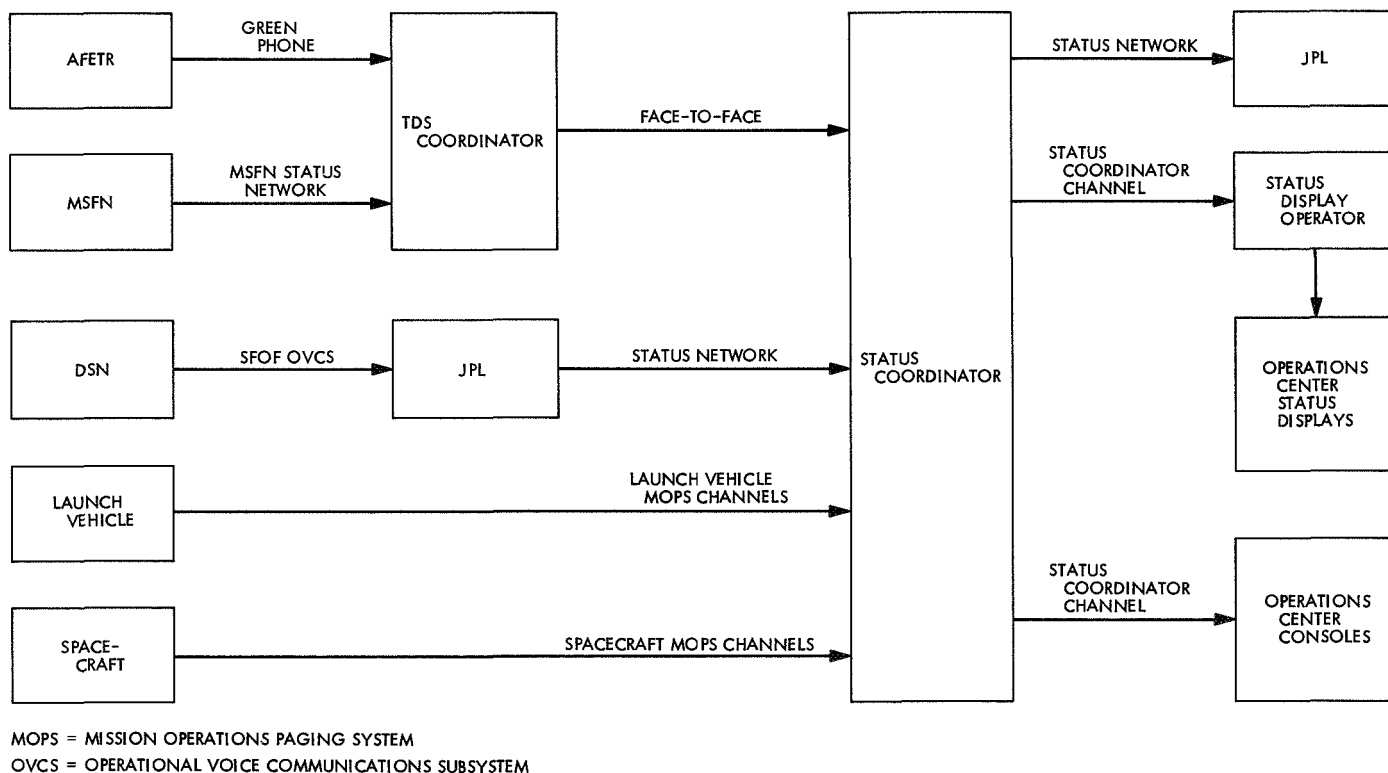


Fig. 25. Data dissemination during countdown phase

The TDS coordinator received information on the status and readiness of MSFN and AFETR systems, stations, and ships via the MSFN status network and the green phone from the Superintendent of Range Operations (SRO). This information was forwarded to the status coordinator via face-to-face communication.

Also, JPL received information on the status and readiness of each of the elements of the DSN via the SFOF operational voice communications subsystem (OVCS), and forwarded this information to the status coordinator over the status network.

In addition to the two-way exchange of status information on the status network, status information was disseminated by the status coordinator within the operations center through use of the status displays discussed above and by announcements on the internal status coordinator channel.

b. Near-earth flight phase. Following liftoff, the flow of status information differed from that during the count-down phase, both in sources of information and in the type and routing of information. The time (GMT) of in-flight events was received from the SRO on MOPS

channel 15 and from the MSFN network controller on the MSFN status network.

The operations center converted the GMT of the events to "launch-plus" times expressed in seconds. These times plus the original GMT times were announced on the status network by the status coordinator, forwarded to the TDS analyst, and displayed on the operations center display board. After consultation with personnel at the Mission Director's Center (MDC), the TDS analyst coordinated with FPAC on the AFETR network to determine the times that were used in SFOF computations.

The dissemination of other status information reported during the near-earth flight phase is described in Table 31.

5. Joint facilities. The facilities of the field station supporting the *Pioneer VIII* mission are the JPL/AFETR operations center and the JPL/AFETR communication center, both in Building AO.

The station at Cape Kennedy (JPL/DSS 71) was used extensively, participating in the prelaunch, launch, and near-earth operations of the *Pioneer* Project.

Table 31. Flow of status information during near-earth flight phase

Information	Source	Routing
General commentary summarizing flight performance data in real-time	KSC/ULO ^a announcements on channel 2	Monitored by status coordinator; reported to SFOF on status network
General commentary evaluating launch-vehicle telemetry in real-time	KSC/ULO announcements on channel 11 based on launch-vehicle telemetry displays in Hangar AE	Monitored by status coordinator; reported to SFOF on status network
General commentary evaluating flight-path data in real-time	KSC/ULO announcements on channel 13 based on range safety plotting boards	Monitored by status coordinator; reported to SFOF on status network
Liftoff report	SRO ^b announcement on channel 15 based on range timing	Monitored by status coordinator; reported to SFOF on status network; displayed in operations center
AOS/LOS ^c reports	SRO announcement on channel 15	Monitored by status coordinator; reported to SFOF on status network; displayed in operations center by flashing station titles
RTCF status and performance	JPL data coordinator	Reported to FPAC on AFETR network
Tracking and computed data flow status	JPL/AFETR communication center	Monitored by status coordinator via closed-circuit TV; reported to SFOF on status network
DSN status and performance	SFOF	Reported to status coordinator on status network; displayed in operations center; announced over status coordinator channel

^aKSC/ULO = Kennedy Space Center/unmanned launch operations.
^bSRO = Superintendent of Range Operations.
^cAOS/LOS = acquisition of signal/loss of signal.

The JPL/AFETR field station was to support the *Pioneer VIII* mission launch-phase operations by providing the necessary operational interface between Project elements at the SFOF in Pasadena, the AFETR and Project elements at the AFETR, and the MSFN at Goddard Space Flight Center. This operational interface comprised the following activities:

- (1) Monitoring and informing Project personnel in MDC, JPL/AFETR operations center, and SFOF of status of MSFN and AFETR stations, ships, and equipment; launch-vehicle and spacecraft status; progress through countdown; and occurrence and time of in-flight events.
- (2) Receiving and informing Project personnel at Cape Kennedy of reports on status of DSN systems, stations, and equipment and their readiness to support the mission.
- (3) Providing liaison between FPAC group and AFETR Real Time Computing Facility through JPL data coordinator at RTCF.
- (4) Receiving MSFN and AFETR metric tracking data and computed data—including injection conditions, orbital elements, and Deep Space Station acquisition information—and retransmitting these data to SFOF.
- (5) Receiving RTCF orbital information and retransmitting it to Building AE.
- (6) Receiving Deep Space Station tracking data for use in RTCF orbital computations from SFOF and retransmitting these data to RTCF.
- (7) Routing spacecraft engineering and scientific telemetry data from DSS 71 to Building AM and SFOF, and DSN spacecraft telemetry data from SFOF to Building AM.
- (8) Coordinating launch-phase TDS activities, performing analyses of current readiness during countdown, and evaluating TDS performance during near-earth phase.
- (9) Providing necessary communications and status information, through use of JPL/AFETR operations and communication centers, to allow effective control and coordination of TDS and mission operations during launch-countdown and near-earth phases.

a. *Joint operations center.* Control of JPL/AFETR operations during the launch phase was exercised from

the JPL/AFETR operations center. The operations center contained status displays that indicated the status of all participating elements of the operation, a timing system, and consoles for the operating personnel.

Status displays. There are four display boards in the operations center. One of these, the operational status display board, is used to indicate current operational status of Cape Kennedy instrumentation sites, the space vehicle, and communication links. Another, the in-flight events display board, is used to display the time of significant in-flight events. The AFETR and DSS status display boards are used to indicate the status of the participating AFETR facilities and Deep Space Stations.

Television monitors display the range safety flight-line and program-line TV signals. These are part of a system for monitoring the flight path of the vehicle, both in the plane of the flight azimuth (flight-line) and normal to the plane of the flight azimuth (program-line). Finally, an optically projected map display (a map of the world projected onto the status board wall) shows the earth track of the flight azimuth and locations of key in-flight events. Colored circles, indicating metric coverage from each tracking station, are also superimposed on the map.

Timing system. An automated timing system continuously displays Pacific, Eastern, and Greenwich Mean Time; countdown and launch-plus-time data; anticipated time to launch and actual liftoff time; accumulated hold time at any point in the countdown; and time remaining in the launch window for that day.

Consoles. In addition to the integrated communication consoles used by each of the operators, there are two dual TV monitor consoles and the status display control console. Each of the integrated communication consoles contains a green phone switch panel, two communications panels, and a communication control panel.

During operations, the green phone switch panel is used to provide direct point-to-point circuits between major operating facilities and the operations center. These are private-line automatic-signaling circuits used by key personnel. The green phone system is operable from emergency power, which allows it to serve as a backup for the AFETR communications network. Table 32 shows the operational usage of green phone circuits.

Table 32. Operational usage of green phone circuits

Circuit	Operational usage
SRO ^a	Coordination of TDS activities and discussions of range status
RCC ^b	Discussions between JPL representative at RCC and JPL/AFETR operations supervisor
RTCF ^c	Communication between operations center personnel and JPL data coordinator at RTCF relative to orbital computations and data transmission
DSS 71	Coordination between DSS 71 and operations center
Building AE	Coordination between mission director and his staff and operations center
CNC ^d	Coordination between TDS coordinator and MSFN CNC relative to TDS activities and MSFN status
Building AM	Coordination between spacecraft personnel and operations center

^aSRO = Superintendent of Range Operations.
^bRCC = range control center.
^cRTCF = Real Time Computing Facility.
^dCNC = Cape network coordinator.

The AFETR communications panels provided party-line communications for operational testing. The panels, combined, provided the capability of monitoring 24 channels. These channels were the prime communication links for the conduct of launch operations. Access to two cross-country voice circuits from the SFOF at Pasadena is provided by the communication control panel. This panel is also used to answer administration telephone calls, and can be connected to the green phone switch panel and the AFETR communications panels.

Each of the two dual TV monitor consoles contains a dual small-screen TV monitor used to view the page printers for two of the outgoing teletype circuits to the SFOF. A separate permanent console is provided for status display. This console contains a range countdown indicator and control panels for the timing system and the status display boards.

b. Joint communication center. The JPL/AFETR communication center contains the necessary equipment to provide (1) a local terminus and interfaces for voice, teletype, and data circuits from both the SFOF in Pasadena and the AFETR and local Project elements; and (2) local voice, teletype, and data circuits in support of prelaunch tests and launch operations. This equipment is described in the paragraphs that follow.

Voice circuits. The communication center has the capability of terminating up to 50 voice channels from various Cape Kennedy locations; any 24 of these can be patched into the communication system in the operations center. Figure 26 shows the voice-channel identification and routing indicators configured to support *Pioneer VIII*.

To provide direct voice circuits to the SFOF in Pasadena, two commercially leased lines (NASCOM) are terminated in two 4-wire bridges. Special telephone panels, which allow certain administrative phones to be switched into the 4-wire bridge, provide a backup for the two leased lines.

Teletype circuits. Six full-duplex, 60-wpm NASCOM teletype circuits from the SFOF are terminated in the JPL/AFETR communication center; three of these are routed on a "normal-through" basis to DSS 71. A local circuit from DSS 71 to the communication center is also provided. Nine incoming circuits from the AFETR are terminated in the communication center. These may be patched into six typing reperforators, which are operated taut-tape to six transmitter-distributors. These, in turn, can be patched to any of the outgoing circuits to Pasadena. Three additional local circuits, two from Building AM and one from Building AE, are terminated in the communication center. These may be patched to any of the SFOF, AFETR, or DSS 71 lines.

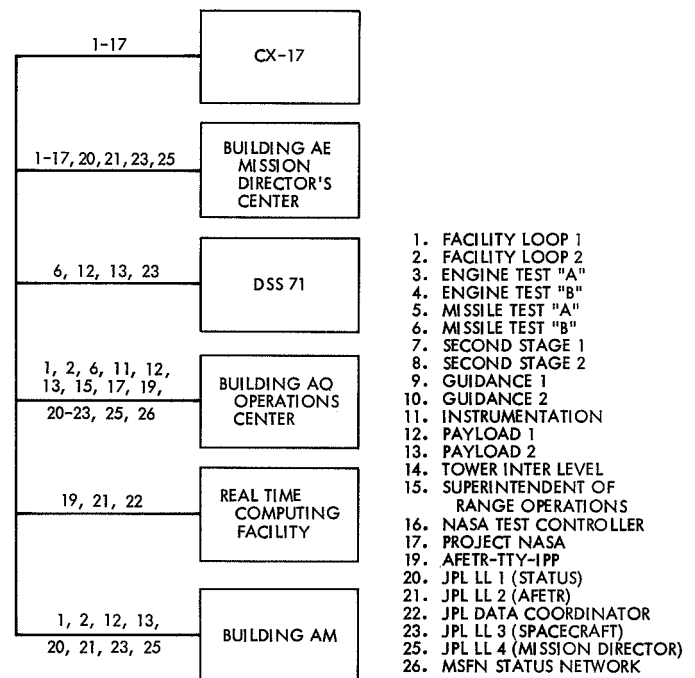


Fig. 26. Voice channel identification and routing

Metric tracking data, injection conditions, orbital elements, Deep Space Station acquisition information, and other operational messages were received at the JPL/AFETR communication center on nine half-duplex, 100-wpm teletype circuits from the RTCF. These data were retransmitted to the SFOF on three full-duplex, 60-wpm circuits. An additional three full-duplex, 60-wpm circuits—from the SFOF to DSS 71—were used for DSN operational traffic. One half-duplex, 60-wpm circuit was used to relay RTCF orbital elements from the JPL/AFETR communication center to the mission control center in Building AE, and two full-duplex, 60-wpm circuits were used to transmit spacecraft information to Building AM from DSS 71 during the countdown and from DSS 51 during flight.

Data circuits. A NASCOM data line is routed between the SFOF and the JPL/AFETR communication center. This line is terminated in a patch panel in the communication center that allows either digital or analog data to be patched in. The data line also provides an alternate capability for voice use.

c. JPL/AFETR operational support. The JPL/AFETR field station was to support the launch-phase operations of the *Pioneer VIII* mission by providing the necessary operational interface between Project elements at the SFOF in Pasadena and the AFETR and Project elements at the AFETR. This facility, operated by JPL/AFETR field station personnel, provides the necessary communications and status information to allow effective control and coordination of TDS and mission operations during the launch countdown and near-earth flight phases.

The operations center, which acts as an operational interface, comprises the following activities:

- (1) Monitoring and informing Project personnel in SFOF of status of AFETR stations, ships, and equipment; launch-vehicle and spacecraft status; progress through countdown; and occurrence and time of in-flight events.
- (2) Receiving and informing Project personnel at Cape Kennedy of reports on status of SFOF and Deep Space Stations and equipment, and their readiness to support the mission.
- (3) Providing liaison between FPAC group and RTCF through the JPL data coordinator at the RTCF.
- (4) Receiving AFETR metric tracking data and computed data—including injection conditions, orbital

elements, and Deep Space Station acquisition information—and retransmitting them to the SFOF.

- (5) Receiving RTCF orbital information and retransmitting it to Building AE.
- (6) Receiving Deep Space Station tracking data for use in RTCF orbital computations from the SFOF, and retransmitting these data to the RTCF.
- (7) Relaying spacecraft telemetry data from DSS 71 to the SFOF and to Building AM.
- (8) Receiving (from SFOF) spacecraft telemetry data from DSS 51 and retransmitting these data to Building AM.

Personnel responsibilities at the JPL/AFETR operations center are described in the paragraphs that follow.

Operations center coordinator. The operations center coordinator exercises control of JPL/AFETR operations during the launch operations. He supervises the overall activities within the operations center, and acts as network controller for the operations center network and the AFETR stations of the cross-country AFETR network. He and the SRO coordinate the prelaunch and in-flight flow of tracking data from the RTCF and Cape Kennedy communications control to Building AO.

Status coordinator. The status coordinator acts in the capacity of assistant operations center coordinator and as network controller for the status coordinator network (internal operations center network) and the AFETR stations of the cross-country status network. He receives and disseminates status information from the SFOF in Pasadena and from the AFETR and local Project elements, and ensures that all status displays are current and correct.

Status display operator. The status display operator monitors appropriate communications networks for status reports, and operates the display boards that indicate the status of the different elements of the mission. In addition, he operates the control panel for the operations center timing system.

Communication center coordinator. The communication center coordinator supervises data handling and transmission activities within the communication center and coordinates—with the operations center and SFOF communication center—the overall operation of the communication center in support of the mission.

Equipment room and message center operators. The equipment room and message center operators operate the data handling and transmission equipment within the communication center. They perform the necessary patching of voice, teletype, and data circuits to establish the proper circuit configurations for the mission.

JPL Deep Space Network representative. The JPL Deep Space Network representative monitors DSN activities and acts as local advisor to the mission director and operations center personnel on DSN matters.

JPL data coordinator. The JPL data coordinator acts in conjunction with the FPAC group to coordinate RTCF operations in the area of computation of orbital and Deep Space Station acquisition information, and in reformatting and transmission of metric tracking data.

JPL Project representative. The JPL Project representative performs a liaison function between the SRO and the JPL/AFETR operations center. He monitors the overall operation and, upon request of the SRO, advises him on DSN support matters.

d. JPL/AFETR data transmission. This subsection identifies key communication networks and channel assignments, and specifies proper usage and procedures for each.

Mission Operations Intercommunication System (MOIS). The MOIS, which provides party-line communication, is the primary communication system for the conduct of launch operations. The MOIS channel assignments in effect for the *Pioneer VIII* launch-phase operations, and their availability at each of the major supporting facilities, are listed in Table 33.

Green phone system. The green phone system provides direct point-to-point communication circuits between major operating facilities (e.g., blockhouse, Cape Kennedy computer, operations center). These circuits are private-line, automatic-signaling circuits used by key personnel. Provisions were made to allow the green phone system to operate from emergency power. This system, therefore, served as a backup for the MOIS.

Cross-country voice circuits. Three NASCOM voice circuits between JPL/AFETR and the SFOF are used for voice communications in support of launch operations. Switching and control of stations that have access to these networks are maintained at both terminals. Opera-

tional usage of these networks is defined in the paragraphs that follow.

The status network was used to keep various SFOF stations informed of the operational status of the AFETR stations and of the launch vehicle and spacecraft, mission readiness to launch, progress through the countdown, and the occurrence and time of in-flight events; it was also used to inform the mission director and Project elements at AFETR of the status of the various Deep Space Stations and their readiness to support postlaunch operations. Stations normally "active" on this network were the JPL status coordinator at AFETR and Prime One at the SFOF.

The AFETR network was used for detailed discussions pertaining to the condition and flow of both metric tracking and computed data from the AFETR to the SFOF. Stations normally "active" on this network at AFETR were the JPL data coordinator at the RTCF, operations center coordinator, and mission and flight analysis. The mission director and other Project officials in the MDC had monitoring capability and access to both the status and the AFETR networks, as required.

The spacecraft network was used by *Pioneer* Project personnel in the Mission Director's Center and the SFOF for detailed discussions of spacecraft performance and status. The SFOF reported DSN and SFOF readiness to the mission director on this network.

Data transmission. This subsection describes the methods and procedures that were used by the AFETR to acquire, process, and transmit to JPL (Building AO)—for relay to the SFOF—metric tracking and computed data during the launch phase of the *Pioneer VIII* mission.

Metric tracking and computer data. The AFETR radars were assigned to provide real-time metric tracking data to JPL (Building AO) for relay to the SFOF. In addition, the AFETR Real Time Computing Facility used these data to compute orbital elements and injection conditions for the parking orbit and theoretical transfer orbit, which were transmitted to JPL in the following formats:

- (1) Standard JPL orbital-message format.
- (2) AFETR interrange vector.
- (3) AFETR standard orbital parameter message.

Table 33. Operational usage of MOIS^a channels

Switch number	Channel		Operational usage		Switch number	Channel		Operational usage
	No.	Title				No.	Title	
Upper panel:								
1	1	Facility loop 1	Used by test conductor for conducting space-vehicle countdown until liftoff		8	—	Spacecraft network	Used by Pioneer Project personnel to discuss spacecraft performance and status
2	2	Facility loop 2	Used by blockhouse monitor for stand operations; following liftoff, flight-performance data are summarized in real-time on this channel		12	15	SRO	Used by SRO for communicating with NASA test controller in blockhouse and associate test controller in operations center; following liftoff, AFETR mark events and AOS/LOS ^c were reported on this channel
3	6	Missile test	Used for launch-vehicle systems test		Lower panel:			
4	11	Instrumentation	Used for vehicle telemetry and RF systems activities; following liftoff, this channel is used for real-time launch-vehicle telemetry commentary		1	—	Status coordinator	Internal operations center channel, used by status coordinator for status announcements within center, and as a general channel for intracenter calls by operating personnel
5	12	Payload 1	Used for spacecraft systems test and spacecraft count-down		4	—	RTCF	Used by JPL/AFETR communication center for coordination of metric data transmission activities with RTCF
6	13	Payload 2	Used as spacecraft work channel for detailed discussions of spacecraft problems; following liftoff, this channel was used for real-time commentary on flight path based on range safety plotting boards		7	—	MSFN status	Used by TDS coordinator and GSFC network controller to discuss MSFN status
7	16	NASA TC	Used by KSC/ULO ^b Project personnel to coordinate launch countdown		12	—	Communications coordination	Used by operations center personnel for coordinating communication and data-transmission activities with JPL/AFETR communication center
^a MOIS = Mission Operations Intercommunication System. ^b KSC/ULO = Kennedy Space Center/unmanned launch operations. ^c AOS/LOS = acquisition of signal/loss of signal.								

Deep Space Station acquisition information for DSSs 72, 51, and 42 was prepared by the RTCF and forwarded to JPL. In addition, the AFETR transmitted interranging vector messages and DSS 72 predicts directly to DSS 72. Following the single-station solutions, the RTCF computed and transmitted to JPL recursive accumulative orbits. An I-matrix based on each solution was included.

B. Deep Space Phase Configuration

The major elements of the DSN, configured to support the *Pioneer VIII* mission, were (1) the DSIF, (2) the SFOF, and (3) the Ground Communications Facility

(GCF). Figures 27, 28, and 29 give the generalized data flow of *Pioneer* tracking, telemetry, and reloaded data within the DSN.

1. Deep Space Instrumentation Facility. The DSIF comprises the Deep Space Stations. The function of these stations was to obtain angular position, doppler, and telemetry data from the *Pioneer VIII* spacecraft during the postinjection phase of the mission. Data obtained by the Deep Space Stations were to be transmitted to the SFOF in real-time via teletype circuits. In addition, the same data were to be recorded on magnetic tape at each Deep Space Station and dispatched to JPL by air service.

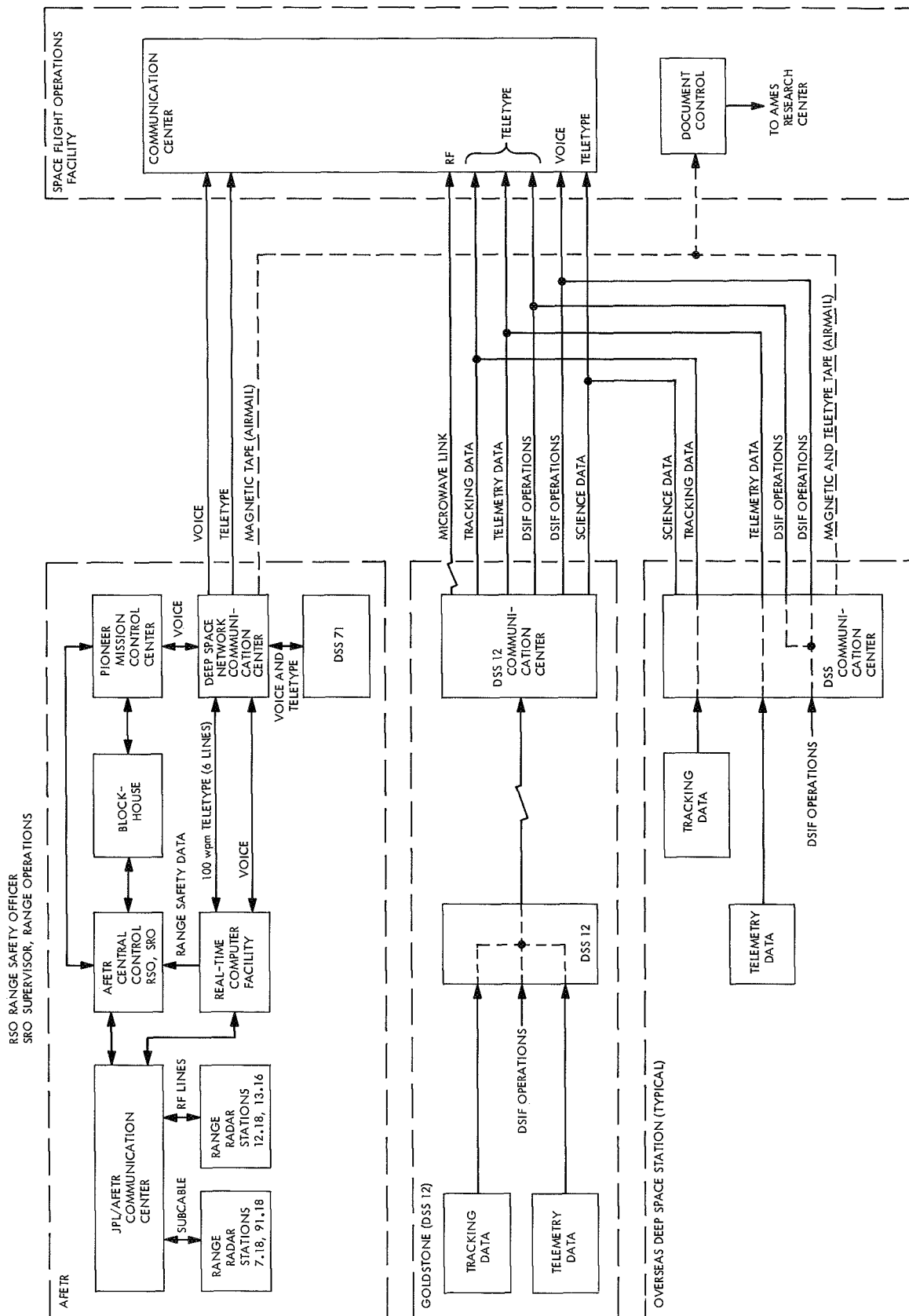


Fig. 27. Telemetry and tracking data flow from AFETR and DSIF to SFOF

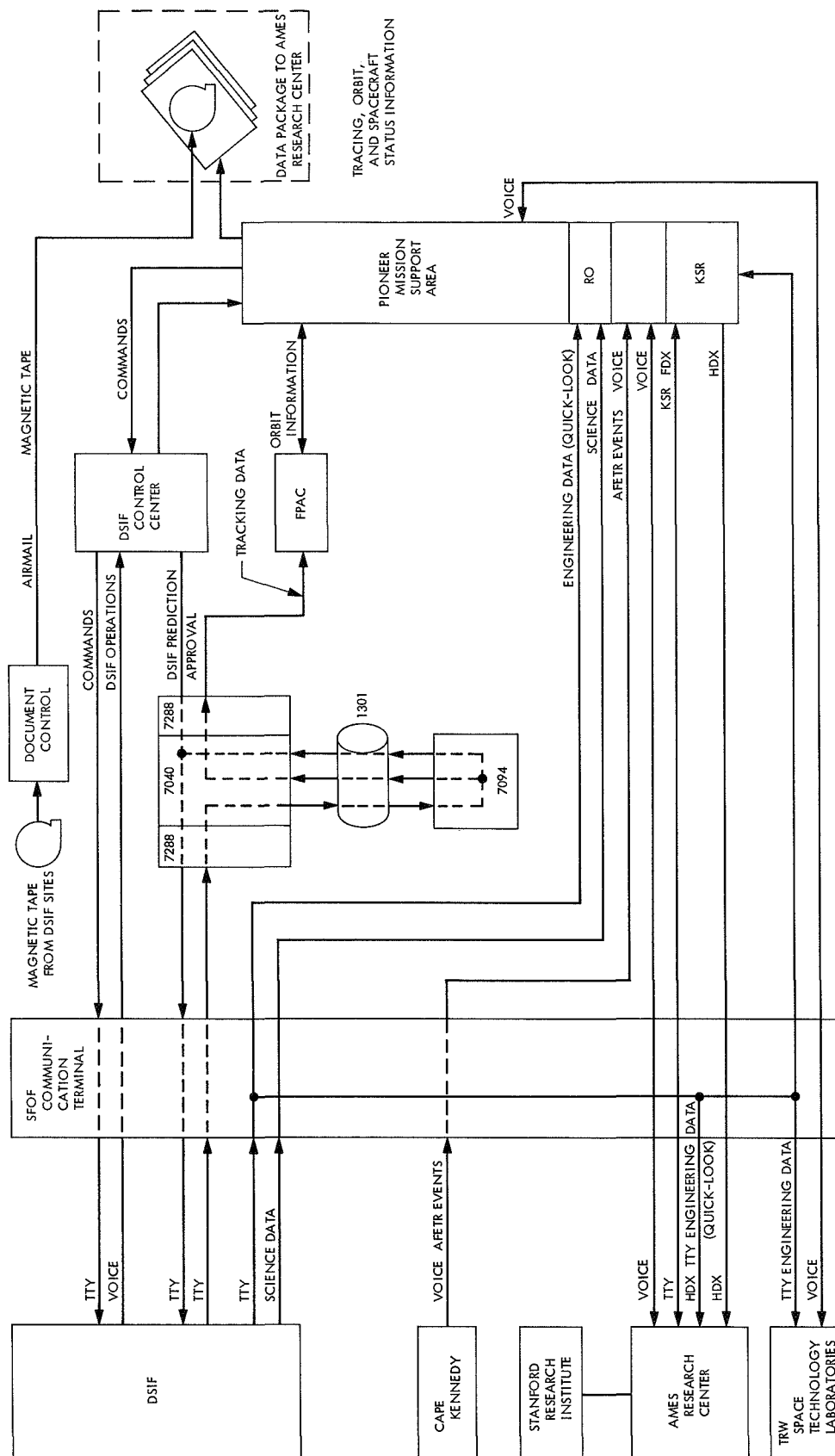


Fig. 28. Pioneer Space Flight Operations Facility data flow

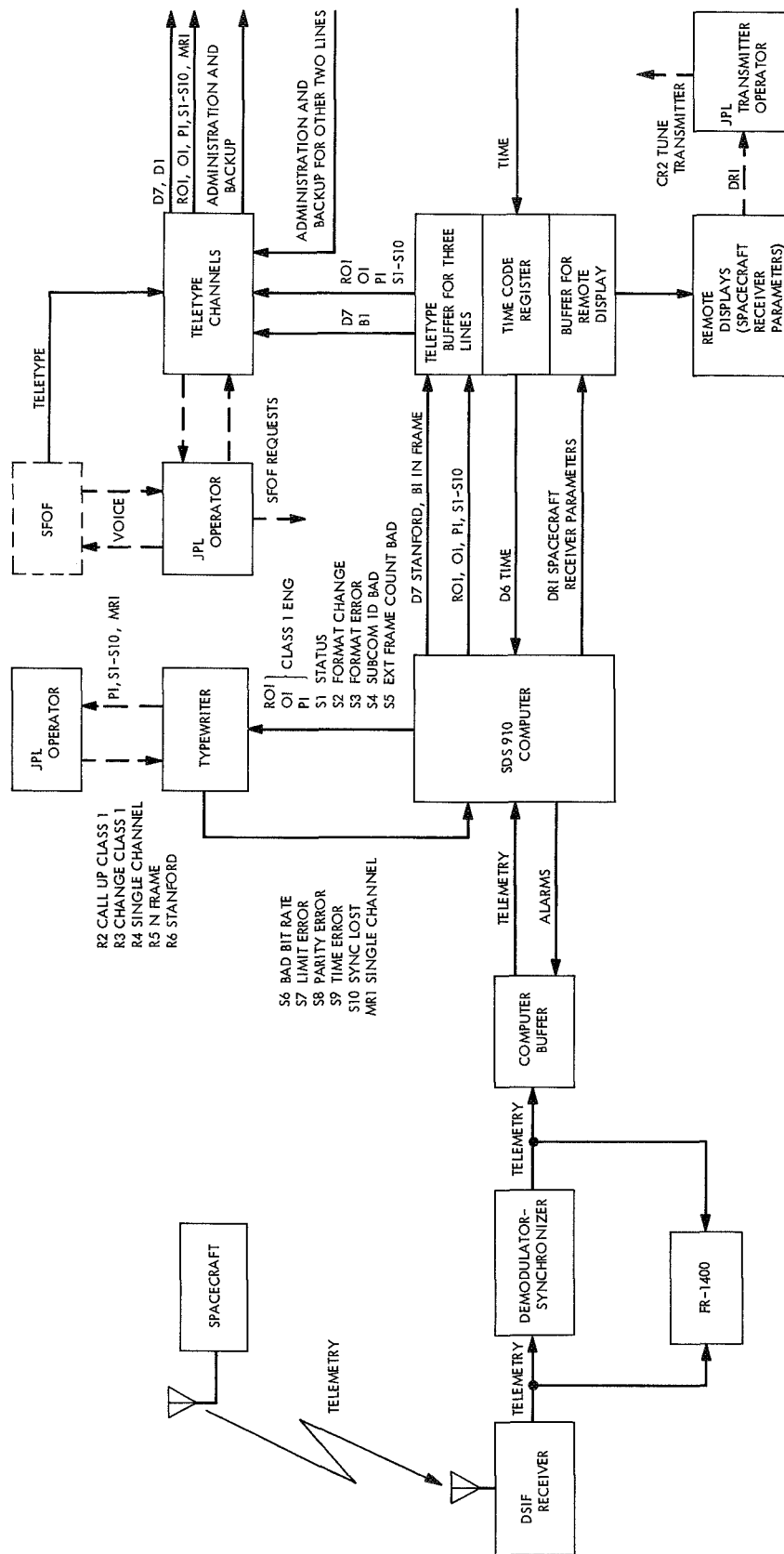


Fig. 29. Pioneer telemetry data flow and associated functions (excluding orientation-peculiar telemetry processing)

a. *Deep Space Stations.* The following Deep Space Stations were designated as primary in support of the *Pioneer VIII* mission:

Station	Location
DSS 12	<i>Echo</i> Station, Goldstone, Calif.
DSS 41	Woomera, Australia
DSS 51	Johannesburg, South Africa (best obtainable)
DSS 62	Madrid, Spain
DSS 71	Cape Kennedy, Fla. (launch operations only)

The operational frequency assignments of these Deep Space Stations are listed in Table 34. Compatible telecommunication modes are listed in Table 35. The tracking data format is shown in Table 36. The Deep Space Station tracking modes are listed in Table 37. Block diagrams of the stations are presented in Figs. 30 and 31. See Table 26 for the mission-dependent equipment that was necessary to be operational for the launch to occur.

b. *Backup stations.* The following backup stations were available for emergency recording of the telemetry subcarrier on magnetic tape whenever possible throughout the mission:

Station	Location
DSS 11	<i>Pioneer</i> Station, Goldstone, Calif.
DSS 42	Tidbinbilla, Australia
DSS 72	Ascension Island (engineering basis only)

c. *Mission-dependent equipment.* A significant amount of special-purpose and mission-dependent equipment and many facilities were provided by the *Pioneer* Project for accomplishing the mission objectives. The spacecraft and scientific instruments are easily recognized as belonging to this group. In addition, however, EGSE was provided for checking out the spacecraft and scientific instruments, and for verifying their launch readiness. Ground operational equipment was supplied to four Deep Space Stations for processing telemetry data and transmitting commands to the spacecraft. Equipment was specially designed and fabricated for decommutating and processing telemetry data recorded on magnetic tapes. General-purpose equipment was installed at ARC and the SFOF to provide for mission control from these sites.

Table 34. Operational frequency assignments

Channel	Receive, MHz	Channel	Transmit, MHz
6A	2292.037037	6B	2110.584105
7A	2292.407407	7B	2110.925154

Table 35. Compatibility matrix

Mode	Doppler (1-way)	Doppler (2-way)	Non-coherent doppler (2-way)	Angle tracking	Ranging	Command	Telemetry
Doppler (1-way)				X			X
Doppler (2-way)				X		X	X
Noncoherent doppler (2-way)				X ^a		X	X ^a
Angle tracking	X	X	X ^a			X	X
Ranging							X
Command		X		X			X
Telemetry	X	X	X ^a	X		X	

^aOnly at receiving station.

d. *Ground operational equipment.* The worldwide DSN provided the entire tracking, data acquisition, and command transmission during the free-flight portion of the *Pioneer VIII* mission. To permit partial telemetry data processing in real-time, three of the Deep Space Stations were supplied with mission-dependent equipment. As shown in the functional block diagram of Fig. 32, the in-line GOE consists of a command encoder, a computer buffer, and a demodulator-synchronizer. Associated test equipment, consisting of a test transponder and an error-rate tester, was also supplied to each of these three facilities; in addition, a data format generator was supplied to DSS 12. Display and plotting equipment for use during the Type II orientation was also supplied to DSS 12.

The in-line equipment, in conjunction with the mission-independent equipment shown in Fig. 21, processed the spacecraft telemetry data to provide:

- (1) Preselected spacecraft engineering data and up to 2176 words (7 bits long) of consecutive spacecraft telemetry for immediate teletype transmission to SFOF and ARC.

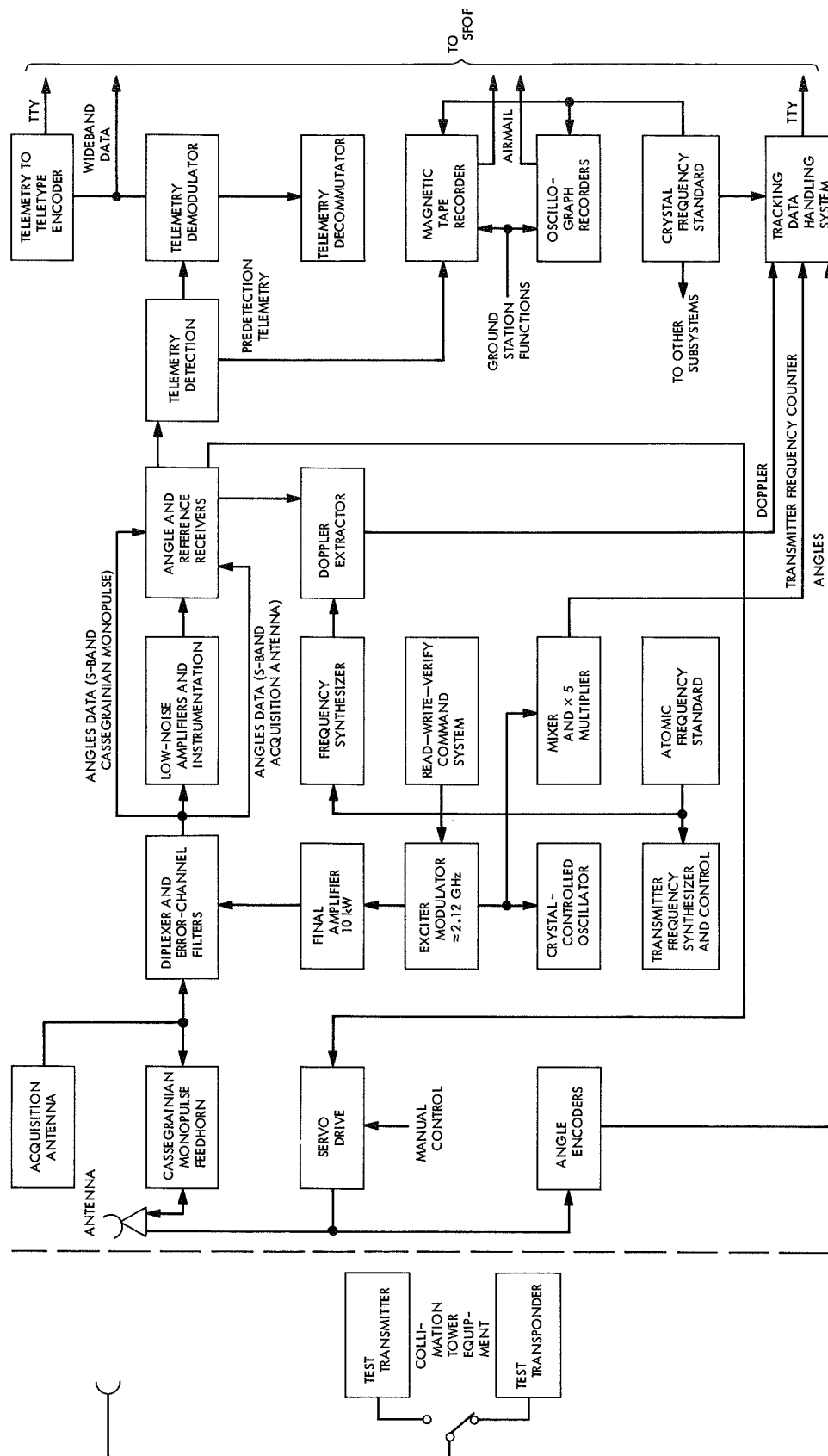


Fig. 30. Pioneer VIII typical Deep Space Station S-band configuration

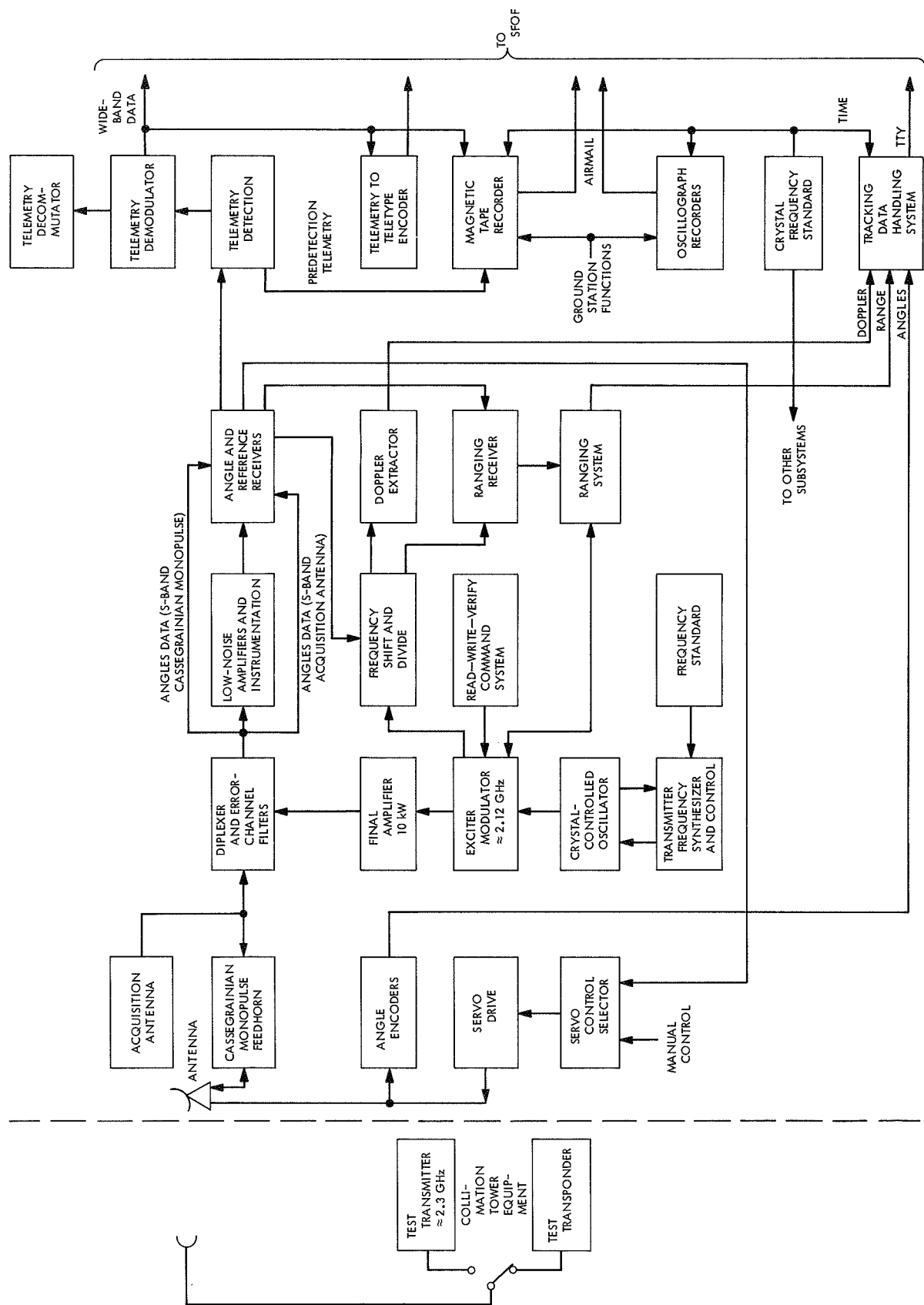


Table 36. Form and sequence of metric data transmitted from the Deep Space Stations

Sequence	Long-form format	Short-form format	Classification of data	Identification designation
1	C/R L/F	C/R L/F	Station identification Format identification Spacecraft identification Data condition Greenwich Mean Time Day of mission	Descriptor (precedes each data transmission)
	F XX S 02 S	F XX S 03 S		
	XX S	XX S		
	XXXX S	XXXX S		
	XXXXXX S	XXXXXX S		
	XXX S	XXX S		
2	XXXXXXXXXX S	XXXXXXXXXX S	Doppler identification	Data transmission
3	XXXXXXXXXX S	XXXXXXXXXX S	Range and range dc	
4	XXXXXX S	—	Local hour angle	
5	XXXXXX S	—	Declination angle	

- (2) Continuous evaluation of preselected engineering measurements and generation of alarm signals for teletype transmission to SFOF and ARC (to indicate data-processing irregularities).
- (3) Computer typewriter printout of preselected spacecraft engineering data and selectable engineering or scientific measurements.
- (4) Displayed values of spacecraft parameters to verify up-link acquisition and the quality of spacecraft receiver lock.
- (5) Preselected scientific data for immediate teletype transmission to Stanford University.

The capabilities of the system related to command transmission provide:

- (1) A command message corresponding to a manually inserted command.
- (2) A means of preventing the transmission of any command not contained in a *permissive command list* previously inserted in the computer.
- (3) Verification, by means of the command monitor receiver and the computer, that the transmitted command message corresponds to the manually inserted command, and termination of transmission when an error is detected.
- (4) Spacecraft command status, notation of the transmitted commands and their time of transmission, and verification (where possible) of command execution on the spacecraft for immediate computer typewriter printout at the Deep Space Station and teletype transmission to SFOF and ARC.

Table 37. Deep Space Station tracking modes

Prefix	First digit identification		Last digit identification	
	Digit	Definition	Digit	Definition
GM	0	No receive (transmit only)	0	Not used
GM	1	1-way (receive only) doppler	1	Feedhorn-diplexer (85-ft-diam antenna)
GM	2	2-way, 1-station (transmit-receive)	2	Acquisition antenna-diplexer (85-ft-diam antenna)
GM	3	2-way, 2-station, noncoherent mode (receive only)	3	Acquisition antenna
GM	4	2-way, 2-station, coherent mode (receive, with reference signal from transmitting station)	4	Dipole (6-ft-diam antenna)
GM	5	Receive only (no doppler)	5	Feedhorn without diplexer (85-ft-diam antenna)

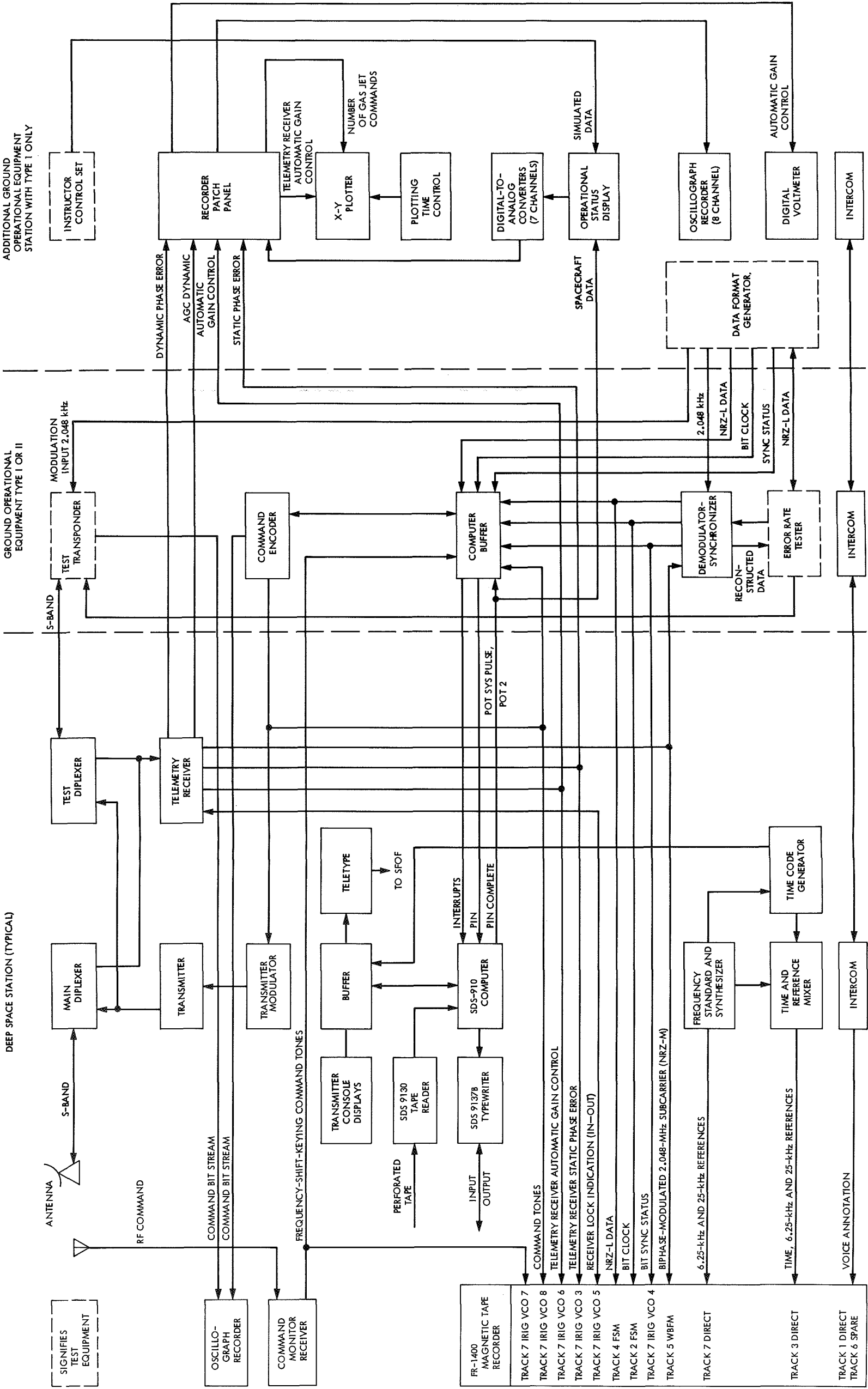


Fig. 32. Ground operational equipment functional block diagram

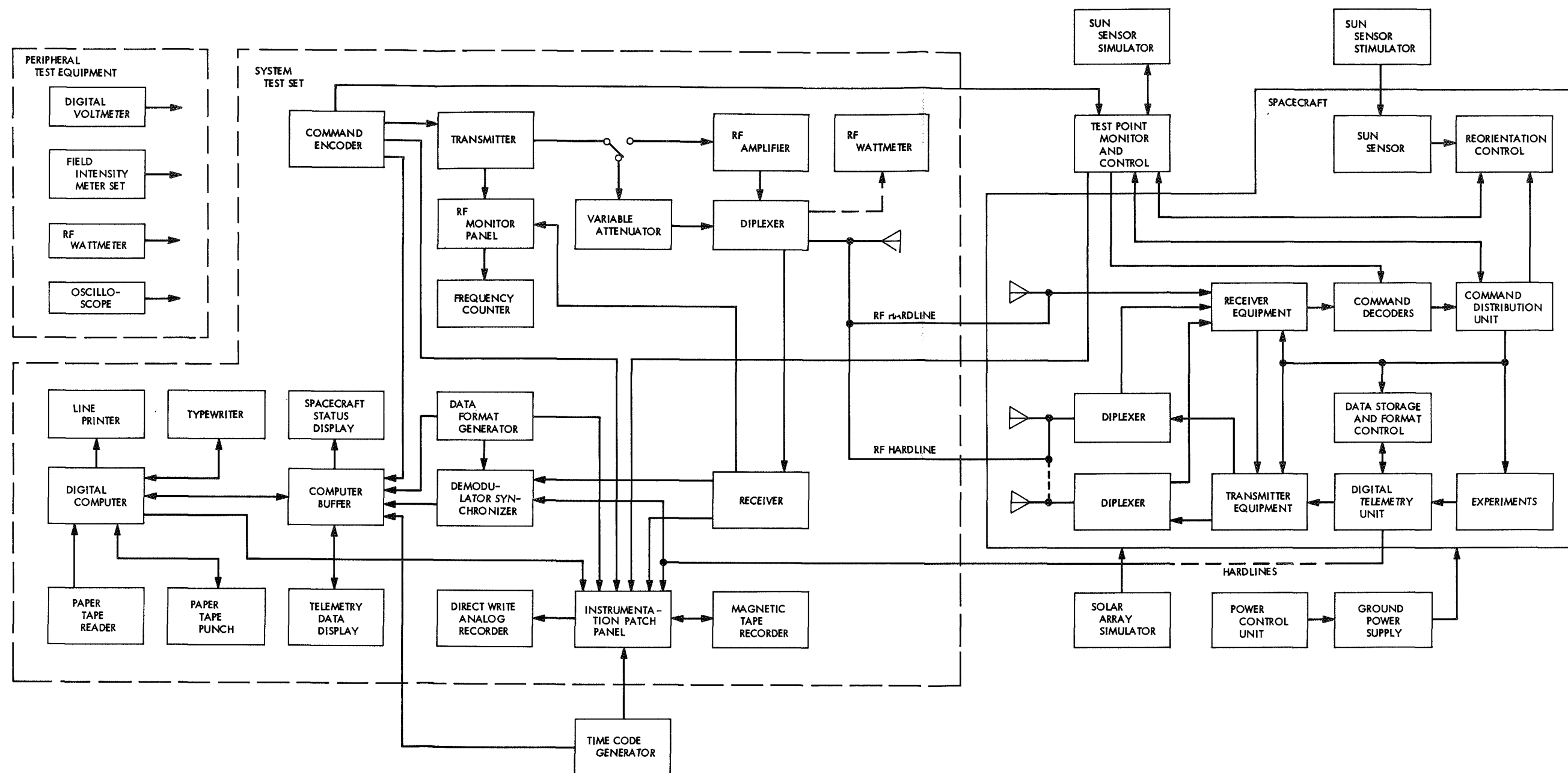


Fig. 33. Block diagram of electrical ground support equipment showing relationship to spacecraft

The system also prepares messages pertaining to the operating status of the GOE and the computer and the parity error rate of the processed telemetry data for the typewriter printout and teletype transmission.

Because of teletype limitations, the system could not transmit all of the telemetry data received at the four highest bit rates. The telemetry data were, therefore, recorded on magnetic tape, together with command messages, verbal messages by station personnel during a *Pioneer VIII* track, timing signals, and performance data pertaining to selected equipment, for later processing at the *Pioneer* off-line data processing station at ARC.

Demodulator-synchronizer. The function of the demodulator-synchronizer is to demodulate simultaneously the *Pioneer* telemetry subcarrier and generate a bit clock pulse train (synchronous with the data). The input to the demodulator-synchronizer is the biphase-modulated 2.048-kHz subcarrier from the Deep Space Station receiver during tracking, but it can also be a similar signal from the data format generator, the error-rate tester, or the magnetic tape recorder during testing. (The output of the unit is a noise-free replica of the data bit stream, a pulse train synchronous with the data, and a sync status signal. For most conditions, operation of the demodulator-synchronizer is fully automatic except for source and bit-rate selection.)

Command encoder. The command encoder produces a 23-s command message corresponding to a manually inserted command, which phase-modulated the Deep Space Station transmitter signal. The equipment permits visual inspection of the inserted command and operates in combination with the Deep Space Station computer to provide the *permissive command list* check mentioned above. Switches are provided to override this feature in the event of computer malfunction or to stop command transmission.

Computer buffer. The computer buffer served as a communication link between the mission-dependent equipment and the computer. It accumulated data to be entered into the computer and distributed data from the computer. The buffer provided audible and visible alarms when either bit synchronization or word synchronization was lost or when spacecraft engineering data were out of limits.

Test equipment. Useful for all *Pioneer* missions, the test equipment simulated spacecraft communications in

all of the various modes of operation for use during check-out of the in-line mission-dependent and -independent equipment. The test equipment also facilitates troubleshooting of the GOE.

The transponder has a receiver (two receivers in the DSS 12 unit), a command decoder (a display in the DSS 12 unit), and a transmitter driver that can be suitably modulated and that produces an S-band signal whose strength can be attenuated over a range of 100 dB. The transponder can operate in either a coherent or non-coherent mode. The data format generator produces a simulated spacecraft data bit stream that can modulate the transponder or be sent directly to the demodulator-synchronizer or to the computer buffer.

To evaluate the performance of the demodulator-synchronizer, the error-rate tester supplies the demodulator-synchronizer with a biphase-modulated 2.048-kHz square-wave subcarrier of selectable signal-to-noise ratio (SNR) and known bit sequence. The tester compares the reconstructed data returned by the demodulator with the original bit sequence. The data stream available from the data format generator can be substituted for the bit sequence generated within the tester to simulate a modulated spacecraft telemetry subcarrier of known SNR.

e. Electrical ground support equipment. The EGSE of the *Pioneer* Project was designed and built to support testing and performance evaluation of the spacecraft before launch; it was the central point for test control and monitoring, command transmission, telemetry acquisition, spacecraft subsystem simulation, and the processing, display, and recording of spacecraft and scientific instrument data. This equipment, which is composed of various assemblies, together with their relationship to the spacecraft, is shown in Fig. 33. Several of these assemblies (such as the demodulator-synchronizer, the command encoder, and the computer buffer) are similar to those used in the GOE.

The EGSE (Fig. 34) is composed of a digital computer subsystem and five dolly-mounted consoles: the ground power console, test console, recorder console, radio-frequency console, and telemetry data console.

The digital computer subsystem, which processes (in real-time) spacecraft data received from the demodulator-synchronizer, consists of a digital computer, typewriter, line printer, paper tape reader, and paper tape punch.

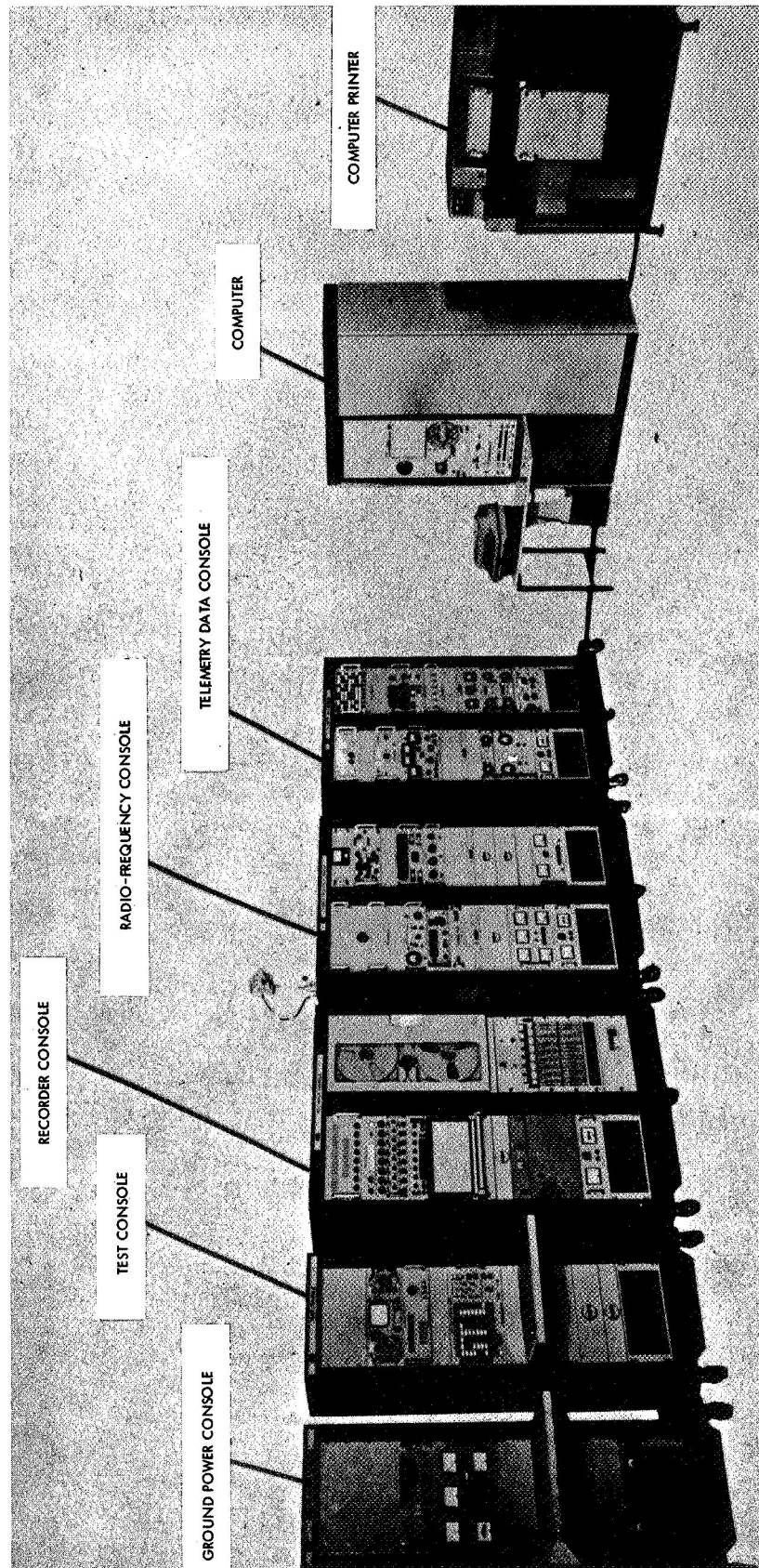


Fig. 34. Electrical ground support equipment system test station

The subsystem controls the spacecraft status and telemetry data displays and performs a number of computations, so that the printout of spacecraft and scientific instrument data is in meaningful measurements and units and in a form suitable for analysis and evaluation.

The ground power console provides and controls power to the spacecraft during tests and monitors the spacecraft bus and battery voltages and currents.

The test console consists of a test point monitor and control and a sun sensor simulator. This console acts as an interface for all hardline signals between the spacecraft and the electrical test equipment (exclusive of ground power and RF signals). The sun sensor simulator provides signals to the orientation subsystem that simulates operation of the five sun sensors. Various spacecraft spin rates can also be simulated.

The recorder console consists of an instrumentation patch panel, a direct-write analog eight-channel oscillograph, and a magnetic tape recorder. The latter provides the capability for recording signals and playing them back.

The RF console contains the command transmission and data receiving equipment, which consists of a command encoder, command transmitter, ramp generator, antenna, and telemetry receiver. The signal is transmitted either through a coaxial cable connected to the spacecraft or via RF radiation. The command encoder has no capability for a *permissive command list* check. The ramp generator provides a means to vary the transmitter carrier frequency in a manner simulating doppler rate.

The telemetry data console consists of a demodulator-synchronizer, computer buffer, data format generator, and display units, all with functions comparable to like units of the GOE.

In addition to the above, a sun sensor stimulator is available that can apply appropriate light pulses to the sun sensors to check their operation.

f. *Commands.* The *Pioneer VIII* spacecraft command messages were generated semiautomatically under operator control in the command encoder. The encoder may generate up to 128 unique 23-bit command messages in the format recognized by the spacecraft, including preamble, sync, address, command complement, command, and postquelch bits. The command and address portions of the messages were generated in binary-coded octal

format and placed in a 10-bit register. The register contents were changed to frequency-shift-keying tones for RF transmission. A binary one (1) is represented by a 240-Hz sine wave and a binary zero (0) by a 150-Hz sine wave. Figure 35 is a block diagram of the DSIF command signal flow for normal operations.

Any command or commands deemed necessary for corrective actions or for achieving a spacecraft mission must be approved by the SFOD. Upon concurrence of the Project manager, the commands are transmitted to the Deep Space Station for execution. Command requests were made only by the technical and operations teams within the SFOF using approved command-decision procedures outlined in the spacecraft operating procedures.

Routine command sequences were listed in the daily operations plan for station passes. After approval of the daily operations plan by the Project manager, the SFOD was responsible for routine execution of such commands. All *Pioneer VIII* commands sent in the normal command mode were transmitted under computer control and then checked against a permissive command tape loaded into the SDS 910 computer at the beginning of a pass or segment of the operation.

The SDS 910 computer verified the commands sent to the spacecraft at three different times: (1) pretransmission, (2) during transmission, and (3) posttransmission.

To accomplish pretransmission verification, a perforated tape was loaded into the computer (containing the applicable spacecraft command decoder address and all permissible commands) at the beginning of each pass. After the operator had manually selected both the spacecraft decoder address and the command, the computer could be interrogated (by use of a button on the command encoder that caused a computer interrupt) to verify that the manual selection was indeed permissible for the pass. When the command was permissible, a signal was sent to the command encoder to visually indicate the fact. If the manual command was not permissible for any reason, an appropriate message would be typed out.

During each transmission of the command, the command generator sent 23 interrupts to the computer (at 1 bit/s). At the same time, the outputs of the command monitor receiver were also available as a computer input. On this basis, the computer could check each of the 23 bits as they were serially transmitted. If any of the bits was incorrect, the computer would generate an output

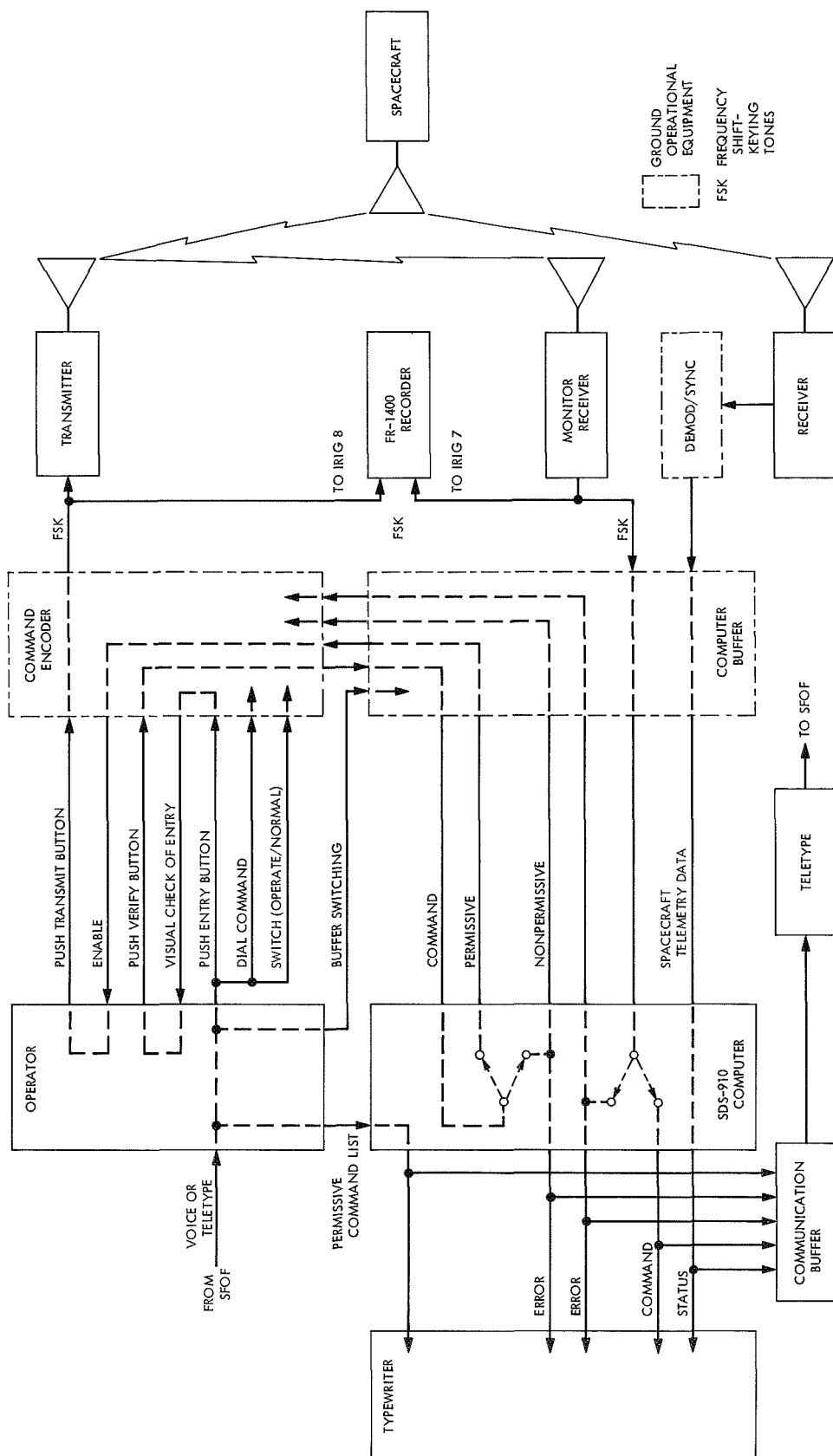


Fig. 35. Command signal flow for normal operations, DSIF

signal to inhibit any further transmission; the computer would also type and punch an appropriate message to generate an alarm. If all 23 bits verified properly, a message was both punched and typed, indicating that a spacecraft command was sent to the spacecraft at the indicated time.

The posttransmission verification was based on received telemetry signals. If the transmitted command was verifiable, it was entered into a *command sent* storage list. Then, as changes were detected in the spacecraft status bits from the received telemetry, these changes would be verified against the contents of the *command sent* list. Should any status bits change without having been called for by a command, an appropriate message would be typed and punched, and an alarm signal generated. Furthermore, the contents of the *command sent* list were printed out at the end of each standard print-out. Hence, if a command had been sent but not executed, this could be readily seen on the basis of the typed output.

Assuming normal spacecraft operation, all commands were prohibited during the launch phase through completion of Type I. All commands were permitted after the conclusion of the initial Type I maneuver.

g. Facilities.

Woomera, Australia Station (DSS 41). The DSN provided a room approximately 15 by 30 ft in the control building for the exclusive use of the *Pioneer* Project for the installation of Project-peculiar equipment. Facility support provided for this space was as follows:

- (1) Power: 120 V $\pm 10\%$, 60 ± 1 Hz, with capacity sufficient for Project-peculiar equipment; 120-V, 60-Hz power outlets for auxiliary equipment.
- (2) Room temperature: 70 $\pm 5^\circ\text{F}$.
- (3) Plenum air temperature: 55 $\pm 5^\circ\text{F}$.
- (4) Humidity: 50 $\pm 10\%$ relative.
- (5) Lighting: 100 ft-cd.
- (6) Acoustic level: 65 dB above 10^{-16} W/cm² max.
- (7) Furniture: Sufficient desks and chairs for use by Project personnel during installation, testing, and training were provided. A storage cabinet for spare assemblies was also provided.

The DSN provided one SDS 910 computer, with 8192 words of memory, for use of the Project with a degree of reliability comparable to other elements of the DSN. The computer was available on the date shown in the DSN schedule of operational dates. This computer was to remain integral to the digital instrumentation system at each station.

The specific equipment made available at the DSN stations committed to the *Pioneer* Project is described in the DSN on-site data processing system capabilities document, and was included in the *Pioneer*/DSN interface description. The DSN was not to fund or procure any special buffer registers, logic-level converters, or special interface equipment for input or output of data to or from this computer.

The DSN was to operate and maintain the Project-dependent equipment (GOE) supplied by the Project.

The DSN was to provide (subject to circuit priorities) two full-duplex teletype circuits between the SFOF and the Woomera station (DSS 41) for full-time use by the *Pioneer* Project during a pass to which the station is assigned and on a shared basis at other times. The maximum usable bit rate on these circuits is 23 bits/s.⁵

A full-time duplex teletype circuit and a voice circuit between the SFOF and the Canberra station were assigned for network control by the Deep Space Stations. Subject to the approval of the station manager, the DSN operations manager, or their delegates, these circuits could be used by the *Pioneer* Project when they were not busy or during emergencies.

The Woomera station was to provide a voice communications circuit to interconnect the Project-dependent equipment command operator with the station receiver, data handling, computer, transmitter, and antenna operators.

Goldstone Echo Station (DSS 12). The DSN provided an area of approximately 400 ft² in the control building

⁵This rate is derived as follows: Maximum teletype transmission rate is 60 wpm. Each word contains six characters (five letters plus one space) and each character contains seven bits (one start, one stop, one parity, and four data). If line feed and carriage return characters are assumed to require an average of 1 bit/s, the usable bit rate (not counting the requirements for message preamble, identification, date/time groups, etc.) is $4 \times 6 - 1 = 23$ bits/s.

for the exclusive use of the *Pioneer* Project for the installation of Project-peculiar equipment. The following facility support for this space was provided:

- (1) Power: 120 V $\pm 10\%$, 60 ± 1 Hz, with capacity sufficient for Project-peculiar equipment; 120-V, 60-Hz power outlets for auxiliary equipment.
- (2) Room temperature: 70 $\pm 5^\circ\text{F}$.
- (3) Plenum air temperature: 55 $\pm 5^\circ\text{F}$.
- (4) Humidity: 50 $\pm 10\%$ relative.
- (5) Lighting: 100 ft-cd.
- (6) Acoustic level: 75 dB above 10^{-16} W/cm² max.
- (7) Furniture: Sufficient desks and chairs for use by Project personnel during installation, testing, training, and operations during orientation maneuver were provided. A storage cabinet for spare assemblies was also provided.

The data system hardware commitment made to DSS 41 was applicable at this site.

It was agreed that the DSN would normally operate and maintain the Project-dependent equipment supplied by the Project except during special events, such as an orientation maneuver, when the Project manager, at his option, would furnish personnel to operate and maintain this equipment.

Communications facilities were similar to those for DSS 41.

The DSN was to provide (subject to circuit priorities) two full-duplex teletype circuits between the SFOF and the Goldstone *Echo* station (DSS 12) for full-time use by the *Pioneer* Project during a pass to which the station is assigned and on a shared basis at other times. The maximum usable bit rate on these circuits is 23 bits/s. During orientation maneuvers, a third full-duplex teletype circuit and a voice circuit were available for use by the Project.

A full-time duplex teletype circuit and a voice circuit between the SFOF and the Goldstone *Echo* station were assigned for network control by the DSN. Subject to the approval of the station manager, the DSN operations manager, or their delegates, these circuits could be used by the *Pioneer* Project when they were not busy or during emergencies.

The Goldstone *Echo* station was to provide a voice communications circuit to interconnect the Project-dependent equipment orientation director and the spacecraft status advisor with the station manager, as well as the receiver, transmitter, antenna, computer, and data handling operators.

Johannesburg Station (DSS 51). The DSN provided an area of approximately 300 ft² in the control building for the exclusive use of the *Pioneer* Project for the installation of Project-peculiar equipment. The following facility support for this area was provided:

- (1) Power: 120 V $\pm 10\%$, 60 ± 1 Hz, with sufficient capacity for Project-peculiar equipment; 120-V, 60-Hz power outlets for auxiliary equipment.
- (2) Room temperature: 70 $\pm 5^\circ\text{F}$.
- (3) Plenum air temperature: 55 $\pm 5^\circ\text{F}$.
- (4) Humidity: 50 $\pm 10\%$ relative.
- (5) Lighting: 100 ft-cd.
- (6) Acoustic level: 75 dB above 10^{-16} W/cm² max.
- (7) Furniture: Sufficient desks and chairs for use by Project personnel during installation, testing, and training were provided. A storage cabinet for spare assemblies was also provided.

Similar data system hardware commitments to those made to DSS 14 were applicable at this station.

Similar Project-dependent equipment (GOE) commitments to those made to DSS 41 were applicable at this station.

Similar communications commitments to those made to DSS 41 were applicable at this station.

Madrid Station (DSS 62). The DSN provided an area of approximately 400 ft² in the control building for the exclusive use of the *Pioneer* Project for the installation of Project-peculiar equipment. The following facility support for this space was provided:

- (1) Power: 120 V $\pm 10\%$, 60 ± 1 Hz, with capacity sufficient for Project-peculiar equipment; 120-V, 60-Hz power outlets for auxiliary equipment.
- (2) Room temperature: 70 $\pm 5^\circ\text{F}$.
- (3) Plenum air temperature: 55 $\pm 5^\circ\text{F}$.
- (4) Humidity: 50 $\pm 10\%$ relative.

- (5) Lighting: 100 ft-cd.
- (6) Acoustic level: 75 dB above 10^{-16} W/cm² max.
- (7) Furniture: Sufficient desks and chairs for use by Project personnel during installation, testing, training, and operations during orientation maneuver were provided. A storage cabinet for spare assemblies was also provided.

The data system hardware commitment made to DSS 41 was applicable at this station.

It was agreed that the DSN would normally operate and maintain the Project-dependent equipment supplied by the Project except during special events, such as an orientation maneuver, when the Project manager, at his option, would furnish personnel to operate and maintain this equipment.

Communications facilities were similar to those for DSS 41.

Spacecraft monitoring station, Cape Kennedy, (DSS 71). The DSN provided an area of approximately 300 ft² in the control building for the exclusive use of the *Pioneer* Project for the installation of Project-peculiar equipment. The location of this space is shown in Fig. 28. The beneficial occupancy date was May 1, 1965. The following facility support for this area was provided:

- (1) Power: 120 V $\pm 10\%$, 60 ± 1 Hz, with sufficient capacity for Project-peculiar equipment; 120-V, 60-Hz power outlets for auxiliary equipment.
- (2) Room temperature: 70 $\pm 5^\circ$ F.
- (3) Plenum air temperature: 55 $\pm 5^\circ$ F.
- (4) Humidity: 50 $\pm 10\%$ relative.
- (5) Lighting: 100 ft-cd.
- (6) Acoustic level: 75 dB above 10^{-16} W/cm² max.
- (7) Furniture: Sufficient desks and chairs for use by Project personnel during installation, testing, and training were provided.

The Cape Kennedy station of the DSN was used to verify prelaunch compatibility of the spacecraft with the DSN during the prelaunch countdown.

The data system hardware and Project-dependent equipment (GOE) commitments made to DSS 42 were

applicable at this station. Communications facilities were similar to those for DSS 41.

The DSN provided three half-duplex teletype circuits and one voice circuit between the SFOF and the JPL communications center at Cape Kennedy for full-time use by the *Pioneer* Project during launch operations. The maximum usable bit rate on the teletype circuits is 23 bits/s. During nonlaunch-operation periods, the normal communications facilities maintained between JPL and Cape Kennedy were available to the *Pioneer* Project on a shared basis.

The Cape Kennedy station provided a voice communications circuit to interconnect the Project-dependent equipment operator with the station receiver, transmitter, data handling, computer, and antenna operators.

2. Ground Communications Facility. The GCF is the means by which the Deep Space Stations communicate with the SFOF. The GCF provides interfacility as well as on-site communications and an overall operational communications complex for flight project support. Communications responsibilities for the *Pioneer* Project include controlling, operating, and maintaining all circuits, switching, and terminal equipment committed to *Pioneer*. Goddard Space Flight Center is responsible for technical control of all NASCOM circuits used by the DSN. (Technical control includes maintenance of the communication network.) In fulfillment of the responsibility for technical control, GSFC informs JPL of the availability and condition of alternate circuits during periods of use, but does not perform the actual switching without prior approval of JPL, which has responsibility for mission control of the NASCOM circuits used by the DSN. Mission control, by contrast, means the determination of what traffic will flow, when and to what points this traffic will flow, and on what circuits the flow will occur. Communication lines between the Deep Space Stations and the SFOF are shown in Fig. 36. The AFETR communications and circuits to ARC, Stanford University, and TRW are also shown. Figure 37 is a chart of the *Pioneer VIII* profile, communications circuit activation, and major events.

There had been many changes in the GCF since the *Pioneer VII* launch, but all had been used in normal *Pioneer VI* and *VII* passes. The system support is described in the paragraphs that follow.

a. Voice. One voice circuit to each Deep Space Station, three to ARC, and four to AFETR (Building AO)

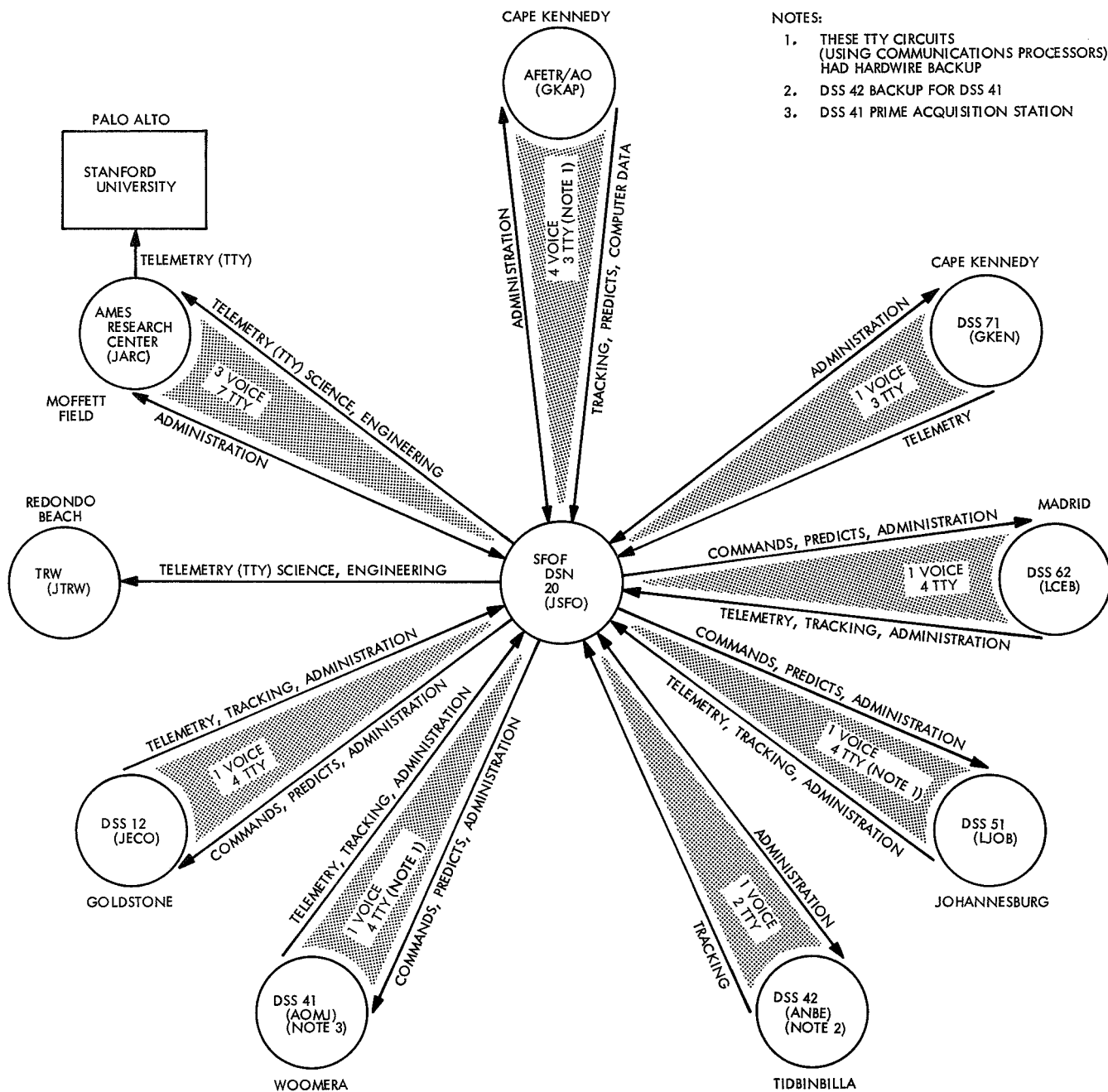


Fig. 36. Pioneer VIII communication lines

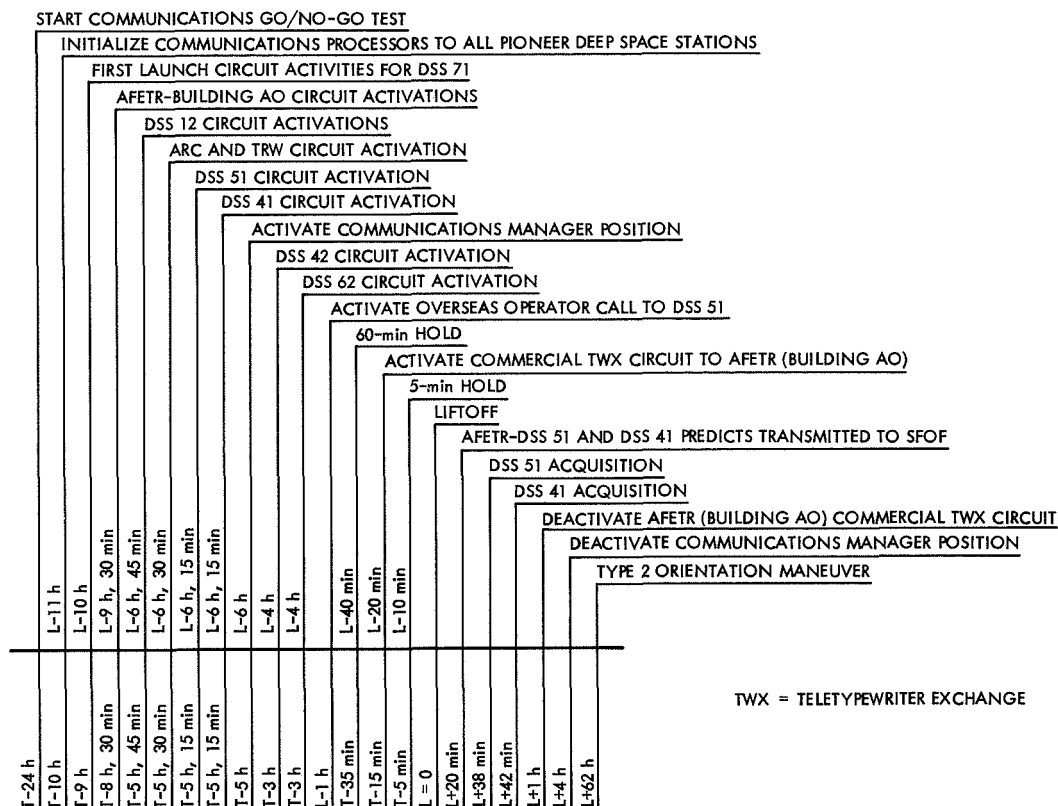


Fig. 37. Pioneer VIII mission profile, communications circuit activation, and major events

were allocated. Figure 38 shows the SFOF/ARC/TRW voice and teletype circuit configuration.

b. Teletype channels. Teletype channels were via communications processors at either London or Canberra, Goddard Space Flight Center, and JPL, as follows: three to DSS 71, three to AFETR (Building AO), one to TRW, four to each Deep Space Station, and seven to ARC. The latter seven include six available for data and one for NASCOM administrative messages only. Figures 39 and 40 show the DSN-GCF-NASCOM teletype routing configuration.

- (1) SFOF-DSS 71: (Fig. 41): one voice network and one teletype circuit (frequency reports).
- (2) SFOF-DSS 41: one voice network and one duplex teletype circuit (predicts and tracking data).
- (3) SFOF-DSS 51: one voice network and one duplex teletype circuit (predicts and tracking data).
- (4) SFOF-DSS 62: one voice network and one duplex teletype circuit (predicts and tracking data).

- (5) SFOF-DSS 12: one voice network and one duplex teletype circuit (predicts and tracking data).
- (6) SFOF-DSS 11: one voice network and one duplex teletype circuit (predicts and tracking data).
- (7) SFOF-ARC: one voice network and one duplex teletype circuit (predicts for Stanford and Type II maneuver data).
- (8) SFOF: communications processor; communications area support; data processing systems—one string of computers in Mode 2 (7044—disk—7094) from L-5 to L+11 h plus continuous Mode 3 operations until L+88 h, with periodic Mode 2 operations for orbit determination, predicts, and trajectory generation; *data chief* area support; data control area support; either FPAA-1 or FPAA-2; track area support; internal communications (OVCS); use of TV monitors; and SDCC support from L-5 to L-3 h.

c. Circuits. The minimum number of DSN-GCF and SFOF-ICS (Internal Communication System) circuits

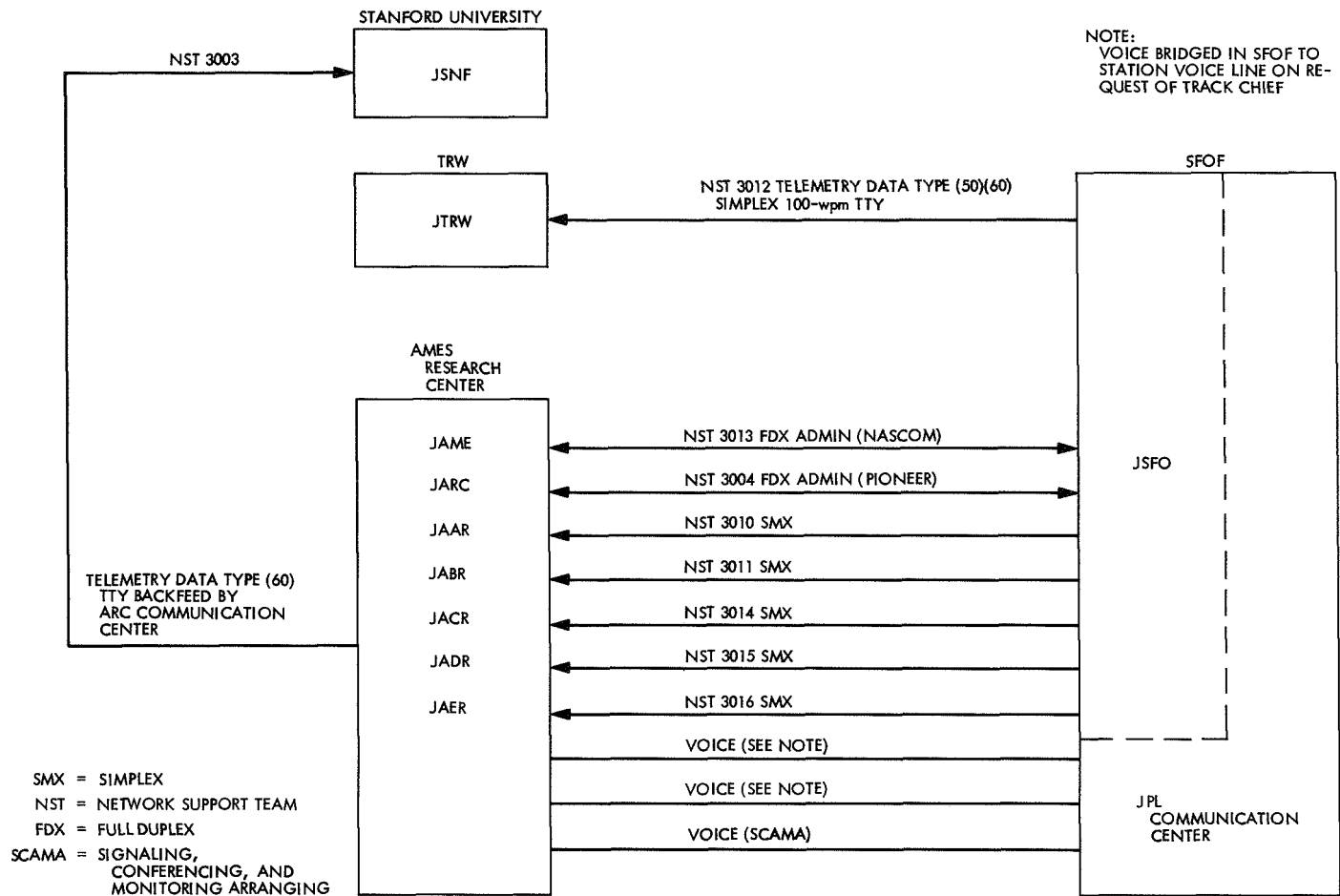
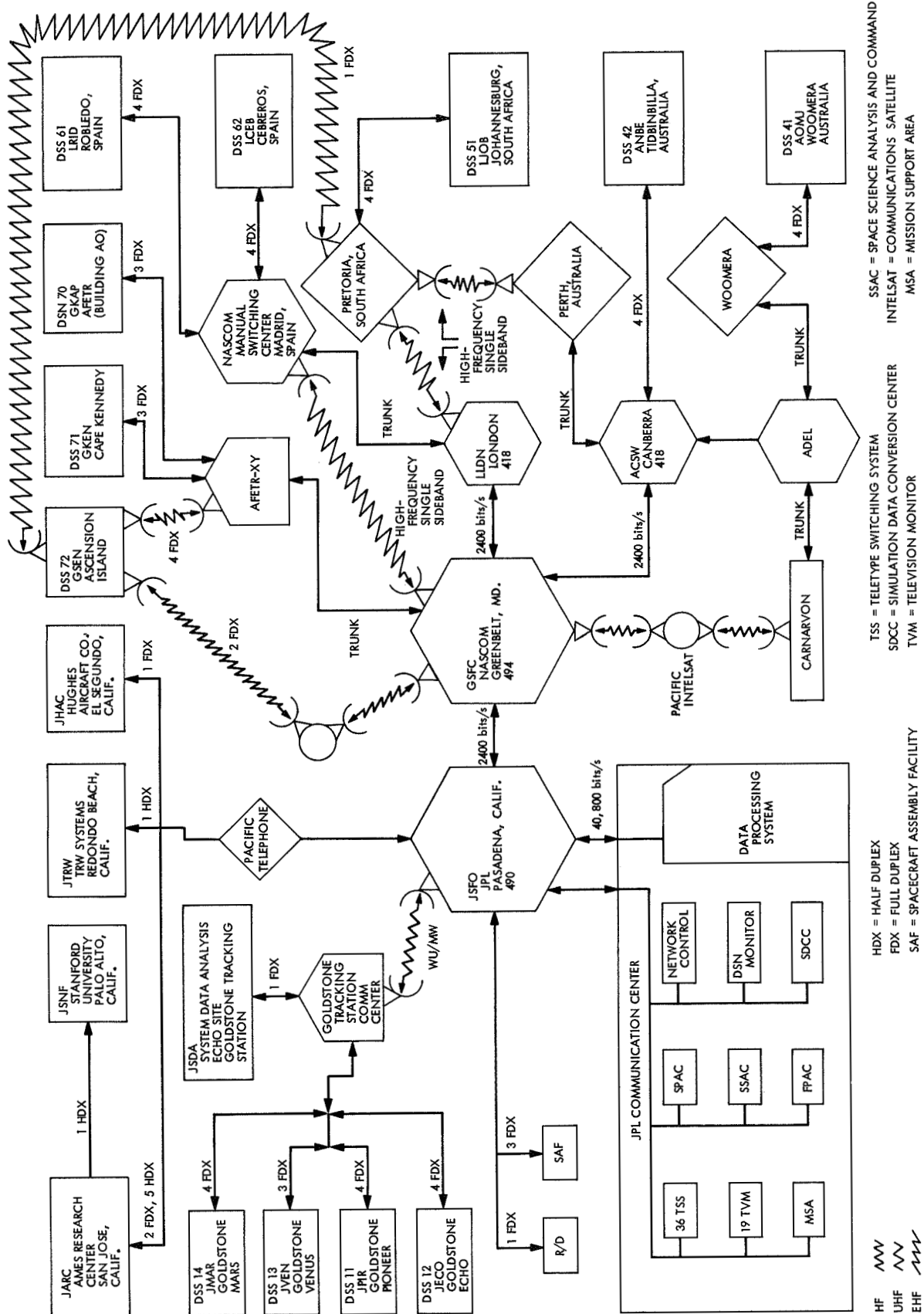


Fig. 38. SFOF/ARC/TRW voice and teletype circuit configuration for Pioneer VIII



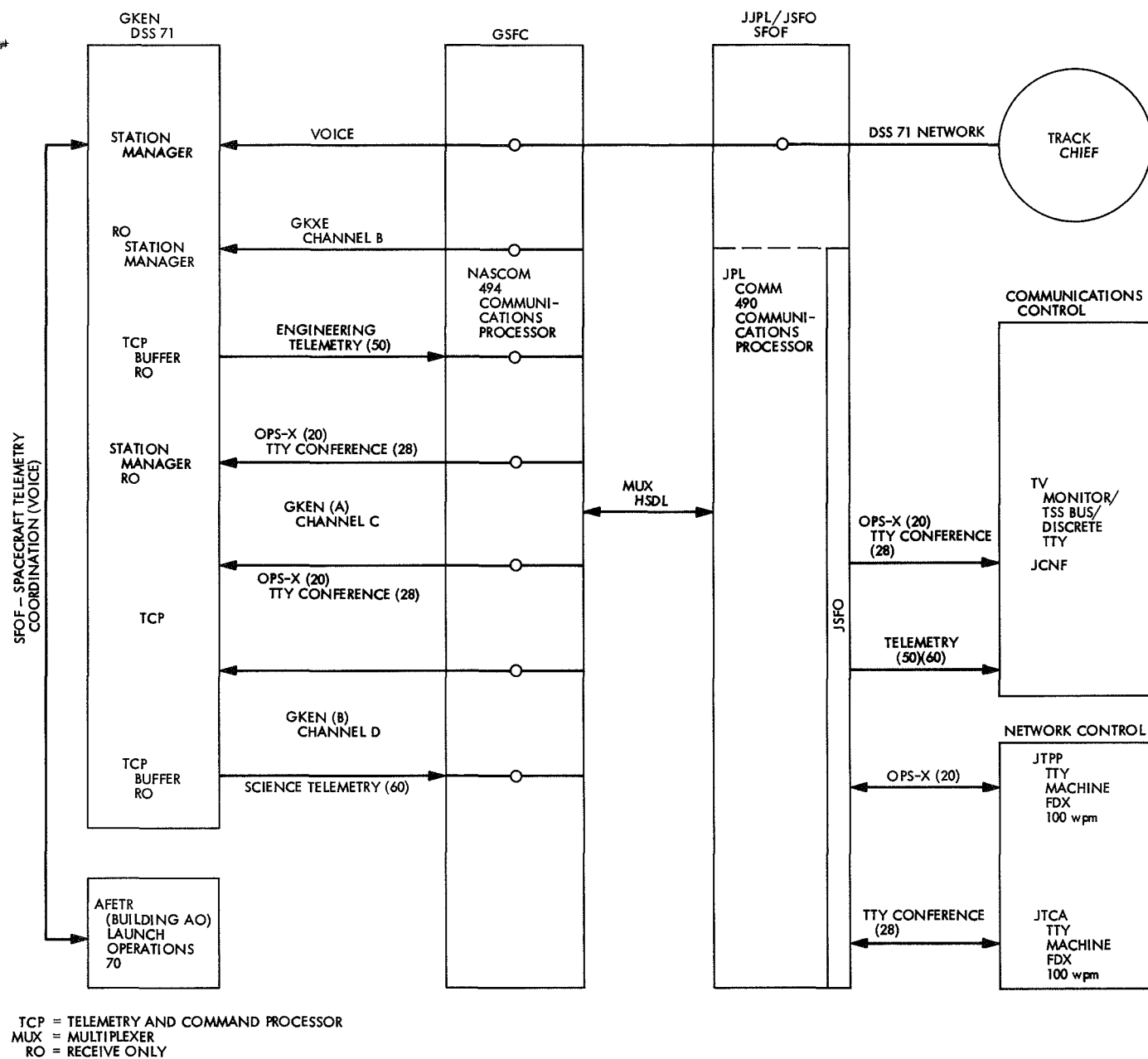


Fig. 41. SFOF-DSS 71 voice and teletype communications traffic flow configuration

and minimum equipment configured to operational was as follows:

*DSN-GCF operational circuits (Class I):*⁶

- (1) AFETR-SFOF: one voice network (AFETR network) and one teletype circuit.
- (2) SFOF-DSS 71 (Fig. 42): one voice network and one teletype circuit.
- (3) SFOF-DSS 41 (Fig. 43): one voice network and one teletype circuit.
- (4) SFOF-DSS 51: one voice network and one teletype circuit.
- (5) SFOF-DSS 12 or 11: one voice network and one teletype circuit.

*DSN-GCF operational circuits (Class II):*⁷ AFETR-SFOF (Fig. 44): three voice networks (AFETR, status, and mission director's networks) and three duplex teletype circuits (one for raw and two for computed data).

3. Space Flight Operations Facility. The SFOF is a flexible facility in which areas and hardware can be set up and restructured as required to meet the needs of various projects.

a. Areas. The DSN, in meeting the requirements of the *Pioneer VIII* mission, made use of the following areas, which are shown in Fig. 45:

- (1) *Pioneer* mission support area, Rooms 132 and 132A.
- (2) Operations area, Room 113.
- (3) Mission control, Room 2.
- (4) Flight path analysis area, Room 117.
- (5) Project manager, Room 115A.
- (6) Gallery.
- (7) DSIF control, Rooms 101 and 101A.
- (8) DSN control, Room 118.

⁶Class I requirements reflect minimum essential needs to ensure accomplishment of primary mission objectives. These Class I requirements are mandatory; if they had not been met, a decision not to launch could have resulted.

⁷Class II requirements define the needs to accomplish all stated mission objectives.

Pioneer mission support area. This area was used as the operational control center during the low-activity phase of the mission. Spacecraft-performance analysis and space-science analysis were accomplished in this area.

The DSN provided an area approximately 40 by 35 ft, called Mission Support Area 4, on the first floor of the SFOF, to the *Pioneer* Project for exclusive use by the Project. Included in this area is a 10 by 12 ft walled conference room. (See Fig. 45.)

The DSN installed the following operations equipment in the *Pioneer* Project mission support area:

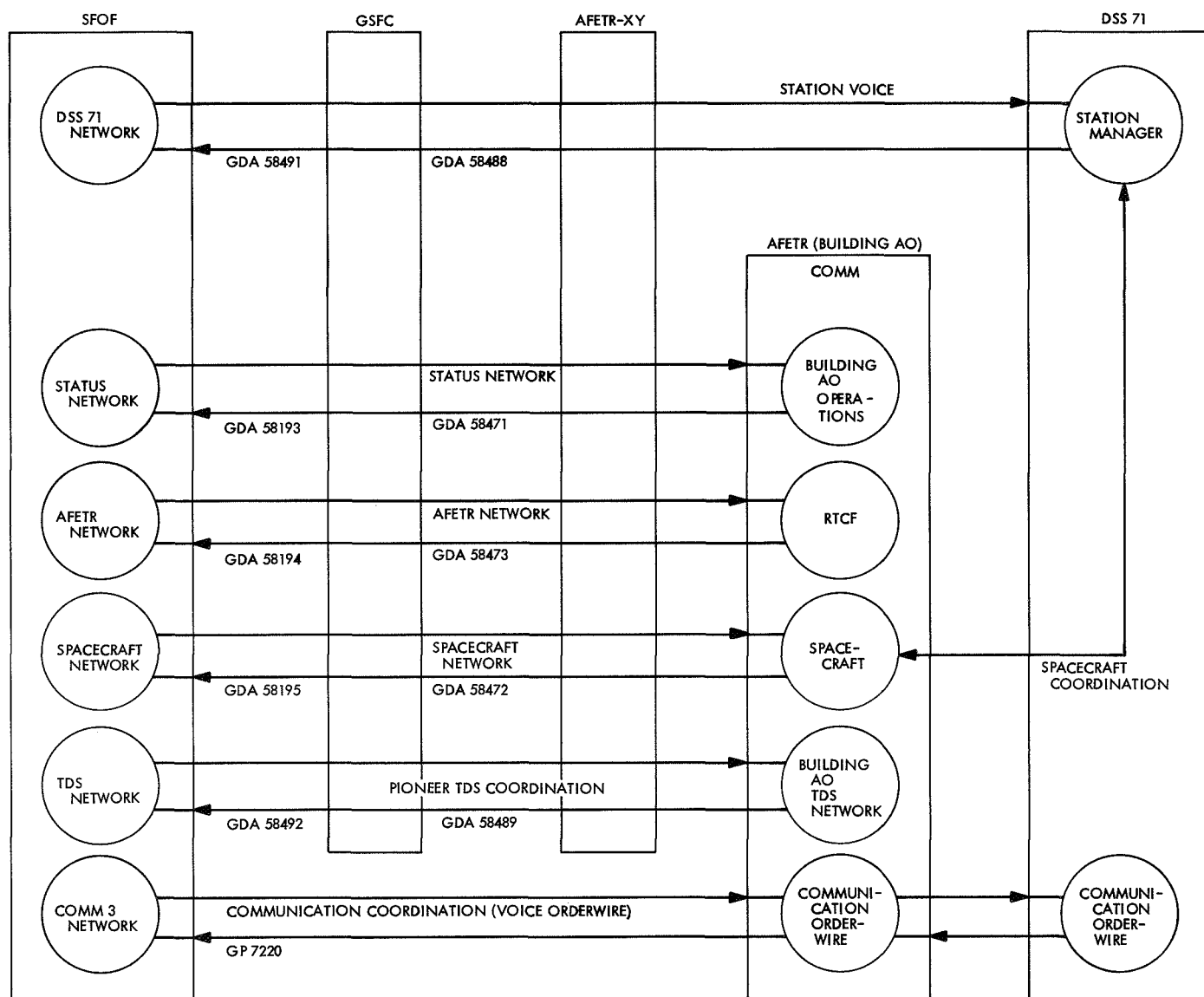
- (1) One console (operations with OVCS).
- (2) Three consolettes (TV monitor, channel selector, and OVCS).
- (3) Six TV monitors for general display.
- (4) Two TV monitors for time display.
- (5) One TV camera (hard copy).
- (6) Five intercom and telephone sets (OVCS).
- (7) Four printers (teletype page with selector box).
- (8) One printer-sender, teletype, keying send-receive, with selector box.
- (9) One reader, teletype TD (tape reader).
- (10) Two reperforators, teletype (tape punches).

In addition, the DSN furnished a TV time-display camera.

The DSN provided the following furniture in the *Pioneer* Project mission support area and conference room:

- (1) Twelve desks, office.
- (2) Five tables, office (30 by 60 in.).
- (3) Four bookcases, office.
- (4) Thirty-one chairs, office.

One of the mission control rooms, with all of its support facilities and a flight-path analysis area (see Fig. 45), was available for support of the *Pioneer* Project during critical phases of the mission. These phases include launch, orientation maneuvers, and system tests. Availability of these facilities was subject to priority arrangements with other flight projects.



GDA = GENERAL DYNAMICS ASTRONAUTICS

Fig. 42. Pioneer VIII voice configuration: SFOF-DSS 71

TCP = TELEMETRY AND COMMAND PROCESSOR
 TDH = TRACKING DATA HANDLING
 ASR = AUTOMATIC SEND-RECEIVE
 TPS = TELEMETRY PROCESSING STATION
 DPS = DATA PROCESSING SYSTEM
 TSS = TELETYPE SWITCHING SYSTEM
 RO = RECEIVE ONLY

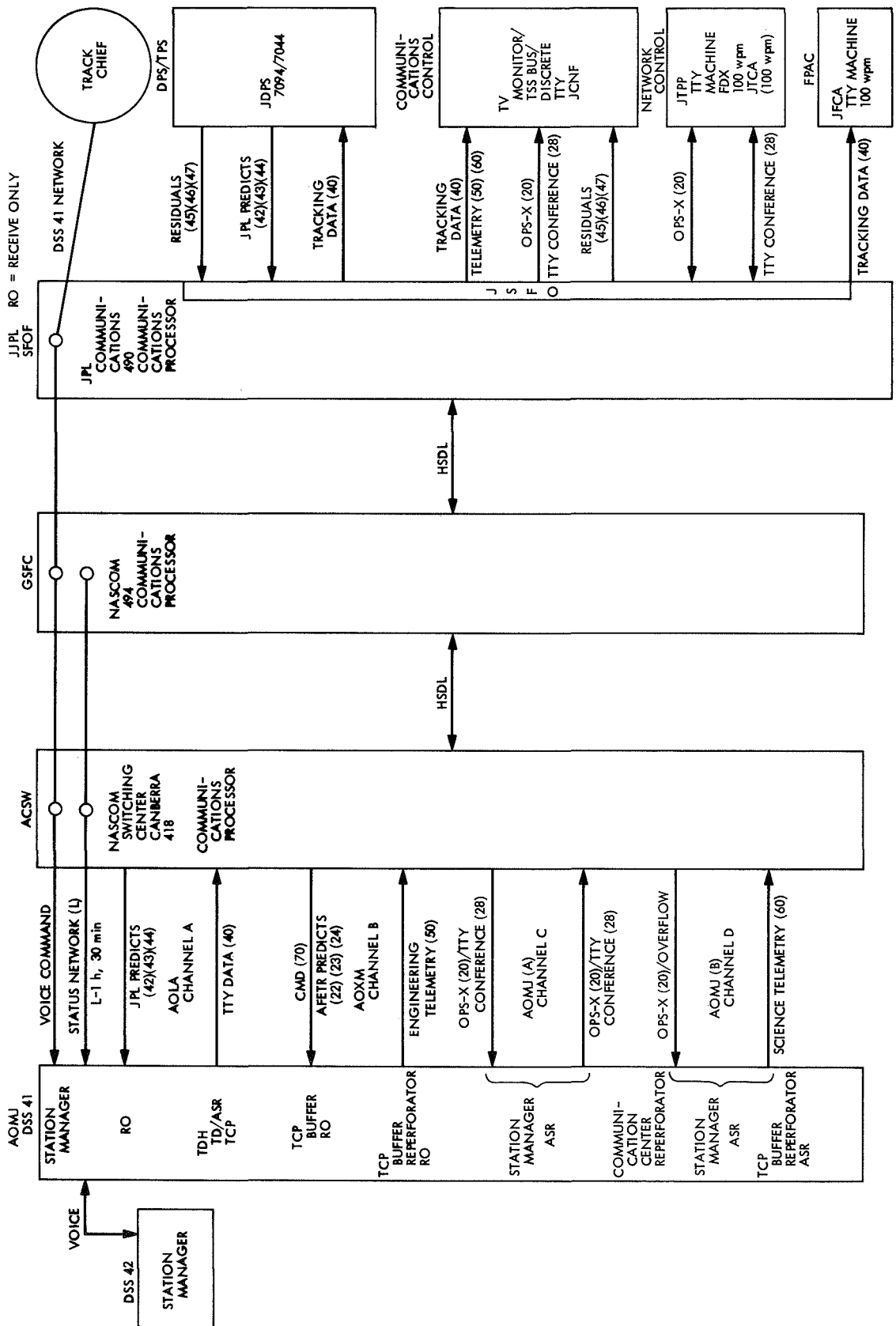


Fig. 43. SFO-DSS 41 voice and teletype communications traffic flow configuration

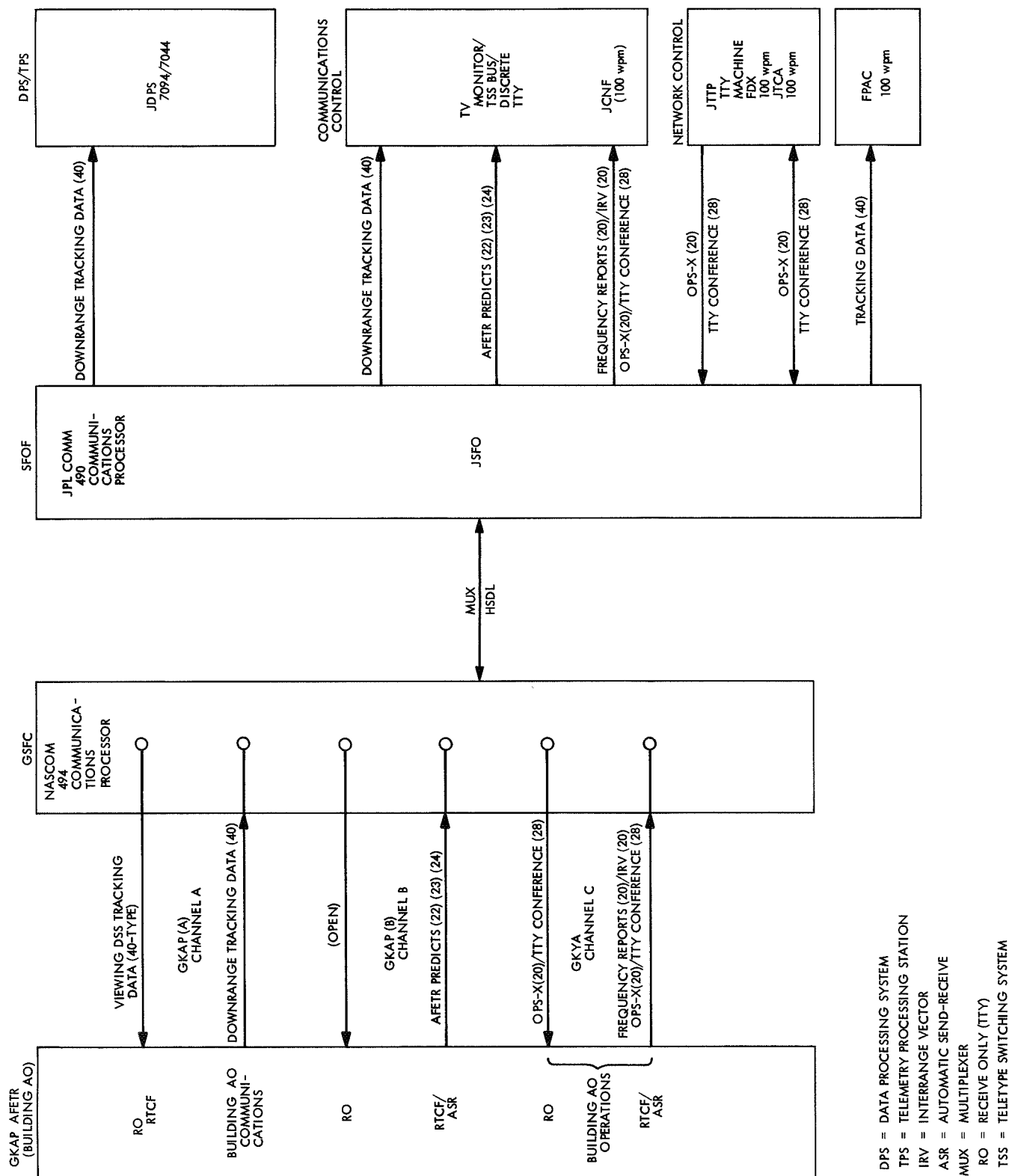


Fig. 44. SFOF-AFETR (Building AO) teletype communications processor traffic flow configuration

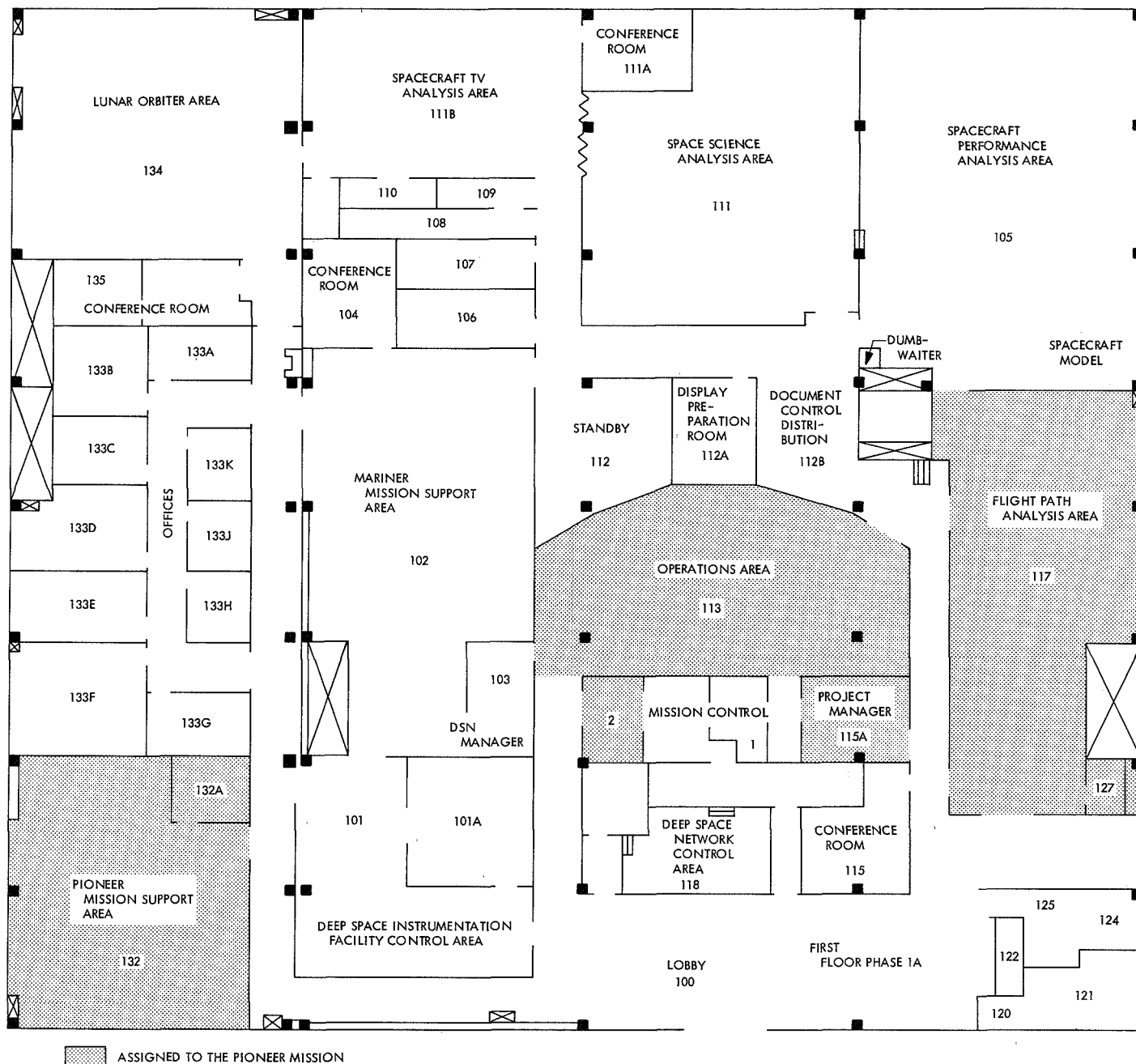


Fig. 45. First floor, Space Flight Operations Facility

Standard DSN operational voice communications were provided to the Project in all areas assigned to the Project. Terminations at the SFOF for teletype and voice circuits between ARC-Stanford and the SFOF were provided by the DSN. The SFOF circuit configuration is shown in Fig. 46.

Operations area and Mission Control Room 2. These areas were used only during the high-activity phases (launch and orientation) of the mission.

Flight-path analysis area. The configuration of the FPAA was in accordance with the requirements of the *Pioneer* Project. Numerous flight-path tests have demonstrated the adequacy of this configuration.

b. Systems. The data processing, communications, and support systems are used in support of the *Pioneer* missions as described in the subparagraphs that follow.

The data processing system includes the processing of tracking data for the establishment of a maximum-accuracy orbit and for Deep Space Station predicts. The telemetry processing station processes data for validation purposes. The TPS receives telemetry magnetic tapes for reproduction. During the reproduction (duplicating) process, the TPS provides data validation by monitoring and verifying recording levels, and by inspecting recorded data for continuity.

A data log on each tape is generated, containing the following indications:

- (1) Receiver flag (a time printout occurring each time there is a receiver out-of-lock state).
- (2) Demodulator flag (a time printout occurring each time there is a demodulator out-of-lock state).
- (3) Time flag (an error printout occurring when the *delta* time disagrees with the data rate).

Validation is accomplished on the duplicated tape. After processing, the TPS returns the original tapes, along with the duplicate and one copy of the data log, to the SFOF operational document control office for shipment to the *Pioneer* Project Office.

All areas within the SFOF assigned to the *Pioneer* Project have a complement of intracommunications devices.

c. Support system. The DSN-SFOF support system includes the following:

- (1) Maintenance of electrical and air-conditioning systems.
- (2) Preparation of display boards.
- (3) Receiving, distributing, and shipping of data by operational document control group.
- (4) Technical assistance.
- (5) Scheduling.

The paragraphs that follow give a brief summary of the status and activities of each of these functions.

Electrical and air-conditioning systems. These systems, including the backup power system, have been maintained in their normal manner and are ready to support *Pioneer* requirements in the SFOF.

Displays. The SFOF operations group prepares all displays that are not the responsibilities of the DPS and communications groups. All displays are operational. These displays include those in the FPAA.

Operational document control. In its non-real-time, mission-independent function, this group receives, logs, and distributes data from the Deep Space Stations. Data are forwarded to the TPS. After processing, the data packages are shipped to ARC.

Technical assistance. At least one technical area assistant is provided, as requested, in the *Pioneer* mission support area. The functions of the assistant include the distribution of data printouts throughout the area, the maintenance of teletype machines in the area, and the performance of other miscellaneous duties pertinent to the *Pioneer* Project.

Scheduling. Areas and equipment are ready for operations according to the DSN utilization schedule and the DSN 10-day schedule.

d. Data processing system. The SFOF data processing system is organized into the computer subsystem (Fig. 47), the telemetry processing station subsystem, the data processing control and display subsystem, and the programming subsystem.

The only tasks performed in support of the *Pioneer* Project by the SFOF data processing system are the

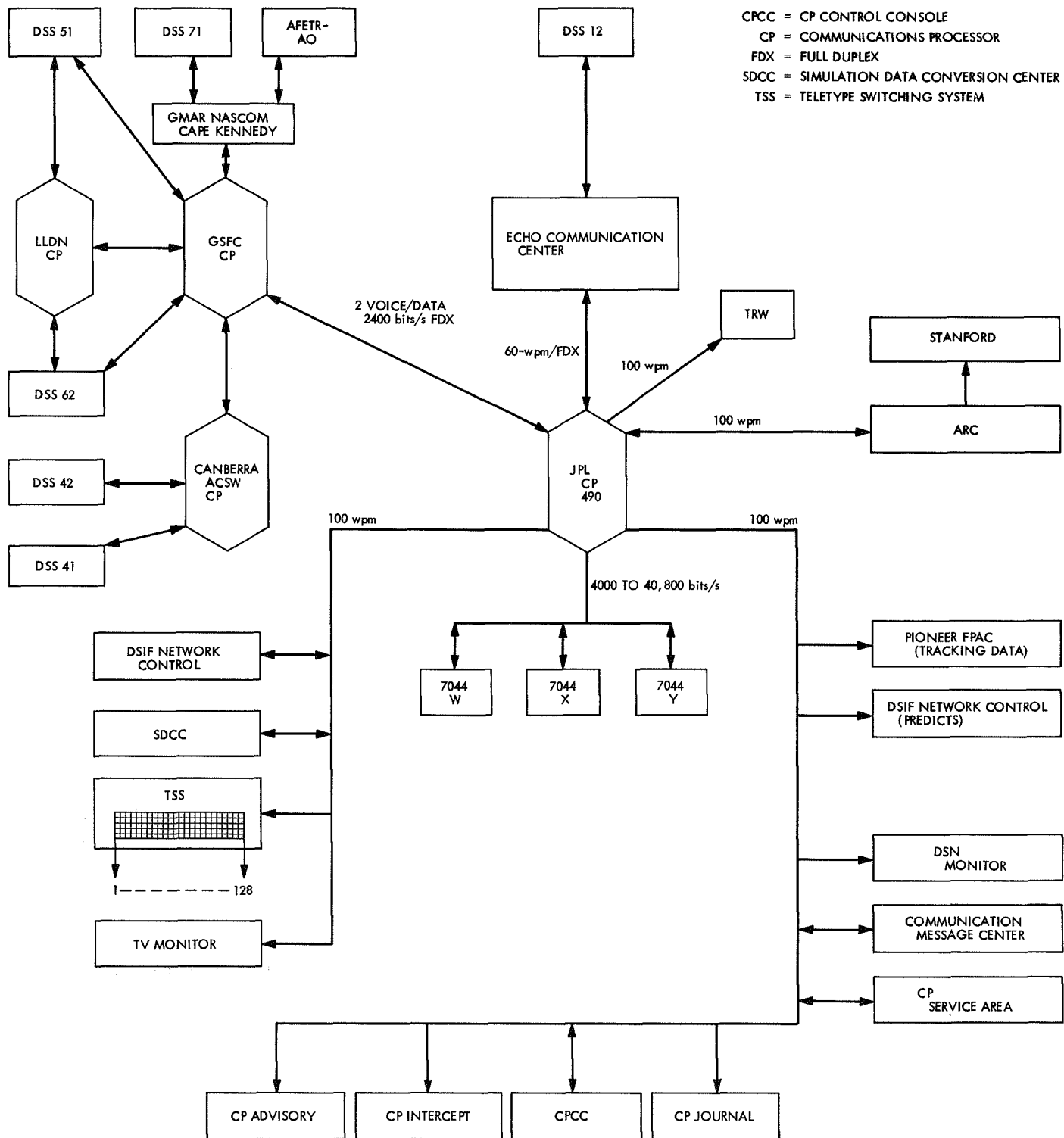


Fig. 46. Pioneer VIII communications processor, 7044R, and GCF circuit configuration at SFOF

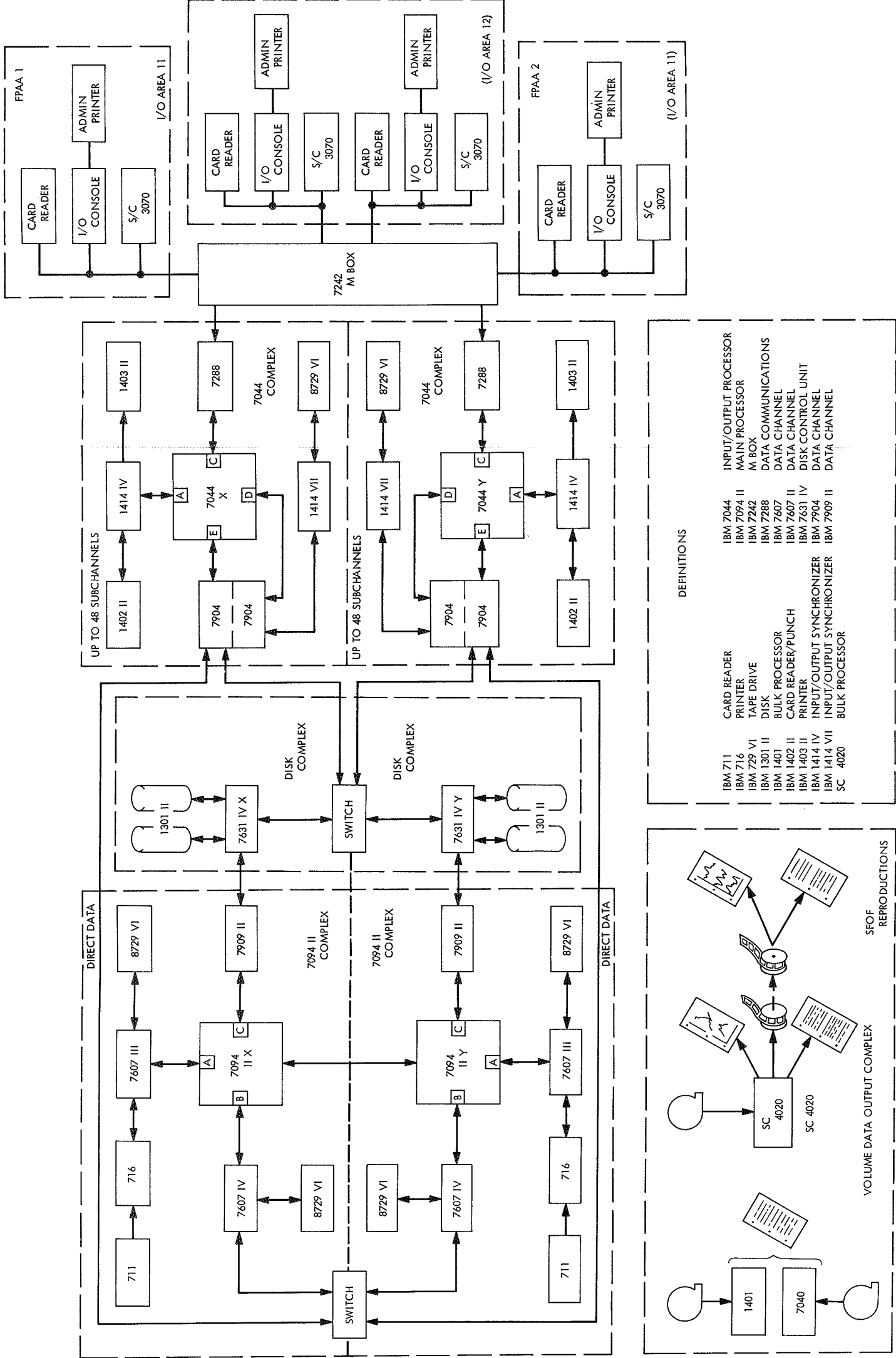


Fig. 47. Computer subsystem

processing of tracking data for the establishment of a medium-accuracy orbit and Deep Space Station predicts. All other processing of data (except for the science data) is done at the Deep Space Stations with SDS 910 computers.

Engineering data. These data are processed at the Deep Space Stations by the SDS 910 computers, encoded in English (the language format), and selected portions are transmitted to the SFOF by teletype (Fig. 48). At the SFOF, the data are relayed in real-time directly to the *Pioneer* mission support area, to ARC, and to TRW. The computer-selected Class I engineering measurements, printed out in the MSA, are then routed to the various agencies. Figure 49 shows the complete data flow from the SFOF. The engineering data received in the SFOF *Pioneer* MSA are analyzed by analysts from ARC and TRW.

Scientific data. These data are separated from the engineering data subcommutator at the Deep Space Stations by the SDS 910 computers. The information is recorded on magnetic tape. A duplicate of this tape is mailed to the SFOF, from which it is forwarded to ARC for computer processing. Scientific data analysis is performed at ARC by NASA representatives and the experimenters.

Flight-path data. During the launch phase (less than 24 h), there is:

- (1) Continuous transmission of tracking data from each Deep Space Station committed to track the *Pioneer* spacecraft.
- (2) Mode I operation of the SFOF data processing system until 1 day's predicts have been prepared; shifting to Mode IIA for the remainder of the launch phase.
- (3) A fully manned FPAC team in real-time operation until 3 days' predicts have been prepared. (Metric data from about half of the first Goldstone pass are required before the launch phase is considered completed.)

From completion of the launch phase through Type II reorientation plus 1 day (about $L+10$ days), there is:

- (1) Batch transmission of metric data from each Deep Space Station committed to track the *Pioneer* spacecraft, with "on call" continuous transmission of tracking data, if required by the FPAC team.

- (2) Mode IIIA operation of the SFOF data processing system when metric data are being transmitted.
- (3) Determination of an orbit each day by FPAC and preparation of 10 days' predicts, if necessary, using a Mode IV configuration of the SFOF data processing system.

After completion of Type II orientation, there is:

- (1) Batch transmission to track the *Pioneer* spacecraft.
- (2) Mode IIIB operation of the SFOF data processing system when tracking data are being transmitted.
- (3) Determination of an orbit once a week by FPAC and preparation of 10 days' predicts using Mode IV operation of the SFOF data processing system.

ARC data processing. The volume of telemetry data from the spacecraft (together with other information and measurements made at the Deep Space Stations) that are required by the data user is too large for teletype transmission to the central processing station and subsequent dissemination to the user. The data are transmitted primarily by shipment of magnetic tapes. This data flow begins when the spacecraft telemetry data and other necessary information are recorded on two FR-1400 tape recorders operating in parallel at the Deep Space Station. The time for tape loading on each machine is staggered to avoid loss of data during such periods. One set of tapes, selected to contain all data received, is then shipped to JPL, where it is examined to ensure the quality of the reproduction. These tapes are then shipped to the *Pioneer* off-line data processing station at ARC for data processing and subsequent dissemination to the user.

The data are processed at ARC in a two-level system. The first level translates the seven channels of data on the FR-1400 tapes into a digital format. The equipment used includes a tape playback machine, a demodulator-synchronizer, three racks containing digital logic, and an SDS 910 digital computer with associated peripheral equipment. This equipment, known collectively as the tape processing station, can process data from any Deep Space Station whether or not it is equipped with ground operational equipment.

The output of the tape processing station, a multiframe digital tape, is the input to the second level of processing. This level utilizes an IBM direct-coupled 7040/7094

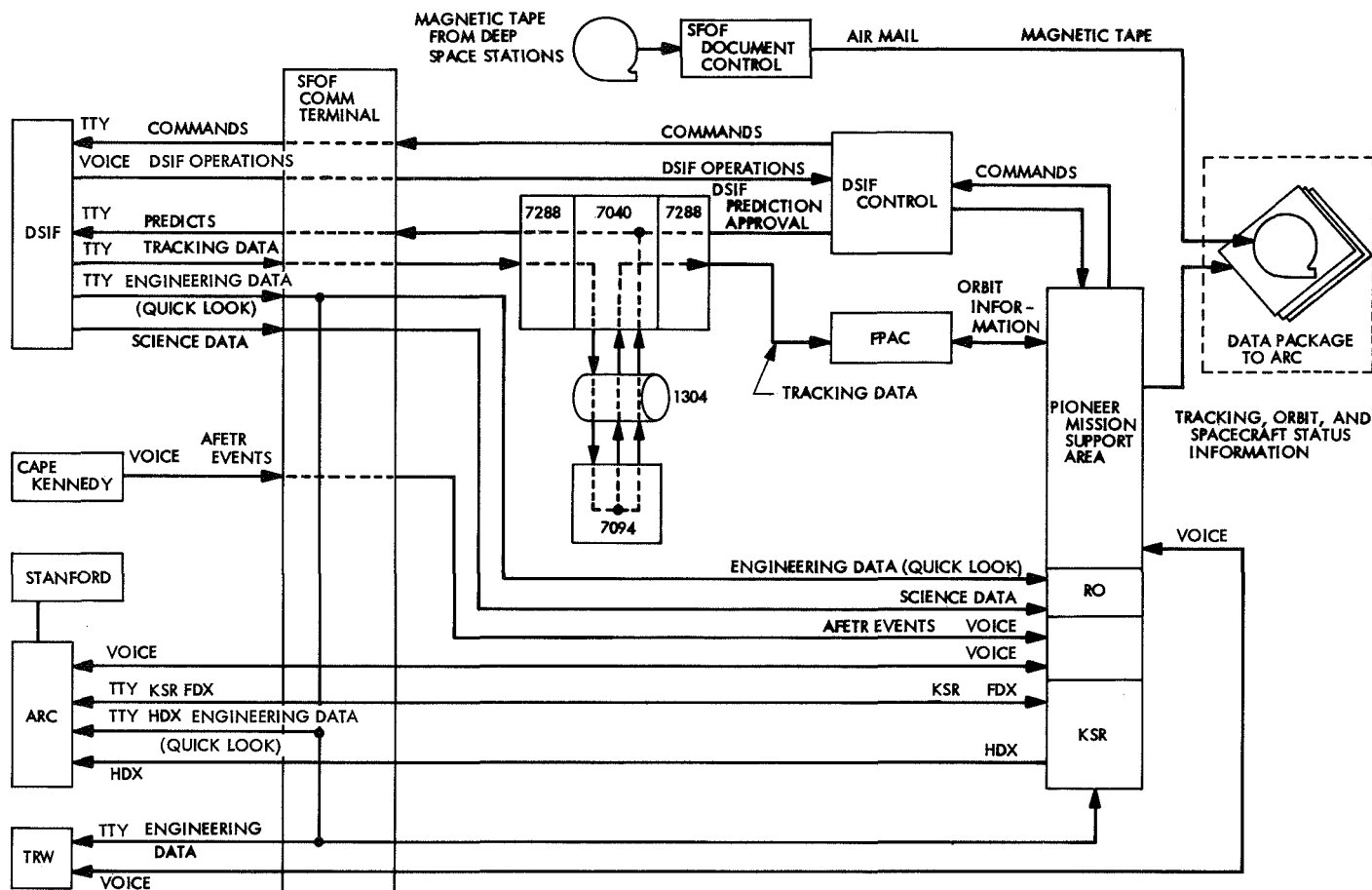


Fig. 48. Pioneer-SFOF data flow

computer system, and consists of timing the data, checking the spacecraft word parity, validating the commands sent to the spacecraft, qualifying the data on the basis of the ground station parameters measured at the Deep Space Station, and decommutating the data stream so that each experimenter receives only data from his instrument and any of the telemetered engineering data required. These output data are recorded on a digital magnetic tape in a format and density compatible with the particular computer system each experimenter uses to analyze his data.

In addition to the spacecraft telemetry data, trajectory tapes are also sent to the experimenters several times during the mission. This periodically updated information, originating at JPL, contains spacecraft position in three coordinate systems as a function of time. The data on the tape are reprocessed at ARC and put into the format and density compatible with each experimenter's computer facility.

IV. Pioneer VIII Preflight Test Program

As with *Pioneers VI and VII*, the *Pioneer VIII* mission required a great deal of preflight testing support to ensure mission success. The *Pioneer VIII* launch culminated 2 yr of intensive testing and proving. The paragraphs that follow describe a small part of the aforementioned test program.

A. Preflight Review

One of the major *Pioneer VIII* program evaluation meetings, the preflight review, was held at TRW, Redondo Beach, Calif. Participants included representatives of NASA Headquarters, GSFC, JPL, ARC, the experimenters, and TRW. The purpose of the meeting was to review the program, evaluate the preparedness of the spacecraft and instruments for commencement of launch activities at Cape Kennedy, and obtain approval from the participating agencies for shipping the spacecraft and instruments to Cape Kennedy.

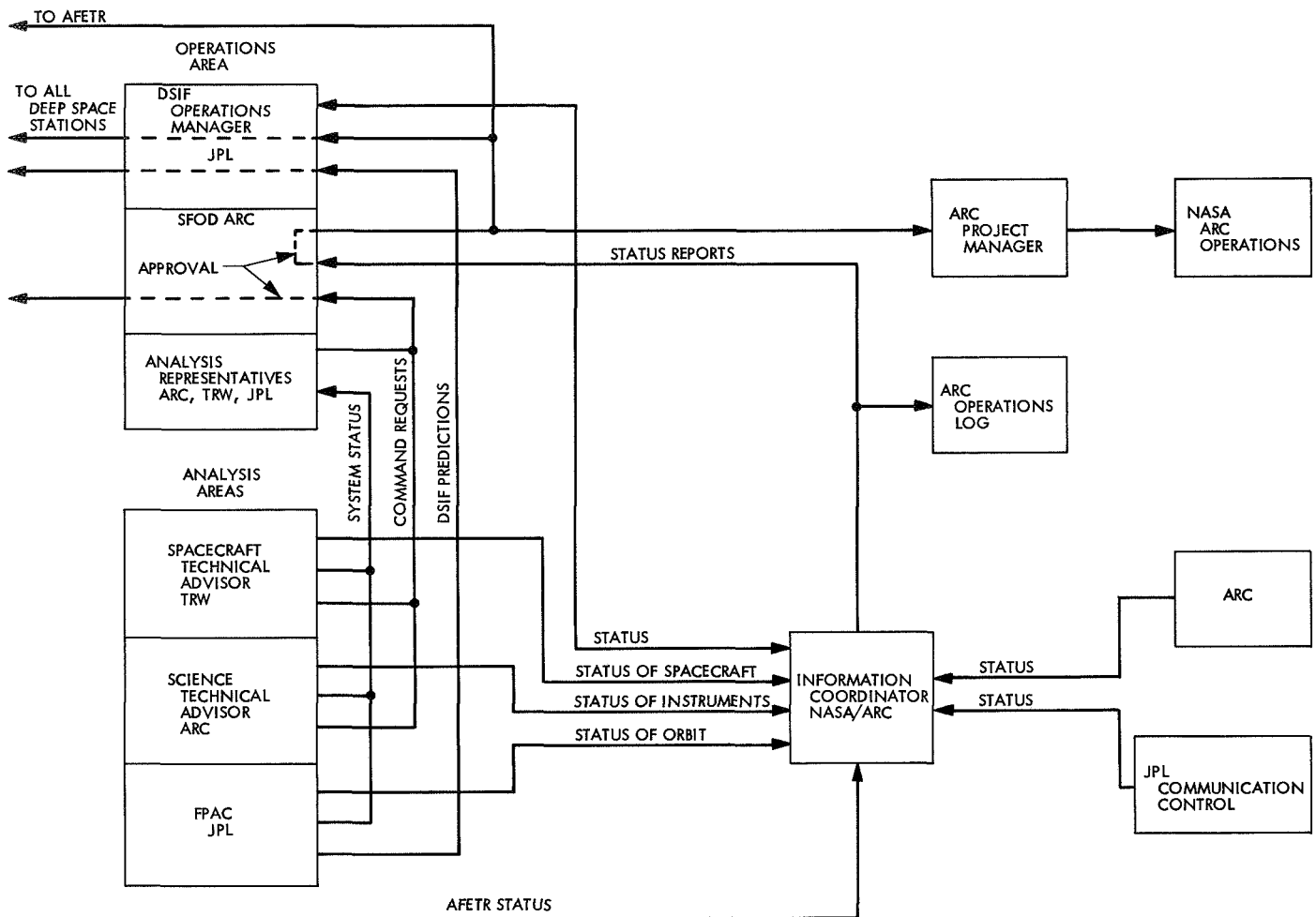


Fig. 49. Complete data flow from SFOF

During the preflight review, the spacecraft and instrument development programs were described in detail to provide assurance of the suitability of the design to accomplish the mission objectives and the reliability of the design to achieve long lifetime. Events occurring during the design reviews and the use of breadboard and engineering models of the spacecraft and instruments during the development phase were discussed.

The test program was discussed in detail during the preflight review so that its adequacy in evaluating the reliability and quality of the equipment could be determined. The test programs for both the spacecraft and scientific instruments were described with the aid of a test-flow diagram, which is reproduced in Fig. 50. It was explained during the discussion that all equipment destined to be flight hardware had been acceptance-tested at the assembly level and then at the system level at

expected flight environmental conditions, whereas the qualification assemblies and prototype spacecraft had been tested at environmental conditions more severe than those to be encountered in flight.

Before the test results were discussed, the philosophy of the *Pioneer* Project pertaining to "failures" was explained to the reviewers. Any nonconformance to specifications, malfunctions, defects, improper test setups, procedural errors, anomalous test data, etc., had been classified as "failures." All such failures had required a formal review and evaluation by a failure review board.

During the review meeting, all failures of the spacecraft and instrument assemblies since fabrication were reviewed, along with the corrective actions and retest results. The malfunctions that had occurred during system testing of the spacecraft were summarily corrected.

A study of these malfunctions showed that a large portion were minor electrical malfunctions that had been corrected as they occurred. It was concluded that the majority of problems would not have affected or degraded the objectives of this mission because of the presence of redundant equipment.

There were no open items from the failure review board on any of the scientific instruments at the time of the preflight review.

B. Spacecraft Checkout

Spacecraft testing ran very smoothly, with no major problems experienced. The paragraphs that follow contain information relative to spacecraft testing.

1. *Thermal-vacuum test.* The thermal-vacuum acceptance test of the *Pioneer VIII* spacecraft was started on September 27, 1967, and successfully completed on October 5, 1967. All of the thermal-vacuum test requirements were satisfactorily fulfilled after 7 days in the simulated space environment, and the spacecraft was accepted on October 10, 1967, as operationally ready for the next phase of the *Pioneer* test program. The thermal-vacuum test was conducted in a professional manner and in accordance with TRW procedures.

2. *General test results.* In reviewing the six major subsystems of the spacecraft, the testing group found no problems identified with the performance of the electrical, thermal control, and structures subsystems. A minor test configuration problem was encountered in the orientation subsystems, and only the communications and data handling subsystems were associated with significant performance discrepancies.

No known experiment failures occurred during thermal-vacuum testing as a result of the space environment. Analyses following testing indicated that the significant experiment performance discrepancies were related to instrument deficiencies that existed before the start of the thermal-vacuum test. Only one command and experiment response could not be adequately verified during the thermal-vacuum test activities.

Although various problems tended to jeopardize the success of the thermal-vacuum test, none indicated a spacecraft or subsystem failure. In all cases, the problems could be associated with (or attributed to) the thermal-vacuum test configuration as influenced by questionable ground loops, excessive noise levels, slip-ring deteriora-

tion, or instrumentation incompatibility. In fact, none of the "anomalous" thermal-vacuum test problems was encountered since completion of the thermal-vacuum acceptance test except when the spacecraft was subjected to a troubleshooting mode of operation employing special instrumentation and test configurations.

Similarly, experiment performance was also more satisfactory when independent of the thermal-vacuum chamber and test configuration. Nevertheless, the thermal-vacuum test facility should be credited for revealing major defects in the ARC plasma and GRCSW instruments; i.e., the radiation-leak path within the plasma probe and the light leak in the Mylar cover of the cosmic ray detector. Evidently, neither instrument deficiency was detectable or disclosed at the unit test level.

On the basis of thermal-vacuum test results and inspection, the chamber-spacecraft slip-ring assembly is considered to be the single component "failure" that could account for most of the test anomalies. Photographs are available showing terminals short-circuited by metallic slivers from the silver slip rings. The metallic debris found at the base of the slip-ring assembly also suggests that buildup of particles and shavings contributed to the intermittent problems experienced frequently during the latter portion of the thermal-vacuum test.

The purpose of this test was to demonstrate that the *Pioneer VIII* spacecraft would satisfactorily meet all performance criteria for a period of 7 days in a simulated space environment and an "orbital operations" profile.

3. Major test objectives and requirements.

- (1) Determine overall spacecraft and experiment subsystem and component performance under simulated space environments at 0.8, 1.0, and 1.2 AU.
- (2) Evaluate spacecraft thermal-control subsystem operation.
- (3) Determine operating characteristics of a TWT and all experiments during exposure to a low temperature of $30 \pm 10^\circ\text{F}$ and a high temperature of $90 \pm 5^\circ\text{F}$.
- (4) Demonstrate end-to-end orientation subsystem performance using simulated sun angles.
- (5) Evaluate electrical subsystem performance and plot solar array current-voltage curves with spacecraft rotating at 60 rev/min to verify design data.

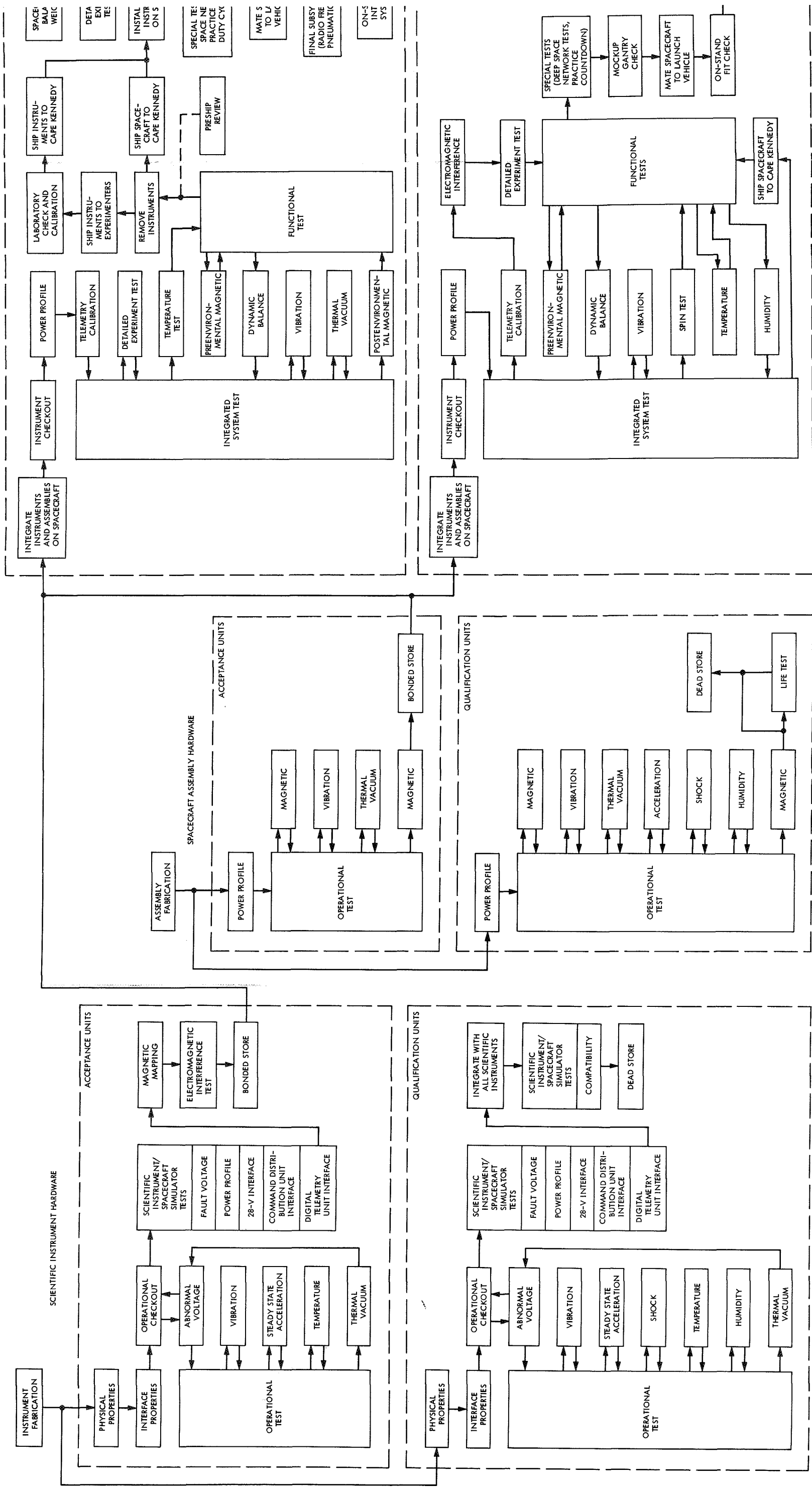


Fig. 50.

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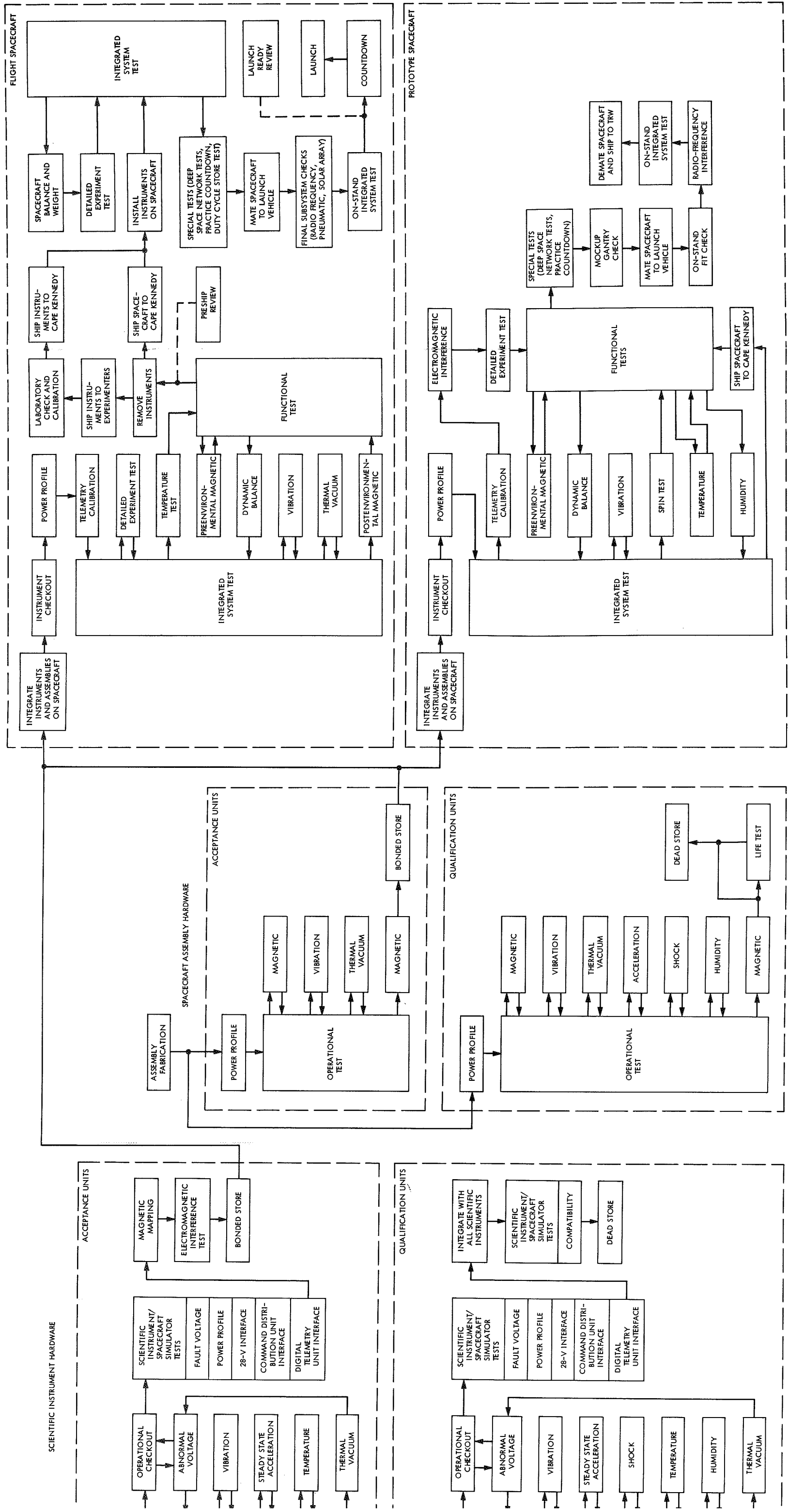


Fig. 50. Pioneer VIII general test program

- (6) Perform solar wind simulations for testing ARC plasma probe and Stanford-TRW electrical field detector experiments.
- (7) Determine corona effects during pumpdown and outgassing effects at high vacuum.

C. Air Force Eastern Test Range

The AFETR prelaunch testing operations for the *Pioneer VIII* mission are covered in the paragraphs that follow. Milestones and significant prelaunch events are listed in Table 38.

Prelaunch preparation began upon arrival of the spacecraft at the AFETR on November 12, 1967. These preparations required approximately 20 working days, during which the spacecraft was integrated and balanced with the third stage, and the third-stage-spacecraft combination was placed on the launch-vehicle configuration at pad 17-B, where testing began. The DSIF spacecraft system compatibility test was performed in conjunction with DSS 71, Building AM, and JPL (SFOF) to establish RF compatibility of the *Pioneer VIII* spacecraft with a typical Deep Space Station. The significant activities associated with the *Pioneer VIII* prelaunch operations are shown in Table 38.

Table 38. *Pioneer VIII* prelaunch events

Date (1967)	Event
Oct 4	FPAC acceptance at SFOF
Oct 19	Experiment calibration
Oct 27	SPAC-SSAC acceptance at SFOF
Nov 9	Receive EGSE
Nov 12	Receive spacecraft at AFETR
Nov 14	Second SFOF integration
Nov 30	Mate spacecraft third stage to <i>Delta</i>
Dec 4	First operational readiness test
Dec 7	All-systems test—practice countdown (prefairing)
Dec 8	Second operational readiness test
Dec 11	Countdown initiation
Dec 12	FW-4 hookup Second-stage propellant servicing First-stage fueling
Dec 13	Tower removal LOX fill

1. Dual composite test summary. No major anomalies occurred during the dual composite testing that was carried on for *Pioneer VIII*. A normal start sequence was obtained, and the testing proceeded according to schedule.

2. Acceptance and RFI test summary. This portion of the test program was carried out with alacrity and proficiency. No serious problems were encountered, and the testing was carried out to completion.

3. All-systems test summary. The performance of this test was smoothly executed, with no significant problems reported.

4. Electrical systems test summary. No problems were encountered during the test.

D. Manned Space Flight Network

The MSFN participated fully in the operational readiness tests on December 4 and 8, 1967. All results were considered satisfactory.

During the December 4 test, a Tananarive acquisition message was transmitted by GSFC/data operations branch (DOB) approximately 6 min after predicted AOS because of problems encountered in calculating the nominal *Delta* third-stage burn maneuver. During the December 8 test, a Tananarive acquisition message was again transmitted late because of 7094/494 computer-interface problems. On launch day, 7094/494 computer-interface problems were again encountered, causing delays in acquisition-message transmissions.

E. Deep Space Network Testing

The tests conducted to ensure the readiness of all elements of the DSN committed to support the *Pioneer VIII* mission are classified as follows:

- (1) Telemetry and command system acceptance tests.
- (2) Subsystem acceptance tests.
- (3) Integration tests.
- (4) Operational readiness tests.

Descriptions of these DSN tests are given in the paragraphs that follow. The tests performed are listed in Table 39.

All of the tests were completed satisfactorily. The problems encountered were resolved before the launch.

Table 39. DSN prelaunch tests for *Pioneer VIII*

Date (1967)	Test	Purpose
Aug 28	FPAC test	Program checkout
Sep 1	FPAC test	Software system checkout
Sep 14	FPAC test	FPAC team training
Oct 4	FPAC test	FPAC acceptance
Oct 25 and 26	SPAC-SSAC test	Team training
Oct 27	SPAC-SSAC test	Acceptance test
Nov 15	SFOF integration test	Training and acceptance of SPAC, SSAC, and FPAC as a flight operations team
Nov 16	DSN spacecraft compatibility test at DSS 71	Test for compatibility of spacecraft with DSN
Nov 28	DSS-AFETR integration test	Training of all elements participating in <i>Pioneer VIII</i> launch
Dec 2	DSN spacecraft compatibility test (on-stand)	Verify compatibility of spacecraft with DSN
Dec 4	First operational readiness test	Verify readiness of all elements to support launch
Dec 8	Final operational readiness test	Verify readiness of all elements to support launch

Some of the more significant problems are described below.

The SFOF integration test was scheduled for November 14; however, because the SDCC computer was down, the test had to be rescheduled for the next day.

During the first operational readiness test, the predicts sent from the SFOF were not received properly by DSS 41. This turned out to be both a procedural and a configuration problem, as the station was expecting to receive predicts from the AFETR. The problem was resolved by ensuring that DSS 41 and all others concerned knew whence and when the predicts would be transmitted. Also, a second teletype machine was installed at the station to allow reception of predicts from both the SFOF and the AFETR with no near-real-time configuration change required.

A 77-min delay occurred in activating the voice circuits to Station 70 during the final operational readiness test. The problem was traced to a circuit-configuration error, which was corrected 3 h and 36 min before the simulated launch.

During the same test, the 7044-W computer at the SFOF went into recovery, causing a 30-s interruption in FPAC processing. This occurred 5 h before the simulated launch, and subsequent investigation of the system (both hardware and software) revealed no reason for the occurrence.

1. Telemetry and command system acceptance tests. The purpose of these tests was to evaluate the performance of personnel and equipment associated with the telemetry data and command systems. These tests were conducted at DSSs 12, 41, 51, and 62.

2. Subsystem acceptance tests. The purpose of these tests was to demonstrate to the SFOF, operating from the SFOF, the satisfactory performance of equipment and personnel of each element of *Pioneer* operations. The subsystem acceptance tests were as follows:

- (1) Daily operations tests and Type II orientation tests (DSS 12).
- (2) Daily operations tests (DSS 62).
- (3) First acquisition test. This test involved station performance during the initial pass of the spacecraft, including critical activities of first acquisition (DSSs 41 and 51).
- (4) FPAC, SPAC, and SSAC groups (SFOF).

3. Integration tests. The purpose of these tests was to familiarize space flight operations personnel with all phases of *Pioneer* procedures and intercommunications. Actual operation of the *Pioneer* mission was performed in the exercise of all elements.

Deep Space Stations 12, 41, and 62 repeated the subsystem acceptance tests listed above.

A DSN-AFETR integration test was conducted on November 28, 1967, before the two Project operational readiness tests. During the integration test, the AFETR provided simulated metric tracking data, and DSN data were supplied to the AFETR in real-time. The MSFN did not participate in this test. No significant problems were encountered, and the test was considered successful. A summary of the integration test follows:

- (1) MSFN was not required to participate.
- (2) AFETR provided simulated metric tracking data for near-earth tracking system.

- (3) DSN data were supplied to AFETR in real-time.
- (4) AFETR performance was good.
- (5) Problems occurred in Building AO-DSN interface in use of routing indicators for telemetry data being backfed to Hangar AM. This was corrected after the test. Routing circuit GKYA to be used for science data and GKXE for engineering data.

4. Operational readiness tests. The purpose of these tests was to demonstrate that all personnel and equipment participating in the flight operations of the spacecraft were prepared to support the mission. Every unit was activated for these tests. The two tests were developed so as to reflect sequential improvement, thereby ensuring maximum operational readiness.

The operational readiness tests were conducted on December 4 and 8, 1967. These were full-system tests, with all TDS elements participating. No significant problems were encountered and, at the conclusion of the tests, the TDS was considered ready to support the launch. There were no unresolved problems before launch.

The two operational readiness tests represented dress rehearsals to assure the proper interface timing of all elements and procedures of the space flight operations team. All procedures used were those derived to support a nominal flight mission. Between the tests, and following the final launch operation checks, the launch readiness review was conducted, for which all areas of responsibility for launch operations and space flight operations were represented. The purpose of this meeting was to review the readiness of all elements of all operations to support a launch, and provide the mission director with background for his decision of *go* or *no go*.

Following the final operational readiness test, DSSs 51, 41, 62, and 12 underwent a *Pioneer* configuration freeze.

During the countdown, the Deep Space Stations calibrated the station and mission-dependent equipment, and DSSs 51 and 41 performed a detailed transmitter-frequency spectrum analysis.

The initial activity at JPL-SFOF consisted of establishing and checking voice and teletype circuits; assessment of spacecraft condition, with particular emphasis on the best frequencies of the receiver and transmitter; and initializing all computer facilities.

a. Operational readiness test summary.

- (1) December 4, 1967:
 - (a) All systems participated except real-time vehicle telemetry.
 - (b) No serious problems encountered.
 - (c) Trouble between Buildings AO and AE Mission Director's Center in setting up voice networks.
- (2) December 8, 1967:
 - (a) All systems participated.
 - (b) No serious problems encountered.

b. Conclusion. All testing proved the operational readiness, within current commitments and time constraints, of all elements of the DSN to support the *Pioneer VIII* mission.

The DSN manager provided the Project manager with a real-time operational readiness evaluation at $T-5$ days to confirm that all systems were prepared to go.

F. Pioneer/S-Band Compatibility Tests

These tests were conducted at Patrick Air Force Base to verify the compatibility of the AFETR user equipment and its capability to support the *Pioneer* S-band telemetry requirements. The primary test objective was to simulate the *Pioneer* transmitted data, and to receive, translate, and record them with the AFETR telemetry system to evaluate how successfully the range user equipment could recover such data.

These tests successfully demonstrated that the AFETR and range user equipment, planned for the *Pioneer* S-band telemetry requirements, were compatible.

V. Pioneer VIII Tracking and Data System Flight Support

A. Near-Earth Phase Support

The TDS near-earth phase support for *Pioneer VIII* was provided by selected resources of the AFETR, GSFC, MSFN, and DSN. A review of activities from prelaunch through the end of the nominal mission is summarized herein.

The *Pioneer VIII* spacecraft was launched from the AFETR with the use of the improved thrust-augmented

Delta launch vehicle. The spacecraft spin axis was oriented perpendicular to the ecliptic so that the scientific instruments, mounted perpendicular to the spin axis of the spin-stabilized spacecraft, were able to scan 360 deg of the ecliptic.

After injection into orbit, tracking and data acquisition were accomplished by the Deep Space Network throughout the duration of the deep space phase of the mission.

1. Prelaunch. The prelaunch activities were the final checkout phase of *Pioneer VIII* in preparation for the countdown-to-launch operation. The prelaunch activity phase was started when the spacecraft was received at Cape Kennedy, and terminated with the countdown phase on December 13, 1967.

a. Test program. An important phase of the prelaunch activities involved the prototype spacecraft in trial runs, evaluations, and special tests. This approach provided maximum preparedness for the flight spacecraft without exposing it to unproved or hazardous conditions, and resulted in the application of proved equipment and tested checkout procedures during actual launch operations with the flight spacecraft.

The test program for the flight spacecraft was somewhat similar to that for the prototype. One difference between prototype and flight-spacecraft activities related to the scientific instruments: The prototype spacecraft had been delivered to Cape Kennedy as an integrated system with all scientific instruments on board. In contrast, the scientific instruments for the flight spacecraft (except the Stanford University instrument) had been returned to the laboratories of the experimenters for final calibration and checking before delivery to Cape Kennedy. It was necessary, therefore, that these instruments be reintegrated into the flight spacecraft and tested as a system. Also, the TWTs and TWT converters of the flight spacecraft were temporarily replaced by the units from the prototype spacecraft to inspect the former for high-voltage breakdown, and were then reinstalled on the flight spacecraft when found to be in satisfactory condition.

Special tests, training, and practice runs for different phases of the countdown were made with the flight spacecraft. Numerous round-the-clock duty-cycle store tests were conducted. Deep Space Station training exercises and detailed experiment tests were also performed.

Despite fit checks with the prototype spacecraft, certain insignificant intolerances between the launch-vehicle interstage structure and the flight spacecraft were discovered during mating of the spacecraft and the third stage. The situation was corrected and the activity completed by the launch date.

During the on-stand integrated system test, which was the last system check before launch countdown, minor defects in electrical ground support and test equipment were found and rectified. The overall system of the spacecraft and launch complex was then ready for the launch countdown.

To ensure tracking, data acquisition, and flight control during powered and free flight, training exercises and tests were conducted with the various launch and flight support groups. Personnel were indoctrinated, equipment was checked, and operation procedures for normal and emergency situations were tested thoroughly. In this way, the readiness of the various domestic and overseas stations, the worldwide communications networks, and the launch and flight procedures were thoroughly evaluated.

The training exercises were conducted in three different phases (see Section IV). The first was the training of personnel and checking of equipment and procedures at individual stations. The second phase was the operation of a remote station in conjunction with the mission control center at JPL or Cape Kennedy to evaluate and correct any interface deficiencies. The third phase consisted of the operational readiness tests. The entire system and personnel that would be operational from the launch countdown through the deep space phase of flight participated in these tests. The operational readiness tests concentrated on the sequence of events and procedures covering the period from 4 h before launch until the completion of orientation about 44 h after launch. Tracking stations were supplied with spacecraft trajectory predictions so that they could generate pseudometric data to exercise the metric data handling system. Also, the tracking stations were supplied with telemetry data prerecorded on tapes to simulate spacecraft and instrument behavior and to rehearse the ground operational system and personnel.

Upon satisfactory completion of the on-stand integrated system test and the third operational readiness test, a launch readiness review meeting was held with representatives from all responsible agencies. The highlights of the meeting are presented below.

b. Spacecraft status. The spacecraft was reported to be in a satisfactory condition for launch. The scientific instruments removed at the contractor's plant before shipping the spacecraft to Cape Kennedy had been successfully reintegrated. All qualification and acceptance tests had been completed, and all failure reports had been disposed satisfactorily. The spacecraft had completed many hours of failure-free operation. The TWT and TWT converter high-voltage breakdown, which had been encountered on *Pioneer VI*, was no longer considered a potential problem. The spacecraft had logged hundreds of hours of operation and testing, including a 2-wk continuous test run, before mating with the launch vehicle.

During $T-2$ day operations on December 11, there was a power failure in the spacecraft area. A standby generator for the spacecraft shroud air conditioner, which was required during this period, was not available. As a result, the humidity in the shroud area rose above the maximum tolerance of 50%. However, power was restored after 25 min and there was no damage to the spacecraft. The range user pointed out that, if power had not been restored, serious damage to the spacecraft would have resulted. A generator was subsequently provided to prevent a recurrence of this problem.

During an electrical system test on December 11, the beacon readout van interrogator was observed to be approximately 10 dB below the reported blockhouse reading. The test was delayed while the van was moved to another position that provided a clearer view of the pad. The situation improved, but the AFETR stated that more accurate interrogations and readouts could be made if the gantry were pulled back.

2. Countdown.

a. Countdown tasks. The launching of *Pioneer VIII* was scheduled for December 13, 1967. On December 11, the launch countdown was initiated as planned. The tasks in the countdown for the spacecraft and instruments are described in the paragraphs that follow.

Task I—preparation. The spacecraft and EGSE were prepared for the countdown operation. The EGSE was checked and turned on for the required warmup period.

Task II—spacecraft and instrument functional checks. The launch readiness of the spacecraft and the instruments was evaluated. Radio-frequency checks were made

with both spacecraft receivers. All instruments were turned on and commanded to various operating modes. The spacecraft was commanded into all of the different formats, modes, and bit rates. The flight battery was installed as the last step.

Task III—final pneumatic pressurization. The orientation pneumatic subsystem of the spacecraft was pressurized for the last time, and a final gross system check was made.

Task IV—ordnance installation and checks. The resistance of the ordnance devices and their associated firing cables was measured and compared with previous resistance measurements.

Task V—final preparation. This task completed preparations and secured the spacecraft. All protective covers were removed, the final configuration was checked, and a visual inspection was made. The spacecraft was ready for fairing installation when this task was completed.

Task VI—umbilical and RF checks. This task included a continuity check of the umbilical cables, connection of umbilical cables to the spacecraft, adjustment of lanyard length, and visual inspection of all lines and terminations.

b. General countdown. Table 40 gives the general countdown adhered to by the AFETR.

c. Actual countdown. The actual countdown proceedings for the *Delta-Pioneer VIII* spacecraft was picked up at 0643 GMT^s on December 13, 1967. There were two planned built-in holds—one at $T-35$ min for 60 min, the other at $T-5$ min for 5 min. The count proceeded smoothly to liftoff, which occurred at 1408. The launch window duration was 35 min. The actual countdown time summary is shown in Table 41.

Propulsion, guidance, and control system performance of all three stages was near nominal. The *Pioneer VIII* spacecraft was injected into the desired heliocentric orbit with all spacecraft systems and experiments operating normally. The *Target Tracking Satellite* (TTS) spacecraft, carried on the *Delta* second stage, was inserted into a geocentric orbit as planned, and responded satisfactorily to ground commands.

Telemetry performance and data acquisition were very good. The weather on launch day remained above the

^sUnless otherwise noted, all times are in GMT.

Table 40. Pioneer VIII general countdown

Count	Responsibility	Action	Count	Responsibility	Action
0 — 285 min	GSFC and AFETR	All voice, TTY, and HSDL circuits operational; visual countdown display available	0 — 30 min	SRO reports for applicable (CRF) ^f telemetry links center frequency deviations to network controller; relay information to sites	—
0 — 225 min	Ascension, Pretoria, GSFC, DOB, and RTCF	Ascension and Pretoria transmit static points to GSFC	0 — 30 min	SRO and network controller	SRO provide CRF report to network controller
0 — 205 min	SRO ^a and network controller	AFETR status report to network controller	0 — 15 min	SRO and network controller	SRO provide CRF change or no change to network controller
0 — 200 min	MSFN communication circuits operational	—	0 — 15 min	SRO and network controller	AFETR status report to network controller
0 — 200 min	High-speed interface between MCC-K ^b Mod 70 and GSFC	—	0 — 15 min	Network controller, SRO, and CNC	Network status report to SRO and CNC
0 — 195 min	GSFC, DOB, AFETR radars, and RTCF	AFETR radars transmit static points to GSFC	0 — 15 min	Final network status to GSFC network controller; relay to KSC Project console at central control	—
0 — 190 min	GSFC Mod 70 buffers—high-speed interface test of RTCF	—	0 — 10 min	Change/no-change report of telemetry center frequency; relay to sites	—
0 — 180 min	MSFN brief message and status check—all sites	—	0 — 10 s	Final count to sites	—
0 — 175 min	AFETR status report to MSFN and network controller	—	0	Announce liftoff	—
0 — 165 min	Network controller, SRO, and CNC ^c	Network status report to SRO and CNC	T + 03 min	Send liftoff time to all sites	—
0 — 160 min	RTCF, GSFC DOB ^d	RTCF transmit theoretical trajectory to GSFC DOB	T +	GSFC DOB/AFETR	Transmit high- and low-speed radar data to GSFC from supporting mainland and sub-cable radars
0 — 135 min	SRO and network controller	AFETR status report to network controller	T +	AFETR	Transmit Ascension, Pretoria, and RIS ^e (if supporting) low-speed radar data to GSFC
0 — 80 min	Network controller, SRO, and CNC	Network status report to SRO and CNC	T + 1260 s	AFETR	Transmit updated orbital look angles to MSFN stations
0 — 70 min	RTCF, GSFC DOB, and Bermuda	Start slew check with Bermuda high-speed data to RTCF	T + 1500 s	AFETR	Transmit updated orbital look angles to MSFN stations
0 — 60 min	MSFN brief message and status check—all sites	—	H ^h — 1 min	Maintenance and operations (M&O) direct all recorders to operational speed	—
0 — 50 min	Bermuda and RTCF	Bermuda send weather report to GCNV/RTKEN and GCEN/MSFNOC	H	Horizon time; acquisition; record times for each subsystem; announce telemetry contact	—
0 — 45 min	SRO and network controller	AFETR status report to network controller			
0 — 45 min	Site status TTY to GSFC network controller; relay to KSC ^g Project console at central control	—			
0 — 35 min	Brief message to sites—voice check	—			

*SRO = Superintendent of Range Operations.

^bMCC-K = mission control center, Cape Kennedy.^cCNC = Cape network coordinator.^dDOB = data operations branch.^eKSC = Kennedy Space Center.^fCRF = central receive frequency.^gRIS = Range Instrumentation Ship.^hH = horizon time.

Table 40 (contd)

Count	Responsibility	Action
$H + 1$ min	Report telemetry solid to network controller	—
$H + 5$ min	Send CRF (if necessary)	—
LOS ¹	At telemetry LOS, record times and report LOS to network controller	—
LOS + 5 min	Perform postpass calibrations and prepare postpass telemetry report	—

¹LOS = loss of signal.

Table 41. Actual countdown time summary

Event	Count	Time (GMT)
Start spacecraft systems checks	—	0452
Start vehicle countdown	$T - 380$ min	0643
Start spacecraft terminal count	$T - 140$ min	1043
Start 60-min built-in hold	$T - 35$ min	1228
End built-in hold; resume count	$T - 35$ min	1328
Start 5-min built-in hold	$T - 5$ min	1358
End built-in hold; resume count	$T - 5$ min	1403
Liftoff	T	1408

AFETR safety minimums. Limited coverage was obtained by the tracking cameras because of cloud coverage in the launch area. There was no pad damage, and no AFETR safety actions were required.

During countdown operations, the spacecraft was supplied with external power to conserve the spacecraft battery in case of orientation difficulties after injection. The spacecraft was finally put on internal power (battery) exclusively only about 10 min before launch. Also, because of the necessity to conserve battery power, the spacecraft was launched with TWTs off. During the final stages of the launch-operations countdown, the transmitter driver was commanded to low-gain antenna 2 for transmission of telemetry data, spacecraft receiver 2 was commanded to low-gain antenna 2 for receiving commands, and the receiver and transmitter driver were set for operation in the coherent mode. The undervoltage-protection system was disabled so that the TWT would

not be disconnected from the bus when (because of insufficient power from the solar array) the voltage drops after the TWT is automatically turned on at separation of the spacecraft from the launch vehicle. The equipment converters were operating, but the power for the orientation electronics was off until turn-on when the spacecraft separated from the launch vehicle. Because no scientific instruments are required to be on during the launch phase, the spacecraft was launched with the telemetry system in the engineering data format (Format C) and a data rate of 64 bits/s.

Spacecraft power was applied at 0452 for the start of Task VII—systems checks. This was followed by Task VIII—standby status preparations, which began at 0726, and by Task IX—ordnance connection and final securing, which was started at 0736. Upon completion of Task IX, the spacecraft was essentially in launch configuration and ready for the start of Task X—terminal count, which was scheduled for 1043. No problems were experienced during the spacecraft countdown operations and the spacecraft remained in a *go* condition throughout.

The vehicle countdown was started on schedule at $T - 380$ min (0643). Countdown operations proceeded normally, with no problems encountered.

At $T - 345$ min, the DSN was considered in a *go* condition, with all preliminary operations running smoothly and on time. However, a disk-file problem was experienced with the W-string 7094 computer at $T - 280$ min. The computer remained down until $T - 180$ min (1003), when it was again declared operational. Commercial power failures, caused by locally severe weather conditions, again dropped the W-string off line at 1045. It was then decided to assign the X-string, which was operating on generator power, as prime.

The maser at DSS 12 was reported down at 1000. It was estimated that it could require 14 h to return the maser to service; therefore, it was decided that DSS 12 would support the initial flight phase operations with its parametric amplifier. No other failures or anomalies occurred, and the DSN remained in a *go* condition throughout countdown and launch.

The MSFN reported all stations and systems in a *go* condition, with the exception of Tananarive, which was qualified as providing limited metric support. The first static-point transmission from Tananarive was invalid and required a replay, and the Carnarvon static point was delayed because of station equipment problems. No

other problems were reported, and the MSFN remained in a *go* condition through launch.

The AFETR experienced no problems during the countdown and launch phase, and remained in a *go* condition throughout. The RF propagation forecast, which was received at $T-105$ min, predicted condition 3 for all HF data circuits.

The spacecraft terminal count was initiated at $T-140$ min (1043), and operations proceeded normally through liftoff.

The built-in hold at $T-35$ min was entered at 1228, with the count resuming on schedule at 1328. The 5-min built-in hold at $T-5$ min began at 1358. After resuming count at 1403, all operations progressed normally through liftoff, which occurred at 1408:00.265 GMT, with a flight azimuth of 108 deg.

3. Liftoff and first powered flight. The powered-flight phase for *Pioneer VIII* was considered to extend from liftoff on December 13, 1967, through separation of the third-stage motor from the spacecraft. During this period, primary control of the mission was transferred from the mission control center at Building AE to the *Pioneer* mission support area at the SFOF. Other activities during this period relate primarily to tracking and telemetry acquisition, which are discussed in Section VI as part of the performance evaluation of the various elements.

The moderately low data bit rate (64 bits/s) was selected to increase the probability of obtaining good diagnostic data if the TWT failed to turn on automatically after injection or if difficulties were encountered because of spacecraft orientation during initial acquisition by DSS 51 or 41. The significant sequence of events for launch operations is given in Table 42.

In Table 42, it should be noted that the times for third-stage ignition, third-stage burnout, and spacecraft separation reported by the AFETR were 1439:32, 1440:18, and 1440:20, respectively. However, the times listed in Table 42 are considered to be more accurate because they were received via the C-band beacon.

The *Pioneer VIII* space vehicle was successfully launched at 1408:00 GMT on December 13, 1967, with a flight azimuth of 108 deg. The launch vehicle and spacecraft systems performed nominally during the near-earth phase of the flight. The support provided by the Tracking and Data System was nominal except for diffi-

Table 42. Sequence of events for launch operations

Time (GMT)	Mark event
1408:00	Liftoff
1409:10	Thrust-augmentation rocket jettison
1410:30	Main engine (first stage) cutoff
1410:35	Second-stage ignition
1411:08	Fairing jettison
1416:56	Second engine cutoff
1438:42	Third-stage spinup
1438:45	Second- and third-stage separation
1438:58	Third-stage ignition
1439:31	Third-stage burnout
1440:18	Spacecraft separation

culty in acquiring tracking and telemetry data from the third stage, which was attributed to tumbling of the stage following spacecraft separation.

The RIS *Twin Falls* reported good S-band telemetry signals, but could not obtain an S-band signal lock on her receivers. The ship was commended for her excellent support on this mission. Metric data from the *Twin Falls*, together with those from Station 13, were of sufficient quality for the RTCF to compute predicts, which were forwarded to NASA stations for spacecraft-acquisition purposes.

All AFETR real-time data and the doppler data from Stations 91 and 12 were very good. The real-time read-outs of third-stage burn time mark events by the AFETR indicated a 50% longer burn time than was expected. It appeared that other mark event times were being reported in error.

The MSFN stations at Bermuda, Tananarive, Carnarvon, Guam, Hawaii, Guayamas, and the GSFC computers provided support to the *Pioneer VIII* mission.

Preliminary data indicated nominal first- and second-stage propulsion-system performance. All three TX33 solid-propellant boosters performed as expected and were ejected on time.

Doppler information from downrange indicated nominal third-stage FW-4D solid-motor performance, with a burn time of 33.6 s.

4. Initial acquisition. Johannesburg (DSS 51) acquired one-way down-link acquisition, as planned. Tracking data

were assessed and indicated all systems in the green. Up-link acquisition was not attempted because of the short pass and excessive tracking rates near the beginning of the pass. Therefore, DSS 41 was considered to be the first acquisition station.

Initial acquisition took place at Woomera, Australia (DSS 41). Following successful two-way lock, DSS 41 reported that all station systems were in a green status to support command activity. Because the spacecraft was launched in the engineering format (Format C), at a bit rate of 64 bits/s, the first transmitted command was to increase the bit rate to 512 bits/s. After the computer at DSS 41 locked at the new bit rate, a command was transmitted to reinstate the Type I maneuver. This was necessary to preclude the possibility that the spacecraft attitude was not as desired because of a premature termination of the Type I orientation maneuver following automatic turn-on.

The scientific instruments were then turned on, with the GSFC and ARC instrument activation followed by the Format B scientific format command. The turn-on of each instrument was spaced approximately 20 min apart to allow sufficient time for evaluation.

The Type II orientation maneuver was successfully performed and controlled from DSS 12, establishing a spin axis normal to the ecliptic plane. This was accomplished by orienting the spacecraft spin axis normal to the spacecraft-earth line while maintaining a normality to the spacecraft-sun line, thus resulting in a final spin-axis orientation normal to the ecliptic plane.

The significant initial-acquisition sequence of events summary is shown in Table 43. The *Pioneer VIII* orbital parameters are shown in Table 44. The heliocentric orbit parameters are given in Table 45.

Table 43. Initial-acquisition sequence of events

Time (GMT)	Event
1455	DSS 41 rise
1455	DSS 41 acquisition
1511	DSS 41 set
1535	512-bits/s bit rate commanded
1538	Type I restart commanded
1550	Cosmic dust experiment power on commanded
1605	Plasma probe experiment power on commanded
1615	Magnetometer experiments power on commanded
1630	Format B commanded
1715	Cosmic dust experiment calibrate commanded
1708	Electric field detector experiment power on commanded
1800	GRCSW cosmic ray experiment power on commanded
1815	GRCSW cosmic ray experiment calibrate commanded
1730	ARC plasma probe experiment calibrate commanded
1945	Minnesota cosmic ray experiment power on commanded
2030	Stanford radio propagation experiment power on commanded

Table 44. Heliocentric orbital parameters

Event	Nominal	Actual
Aphelion, AU	1.0985	1.0886
Perihelion, AU	—	0.9917
Period, days	—	387.5
Inclination (heliocentric), deg	0.0273	0.0568
Earth-to-spacecraft distance at syzygy, earth radii	500.0	464.9
Time to syzygy, days	—	36.0
Spacecraft distance out of ecliptic at syzygy, earth radii	—6.0	+8.3

Table 45. Parking- and transfer-orbit parameters

Parameter	Parking orbit		Transfer orbit	
	Expected	Computed	Expected	Computed
Semimajor axis	6845.5 km	6775.1 km	—1175800.00 nmi	—4100700.00 nmi
Eccentricity	0.0213	0.0139	1.0059	1.0017
Inclination, deg	32.91	32.90	32.83	32.77
C ₃	—58.22	—58.83	0.3390	0.0972
Longitude of ascending node	90.2546	90.3069	90.08	90.15
Argument of pericenter focus	84.5130	61.0565	224.94	226.42
True anomaly	53.512	78.764	0.0	—1.1

B. Deep Space Phase Support

As part of the TDS for a flight project, the DSN is normally assigned to support the deep space phase of each mission. Responsibility for providing TDS support from liftoff until the end of the mission was assigned to the JPL office of tracking and data acquisition. A TDS manager worked with the JPL technical staff at the AFETR to coordinate the support of the AFETR, MSFN, and NASCOM with certain elements of the DSN needed for the near-earth phase support. A DSN manager and Project engineer, together with representatives from the DSIF, GCF, and SFOF, formed a design team for the planning and operational phases of flight support. A typical functional organization chart for operations is shown in Fig. 51.

Because of the excellent performance of the *Pioneer VI* spacecraft and the larger-than-anticipated amount of scientific data obtained during that mission, the DSN tracking and data acquisition support requirements and commitments were increased for the *Pioneer VII* mission, and increased in proportion for the *Pioneer VIII* mission.

The Deep Space Stations committed to support *Pioneer VIII* were DSSs 12, 41, 51, and 62, which were equipped with *Pioneer* ground operational equipment. With GOE, the spacecraft is commanded by the Deep Space Stations into desired modes of operation, bit rates, calibration, and maneuvers, and telemetry data can be sent during the pass to verify proper operation of the spacecraft and scientific instruments. In addition, at these stations, all telemetry data are recorded on magnetic tapes for future processing. These magnetic tapes are the only complete data record for a given pass.

The DSN support commitment for these stations was one tracking pass per day during the first four days after launch, one maximum pass⁹ per day from five until thirty days after launch, and a maximum of two passes per week thereafter. The Tidbinbilla station was committed for one tracking pass per day during the first four days after launch and a maximum of one pass per day from five to thirty days after launch. The services of the Johannesburg station were planned on an "if available" basis. It was requested that, during the first four days after launch, Johannesburg would be available for one tracking pass each day.

⁹The length of a maximum tracking pass is defined by the duration of direct visibility of the spacecraft, limited only by the terrain and antenna hardware constraints.

The Cape Kennedy station (DSS 71) was also committed for *Pioneer VIII* mission support to make possible the RF compatibility-verification tests for the spacecraft.

Beginning 31 days after launch, a maximum of 5 tracking passes per week was planned, using any combination of the following stations: *Pioneer*, *Echo*, Woomera, Tidbinbilla, Johannesburg, Robledo, and Cebreros. Within the limits of DSN loading and station availability, it was also planned to use any or all of the Deep Space Stations to provide a minimum average coverage of the equivalent of 1 pass per day from 31 days after launch until the end of the mission.

Because the main objective of the mission was to collect scientific data relative to interplanetary phenomena, special emphasis was given to support during solar-flare activities. The DSN commitment stated that, in the event of Class II or greater solar-flare events, continuous tracking and data-acquisition coverage would be provided.

It was also agreed that the *Pioneer VIII* spacecraft tracking coverage from the stations equipped with 85-ft-diam antennas would be terminated when the 8-bit/s telemetry data were distorted by a bit-error rate of 10^{-3} (1 error in 1000 detected bits, or 0.1% error) or larger, making further telemetry acquisition effort impracticable. Telemetry data with a bit-error rate of 10^{-2} would be acceptable to the *Pioneer* Project. If available error-correction techniques were applied, meaningful readout of measurements generated by the flight instruments would be possible.

Tracking and data-acquisition support was also planned from the Goldstone Mars station after the support by the 85-ft-diam antenna stations had phased out. At the time the *Pioneer VIII* commitments were made, this station was not fully completed, and had not been given an operational status; therefore, this facility was made available on a "best effort" basis.

It was also planned to have daily tracks available at the Mars station (DSS 14) with its 210-ft-diam antenna for each *Pioneer* mission. Because of the limitations of a single-station capability, the support ratio among the *Pioneer VI*, *VII*, and *VIII* missions at DSS 14 was to be coordinated by the *Pioneer* Project for the best utilization of all spacecraft instruments.

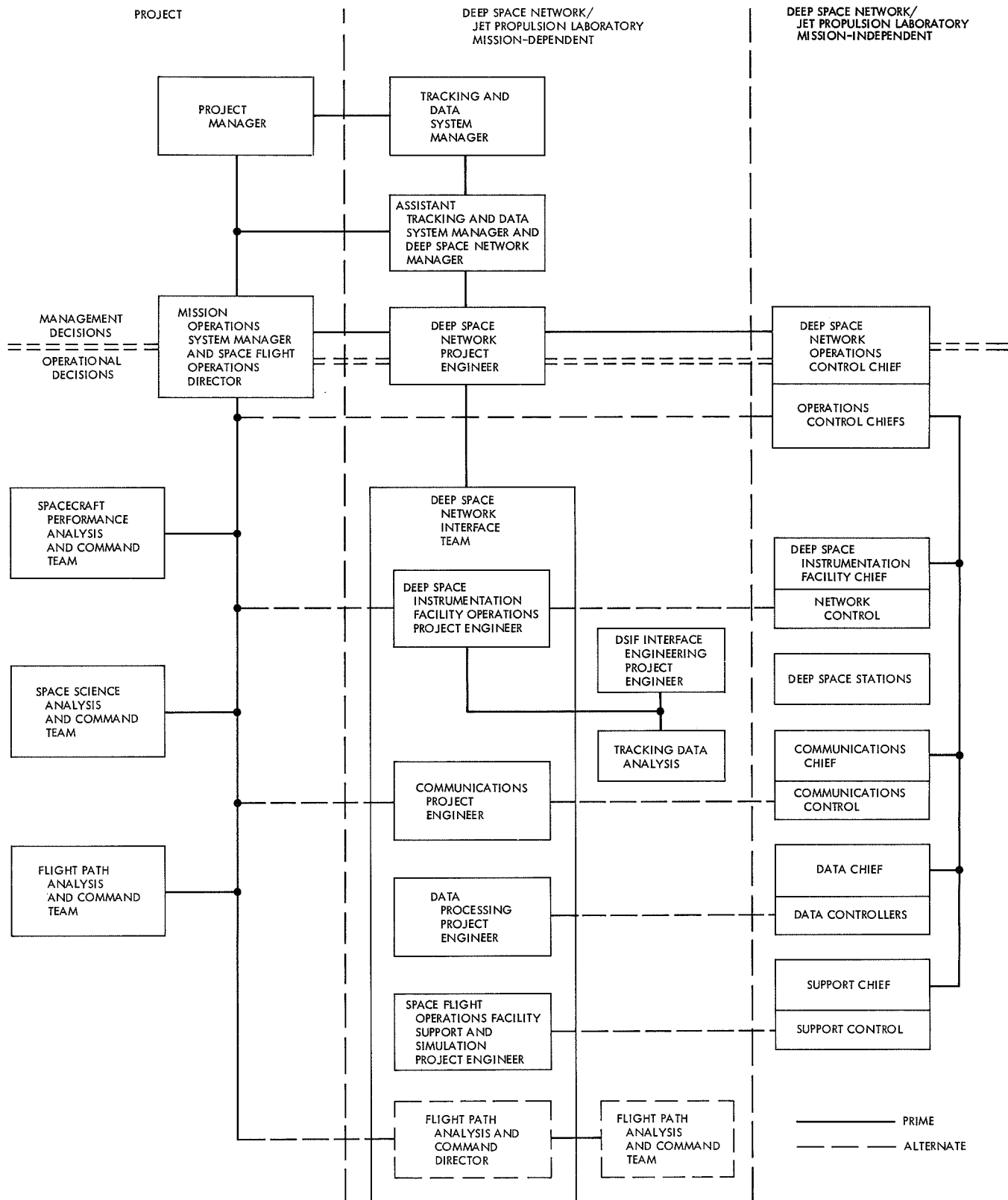


Fig. 51. Typical functional organization for DSN mission support operations

Teletype and voice circuits between the SFOF and the *Echo*, Tidbinbilla, Johannesburg, and any other scheduled Deep Space Stations were assigned as part of the GCF mission support for *Pioneer VIII* (subject to circuit priorities). It was also planned to furnish, during launch operations, three full-duplex teletype and three voice circuits between the SFOF and the JPL communications center at Cape Kennedy, and three full-duplex teletype and voice circuits between the SFOF and DSS 71.

The *Pioneer* mission support area in the SFOF was committed for the SFOD and his team to direct, during launch operations, all elements of space flight operations, SPAC, and SSAC functions. It was also planned that the FPAC team would perform all prelaunch and postlaunch computations necessary for orbit determination and predictions. The SFOF was committed to generate medium-accuracy orbits based upon tracking data received from the Deep Space Stations, provide continuous data validation, and render any other services necessary to make a reliable spacecraft acquisition as soon as possible and to make precision orbit data available to meet the required accuracies. A further commitment was to furnish the *Pioneer* Project with the best possible telemetry data.

1. Deep Space Network mission support. During the prelaunch countdown, DSS 71 received telemetry data from the spacecraft and continuously monitored the spacecraft communications subsystem performance and the compatibility of the subsystem with the DSN. The direction and status monitoring of the DSN was performed at the SFOF. Also, the performance of the spacecraft and scientific instruments was analyzed at the SFOF from spacecraft telemetry data teletyped from DSS 71. These activities served as backup to similar tasks performed at Building AN.

The *Pioneer VIII* spacecraft was launched by the two-stage Douglas launch vehicle—the thrust-augmented improved *Delta*. The third stage, which injected the spacecraft into its escape trajectory, was a United Technology FW-4. The guidance equipment aboard the *Delta* vehicle required that a fixed launch-azimuth and parking-orbit coast time be used for each launch block.

The launch vehicle boosted the third-stage-spacecraft combination into a rather elliptical parking orbit. Near the end of the parking-orbit coast period, the third-stage-spacecraft combination was spun up, the second stage was separated from the third stage, and the third stage was ignited.

The third-stage burn had a fixed direction in space. The thrust vector lay in the inertial launch plane, and was so directed that the flight-path angle at the end of the burn was very nearly zero.

About 1 min after third-stage burnout, the spacecraft separated from the third stage, the spacecraft booms were deployed, the TWT amplifier was turned on, and the Type I orientation maneuver was begun. This maneuver, which is performed with sun sensors, places the spin axis of the spacecraft normal to the sun-spacecraft line. This orientation permits maximum output from the solar panels located on the sides of the cylindrically shaped spacecraft.

The Type II orientation maneuver is normally done during the second pass over Goldstone. This maneuver places the spin axis of the spacecraft approximately normal to the ecliptic plane—an orientation that allows the high-gain antenna to illuminate the earth continuously throughout the mission.

About 35 days after launch, the spacecraft passed through syzygy (Fig. 52) with the sun and earth. At this time, *Pioneer VIII* was about 500 earth radii from the earth. Valuable scientific measurements of the magnetosphere of the earth were made during the 10 days or so that the spacecraft spent in the “tail of the earth.”

The major objectives and events during the early phase of the mission are shown in Table 46.

Following syzygy, *Pioneer VIII* continued on its outward mission, reaching an aphelion distance of approximately 1.1 AU about 180 days after launch. Scientific

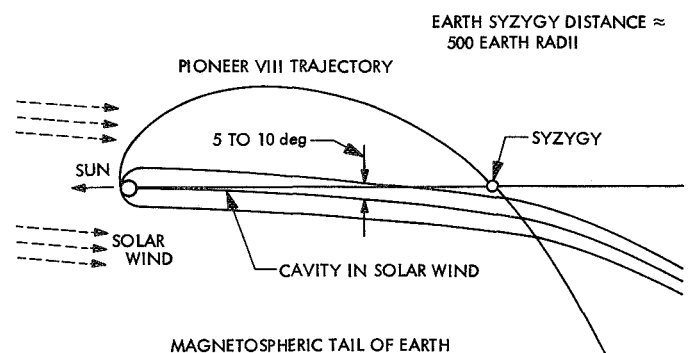


Fig. 52. *Pioneer VIII* syzygy, approximately 35 days after launch

Table 46. *Pioneer VIII* major events

Approximate time (GMT)	Event	Objective
1408 (Dec 13)	Launch	Place <i>Pioneer VIII</i> in a heliocentric orbit with an aphelion of 1.1 AU
L+32 min	Separation	
L+34 min	Type I orientation	Orient spacecraft so that solar panels receive maximum energy from sun
L+31 to L+44 min	DSS 51 view period	Obtain telemetry data to assess health of spacecraft (only during last 5 to 7 min of view period are data obtained because of high tracking rates)
L+49 min	DSS 41 acquire one-way	Obtain telemetry data to assess spacecraft health and verify Type I orientation
L+55 min	DSS 41 acquire two-way	Obtain both tracking and telemetry data to assess spacecraft health and determine trajectory
L+20 h	Monitor science data	Determine magnetosheath characteristics
L+64 to L+68 h	Type II orientation	Orient spacecraft to obtain maximum signal from high-gain antenna
L+35 days	Syzygy	Monitor science data to determine characteristics of geomagnetospheric tail

measurements on fields and particles continued throughout the early lifetime of the mission (6 mo).

The DSN performed one-way data acquisition at Johannesburg, South Africa (DSS 51) at 1443. Deep Space Station 51 tracked *Pioneer VIII* for approximately 10 min. The station at Woomera, Australia (DSS 41) acquired spacecraft data at 1455. The first command was transmitted from DSS 41 at 1462. Initial data analysis indicated that all spacecraft subsystems were performing normally. All on-board scientific instruments were commanded on, and transmitted valuable scientific informa-

tion on the interplanetary medium. Data were also transmitted by the *Test and Training Satellite*, a radio-relay communications satellite that was placed into an earth orbit.

During this phase, the SFOF provided all necessary services, functions, and equipment. The FPAC team made computations of the parking orbit, which was nominal. The orbit computed by the SFOF, available 35 min after launch, was used as a backup to the orbit computed by the AFETR. The deviation between the two orbits was within the required accuracy limits. The computation of the solar orbit started 1 h after launch, using two-way tracking data from DSS 41. The first computed solar orbit, available approximately 2 h after launch, was used immediately to generate new predictions for the Deep Space Stations. Three more orbits were generated within 20 h after launch, also using two-way tracking data from the Deep Space Stations. All of the computed orbits were very similar, and fit the available data almost perfectly.

The GCF supplied all necessary support prior to, during, and after the launch of *Pioneer VIII*.

All committed tracking and data-acquisition services were furnished to the *Pioneer* Project to make available almost continuous telemetry information, with the lowest bit-error rate, as well as the necessary two-way doppler tracking information required to update the orbit parameters and generate frequency predictions for the Deep Space Stations.

Every phase of the mission was very successful, and all flight instruments sent back excellent data on fields and particles. Based on its performance thus far, the estimated total lifetime of the *Pioneer VIII* spacecraft is 5 yr. This period is used in DSN planning to estimate the future tracking and data-acquisition support necessary for the mission.

2. Deep Space Instrumentation Facility.

a. Deep Space Station operations. The information given per pass is a sequence of problems and corrections from the launch pass through pass 171 (May 31, 1968). Only those equipment malfunctions and failures that affected data acquisition or were of a great enough magnitude to require extensive investigation are listed in the paragraphs that follow.

Launch through pass 15. During this period, *Pioneer VIII* was supported by a network consisting of DSSs 12, 14, 41, 51, 62, and 71¹⁰ that provided continuous coverage of the *Pioneer VIII* spacecraft. The predicted vs actual signal levels for the launch phase are illustrated in Figs. 53, 54, and 55 for DSSs 71, 51, and 41, respectively.

When the time and number of stations tracking the spacecraft are considered, the number of anomalies during the subsequent period were few. Major anomalies were as follows:

- (1) Maser down at DSS 12 because of compressor oil leak that contaminated lines, but backup support of paramp prevented loss of data.
- (2) Several transmitter failures throughout network were attributed to excessive forward power indications that tripped interlock switch.
- (3) An intermittent receiver acquisition frequency control module resulted from a defective potentiometer. No loss of data occurred.

The transmitter failure was evaluated and, as a result, the overload interlock requirements were revised. No other equipment problems caused loss of data.

Passes 16 through 30. During passes 17 and 19, the transmitter at DSS 62 tripped off because of excessive forward power. After investigation by the cognizant engineer, it was decided to increase the forward power interlock to the maximum point. The CEC recorder failed during pass 19 at DSS 12. This was caused by a defective relay. Investigation showed that the points were burned, and replacement was necessary.

During pass 20, DSS 62 reported a malfunction in the maser-paramp coaxial switch during the precalibrations, and that the pass would have to be performed in the paramp configuration. The switch was changed at the end of the pass, and created no other problems. Because of the strong signal level at this range, no loss of data occurred.

During pass 29, the secondary rubidium standard at DSS 12 was taken out of service because of a noisy internal loop, and replaced by a Knight oscillator. This unit has had the same problem in the past, and was subjected to extensive testing and checkout in the repair depot.

A predicted signal strength for the first 200 days of the *Pioneer VIII* mission was calculated, and is shown in Fig. 56.

Passes 31 through 45. Deep Space Stations 12, 14, 41, 51, and 62 continued to provide 24-h tracking support of *Pioneer VIII* during this period. At DSS 51, the cone-aperture polarizer was used with satisfactory operation. Nominal tracking support was reported except for the significant anomalies described below.

During pass 31, at DSS 51, excessive oxide buildup required the stripping of the recorder for head cleaning. No data were lost; however, prime data tapes were from alternate recorders.

At DSS 41, during pass 31, the maser failed because of a broken spring on the displacer assembly. Tracking was switched to paramp, with approximately 2 min of data lost. Deep Space Station 41 continued paramp operation through passes 32 and 33.

During pass 37, at DSS 41, a transmitter current overload interlock tripped and immediately reset; no data were lost.

At DSS 12, during pass 45, a power failure caused a partial warmup of the maser. The antenna was switched to paramp and back to maser after approximately 2 h. The same power failure also caused the transmitter to go off; no data were lost.

Passes 46 through 79. *Pioneer VIII* received tracking support from DSSs 11, 12, 41, 42, 51, 61, and 62 during this period.

During pass 50, DSS 11 provided support rather than DSS 12. A command was scheduled to be sent to the spacecraft during this pass; however, incorrect microwave patching prevented the command from being received at DSS 11. Record-only support was provided by DSS 42 during passes 48 through 52 because DSS 41 was committed to support termination of the *Lunar Orbiter* spacecraft.

At the start of pass 50, DSS 62 was unable to move its antenna because of a short circuit in the emergency-disable line of the declination axis; the emergency line was disconnected. Deep Space Station 61 was called up on a record-only basis to back up DSS 62 for approximately 2 h to accomplish the necessary repairs. Approxi-

¹⁰DSS 71 was used for launch only.

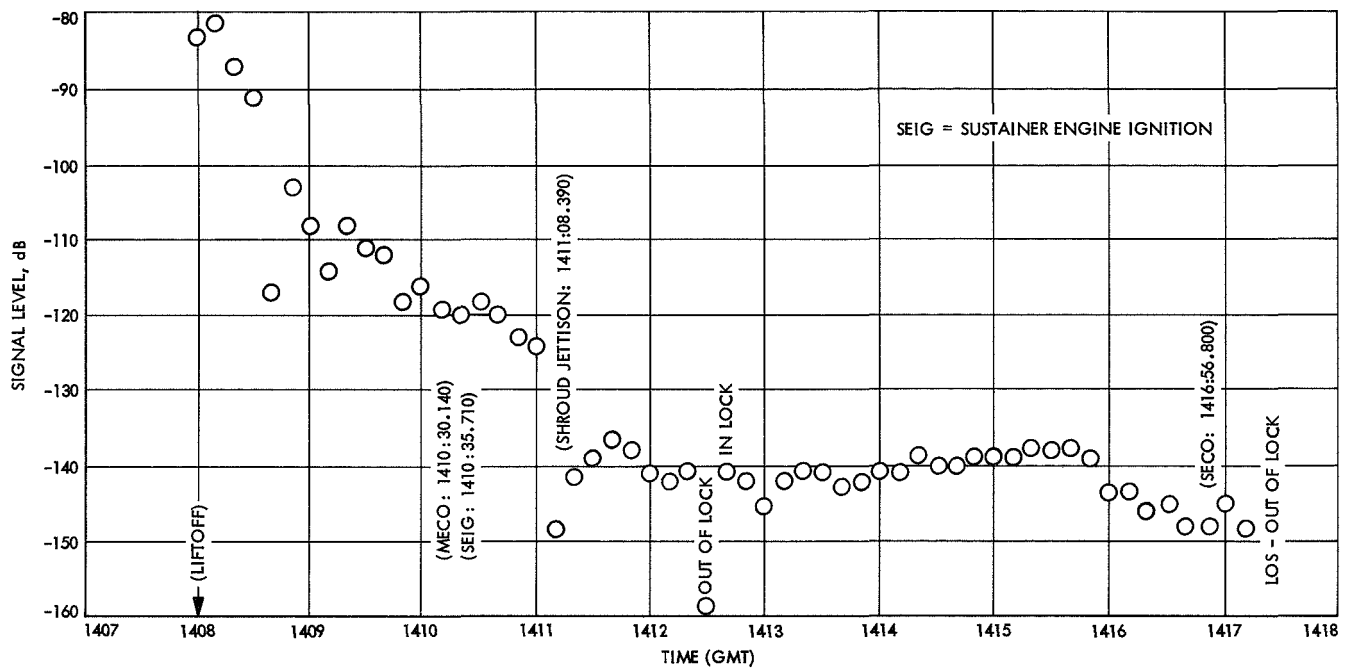


Fig. 53. Signal strength vs time at DSS 71 during Pioneer VIII launch, December 13, 1967

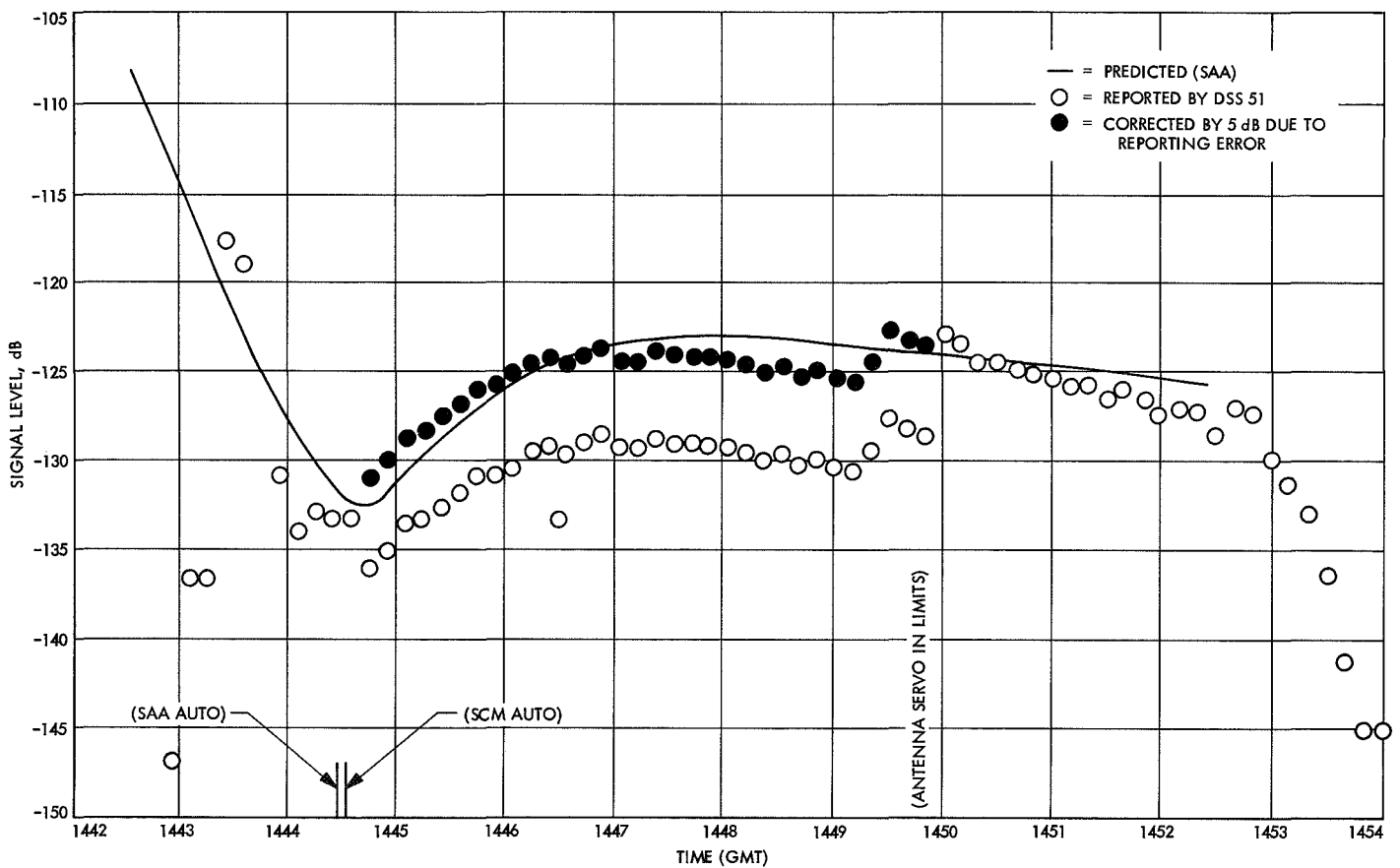


Fig. 54. Signal strength vs time at DSS 51 during Pioneer VIII launch, December 13, 1967

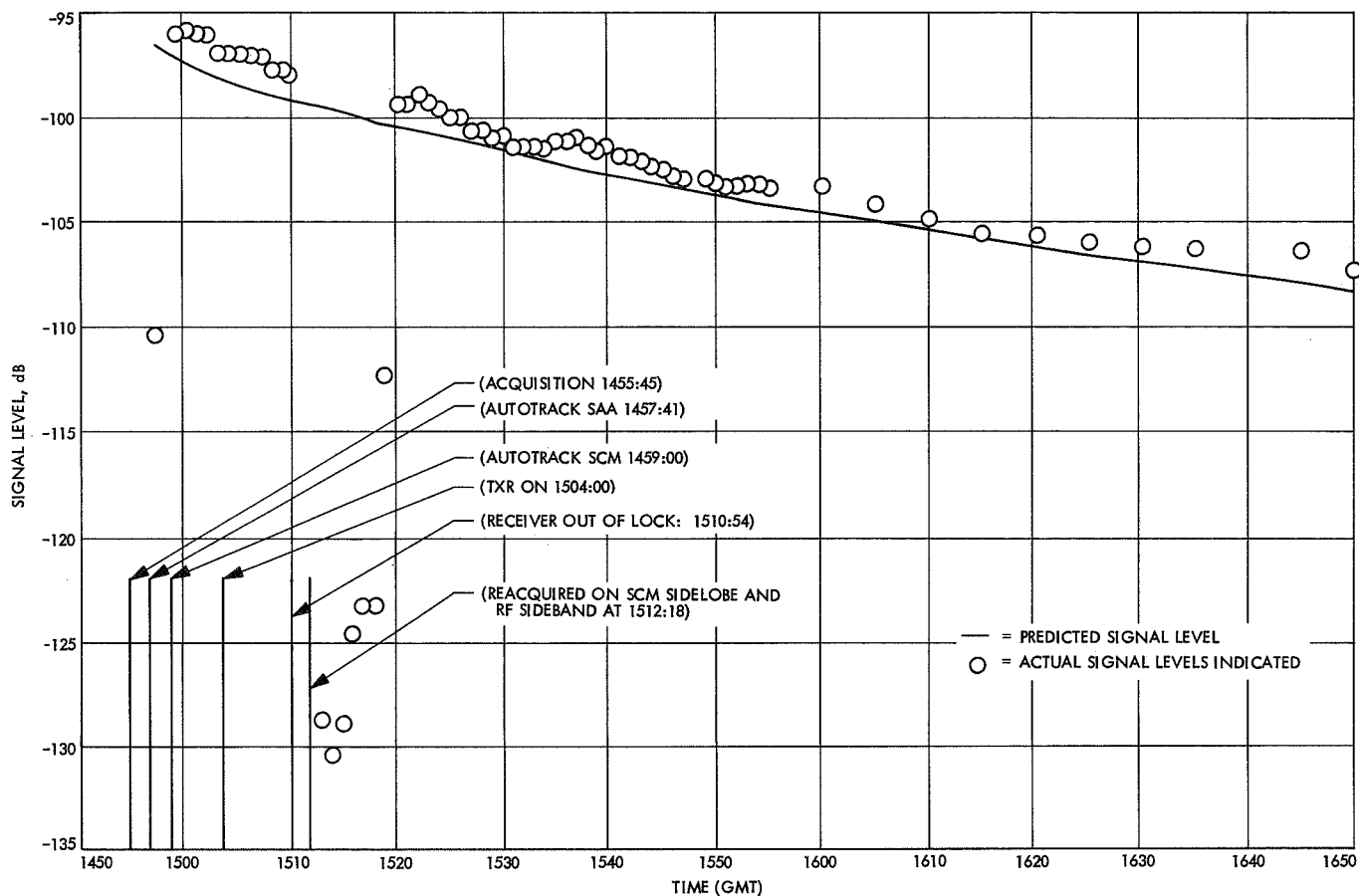


Fig. 55. Signal strength vs time at DSS 41 during Pioneer VIII launch, December 13, 1967

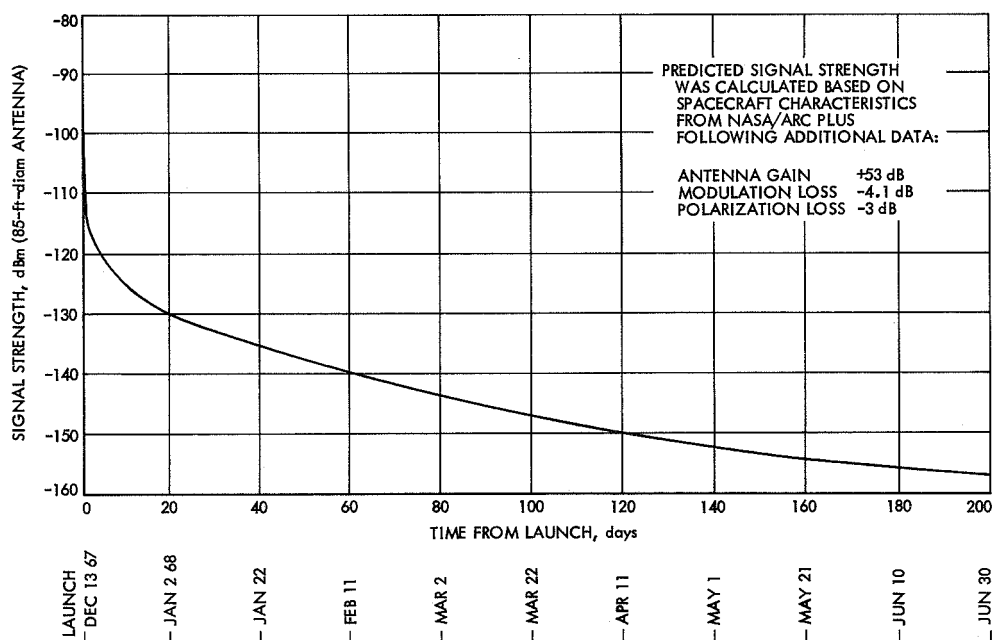


Fig. 56. Pioneer VIII predicted signal strength vs time

mately 2 h and 45 min of tracking time was lost during this maintenance. Also during pass 50, a synthesizer blown fuse at DSS 62 caused an additional 10-min outage of doppler data.

During pass 52, a power failure in the exciter prevented the transmitter from coming on at DSS 71. The antenna was pointed toward zenith to replace the power supply. Approximately 50 min of tracking time was lost during this failure. The doppler data were invalid for approximately 4 min longer after the power supply was replaced because a cable that had been disconnected during troubleshooting of exciter failure was not immediately reconnected. The spare GOE units at DSS 12 were installed in two racks, and checked out. After it had been determined that the proper cooling and cabling requirements were met, the equipment was put on line during pass 55. The data proved to be satisfactory, and the spare equipment was sent to DSS 14 for direct support of *Pioneers VI and VII*, permitting DSS 12 to concentrate on *Pioneer VIII*.

During pass 56, a maser warmup was reported, caused by contamination, at DSS 12. The paramp was then used.

A faulty maser magnet header regulator caused a slight gradual decrease in signal level at DSS 12 during pass 57. No data were lost.

During pass 58, a faulty relay on the DIS tape spool caused loss of Interim Monitoring Program (IMP) data for 40 min at DSS 62. Improper predict format resulted in bad IMP doppler data at DSS 12. During pass 59, an improper selector switch setting resulted in bad IMP doppler data for approximately 45 min.

Johannesburg (DSS 51) was in the record-mode configuration during the above periods because its GOE had been shipped to ARC and to DSS 62 for modification.

The Goldstone *Echo* station (DSS 12) tracked only one pass during this period before the station went down for reconfiguration; the GOE was then used to support DSS 11.

Woomera (DSS 41) experienced multiple transmitter outages. These outages were caused by overload relay operation, which resulted because an engineering change intended to extend the overload limits had not been incorporated. The Woomera station has since been reconfigured and modified.

During pass 72, a spurious interrupt halted the program, causing a loss of teletype data for 20 min at DSS 62. The program was reloaded, and data transmission was continued. These data were recorded on a magnetic tape during this period for data reduction.

Acquisition was delayed 43 min at DSS 11 during pass 78. The waveguide switch on transmitter 1 was stuck between the antenna and the load, preventing operation on either transmitter. When the switch was freed, DSS 11 acquired the spacecraft.

The microwave equipment at the Goldstone communications center was relocated soon thereafter. During pass 78, a test was performed between DSSs 11 and 12 to determine whether there was degradation of the telemetry and command signals between the microwave link and the land line. The best way to compare the two communication links is to compare the parity error rate. At most stations, the parity error rate was 0.000 at this time for *Pioneer VIII*; because of the difference in microwave configuration between DSSs 11 and 12, however, a small error was noted. On the microwave link, the average parity error rate was 0.006 vs 0.010 on the land line, which indicated that the land line could be used while the microwave link was being relocated.

Passes 80 through 110. *Pioneer VIII* was tracked by DSSs 11, 12, 14, 41, 42, 61, and 62 during this period. The following occurrences during this reporting period are of interest:

- (1) Although DSS 12 was down for modification (updating), the GOE and TCP were used to support DSS 11.
- (2) Deep Space Station 14 tracked *Pioneer VIII* for two passes because DSS 11 had prior commitments.
- (3) At the beginning of the month, DSS 41 tracked the *Pioneer VIII* spacecraft for two passes before the station was decommitted for modification (updating).
- (4) Deep Space Station 42 tracked a record-only pass while its GOE was being modified at ARC.
- (5) Deep Space Station 61 tracked one pass to determine the operational status of the microwave link between DSSs 61 and 62. The reduced data were of good quality, and compared well with the data received from DSSs 11 and 12.

The masers were the main problem at DSS 11. The secondary unit was down for repair during pass 97; also, the prime unit developed a crosshead problem. Deep Space Station 11 was released from the *Pioneer* tracking operation to work on the maser problems. The Goldstone Mars Station (DSS 14), which was scheduled for a polarization test, was configured to cover pass 97 in lieu of DSS 11.

The Goldstone *Pioneer* station (DSS 11) had antenna-pointing problems caused by erroneous inputs from the tracking data handling subsystem. This problem caused a loss of data when the antenna was driven off the spacecraft. The antenna-pointing problem was corrected by repairing a connector at the DIS-TDH J-box. Also, an oxidized (dirty) potentiometer in the acquisition control unit caused receiver malfunctions while the exciter VCO was being tuned. This problem was corrected by replacing the unit.

Passes 111 through 140. During this period, the *Pioneer VIII* spacecraft received tracking support from DSSs 11, 12, 42, 61, and 62. Occurrences of note are described below.

Deep Space Station 12 supported DSS 11 via microwave and land line during passes 114 through 135. This support allowed DSS 11 sufficient time to install a

circular-to-linear polarizer during pass 116 and for relocation of microwave equipment. A test was conducted on the land line prior to this support to prove it satisfactory for the *Pioneer* subcarrier. However, although it was satisfactory, there was approximately 0.9-dB loss because of frequency response limitation. During pass 120, DSS 62 also installed a polarizer. These polarizers recovered the standard 3-dB polarization loss. The increased signal level made it possible to reduce data at a higher bit rate, as shown in Fig. 57.

Tidbinbilla (DSS 42) was in the record-only mode during this reporting period. The signal strength at DSS 42 was approximately 3 dB less than that of DSSs 11 and 62 because of the lack of a polarizer. Towards the end of the month, DSS 42 was unable to confirm the quality of the recorded raw telemetry data because of the low signal level. The modified GOE was installed at DSS 42, and was in operation during the next reporting period.

Robledo (DSS 61) tracked several times during this period, with the support of DSS 62. Cerebros (DSS 62) performed most of the tracking operation at Madrid, but was down the next month for updating and reconfiguration. At both stations (DSSs 61 and 62), the microwave link was operating satisfactorily, and no problems were reported.

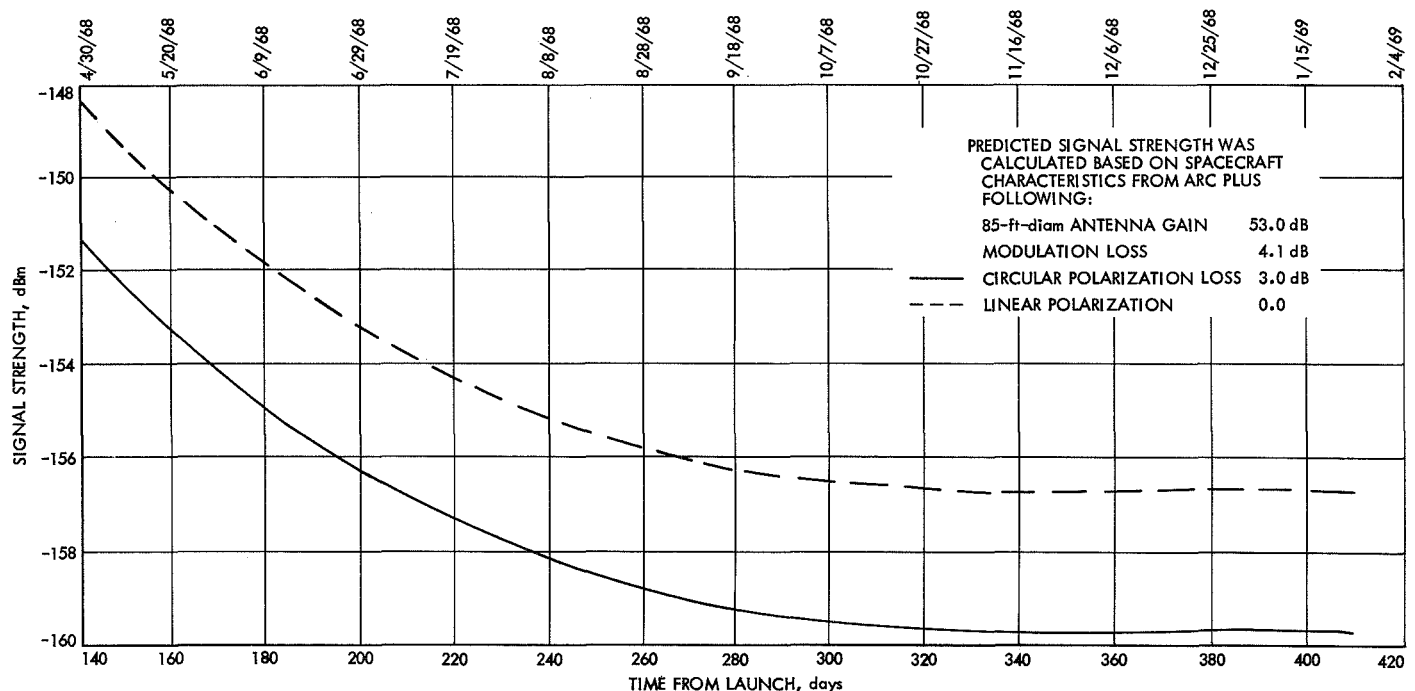


Fig. 57. Predicted signal strength vs time from launch

Passes 141 through 171. Pioneer VIII was tracked by DSSs 11, 12, 14, 42, 61, and 62 during this period. Deep Space Stations 12 and 14 supported DSS 11, and DSS 62 supported DSS 61, via microwave during this reporting period. The Mars station (DSS 14) supported two passes when DSS 12 was down for rework. Tidbinbilla (DSS 42) had its GOE modified for coded-uncoded modes, and tracked in an engineering-evaluation mode only until the final checkout tests were completed towards the end of the month.

A telecommunication design control table for carrier signal strength is described in Table 47. The calculated value agreed quite well with actual values recorded.

Only the problems causing loss of data during this period are included in the paragraphs that follow.

During passes 143, 154, 157, 160, and 161, the antenna pointing subsystem (APS) program at DSS 61 continued to cause intermittent problems; the cause was finally found to be a circuit-board wiring problem.

During pass 147, DSS 42 detected several receiver malfunctions while tuning the exciter. Noise and spikes were observed in the transmitter spectrum, caused by an oscillation in the declination low-speed tachometer

circuit. The receiver problem was solved by replacing the low-speed drive belt.

During passes 152 and 153, DSS 61 experienced receiver malfunctions and loss-of-lock indications while tuning the exciter; however, noise or spikes were observed in the transmitter spectrum. The acquisition potentiometer was changed, which corrected the problem.

During pass 168, DSS 11 was late acquiring the spacecraft because of inoperative declination angle high-speed control on the antenna. The station temporarily used the low-speed control to acquire the spacecraft. A resistor located in the declination servo amplifier was replaced, which corrected the high-speed control problem.

b. Deep Space Station tracking support. Table 48 gives a detailed breakdown of the tracking support provided for *Pioneer VIII* by the Deep Space Stations from launch through pass 171, covering a period of some 6 mo. The following significant information is contained in Table 48:

- (1) Pass number.
- (2) Deep Space Station number.
- (3) Day of year (GMT).

Table 47. Abbreviated telecommunication design control table, *Pioneer VIII*, pass 170 (day 151)

No.	Parameter	Value	Tolerance, dB	
1	Total transmitter power	38.4 dBm	0.2	-0.2
2	Transmitting circuit loss	0.4 dB	0.5	-0.6
3	Transmitting antenna gain	11.2 dB	0.5	-0.5
4	Transmitting antenna pointing loss	(Included in No. 3)	—	—
5	Space loss: 2292 MHz, $R = 3.04 \times 10^7$ km	249.3 dB	—	—
6 ^a	Polarization loss	3.0 or 0 dB	0.3	-0.3
7	Receiving antenna gain (210 ft diam)	53.0 dB	1.0	-0.5
8	Receiving antenna pointing loss	0 dB	—	—
9	Receiving circuit loss	0.2 dB	0.1	-0.1
10 ^a	Net circuit loss	188.7 or 185.7 dB	2.4	-2.0
11 ^a	Total received power	150.3 or 147.3 dBm	2.6	-2.2
12	Receiver noise spectral density (noise bandwidth) (T system = 55°K)	181.2 dBm	0.7	-0.9
13	Carrier modulation loss ($\theta = 0.9 \pm 5\%$)	4.1 dB	0.5	-0.5
14 ^a	Received carrier power	154.4 or 151.4 dBm	—	—
15	Carrier APC ^b noise bandwidth ($2B_{L0} = 12$ Hz) ^c	10.8 dB	0.0	-0.5
16	Measured carrier power	151.4 dBm	—	—
17	Calculated (14) — measured (16) carrier power with polarizer installed	0 dB	—	—

^aThe 3 dB loss is experienced when station is using circular-polarized configuration; 0 dB when using matching linear-polarized configuration.

^bAPC = automatic phase control.

^c $2B_{L0}$ = APC loop bandwidth at 0 dB SNR.

- (4) Acquisition time (GMT).
- (5) End of track (GMT).
- (6) Ground modes (one-, two-, and three-way start and stop times).
- (7) Average received signal levels, dBm.
- (8) Configuration.
- (9) Commands (total).
- (10) Average parity error rate (PER).
- (11) Bit rate, bits/s.
- (12) Comments.

3. *Space Flight Operations Facility.* The SFOF provided all necessary services, functions, and equipment to make a highly successful launch possible for *Pioneer VIII*. The FPAC team started its computation of the parking orbit, which had been nominal at 35 min after launch, as a backup computation to the AFETR activity. The deviation between the AFETR and JPL parking orbits was within the required accuracy limits. The computation of the solar orbit started 1 h after launch, using two-way tracking data from DSS 41. The first solar orbit, available approximately 2 h after launch, was called the PROR orbit, and was used immediately to generate new predicts for the Deep Space Stations. Three more orbits were generated within 20 h after launch, using two-way tracking data from DSSs 12, 41, and 62. The second, third, and fourth orbits were very close, and the fit to the available data was almost perfect. All other necessary support was performed satisfactorily.

VI. *Pioneer VIII* Tracking and Data System Performance Evaluation

A. Mission Objectives of *Pioneer VIII*

The primary objective of the *Pioneer* Project is to obtain scientific information on interplanetary phenomena. This information provides knowledge of the interplanetary environments that is required for planning unmanned and manned interplanetary projects. It is also required to develop knowledge regarding the propagation of particles from the sun to the vicinity of the earth, and to provide tools for exploration of the effects caused by dynamics of the surface of the sun. Acquisition of this information should also provide an increased understanding of solar phenomena in general; it may also permit a detection of the interface between the solar and galactic magnetic field, which might have implica-

tions relative to the origin of cosmic rays and the historic mechanism of the galaxy. Scientific information pertaining to the characteristics of solar radiation related to the capability for solar-flare prediction, and information revealing the properties and distribution of particles in interplanetary space, are of particular importance to *Apollo* and other planetary exploration programs.

Scientific observations of the characteristics of magnetic fields, plasma, and high-energy particles in interplanetary space beyond the influence of the earth can provide a better understanding of the mechanism related to the propagation through space of solar disturbances, terrestrial phenomena related to such disturbances, and the relationship between solar and galactic fields.

These characteristics are influenced by solar phenomena, and vary both temporally and spatially. It is believed that they are influenced, on a large time scale, by the magnitude of solar disturbances, which vary periodically over an 11-yr cycle. Because such disturbances are generally localized on the surface of the sun, and because the sun rotates, the spatial variation is surmised.

The broad objectives of the *Pioneer* Project are to conduct the aforementioned scientific observations and to determine the temporal and spatial variations of the interplanetary phenomena. To implement these objectives, the plan called for five flights, to be launched at intervals of approximately 8 to 12 mo, to cover the period from near-minimum to maximum solar activity.

Spatial effects were to be determined by launching two of these spacecraft in such a direction that they would move ahead of the earth with increasing time (inward launch), and by launching three of the spacecraft to move behind the earth with increasing time (outward launch). *Pioneers VI* and *IX* are in the former category; *Pioneers VII*, *VIII*, and *E* are in the latter category.

All *Pioneer* flight missions were used to fulfill the requirements of the *Pioneer* space weather monitoring mission. A portion of the scientific data was teletyped to Ames Research Center, processed, analyzed, and then transmitted to the Department of Commerce, the Environmental Sciences Service Administration (ESSA), and the Space Disturbance Center within a few hours after the measurements were made. The Space Disturbance Center uses this information as one of many sources in the preparation of its daily *Space Disturbance Forecast*.

Table 48. Operations pass summary, Pioneer VIII

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
Launch	71	347	1408	141716	1408 1417			12	60.0	-160	0			Signal strength varied from -81 dbm at launch to -148 dbm at loss of signal	
Launch	51	347	1443	1453	1443 1453			12	39.3	-173	0	0.000	512	One-way data to access health of S/C	
Launch	41	347	1455	2130	1455 1510	1511 2050	2050 2130	12	44.4	-172	18	0.000	512		
Launch	42	347	1459	1652	1459 1511		1511 1652	12	39.0	-164.7	0			Record only pass as backup to DSS 41; no GOE at station	
1	51	1759	0512		0400 0403	2050 2315	1759 2050	-116.8/-120	12	39.5	-172	5	0.000	512	
1	62	348	1942	0819		2315 0110	1942 2315	-120.5/-120	12	46.9	-171.80	3	0.000	512	
1	12	348	0341	1300		0401 1200	0341 0401	-123.5/-120	12	36.5	-165	6	0.000	512	Paramp track - maser cooling down
2	41	348	1142	2100		1200 2030	1141 1200	-123.5/-120	12			3	0.000	512	
2	51	348	1952	0501			1952 0501	-125/-120	12	38.3	-172.5	0	0.000	512	
2	62	348	1950	0902		2038 0430	1951 2038	-126/-120	12	49.9	-171.8	3	0.000	512	XMTR failed. TFR No. 118057

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Post (dbm)				
					1-Way	2-Way	3-Way								
2	12	349	0400	1300		0430 1230 1300	0400 0430 1300	-128/-120	12	36.5	-165	7	0.000	512	Leaking O-ring in HA valve. TFR-ANT-112226 Performed Type II orientation TGP computer had spurious interrupts. TFR 118064
3	41	349	1153	2100		1235 2030	1153 1235 2030 2100	-128.5/-120	12	45.7	-173	6	0.000	512	
3	12	350	0400	1256		0430 1230	0400 0430 1230 1256	*N/A/-120	12	47.9	-170	177	0.000	512	
3	62	350	0128	0912			0128 0912	-131/-120	12	59.2	-171.8	0	0.000	512	
3	51	350	195808	0440		203015 043002	195808 203000 043015 0440	-127.7/-120	12	43.6	-172	2	0.000	512	
4	41	350	1158	2100		1230 2030	1158 1230 2030 2100	-128.9/-120	12	45.2	-173	7	0.000	512	TDH punch no. failed. TFR - 106174 determined on this pass that experiment G had been causing S/C problems. The experiment was stopped and S/C is ok RCV No. 2 failed. X32 multi S/N Rec U/S
4	51	350	1955	0440		2030 0430	1955 2030 0430 0440	-126/-120	12	41	-171.5	11	0.200	512 64	
4	62	350	1947	0916			1947 0916	-131/-120	12	45	-171	0	0.040	512	
4	12	351	0407	1300		0435 1230	0407 0435 1230 1300	-129.5/-120	12	43.2	-171	22	0.030	512	
5	41	351	1200	2100		1230 2030	1200 1230 2030 2100	-127.1/-120	12	45.9	-173	3	0	512	

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm)	Configuration			Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)			
5	51	351	1958	0451			1958 0451	-126.8/-120	12	42	-172	0.000	512	
5	62	351	1945	0918		2037 0430	1946 2037 0430 0918	-130.6/-120	12	45.7	-171.8	0.000	512	
5	12	352	0408	1300		0432 1230	0408 0432 1230 1300	-128.4/-120	12	42.6	-172	0.000	512	
6	41	352	1200	2204	2038 2115	1230 2036 2115 2104 2119 2122	1200 1230 2036 2104 2119 2122 2204	-127/-120	12			0.000	512	Loss of power in SFOF caused 2 minute loss of data during transfer. Also, loss of up-link for approximately 45 minutes occurred during failure of station transfer
6	51	352	1955	0500	2036 2122 2122 2309	2030 2122 2309	1955 2030 2036 2122 0430 0500	-125.4/-120	12			0.000	512	Voice outage from 1950 Z to 2123 Z. Lost transfer 41/51
6	14	353	0342	1230		0430 1215	0342 0430 1215 1230	-118.5/-120	12			0.000	512	
7	41	353	1159	2100		1215 2030	1159 1215 2030 2100	-127/-120	12	38.8	-173	0.000	512	At 1819 Z receivers out of lock due to glitch; TFR 112234
7	51	353	2049	0500			2049 0500	-125.6/-120	12	41.0	-172	0.000	512	

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
7	62	353	1939	0915		2030 0430 0915	-127.8/-120	12	46.9	-171.8	2	0.000	512		
7	12	354	0402	1300	0403 1230 0915	0402 0403 1230 1300	-128.9/-120	12	44	-172	8	0.000	512		
8	41	354	1200	2100	1230 2030 2100	1200 1230 2030 2100	-127/-120	12	46.9	-173	4	0.000	512		
8	62	354	1935	0915	2030 0430 0915	1935 2030 0430 0915	-128/-120	12			0	0.000	512		
8	51	354	1946	0501		1946 0501	-125.6/-120	12	39.2	-172	0	0.000	512	TDH Punch 1 failed and then replaced	
8	12	355	0359	1240	0430 1230 1240	0359 0430 1230 1240	-127.5/-120	12	44	-173	8	0.000	512		
9	41	355	1159	2100	1230 2030 2100	1159 1230 2030 2100	-127/-120	12	45.7	-173	15	0.000	512	IMP printout incorrect. Possible incorrect AGC curve fit tape entered during pretrack configuration	
9	51	355	1958	0503	0300 0515	1958 2030 0501 0503	-126/-120	12	42.2	-173	1	0.000	512	Command 6-061 not transmitted at 2040 Z. Modulation input from GOE to EXCITER disconnected. Cable reconnected and command transmitted at 2100 Z	
9	12	356	0356	1250	0356 0502 0514 0652 0658 0837	0502 0514 0652 0658 0837	-128.3/-120	12	44.5	-172	1	0.000	512	Command Encoder power supply failed. TFR-12-GOE-106216 power supply repaired. Command Encoder failed. TFR-12-GOE-106221 installed spare. Best lock freq test conducted. TCP was intermittently off and on during pass	

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm)	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
10	41	356	1157	2100		1230 2030	1157 1230 2038 2100	-127.8/ -120	12	45.9	-173	3	0.000	512	Dynamic AGC (RCV 2) trace on CEC recording read zero volts for precalcs and pass due to faulty RCV ISO amp. TFR 112239
10	51	356	1957	0500		2030 0430	1957 2030 0430 0500	-126.3/ -120	12	40.4	-173	1	0.000	512	
10	12	357	0349	1245		0430 1230	0349 0430 1230 1245	-127.7/ -120	12	41.7	-172	1	0.000	512	
11	41	357	1157	2100		1230 2030	1157 1230 2036 2100	-128.3/ -120	12	46.1	-173	3	0.000	512	TFR-41-GOE-112240 excessive ripple in demod power supply
11	51	357	1956	0459		2036 0430	1956 2036 0430 0459	-126.8/ -120	12	38.2	-173	1	0.000	512	Loss of TXR power due to instability of input drive. TFR-51-107039
11	12	358	0400	1245		0430 1230	0400 0430 1230 1245	-127.6/ -120	12	44.2	-172	1			RCV 1 had excessive jitter on dyn phase. TFR-12-RCV 106227. Repaired intermittent J-2 on RCV 1 control
12	41	358	1155	2120	1642 1649 1704 1715	1230 1639 1702 1715 2030	1155 1230	-128.2/ -120	12	46	-173	3	0.000	512	TXR failed twice - at 1639 Z and 1702 Z. Apparently caused by interlock interrupt relay on klystron collector flow
12	51	359	1959	0457		2030 0430	1959 2030 0430 0457	-126.2/ -120	12	43.8	-172	1	0.000	512	

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
12	12	359	0400	1250		0400 1230	0400 0430 1230 1250	-128.0/ -120	12	43.7	-173	1	0.000	512	Heat exchanger bearing seized - TFR-112242
13	41	359	1154	2047	1850 2047	1230 1850	1154 1230	-128.9/ -120	12	45.9	-173	3	0.000	512	
13	51	359	1942	0449		2040 0430	1942 2040 0430 0449	-126.4/ -120	12	41.2	-172	1	0.000	512	
13	12	360	0343	1249		0430 1230	0343 0430 1230 1249	-128.2/ -120	12	42.2	-172	1	0.000	512	
14	41	360	1154	2100		1230 2030	1154 1230 2030 2100		12	46.5	-173	3	0.000	512	RCV 1 acq. control module intermittent failure. TFR-12-RCV-106229. Acq. control panel. RCV 1, control panel failed TFR-12-RCV-106230
14	51	360	1956	0450		2030 0430	1956 2030 0430 0450	-126.7/ -120	12	41.5	-172.5	1	0.000	512	
14	12	361	0400	1300		0436 1230	0400 0436 1230 1300	-128.3/ -120	12	43.2	-171	1	0.000	512	
15	41	361	1155	2100		1230 2030	1155 1230 2030 2100	-129.4/ -120	12	46.9	-173	3	0.000	512	
15	62	361	2000	0500		2033 0436	-2000 2033 0436 0500	-127.4/ -120	12	45.6	-170.8	1	0.000	512	

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time	1-Way	2-Way	3-Way	Loop BW (Hz)	Temp Pre/ Post (°K)	Thres Pre/ Post (dbm)				
15	12	362	0345	1300		0430 1230		0345 0430 1230 1300	12	44.3	-173	3	0.000	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)			
					1-Way	2-Way	3-Way							
16	41	362	1155	2100		1230 2030	1155 1230 2030 2100	-129.3/-120	12	41.7	-173	.000	512	
16	62	362	2000	0500		2030 0435	2000 2030 0435 0500	-128.5/-120	12	45.0	-170.8	.000	512	
16	12	363	0400	1320		0435 1301	0400 0435 1301 1320	-129.3/-120	12	42.7	-171	.000	512	
17	41	363	1159	1950	*1930 1939	1300 1930	1159 1300 1939 1950	-129.7/-120	12	46.5	-173	.000	512	*Station 62 TXR tripped off at turn on. Cause unknown.
17	62	363 364	1900	0500		1938 0430	1900 1930 0435 0500	-128.5/-120	12	45.7	-171	.000	512	TXR tripped off at 1930 Z. TFR 118077. Due to excessive forward power.
17	12	364	0355	1300		0430 1220	0355 0430 1220 1300	-129.7/-120	12	43.1	-173.0	.000	512	
18	41	364	1157	2100		1220 2030	1157 1220 2030 2100	-130.4/-120	12	46.48	-173	.000	512	
18	62	364 365	2000	0500		2030 0430	2000 2030 0437 0500	-128.7/-120	12	43.5	-171.8	.000	512	
18	12	365	0400	1300		0430 1230	0400 0430 1230 1300	-129.3/-120	12	41.5	-172	.000	512	No IMP doppler. Reason unknown.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
19	41	365	1200	2100		1230 2030	1200 1230 2030 2100	-130.2/ -120	12	47.0	-173	3	.000	512	TXR failed, due to excessive forward power. TRF 118078.
19	62	365 001	2000	0500	0424 0433	2032 0423	2000 2031 0433 0500	-129.0/ -120	12	42.0	-171.8	1	.000	512	
19	12	001	0400	1300	0423 0430	0430 1230	0400 0423 1230 1300	-130.2/ -120	12	44.3	-172	1	.000	512	
20	41	001	1200	2100		1230 2030	1200 1230 2030 2100	-130.4/ -120	12	46.9	-173	3	.000	512	
20	62	001	2000	0500		2030 0430	2000 2030 0430 0500	-128.5/ -120	12	*358.24	-163	1	.000	512	*Paramp system noise temperature exceeds specification by 29.24 °K. Station had coaxial switch to RCV 1 hang-up. TRF 118079. Switch replaced after track. Maser could not be used due to coaxial switch problem.
20	12	002	0400	1300		0430 1230	0400 0430 1230 1300	-130.1/ -120	12	43.8	-172	1	.000	512	CEC OSC recorder inoperative for entire pass. TRF 12-AIS-106243.
21	41	002	1200	2114		1230 2145	1200 1230 2045 2117	-130.2/ -120	12	45.6	-173	3	.000	512	
21	62	002	2030	0500		2045 0459	2030 2045 0439 0500	-129.1/ -120	12	45.2	-171.8	2	.000	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
21	12	003	0400	1300		0430 1230	0400 0430 1230 1300	-130.5/-120	12	43.7	-172	14	.000	512	CEC OSC recorder still inoperative.
22	41	003	1200	2100		1230 2030	1200 1230 2030 2100	-130.9/-120	12	45.0	-173	3	.000	512	
22	62	003	2000	0500		2030 0435	2000 2030 0435 0500	-129.3/-120	12	42.3	-171.8	2	.000	512	Goddard CP down for 1 hour at 2400 Z to 0100 Z.
22	12	004	0400	1300		0430 1230	0400 0430 1230 1300	-130.5/-120	12	41.3	-172	1	.000	512	Doppler data flagged 2-way instead of 3-way from 0400 Z to 0426 Z.
23	41	004	1200	2101		1230 2030	1200 1230 2030	-131.4/-120	12	44.53	-173	3	.000	512	TTY machine on JECO "B" CKT dropping a digit. TFR 106286.
23	62	004 005	2000	0500		2030 0435	2000 2030 0435 0500	-130.4/-120	12	43.58	-170.8	1	.000	512	Station had faulty headset. TRF 41 TIC 112272.
23	12	005	0400	1300		0430 1230	0400 0430 1230 1300	-130.7/-120	12	41.8	-172	1	.000	512	
24	41	005	1200	2100		1230 2030	1200 1230 2030 2100	-131.5/-121	12	44.6	-173	3	.000	512	
24	62	005	2000	0500	0308 0500	2030 0308	2000 2030	-129.5/-121	12	42.8	-171.8	1	.000	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)			
24	12	006	0400	1322	0400 0428 0440 0502	0428 0440 0502 1230	1230 1322	-131/-121	12	44.5	-172	.000	512	Performed data point uplink acquisition: CH-6 BIAS +64.0 Hz, CH-7 BIAS +32.8 Hz from predict set 18C & 18d.
25	41	006	1159	2100	1230 2030	1230 2030	1159 1230 2030 2058	-136.2/-121	12	44.5	-173	.000	512	RCV 1 dynamic AGC ISO amplifier has erratic output. TFR 41/RCV 112274.
25	62	006	2000	0500	2030 0300	2030 0300	2000 2030 0300 0500	-129.80/-121	12	41.9	-171.8	.000	512	
25	12	007	0401	1315	0401 0421 0426 0434	0421 0426 0434 1215	1215 1315	-131.2/-121	12	43.2	-171	.000	512	Data point acquisition: CH-7 +28.7 Hz, CH-6 +55 Hz. Wrong switch setting on Comp. Buffer from start of tracking to 0512 Z. Was on TEST; should have been on DEMOD/SYNCH. Record mode switch in KP 144 bad. TFR 12/TDH - 106293. Will be repeated.
26	41	007	1159	2052	2015 2030	2015 2030	1159 2015 2030 2052	-132.3/-121	12	44.5	-173	.000	512	Tape 3A broken. Rejoined at end of track. No data lost. TFR 112277 applies.
26	62	007	2000	0500	0300 0500	2030 0300	2000 2030	-129.9/-121	12	42.6	-171	.000	512	
26	12	008	0400	1300	0400 0425 0427 0443	0425 0427 0443 1230	1230 1300	-131.8/-121	12	42.5	-172	.000	512	Data point acquisition: CH-6 + 90.6 Hz, CH-7 + 41.1 Hz.
27	41	008	1200	2048	1230 2030	1230 2030	1200 1230 2030 2048	-132.5/-121	12	44.4	-173	.000	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
27	62	008	2000	0500	0300 2030	2030 0435	2000 0300 0435 0500	-131.3/ -121	12	49.3	-171.8	1	.000	512	Data point acquisition: CH-6 +48 Hz, CH-7 +33.2 Hz CEC inoperative from 1153 Z to 1210 Z. Replaced galvo lamp. TFR 12 - AIS-106328 At 1629 Z the collector flow interlock tripped. TXR down for 5 minutes. TXR on at 1634 Z. TFR 112282 applies. Data point acquisition: CH-6 +49 Hz, CH-7 +27.4 Hz TDH data condition code 1st digit '0' instead of 8 from start of track to 0540 Z due to two bad P. C. boards in DCC unit. Also negated IMP doppler data until 0540 Z. Boards replaced.TFR TDH-106335 and 106343 apply. Limited post-track calibrations due to PN-6 support with DSS 14, immediately following PN-8 track.
27	12	009	0400	1300	0400 0418 0421 0435 0435	0418 0421 0435 1230	1230 1300	-131.9/ -121.8	12	42.6	-172	1	.000	512	
28	41	009	1159	2043	1630 1649	1230 1630 1649 2030 2030	1159 1230 2030 2043	-132.9/ -121	12	45.0	-173	3	.000	512	
28	62	009	2000	0500	0300 2030	2030 0430	2000 0300 0430 0500	-131.4/ -121	12	43.8	-171.8	1	.000	512	
28	12	010	0400	1300	0400 0417 0420 0431 0431	0417 0420 0431 1230	1230 1300	-131.9/ -121	12	41.5	-172	1	.000	512	
29	41	010	1158	2038	1230 2015	1158 1230 2015 2038		-133/ -121	12	44.6	-173	3	.000	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
29	62	010	2000	0500	0301 0421 0424 0438	2019 0301	2000 2019 0421 0424 0438 0500	-132.6/-121	12	43.2	-171.8	1	.000	512	Servo drive stopped, due to emergency interlock. Unable to determine cause. Restarted servo. At 2047 Z selected "A" converter in DIS beta computer. "B" converter was giving agc readings 10 dbm higher than normal. TFR 118086.
29	12	011	0400	1300	0400 0421 0424 0438	0421 0424 0438 1230	1230 1300	-132/-121	12	41.3	-172	1	.000	512	Data point acquisition: CH-7 + 37.1 Hz, CH-6 + 55 Hz. Secondary rubidium failed. Switched to Knight OSC at 0344 Z. TFR-12-FTS-103348.
30	41	011	1158	2033		1230 2015	1158 1230 2015 2033	-133/-121	12	45.0	-173	3	.000	512	At 201537 Z station on incorrect Track Synfrq of 5538. Operator error. TFR 112288. At 202440 Z on correct Track Synfrq of 5380
30	62	011	2000	0459	0304 0419 0422 0438	2019 0304	2000 2019 0419 0422 0438 0459	-132.1/-121	12	40.03	-171.8	1	.000	512	
30	12	012	0400	1300	0400 0419 0422 0438	0419 0422 0438 1230	1230 1300	-132.6/-121	12	44.9	-172	1	.000	512	Data point acquisition: CH-6 + 63.2 Hz, CH-7 + 16.6 Hz. Station on Knight OSC for FTS.

Table 48 (cont'd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)			
31	41	012	1155	2027		1230 2015	1155 1230 2015 2027	-133.5/-121	12	361.02	-165	0.000	512	Maser failed at 1730, switched to Paramp at 1732 TFR 112290.
31	51	012	2001	0324	2015 0315	2015 0315 0324	2001 2015 0315 0324	-131.8/-122	12	40.1	-173.0	0.000	512	A1 recorder developed poor quality data due to oxide buildup. Prime tapes shipped will be B1, A2, B3 etc. TFR-51-REC-107055.
31	12	013	0300	1300	0315 1230	0315 1230 1300	0300 0315 1230 1300	-132.8/-121	12	42.7	-172	0.000	512	Due to operator oversight, TDH Plan F not complied with.
32	41	013	1155	2022	1230 2015	1230 2015 2022	1155 1230 2015 2022	-134.4/-121	12	376.6	-165	0.000	512	Paramp used this pass. Maser down, TFR 112290 applies.
32	62	013	2000	0500	2015 0420	2015 0420 0500	2000 2015 0420 0500	-131.9/-121	12	42.3	-171.8	0.000	512	
32	12	014	0346	1300	0415 1230	0415 1230 1300	0346 0415 1230 1300	-133.0/-121	12	42.9	-173	0.000	512	
33	41	014	1155	2018	1230 2015	1230 2015 2018	1155 1230 2015 2018	-135.7/-121	12	374.8	-165	0.000	512	Paramp used this pass.
33	62	014	2000	0230	2015 0225	2015 0225 0230	2000 2015 0225 0230	-132.1/-121	12	42.3	-170.8	0.000	512	No post track calibration due to Lunar Orbiter support.

Unless otherwise indicated, times are given in Greenwich Mean Time.

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
33	14	015	0153	1300		0220 1230	0153 0220	-124.1/-120	12	27.0	-172	1	0.000	512	
34	41	015	1145	1930		1230 1900	1145 1230 1900 1930	-134.3/-121	12	46.6	-173	3	0.000	512	Post track calibration, agc's not taken.
34	62	015	1830	0500		1900 0430	1830 1900 0430 0500	-132.5/-122	12	41.2	-171.8	1	0.000	512	
34	12	016	0346	1300		0430 1230	0346 0430 1230 1300	-133.8/-122	12	41.2	-171	15	0.000	512	Partial post track calibration due to Pioneer 6 support.
35	41	016	1155	1930		1230 1900	1155 1230 1900 1930	-134.4/-121	12	46.7	-173	3	0.000	512	
35	62	016	1830	0500		1900 0430	1830 1900 0430 0500	-132.5/-121	12	41.2	-171.8	1	0.000	512	
35	12	017	0358	1300		0430 1230	0358 0430 1230 1300	-133.5/-121	12	41.2	-172	4	0.000	512	Hour Angle brake would not disengage remotely; disengaged manually. TFR/12/ANT/106361. Partial post track calibration due to Pioneer 6 support requirements.
36	41	017	1156	1930		1230 1900	1156 1230 1900 1930	-134.4/-121	12	45.6	-173	3	0.000	512	
36	51	017	1831	0300		1900 0300	1827 1900 0300 1930	-133.3/-120	12	39.2	-173	1	0.000	512	
36	14	018	0300	1300		0303 1236	0300 0303 1236 1300	-125.2/-120	12	27.8	-172	4	0.000	512	At 0200 low film on hydrostatic bearing; problem corrected.

Unless otherwise indicated, times are given in Greenwich Mean Time.

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)			
37	41	018	1155	1930	1441 1447	1230 1441 1447 1900 1930	1155 1230 1441 1900 1930	-134.7/ -121	12	44.9	-173	0.000	512	At 1441 transmitter failed due to high voltage on current interlock. TFR-112302.
37	62	018	1830	0500		1903 0430	1830 1903 0430 0500	-134.5/ -121	12	42.8	-171	0.000	512	
37	12	019	0354	1300		0430 1230 1230 1300	0354 0430 1230 1300	-134.4/ -121	12	42.3	-172	0.000	512	
38	41	019	1200	1930		1230 1900	1200 1230 1900 1930	-134.9/ -121	12	45.5	-173	0.000	512	FR-1400 tape 1B prime.
38	62	019	1830	0500		1900 0430	1830 1900	-133.1/ -121	12	40.6	-171.8	0.000	512	
38	12	020	0350	1300		0430 1230	0350 0430 1230 1300	-133.8/ -121	12	41.5	-172	0.000	512	
39	41	020	1200	1920		1230 1900	1200 1230 1900 1920	-135.3/ -121	12	47.0	-173	0.000	512	
39	51	020	1828	0249		1900 0215	1828 1900 0215 0249	-131.9/ -122	12	41.1	-173	0.000	512	P-1, D1, B12.
39	14	021	0144	1317		0144	1317	-126/ -120	12	28.3	-173	0.000	512	
40	41	021	1200	1927	1341 1358	1230 1341 1358 1900 1927	123000 123002 123002 1900 1927	-135.4/ -122	12	46.2	-173	0.000	512	Transmitter collector flow interlock tripped at 134143. TFR-41/TFR/112310.

Unless otherwise indicated, times are given in Greenwich Mean Time.

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
40	62	021	1830	0500		1900 0430	1830 1900 0430 0500	-133.6/ -121	12	41.04	-171.8	1	0.000	512	
40	12	022	0400	1300		0430 1230	0400 0430 1230 1300	-134.5/ -121	12	42.5	-173	1	0.000	512	
41	41	022	1200	1900		1230 1830	1200 1230 1830 1900	-135.5/ -122	12	45.0	-173	3	0.000	512	
41	62	022	1759	0500		1836 0430	1758 1836 0430 0500	-134.1/ -122	12	41.1	-170	1	0.000	512	
41	12	023	0400	1300		0430 1230	0400 0430 1230 1300	-134.2/ -122	12	42.2	-173	1	0.000	512	RCV 2 acquisition control bound up. TFR-RCV-106372 interim monitor program inoperative; bad A to D converter. TFR DIS-106371.
42	41	023	1200	1900	1831 1836	1230 1830	1200 1230 1830 1831 1836 1900	-135.8/ -125	12	45.2	-173	3	0.000	512	TCP unable to lock up on tape replay during pretrack calibration. However, the problem was gone during post track calibration.
42	51	023	1757	0233	1832 1836	1830 1831 1836 0215	1757 1830 1830 0215 0233	-132.6/ -124	12	42.0	-172.5	1	0.000	512	TFR-51-TXR-107075. Uplink lost due to uneven tuning. Polarizer in during this pass.
42	12	024	0139	1000		0215 0950	0139 0215 0950 1000	-134.7/ -122	12	48.3	-171	1	0.000	512	

Unless otherwise indicated, times are given in Greenwich Mean Time.

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
43	41	024	0942	1900		0950 1830	0942 1830 1900	-136.8/ -122	12	46.2	-173	3	0.000	512	U buss lost at approx. 0800 prior to acquisition - did not effect pass. IMP printout of Doppler 0942-1054 incorrect. Doppler tape faulty due to lack of preparation time on pretrack calibration.
43	62	024	1750	0500	1830 0430	1750 1830 0430 0500		-134.5/ -122	12	315.4	-163.2	1	0.000	512	
43	12	025	0400	1300	0430 1230	0400 0430 1230 1300		-134.5/ -122	12	42.1	-172	1	0.000	512	On Paramp this pass.
44	41	025	1200	1900	1230 1830	1200 1230 1830 1900		-136.5/ -122	12	45.3	-173	12	0.000	512	
44	62	025	1800	0500	1830 0430	1800 1830 0430 0500		-134.7/ -122	12	343.48	-163.2	1	0.000	512	On Paramp this pass.
44	12	026	0400	1039	0430 1000	0400 0430 1000 1039		-134.8/ -122	12	42	-172	1	0.000	512	
45	41	026	0933	1900	1000 1830	0933 1000 1830 1900		-136.5/ -123	12	45.1	-173	3	0.000	512	Polarizer in use.
45	51	026	1757	0221	1830 0200	1757 1830 0200 0221		-133.5/ -126	12	43.5	-173	1	0.000	512	

Unless otherwise indicated, times are given in Greenwich Mean Time.

Table 48 (contd)

Pass No	DSS No	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
45	12	027	0125	1300	0719 0910	0200 0719 0919 1230	0125 0200 1230 1300	-135/ -124	12	44.0	-171	1	0.000	512	Partial post track calibration due to schedule constraints. At 0718 transmitter OFF due to 480V failure. 480V back on at 0810. TFR-12-UTL-106392. At 0719 went to Paramp and one way tracking until 0910. Back to Maser and two-way track at 0919.

Unless otherwise indicated, times are given in Greenwich Mean Time.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg. (dbm) D/U	Configuration			Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)			
					1-Way	2-Way	3-Way							
46	41	027	1158	1900		1230 1830 1830 1900	1158 1230 1830 1900	-136/-122	12	45.4	-173	0.000	512	DIS inoperative from 0844 to 1017. TFR-12-DIS-106393.
46	62	027	1800	0512	1833 0430	1833 0430 0430 0512	1800 1833 0430 0512	-135.2/-122	12	41.2	-171	0.000	512	
46	12	028	0400	1300	0430 1230	0430 1230 1230 1300	0400 0430 1230 1300	-136.2/-122	12	40.3	-172	0.000	512	
47	41	028	1158	1900	1230 1830	1158 1230 1830 1900	1158 1230 1830 1900	-136.6/-119	12	45.6	-173	0.000	512	
47	62	028	1800	0500	1835 0430	1835 0430 0430 0500	1800 1835 0430 0500	-135.5/-122	12	40.7	-171.8	0.000	512	Record only.
47	14	029	0260	1347	0356 0440	0440 1347		-127.4/-120	12	28.5	-173	0.000	512	
48	42	029	1245	1740	1348 1701		1245 1348 1701 1740	Unknown/Record Only	12	42	-172.1	Unknown	Unknown	Record only.
48	51	029/030	1642	0204	1642 1657	1657 0130	0130 0204	-133.9/-128	12	42.1	-172.5	0.000	512	Recorder down prior to start of countdown due to faulty heads. TFR-51-REC-107080.
48	14	030	0033	1343	0135 1343	0135 1343	0033 0135	-127.5/-121	12	Unknown	Unknown	0.000	512	Record only. No D3 predicts available. Bad doppler should have been punched during three-way tracking.
49	42	030	1248	1740	1344 1652		1248 1344 1652 1740	Unknown/Record Only	12	40.4	-172.1	Unknown	Unknown	

Table 48 (cont'd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Post (°K)	Thres Pre/Post (dbm)				
49	51	030	1639	0207	1639 1651	1651 0145	0145 0207	-134.5/ -129	12	41.8	-173	1	0.000	512	Alpha recorder off time, awaiting replacement heads. TFR-51-107080.
49	11	031	0130	1200		0145 1200	0130 0145	-136.8/ -125	12	45.7	-171	3	0.000	512	
50	42	031	1100	1800	1204 1800		1100 1204	Unknown/ Record Only	12	45.6	-171.7	0	Unknown	Unknown	Record only pass.
50	62	031	2145	0126	2145 2151	2151 0120	0120 0126	-135.3/ -125	12	42.1	-171.8	1	0.000	512	ANT serves out due to short in emergency disable lines of Dec axis. Station lost 4 hours and 45 minutes of scheduled time to locate problem and make a fix. Gap in continuous coverage was 1 hour and 28 minutes of data. TFR - 118126.
50	61	031	1915	2225	1915 2153		2153 2225	Unknown/ Record Only	12	Unavailable	-168.7				Record only as back up to DSS 62 ANT failure.
50	11	032	0107	1021		0120 1021	0107 0120	-136.8/ -125	12	46.0	-170	3	0.004	512	Command modulation from DSS 12 not received at DSS 11 - corrected by repatching microwave chart. TFR - 10-12-106400.
51	42	032	0919	1630	1021 1630		0919 1021	Unknown/ Record Only	12	58.4	-171.7				
51	51	032	1628	0157	1628 1656	1656 0130	0130 0157	-134.4/ -128	12	42.4	-172.5	1	0.000	512	
51	11	033	0104	1000		0130 1000	0104 0130	-138.1/ -125	12	46.3	-171	3	0.000	512	
52	42	033	0912	1752	1001 1752		0912 1001	N/A/ Record Only	12	39.7	-171.7	0	N/A	N/A	Record only.
52	51	033	1624	0153	1624 1700 1739 1757	1757 0130	0130 0153	-134.8/ -131	12	42	-173	1	0.000	512	TXR failed to turn on at 1635 due to faulty 4.5 volt exciter power supply. Discontinued tracking at 1700 and returned antenna to zenith to fit replacement. Resumed tracking at 1739.
52	12	034	0054	0954		0130 0930	0054 0930 0945	-136.3/ -125	12	42.1	-172	9	0.000	512	

N/A Not applicable

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
53	41	034	0900	1800	0930 1730 1730 1800	0900 0930 1730 1800	-138.5/-124	12	48.3	-173	1	0.000	512		
53	62	034	1624	0135	1730 0130 0130 0135	1624 1730 0130 0135	-137.3/-125	12	42.2	-171.8	1	0.000	512		
53	12	035	0054	0958	0130 0930 0930 0958	0054 0130 0930 0958	-136.6/-124	12	42.6	-172	3	0.000	512		
54	41	035	0858	1800	0930 1731 1731 1800	0858 0930 0930 1731	-138.1/-123	12	47.9	-173	1	0.000	512		
54	62	035	1622	0130	1730 0115 0115 0130	1622 1730 0115 0130	-136.4/-125	12	40.6	-171.8	1	0.000	512		
54	12	036	0100	1200	0116 1131 1131 1200	0100 0116 1131 1200	-137.5/-125	12	41.3	-172	3	0.000	512		
55	41	036	1058	1800	1131 1731 1731 1800	1058 1131 1731 1800	-138.2/-125	12	47.9	-173	3	0.000	512		
55	62	036	1700	0200	1731 0130 0130 0200	1700 1731 0130 0200	-136.5/-125	12	40.5	-171.8	1	0.000	512		
55	12	037	0100	1200	0131 1131 1131 1200	0100 0131 1131 1200	-137.5/-126	12	43.8	-172	1			Portable ground operating equipment used. Shorted test point on front of Demod caused momentary TCP out of lock at 0418 and 0432.	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PPR	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
56	41	037	1058	1800		1130 1730	1058 1130 1730 1800	-138.9/ -126	12	47.9	-173	3	0.000	512	
56	62	037	1700	0200		1730 0130	1700 1730 0130 0200	-136.8/ -126	12	42.1	-171.8	1	0.000	512	
56	12	038	0100	1200		0131 1131	0100 0131 1131 1200	-137.3/ -126	12	33.4	-165	1	0.030	512	Maser inoperative; tracked on Paramp.
57	41	038	1058	1800		1131 1731	1058 1131 1731 1800	-138.9/ -126	12	48.6	-173	3	0.000	512	TCP "B" inoperative; used TCP "A".
57	62	038	1700	0200		1731 0131	1700 1731 0131 0200	-138.5/ -128	12	42	-171	1	0.000	512	
57	12	039	0100	1200		0131 1131	0100 0131 1131 1200	-140.3/ -122	12	47.6	-172	1	0.000	512	Maser magnet heater regulator defective. Appears to have caused decrease in recorder signal level.
58	41	039	1058	1800		1131 1731	1058 1131 1731 1800	-139.1/ -127	12	48.4	-172	3	0.000	512	
58	62	039	1700	0200		1731 0131	1700 1731 0131 0200	-138.5/ -127	12	43.8	-171	4	0.000	512	
58	12	040	0100	1200		0131 1131	0100 0131 1131 1200	-138.5/ -127	12	44.6	-172	7	0.000	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/G	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	Start/Stop Time		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
59	41	040	1058	1802			1131 1731	1058 1131 1731 1802	12	48.0	-173	3	0.000	512	
59	62	040	1700	0200			1731 0130	1700 1731 0130 0200	12	41.1	-172	1	0.000	512	
59	12	041	0100	1200			0130 1130	0100 0130 1130 1200	12	47.8	-173	1	0.000	512	Loss of interim monitoring program doppler data from 0100 to 0145; operator error.
60	41	041	1059	1801			1131 1730	1059 1131 1730 1801	12	49.4	-173	3	0.000	512	
60	62	041	1700	0200			1731 0130	1700 1731 0130 0200	12	39.7	-172	1	0.000	512	
60	12	042	0058	1200			0131 1130	0058 0131 1130 1200	12	42.6	-173	1	0.000	512	
61	41	042	1058	1800			1130 1800	1058 1130 1800 1200	12	48.4	-173	3	0.000	512	
61	51	042	1600	2400	1801 2304		1600 1801 2304 2400	1600 1801 2304 2400	12	44.0	-172	0	*	512	Record raw TLM only pass No ground operating equipment. Waveguide bypass out. Polarizer in.
61	62	042	2300	0530	2300 2304		2304 0130 0530	2300 2304 0130 0530	12	40.7	-172	1	0.000	512	
61	12	043	0100	1200			0131 1200	0100 0131 1200	12	43.0	-171	1	0.000	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cncls	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	4-Way								
62	51	043	1600	2400	1600 2313	2313 2400	Not Reported/ Record Only	12	44.0	-172	0	*	512	*Record raw TLM only. No ground operating equipment.	
62	62	043	2300	0530	2300 2313 0530	2313 0530	-139.5/ -129	12	51.3	-172	10	0.000	512/256		
63	41	044	0827	1700	0827 0841 1700	0841 1700	-140/ -128	12	47.7	-173	6	0.000	16/512		
63	51	044	1608	2400	1700 2321	1608 1700 2321 2400	Not Reported/ Record Only	12	40.4	-173	0	*	512	*Record raw TLM only. No ground operating equipment. Polarizer off.	
63	62	044	2300	0530	2300 2321	2321 0401 0530	-140/ -130	12	41.3	-172	1	0.000	512		
63	14	045	0136	0700	0136 0401	0401 0700	-131.6/ -124	12	27.6	-173		0.000	512		
64	41	045	0825	1700	0825 0838	0838 1700	-140.2/ -129	12	48.6	-172	3	0.000	512		
64	51	045	1600	2400	1702 2314	1600 1702 2314 2400	-139.2/ Record Only	12	42.0	-173	0	*	512	*Record raw TLM only. No ground operating equipment. Waveguide bypass out. Polarizer out.	
64	62	045	2300	0530	2300 2314	2314 0300 0530	-139.5/ -127	12	42.0	-172	2	0.000	512		
64	14	046	0153	0701	0302 0701	0153 0302	-127.7/ -124	12	27.8	-173	3	0.000	512		
65	41	046	0825	1700	0825 0837	0837 1700	-140.5/ -130	12	48.7	-172	3	0.000	512		
65	51	046	1559	2400	1700 2313	1559 1700 2313 2400	-139.4/ Record Only	12	41.5	-172	0	*	512	*Record only pass, no ground operating equipment.	
65	62	046	2300	0527	2300 2313	2313 0527	-140.2/ -131	12	49.6	-172	7	0.000	512		

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time		Loop BW (Hz)		Temp Pre/Post (°K)	Thres Pre/Post (dbm)					
					1-Way	2-Way					3-Way				
66	41	047	0829	1701	0829 0838	1701		-140.8/ -129	12	48.2	-173	7	0.000	16/512	*Record only pass. Polarizer off, waveguide bypass out.
66	51	047	1535	2400	1701 2310		1535 1701 2310 2400	-139.9/ Record Only	12	40.8	-172	0	*	*	
66	62	047	2300	0523	2300 2310	2310 0523		-139.8/ -131	12	46.8	-172	9	0.000	512/256	*Record only pass. Waveguide bypass and polarizer out.
67	41	048	0828	1701	0828 0840	1701		-140.8/ -130	12	48.4	-173	9	0.000	16/512	
67	51	048	1600	2400	1701 2316		1600 1701 2316 2400	-140.8/ Record Only	12	42.2	-172	0	*	*	
67	62	048	2300	0521	2300 2316	2316 0521		-139.8/ -132	12	41.9	-172	7	0.000	512	123217, TXR failed, causes unknown. 130542, receivers out of lock, operator error.
68	41	049	0826	1701	0826 0840	1233 1244		-140.9/ -129	12	48.3	-173	6	0.000	16/512	
68	51	049	1559	2400	1701 2311	*	1559 1701 2311 2400	-140.4/ Record Only	12	42.0	-172	0	*	*	
68	62	049	2300	0515	2300 2311	2311 0515		-140.2/ -131	12	41.8	-172	7	0.000	512	*Record only pass. Waveguide bypass and polarizer off.
69	51	050	1600	0100	1600 0100	*		-140.0/ Record Only	12	40.0	-172	0	*	*	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength (dbm) D/U	Configuration			No. Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
70	41	051	0803	1701	0803 0826 1106 1139 1226 1306 1701	0826 1106 1139 1226 1306 1701		-141.5/-133	12	48.4	-173	4	0.000	512	Three TXR failures at 0817, 1105, and 1224. Two from body flow interlock, other from causes unknown.
70	51	051	1600	0057	1701 0057	*	1600 1701	-139.9/Record Only	12	41.5	-173	0	*	*	*Record only pass. Waveguide bypass and polarizer off.
71	41	052	0800	1700	0800 0820 1055	0820 1055		-141.7/-130	12	78.7	-173	3	0.000	512	1054, TXR failed. One-way from 1055 to E.O.T.
71	51	052	1556	0049	1156 0049	*	*	-140.6/Record Only	12	41.0	-172	0	*	*	*Record only pass. Waveguide bypass and polarizer off.
72	41	053	0800	1700	0800 0824	0824 1631 1700	1631 1700	-141.6/-130	12	48.17	-173	3	0.000	512	
72	62	053	1600	0100	1631 0100 1631	1631 0100 1631	1600 1631	-141.0/-130	12	41.3	-172	7	0.000/ 0.000	512/64	TCD data lost from 1828 - 1848 - spurious interrupt.
73	41	054	0800	1700	0800 0824	0824 1631 1700	1631 1700	-142.2/-129	12	46.2	-173	6	0.000	16/512	1003 - 1020, transmitter tripped due to high beam current.
73	62	054/055	1600	0100	1631 0100 1631	1631 0100 1631	1600 1631	-141.0/-132	12	41.16	-171.8	7	0.000	512	
73	14	055	0423	0900	0423 0457	0457 0831 0900	0831 0900	-132.8/-132	12	26.8	-174	4	0.000	512	
74	41	055	0800	1700	0831 1631	0831 1631	0800 1631	-142.2/-127	12	48.4	-172	3	0.000	512	
74	62	055/056	1600	0100	1630 0100 1630	1630 0100 1630	1600 1630	-141.4/-130	12	40.9	-171.8	1	0.000	512	
74	14	056	0417	0900	0417 0440	0440 0831 0900	0831 0900	-129.1/-122	12	26.7	-174	1	0.000	512	Dual Maser linear configuration.
75	41	056	0800	1700	0839 1700	0839 1700	0800 0839	-143.2/-128	12	48.75	-172	3	0.000	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm)	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
75	62	056/057	1600	0100			1600 0100	-141.6/ -127	12	42.26	-171.8	6	0.000	512	Operator failed to position TDH X10 switch correctly. No 10 sec data from 220345 through 221602.
76	41	057	0759	1700	0759 0818	0818 1630	1630 1700	-142.7/ -129	12	48.73	-172	7	0.000	512	
76	62	057/058	1600	0100		1630 0048	1600 1630 0048 0100	-142.0/ -130	12	42.61	-170.81	1	0.000	512	
76	11	058	0003	0900		0031 0850	0003 0031 0850 0900	-144.5/ -126	12	48.5	-170	4	0.000	512	*43 minutes late in acquiring spacecraft due to stuck waveguide switch. 0154, switched from microwave to land line between DSS 11 and DSS 12. Using Transmitter 2 in MSFN wing due to Transmitter 1 klystron problems. Transmitter 2 failed due to shorted high voltage cable.
77	41	058	0759	1700		0850 1630	0759 0850 1630 1700	-142.8/ -127	12	47.8	-172	0	0.000	512	
77	62	058/059	1600	0100		1630 0100	1600 1630	-142.1/ -130	12	42.01	-171.8	1	0.000	512	
77	11	059	0230	0900	0230 0250	0250 0830	0830 0900	-143.3/ -131	12	46.1	-171	4	0.000	512	
78	41	059	0759	1700		0830 1630	0759 0830 1630 1700	-143.1/ -127	12	49.08	-172	0	0.000	512	
78	62	059/060	1600	0100		1630 0100	1600 1630	-142.3/ -130	12	39.38	-171.8	1	0.000	512	
78	11	060	*0043	0900	0814 0822	0100 0814	0043 0100 0822 0900	-147.7/ -130	12	46.5/ 58.0	-169.0	4	0.000/ 0.031	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Prc/Post (°K)	Thres Prc/Post (dbm)				
					1-Way	2-Way	3-Way								
79	41	060	0759	1700	0814 0822	0822 1630	0759 0814 1630 1700	-143.5/ -129	12	48.1	-173.0	3	0.000	512	Standard configuration.
79	62	060/061	1600	0059		1630 0059	1600 1630	-142.5/ -130	12	40.25	-170.81	1	0.000	512	Standard configuration.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbn)	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
079	11	061	0000	0900		0103 0810	0000 0810 0900	-143.5/ -134	12	45.1	-171	1	0.000	512	TFR-111787. DSS 12 Ground Operating Equipment (GOE) was unable to give CMD in normal mode. TFR-111788. TDH VCO counter drifting out of tolerance.
080	41	061	0759	1700		0810 1631	0759 0810 1700	-143.6	12	49.5	-173	3	0.000	512	Standard configuration. TFR-112448. FR-1400 Tape 3B broke during rewind.
080	62	061	1600	0100		1631 0031	1600 1631 0031 0100	-142.8	12	41.71	-172	1	0.000	512	
080	11	062	0000	0901	0859 0901	0100 0859	0000 0100	-143.0	12	45.2	-171	4	0.000	512	TFR-111796. TDH punch failure.
081	41	062	0759	1700	0900 0912	0912 1631	0759 0900 1631 1700	-143.8	12	46.5	-173	1	0.000	512	
081	62	062	1558	0100		1634 0031	1558 1634 0031 0100	-143.0	12	40.5	-172	1	0.000	512	
081	11	062	2352	0900		0031 0859	2352 0031	-144.0	12	46.2	-171	1	0.001	512	
082	42	063	0749	1630	0900 1614		0749 0900 1614 0749	-144.0	12	40.0	-171.9	0	0.000	512	Record only.
082	62	063/064	1600	0100	1600 1618	1618 0026	0026 0100	-142.2	12	40.83	-171.8	1	0.000	512	
082	11	063	2349	0900		0025 0900	2349 0025	-143.9	12	47.8	-171	2	0.001	512	TFR-111800. FTS light bank defective; made temporary fix.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
083	42	064	0758	1600	0900 1523		0758 0900 1523 1600	-144.3	12	39.1	-171.9	0	0.000	512	Record only.
083	62	064	1500	0100	1500 1533	1533 0031	0031 0100	-142.6	12	40.82	-171.8	3	0.000	512	
083	11	065	2358	0900		0030 0900	0000 0030	-143.7	12	45.2	-171	1	0.000	512	
084	42	065	0808	1600	0901 1522		0808 0901 1522 1600	-143.6	12	42.5	-171.9	0	0.000	512	Record only.
084	62	065	1500	0100	1500 1534	1534 0031	0031 0100	-143.0	12	41.29	-171.8	3	0.000	512	TFR-118481. Lost 27 minutes of science and engineering data due to bad card in computer buffer. Changed computer buffer drawer and reloaded program.
084	11	066	0000	0900	0245 0255	0041 0245 0255 0900	0000 0041	-144.6	12	46.4	-171	7	0.001	512	TFR-116271. RCV dropped lock. Antenna was not able to stay on spacecraft. APS would not drive antenna; went to Auto Track.
085	42	066	0758	1600	0900 1539		0758 0900 1539 1600	-143.6	12	48	-168	0	0.000	512	Maser 2 down. TFR-111289. Hour Angle low speed integrator failed. TFR-111292.
085	62	066	1500	0100	1500 1551 2231 0009	1551 2231	0009 0100	-143.0	12	42.15	-171.8	1	0.000	512	Spacecraft rest-frequency apparently drifting down. Acquired uplink below original transmitter turn-on frequency.
085	11	067	0000	0900	0000 0006	0006 0900		-144.9	12	45.2	-171	3	0.002	512	Performed data point acquisition.
086	42	067	0801	1600	0900 1515 1521 1545		0801 0900 1515 1521 1545 1600	-144.2	12	46	-171.96	0	0.000	512	Record only. Maser 2 down.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
086	62	067	1500	0120	1500 1515 2231 0014	1515 2231	0014 0120	-144	12	40.77	-171.8	11	0.000	512	
086	11	067	2359	0901	2359 0057	0057 0901			12	45.5	-170	3	0.003 0.036	512	
087	42	068	0800	1600	0901 1518 1529 1538		0800 0900 1518 1529 1538 1600	-144.5	12	47.3	-171.6	0	0.000	512	No telemetry recorded from start of pass at 0800 to 1438 because recorder patch was not connected. TFR-REC-111296. Maser 2 cooling off and awaiting stability run. Record only pass.
087	62	068	1500	0120	1500 1518 1529 1538 2230 0014 0017 0109	1518 1529 1538 2230	0014 0017 0109	-143.2	12	41.4	-172	1	0.000	512	
087	11	069	0000	0900	0000 0014 0017 0109	0014 0017 0109 0900		-146.5	12	49.6	-171	3	0.020	512	Maser 2 not operational during this pass.
088	42	069	0755	1600	0900 1517 1523 1538	*	0755 0900 1517 1523 1538 1600	-144.7	12	37.8	-171		*	*	*Record only.
088	62	069	1500	0110	1500 1517 1523 1539 2230 0120	1517 1523 2230		-143.6	12	42.0	-172	1	0.000	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
088	11	070	0030	0900	0030 0043 0053 0147 0147	0043 0053 0147 0859		-145.1	12	46.1	-171	3	0.010	512	0110 to 0117, receiver out of lock due to error in Interim Antenna Pointing System (IAPS).
089	42	070	0753	1600	0902 1515 1520 1535	0753 0902 1515 1520 1535 1600		-144.4	12	41.5	-172	0	0.000	512	TER-AIS-111298. CEC recorder paper not pulling through. Data missed from 0905 to 0930. Adjusted Spool tension.
089	62	070	1500	0100	1500 1536 2234 0053	1536 2234 0100		-143.8	12	40.0	-172	1	0.005	512	
089	11	071	2359	0900	2359 0012 0015 0150 0150	0012 0015 0150 0859		-146.0	12	47.6	-171	3	0.022	512	Excessive receiver glitches, from 0016 to 0150, while tuning.
090	42	071	0752	1600	0900 1520 1523 1534	* 0752 0900 1520 1523 1534 1600		-145.0	12	45.2	-171	0	*	*	*Record only.
090	62	071	1500	0100	1500 1520 1523 1535 2232 0012 0024 0042	1520 1523 1535 2232 0100		-144.3	12	41.5	-172	1	0.001	512	No magnetic tape for Interim Monitoring Program (IMP) during this pass.
090	11	072	2359	0900	2359 0012 0023 0121 0121	0012 0023 0121 0859		-148.2	12	54.5	-170	3	0.060	512	Still experiencing receiver glitches when tuning.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (*K)	Thres Pre/Post (dbm)				
091	42	072	0757	1600	0900 1516 1519 1533		0757 0900 1516 1519 1533 1600	-145.2	12	42.0	-172.46	0	*	512	*Record only.
091	62	072	1500	0100	1500 1516 1519 1533 2231 0100	1516 1519 1533 2231		-144.2	12	41.21	-171.8	3	0.002	512	TFR-118493. Incorrect doppler reading due to excessively high deviations. Lost CI doppler from 223000 to 010000.
092	42	073	0746	1600	0746 1515 1524 1539		1515 1524 1539 1600	-146.5	12	45.1	-171.9	0	0.000	512	Record only.
092	62	073	1500	0100	1500 1553	1553 0100		-144.4	12	41.96	-171.8	9	0.004	512	Doppler extractor working correctly. TFR-118493 still open.
092	14	074	0753	1000	0753 1000			-133.1	12	28.1	-173	0	0.000	16	Linear diplexer configuration. Four attempts at data point acquisition on Channel 6 unsuccessful. Two-way acquisition never acquired; reason undetermined.
093	42	074	0756	1600	0756 1517 1519 1538		1517 1519 1538 1600	-146.7	12	43.5	-171	0	0.000	512	Wow and flutter on FR-1400 Recorder A (backup recorder). TFR-111305.
093	62	074	1500	0100	1500 1548	1548 0100		-144.5	12	41.48	-171.8	12	0.005	512	
093	14	075	0728	1124	0728 0932	0932 1124		-131.6	12	29.2	-172	2	0.000	16/512	Linear diplexer configuration. Antenna switched to ultracore bypass RCP polarity at 102730; acquired good two-way lock on spacecraft.
094	62	075	1500	0100	1500 1542 1711 1719 1729 2243 0100	1542 1711 1729 2243		-144.7	12	41.4	-172	6	0.004	512	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
094	11	076	0000	0901	0000 0022 0028 0106 0106	0022 0028 0106 0901		-146.1	12	44.4	-171	1	0.040	512	Record only.
095	42	076	0757	1600	0901 1516 1541 1553	0757 0901 1516 1541 1553 1600		-145.6	12	42.8	-171.9	0	0.000	512	
095	62	076	1500	0100	1500 1516 1541 1553 2232 0016 0026 0037	1516 1541 1553 2232		-145.1	12	41.8	-172	3	0.010	512	
095	11	077	0000	0900	0000 0015 0026 0036 0036	0015 0026 0036 0900		-146.9	12	47.3	-171	1	0.100	512	Record only.
096	42	077	0758	1600	0902 1517 1523 1537	0758 0902 1517 1523 1537 1600		-146.3	12	41.7	-171.2	0	0.000	512	
096	62	077	1500	0100	1500 1517 1523 1537	1517 1523 1537 0100		-145.5	12	41.93	-171.8	7	0.012	512	
097	42	078	0700	1530	0700 1501	1501 1530		-146.3	12	44.7	-171.5	0	0.000	512	Record only.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
097	62	078	1433	2400	1433 1458 1538 1547 1550 1553 2336 2348	1458 1538 1547 1550 1553 2323	2323 2336 2348 2400	-145.8	12	42.07	-171.8	6	0.021	512	TFR-118499. Croshead and compressor went off. Electrician turned Switch 1, in Box MDP-EZ, off. System switched to param configuration at 181417 and back to maser at 182005. Station was unable to acquire one-way lock, from 213120 until 220729, after turning transmitter off at 2130. Spacecraft acquired immediately after switching to Channel 6 predicts.
097	11	078	2305	0145	2305 2321 2332 2348 2348	2321 2332 2348 0045	0045 0145	-148.5	12	52.5	-171	0	0.000	512	Maser 1 down. TFR-111892. Maser 2 down. TFR-111895. Station released early due to Maser 2 failure.
097	14	079	0026	0800	0146 0206 0221 0242	0046 0146 0206 0221 0242 0800	0026 0046	-134.8	12	29.2	-172	1	0.000	512	Linear diplexer feed pass was extended due to DSS 11 maser failure.
098	42	079	0657	1530	0801 1447 1450 1506		0657 0801 1447 1450 1506 1530	-147.0	12	41.	-171.67	0	0.000	512	Record only.
098	62	079	1429	2400	1429 1447 1450 1450 1506	1447 1450 1506 2400		-145.6	12	39.63	-171.8	9	0.100	512	
098	11	080	0400	0800	0400 0418 0431 0448 0448	0418 0431 0448 0800		-146.8	12	44.0	-171	5	0.003	16/ 256/ 512	Maser 1 operational as of 079/2215. Maser 2 still down. ETO 081/0600.
099	42	080	0657	1530	0800 1448 1456 1515	0800 1448 1456 1515	0657 0800 1448 1456 1515 1530	-146.7	12	42.8	-172.56	0	0.000	512	Record only.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
099	62	080	1429	0200	1429 1448 1456 1515 2331 0119	1448 1456 1515 2331	0119 0200	-146.0	12	40.96	-171.8	6	0.000/ 0.036	256/ 512	TFR-11855. Excessive receiver glitching while tuning exciter at 6 Hz/minute. Maser 2 inoperative. TFR-118409. Antenna drove off 1 degree in declination, causing loss of receiver lock for 1 minute. The cause was unknown.
099	11	081	0059	0800	0059 0119 0233 0248 0248	0119 0233 0248 0800		-146.5	12	43.3	-171	7	0.000/ 0.242	64/ 256/ 512	
100	62	081	1426	2400	1426 1444 1456 1516 1536 1613 2132 2331 2339 2355	1444 1456 1516 1536 1613 2132	2331 2339 2400	-146.1	12	40.4	-171.8	6	0.050	512	
100	11	081	2306	0800	2306 2331 2339 2356 2356	2331 2339 2356 0800		-147.0	12	44.2	-171	7	0.000/ 0.422	256/ 512	TFR-120369. DSS 12 TCP N-frame request was delayed.
101	42	082	0700	1530	0800 1530	*	0700 0800	-147.6	12	51.5	-171	0	*	*	*Record only. Maser 1 down for maintenance.
101	61	082	2030	2400	2030 2040 2045 2052 2052 2301 2400	2040 2045 2052 2301		-146.7	12	51.8	-172	3	0.000	256	This is the first time that the microwave link between DSS 61 and DSS 62 was used. No IAPS mode during this track.
101	11	082	2302	0800	2302 0046 0049 0120 0120	0046 0049 0120 0800		-148.3	12	48.4	-171	3	0.005	256	

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments	
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)					
					1-Way	2-Way	3-Way									
102	42	083	0658	1530	0800 1511 1518 1528	*	0658 0800 1511 1518 1528 1530	-146.6	12	38.9	-172	0	*	*	*Record only. Maser 1 down for maintenance.	
102	62	083	1430	2400	1430 1511 1518 1542 2132 2321 2322 2339	1511 1518 1542 2132	2321 2322 2339 2400	-146.3	12	41.0	-172	5	0.000/ 0.100	256/ 512		
102	11	083	2257	0800	2257 2321 2323 2340 2340	2321 2323 2340 0800		-148.2	12	44.5	-171	3	0.002	256		
103	42	084	0657	1530	0801 1444 1500 1518		0657 0801 1444 1500 1518 1530	-147.2	12	50.8	-171.8	0	N/A	512		Record only. Maser 1 down at 0744. Antenna drove off the spacecraft in Auto Track – switched to slave and back to Auto Track; everything normal – investigating. TFR-111311. PO/WO/B12.
103	62	084	1430	2400	1430 1444 1500 1518	1444 1500 1518 2400		-146.5	12	40.02	-171.8	5	0.002/ 0.090	256/ 512		
104	42	085	0743	1500	0743 1441 1446 1500		1441 1446	-148.0	12	51	-170.8	0	0.000			TFR-REC-111313. FR-1400 Tape Reel 1A, after removal, was found to be stretched. Reels 1A and 1B were included in the data package. PO/WO/B12 from 0743 to 1500.

N/A Not Applicable.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
104	62	085	1420	0100	1420 1441 1446 1507 2231 0025 0029 0043	1441 1446 1507 2231	0025 0029 0043 0100	-146.7	12	41.52	-171.8	5	0.001/ 0.100	256/ 512	TFR-118411. Hydraulic leakage at the Hour Angle accumulator was caused by a broken weld.
104	11	086	0000	0905	0000 0025 0029 0044	0025 0029 0044 0905		-148.3	12	44.2	-171	12	0.005	256/ 512	PO/WO/B12 from 0000 to 0900.
105	42	086	0753	1500	0904 1500		0753 0904	-147.2	12	39.2	-172.8	0	0.000		Record only. PO/WO/B12 from 0753 to 1500.
105	11	087	0000	0902	0000 0024	0024 0902		-148.5	12	46.4	-171.0	133	0.010	256	PO/WO/B12 from 0000 to 0900. Performed Minnesota Cosmic Ray instrumentation detection check through item 7.1.31 of mse dtg on 026/0015 from F. Nunamaker, /
106	42	087	0753	1500	0900 1442 1449 1500		0753 0900 1442 1449	-150.0	12	42.7	-170.8	0			Record only. TWM 1 gain decreased by approximately 5 db during pass. A 2 dbm degradation in received signal strength from acquisition was the total effect on the mission.
106	62	087	1415	0100	1415 1442 1448 1509 2232 0021 0027 0100	1442 1448 1509 2232	0021 0027	-147.0	12	42.01	-171.8	73	0.000/ 0.216	256/ 512	PO/WO/B12 from 1420 to 0100. The sudden and violent paramp oscillation had leaked through the receiver causing a high parity error. The problem was cleared by reducing the paramp gain. TFR-118415. TCP indicated bad time. Unable to process data or send commands from 1811 to 2001. The problem was solved by replacing the power supply PX-13.
106	11	088	0000	0900	0000 0021 0027 0053 0053	0021 0027 0900		-148.4	12	44.2	-171	7	0.020/ bad	256/ 512	PO/WO/B12 from 0000 to 0900.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Post (°K)	Thres Pre/Post (dbm)				
107	42	088	0754	1500	0859 1432 1441 1500		0754 0859 1432 1441	-148.3	12	58.9	-170.8	0			PO/WO/B12 from 0754 to 1500. Record only.
107	62	088	1416	0100	1416 1432 1441 1441 1539 0100	1432 1441 1539 0100		-146.9	12	49.95	-171.8	7	0.004/ 0.235	256/ 512	PO/WO/B12 from 1416 to 0100.
108	42	089	0753	1500	0753 1435 1440 1500		1435 1440	-149.1	12	39.0	-172	0			PO/WO/B12 from 0753 to 1500. Record only.
108	62	089	1415	0100	1415 1435 1440 1440 1506 0100	1435 1440 1506 0100		-146.3	12	48.13	-171.8	17	0.032	256/ 512	PO/WO/B12 from 1415 to 0100. Antenna drove off point at 1813 and again at 2309. Demod and computer out-of-lock for 1 minute. TFR-118418.
108	11	090	0000	0900	0101 0232 0239 0301 0301	0232 0239 0301 0900	0000 0101	-147.3	12	44.8	-171	1	0.005	256	PO/D1/B12 from 0000 to 0900.
109	42	090	0800	1500	0902 1438 1442 1459	0902 1438 1442 1459	0800 0902 1438 1442 1459 1500	-148.3	12	38.4	-172	0			PO/WO/B12 from 0800 to 1500. Record only. Inexplicable loss-of-lock on receiver 1 from 100257 to 100315. Receiver 2 did not lose lock. TFR-111327. The Antenna Pointing Subsystem (APS) program was reloaded due to an 0.150 error in Hour Angle.
109	62	090	1412	0100	1412 1438 1442 1459 0100	1438 1442 1459 0100		-146.3	12	42.7	-171.8	9	0.014	256	PO/D1/B12 from 1412 to 0100. TFR-118420. GOE was unable to verify commands. A bad card was suspected. Lost 16 minutes of real-time data.
110	62	091	1410	0100	1410 1425 1429 1442 0100	1425 1429 1442 0100		-146.5	12	42.35	-171.8	11		16/256	PO/D1/B12 from 1410 to 0100. Scheduled power outage at the SPOF.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Grnds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
111	62	092	1408	2400	1408 1446 1459 1519 2400	1446 1459 1519 2400		-147.2	12	43.14	-171.8	12	0.000/ 0.151	256/512	P0/D1/B12 from 1408 to 2400.
112	62	093	1415	0001	1415 1426 1441 1450 1500 0001	1426 1441 1500 0001		-147.3	12	43.53	-170.81	12	0.010/ 0.181	256/512	P0/D1/B12 from 1415 to 0001.
113	62	094	1415	2400	1415 1439 1443 1458 2400	1439 1443 1458 2400		-147.3	12	41.04	-171.8	10	0.000/ 0.002	16/256	P0/D1/B12 from 1415 to 2400.
114	62	095	1415	2400	1415 1434 1444 1451 1451 2232 2400	1434 1444 1451 2232		-147.4	12	45.95	-171.8	5	0.008	256	P0/D1/B12 from 1415 to 2400.
114	11	096	0000	0900	0000 0032 0035 0057 0057	0032 0035 0057 0900		-149.5	12	44.6	-171	1	0.051	256	P0/D1/B12 from 0000 to 0900. TFR-111747. No 36-bit time code from astro data TCG. problem; corrected at 0820.
115	42	096	0800	1500	0902 1434 1445 1454		0800 0902 1434 1445 1454 1500	-148.6	2	40.7	172.5	0			Record only. P0/D1/B12 from 0800 to 1500.
115	42	096	0800	1500	0902 1435 1446 1455	*	0800 0902 1435 1446 1455 1500	-148.6	2	40.7	-173	0	*	*	*Record only. P0/D1/B12.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre Post (°K)	Thres Pre Post (dbm)				
115	61	096	1423	0100	1423 1435 1443 1455 2232 0024	1435 1443 1455 2232	0024 0100	-147.1	12	39.8	-172	5	0.050	256	P0/D1/B12.
115	11	097	2359	0900	2359 0023	0023 0900		-150.5	12	48.0	-170	6	0.100	256	At 0433, switched to high-gain antenna on spacecraft. P0/D1/B12.
116	42	097	0800	1500	0902 1432 1436 1451	*	0800 0902 1432 1436 1451 1500	-148.4	12	38.9	-172	0	*	*	Record only. P0/D1/B12.
116	62	097	1415	2400	1415 1432 1436 1451 1451 2304 2400	1432 1436 1451 2304		-147.8	12	43.5	-172	9	0.003	256	P0/D1/B12.
116	11	098	0000	0900	0000 0044	0044 0900		-147.0	12	45.9	-171	1	0	256	At 0030, the DIS mag tape Beta was inoperative. No IMP (Interior Monitoring Program) doppler. P1/D1/B12.
117	42	098	0758	1500	0902 1500	*	0758 0902	-148.5	12	39.2	-172	0	*	*	*Record only. Reel 2B has data gap from 2050 to 2059. Reel 2A in data package. P0/D1/B12.
117	62	098	1415	2400	1415 1511 1515 1522 1522 2232 2400	1511 1515 1522 2232		-148.0	12	46.8	-172	3	0.015	256	P0/D1/B12.
117	11	099	0000	0900	0000 0020	0020 0900		-146.5	12	46.0	-170	3	0/0.300	256/512	P1/D1/B12.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg. (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Post (dbm)				
					1-Way	2-Way	3-Way								
118	42	099	0757	1500	0903 1430 1440 1457	*	0757 0903 1430 1440 1457 1500	-148.5	12	40.0	-173	0	*	*	Record only. P0/D1/B12.
118	62	099	1415	2400	1415 1430 1440 1457 2232 2400	1430 1440 1457 2232		-147.3	12	45.3	-172	10	0.005	256	P0/D1/B12.
118	11	100	0000	0900	0000 0016	0016 0900		146.6	12	46.2	-170	4	0.000	256	P1/D1/B12.
119	42	100	0743	1500	0903 1431 1439 1457	*	0743 0903 1431 1439 1457 1500	-148.8	12	42.0	-172	*	*	*	*Record only. P0/D1/B12.
119	62	100	1415	0000	1415 1430 1439 1457 2232 0000	1430 1439 1457 2232		-148	12	40.5	-171	9	0.033	256	P0/D1/B12.
119	11	101	0000	0900	0000 0027 0033 0057 0223 0023 0440 0900	0027 0033 0057 0223 0440		-149.5	12	45.1	-170	3	0.086	256	P0/D1/B12.
120	42	101	0743	1500	0902 1428		0743 0902 1428 1500	-149	12	42.8	-170.6				Record only. P0/D1/B12.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
120	62	101	1414	0005	1414 1427 2232 2250	1427 2232 2250 0005		-145.7	12	45.3	-171.8	10	0.023	256	PI/DI/B12.
120	11	102	0000	0900		0007 0900	0000 0007	-146.4	12	46.7	-171	3	0.004	256	PI/DI/B12. DSS 12 comm buffer switch in "monitor REC" position instead of "CMD Encoder" position. CMD 112 (calibrate) delayed 37 minutes - no adverse effect on mission.
121	42	102	0754	1500	0902 1434 1443 1500	0754 0902 1434 1443		-149	12	45.3	-171.5	0			Record only. PO/DI/B12. Recorder 1 unserviceable. TFR - 42-RCV-111357. Station investigating. IMP not valid from 0802 to 0853 due to operator error on program instruments.
121	61	102	1412	0100	1412 1435 1444 1505 2232 0020	1435 1444 1505 2232	0020 0100	-149.0	12	41.1	172	4	0.005	64	PO/DI/B12. No Punch 1, data due to bad punch.
121	11	103	0000	0900	0000 0019	0019 0900		-147.2	12	45.0	-171	2	0/0.005	64/256	TDH DCC bad 0000 to 0030. PI/DI/B12.
122	42	103	0754	1500	0902 1500	* 0754 0902		-149.7	12	42.8	-172	*	*	*	*Record only. PO/DI/B12. IMP and APS not working from 0754 to 1153.
122	11	104	0000	0900	0000 0022	0022 0900		-148.7	12	49.4	-170	3	0.006	256	PI/DI/B12. DIS Tape Unit A defective, unable to readout doppler on IMP. TFR - 111937.
123	42	104	0750	1500	0900 1427		0750 0900 1427 1500	-149.4	12	50.2	-171.56	0			PO/DI/B12 from 0750 to 1500. Record only.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
123	62	104	1413	2400	1413 1427 1933 1955	1427 1933 1955 2400		-146.5	12	46.07	-171.8	10	0.002/ 0.125	256/512	P1/D1/B12 from 1413 to 2400. Lost 28 minutes of doppler due to prime Rebidium Standard failure. TFR-118432.
123	11	105	0002	0900	0002 0034 0045 0226 0226	0034 0045 0226 0900		-147.7	12	46.2	-171	2	0.014/ 0.861	256/512	P1/D1/B12 from 0000 to 0900.
124	42	105	0749	1500	0903 1428	0749 0903 1428		-149.5	12	43.2	-172.6	0			P0/D1/B12 from 0749 to 1500. Record only.
124	62	105	1415	2300	1415 1428 2032 2227	1428 2032 2300		-146.2	12	46.7	-171.8	5	0.000/ 0.126	256/512	P1/D1/B12 from 1415 to 2300.
124	11	105	2207	0904	2207 2228	2228 0904		-147.7	12	46.8	-171	1	0.016	256	P1/D1/B12 from 2207 to 0904.
125	42	106	0746	1500	0904 1425	0746 0904 1425 1500		-148.7	12	41.8	-172.55	0			P0/D1/B12 from 0746 to 1500.
125	62	106	1400	2100	1400 1435 2040 2100	1435 2040		-146.6	12	45.66	-171.8	5	0.005/ 0.201	256/512	P1/D1/B12 from 1400 to 2100.
125	11	106	2207	0900	2207 2224	2224 0900		-147.3	12	44.9	-171	3	0/0.005	64/256	P1/D1/B12 from 2207 to 0900.
126	42	107	0754	1500	0900 1422	0754 0900 1422 1500		-149.3	12	39.8	-172.6	0			P0/D1/B12 from 0750 to 1500. Record only.
126	62	107	1400	2100	1400 1422 2032 2100	1422 2032		-146.7	2	45.77	-171.8	5	0.026/ 0.172	256/512	P1/D1/B12 from 1400 to 2100.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
126	11	107	2207	0900	2207 2237	2237 0900		-147.5	12	46.4	-170	9	0.001/ 0.015	64/256	P1/D1/B12 from 2207 to 0900.
127	42	108	0757	1500	0900 1001 1007 1419 1419	1001 1007	0757 0900 1419 1500	-148.9	12	38.9	-172.6	0			P0/D1/B12 from 0757 to 1500. Record only. Data point acquisition on Channel 6.
127	62	108	1400	2100	1400 1425 2032 2100	1425 2032		-147.3	12	46.83	-171.8	5	0.003/ 0.177	256/512	P1/D1/B12 from 1400 to 2100.
127	11	108	2203	0900	2203 2235	2235 0900		-148.0	12	49.0	-170	7	0.020	256	P1/D1/B12 from 2203 to 0900.
128	42	109	0754	1500	0900 0926 0937 1420	0926 0937	0754 0900 1420 1500	-149.4	12	38.5	-172.6	0			P0/D1/B12 from 0750 to 1500. Unable to load IMP program prior to acquisition, W-Buffer errors. Operational at 0833. TFR-111366. APS program hang-up causing loss of receiver lock from 081846 to 082701. Suspect problem due to troubleshooting IMP problem - Investigating. TFR-111367.
128	62	109	1400	2100	1400 1420	1420 2100		-147.3	12	46.33	-171.8	4	0.000/ 0.001	64/256	P1/D1/B12 from 1400 to 2100.
128	11	109	2208	0859	2208 2221	2221 0859		-148.9	12	46.3	-171	8	0.000/ 0.020	64/256	P1/D1/B12 from 2208 to 0859. Signal level approximately 5db down at acquisition. Maser had become detuned after pretrack calibration. Retuned maser and signal level normal at 2339.
129	62	110	1400	2100	1400 1419 2032 2100	1419 2032		-147.5	12	44.6	-171.8	6	0.000/ 0.001	16/256	P1/D1/B12 from 1400 to 2100.
129	11	111	2206	0900	2206 2226	2226 0900		149.1	12	49.1	-171	1	0.050	256	P1/D1/B12 from 2206 to 0900.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments	
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)					
					1-Way	2-Way	3-Way									
130	42	111	0754	1500	0903 1417 1425 1437	0815 0819	0754 0815 0819 0903 1417 1425 1437 1500	-150.3	12	38.2	-173	0	*	*	*Record only. P0/D1/B12 from 0754 to 1500.	
130	62	111	1400	2100	1400 1417 1425 1437 1437 2033 2100	1417 1425 1437 2033		-147.3	12	45.6	-172	5	0/0.030	256/512		P1/D1/B12 from 1400 to 2100. Maser 2 down. TFR-111808.
130	11	111/ 112	2206	0900	2206 2220	2220 0900		-149.0	12	45.9	-171	2	0.040	256		P1/D1/B12 from 2206 to 0900. Maser 2 down. TFR-111808. DSS 12 timing glitch, reset clocks. TFR-111809 and 111811.
131	42	112	0754	1500	0902 0915 0938	0915 0938	0754 0902 1421 1428 1441 1500	-150.1	12	38.6	-172.5	0				P0/D1/B12 from 0754 to 1500. Record only.
131	62	112	1400	2100	1400 1421 1428 1440 1440 2032 2100	1421 1428 1440 2032		-147.6	12	48.13	-171.8	4	0.000/ 0.005	64/256		P1/D1/B12 from 1400 to 2100.
131	11	112	2203	0900	2203 2226	2226 0900		-149.0	12	46.4	-171	2	0.000/ 0.045	64/256		P1/D1/B12 from 2200 to 0900. Maser 2 down. TFR-11808.
132	42	113	0756	1500	0902 0930 0937 1418 1418	0930 0937	0756 0902 0902 1418 1500	-151	12	39.9	-171.6	0				P0/D1/B12 from 0750 to 1500. Dropped receiver lock while tuning to Track Synfrq at 6 HZ per minute, cause unknown.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
132	62	113	1400	2300	1400 1418 2033 2225	1418 2033	2225 2300	-147.6	12	48.3	-172	4	0/0.005	64/256	P1/D1/B12 from 1400 to 2300. No IAPS slave due to bad D/A converter in DIS. 2 hours and 18 minutes of CEC data lost due to bad gear box.
132	11	114	2203	0900	2203 2225	2225 0900		-148.8	12	48.7	-171	10	0.200/0	256/64	P1/D1/B12 from 2200 to 0900. No IMP doppler data, bad tape unit. IMP page print time tag bad. APS failed one time.
133	42	114	0756	1500	0902 0923 0929 1419	0923 0929	0756 0902 1419 1500	-150.8	12	39.7	-172.6	0			P0/D1/B12 from 0756 to 1500. Record only.
133	62	114	1400	2300	1400 1418 2032 2223	1418 2032	2223 2300	-147.6	12	46.18	-171.8	4	0.000/ 0.002	64/256	P1/D1/B12 from 1400 to 2300.
133	11	114/ 115	2202	0900	2202 2232	2232 0900		-149.4	12	45.1	-171	2	0.003/ 0.100	64/256	P1/D1/B12 from 2200 to 0900.
134	42	115	0756	1500	0902 0924 0931 1421	0924 0931	0756 0902 1421 1500	-151.4	12	42	-172.6	0			P0/D1/B12 from 0756 to 1500. Record only.
134	62	115	1400	2300	1400 1423 2032 2222	1423 2032	2222 2300	-147.8	12	45.45	-171.8	4	0.004/ 0.003	64/256	P1/D1/B12 from 1400 to 2300.
134	11	115	2201	0900	2201 2221	2221 0900		-149.4	12	48.1	-171	2	0.000/ 0.160	64/256	P1/D1/B12 from 2200 to 0900. 1) TDH doppler resolver hanging up; replaced card. TFR-111803. (Pre-track calibration,) 2) DSS 12 TCP not receiving data from GOE (Ground Operating Equipment). Reconnected connector on comm buffer; operational normal at 2145. 3) 11 minutes late getting engineering and science TLM on line due to bad TTY Machines 12 and 13. Switched to

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Post (°K)	Thres Pre/Post (dbm)				
135	42	116	0756	1500	0903 0926 0932 1417	0926 0932	0756 0903 1417 1500	-151.2	12	45.7	-172.6	0			Machine 14. TFR-123502. 4) Intermittent APS Declination axis run-away. Tracked in brake mode in AEC axis, updating approximately once an hour. TFR-111844. P0/D1/B12 from 0756 to 1500. Record only.
135	62	116	1400	2300	1400 1418 2033 2225	1418 2033	2225 2300	-148.2	12	46.0	-172	4	0.0005	64/256	P1/D1/B12 from 1400 to 2300.
135	11	117	2200	0900	2200 2235 *0351 *0421 0436 0436 0900	2235 *0351 0436 0900	0756 0903 1424 1500	-148.7	12	46.0	-171	4	0.050	256	P1/D1/B12 from 220 to 0900. *Servo down from 0351 to 0421 due to servo hydraulic leak. No data during this period.
136	42	117	0756	1500	0903 0922 0929 1424	0922 0929	0756 0903 1424 1500	-151	12	40.2	-171.5	0			P0/D1/B12 from 0756 to 1500. No IAPS throughout track due to memory failure in DIS Alpha computer. TFR-DIS-111379. Maser 2 down. No JPL Voice-Line recorded on FR-1400 recorders, Track 1 due to TIC mode. Record only.
136	61	117	1401	2300	1401 1424 2032 2250	1424 2032	2250 2300	-150	12	43.81	-171.63	9	0.000/ 0.745	64/256	P0/D1/B12 from 1401 to 2300. APS program dropped out at 1559 and 1843; Reloaded program. TFR-118344.
136	11	117	2206	0900	2206 2301	2301 0900	0759 0903 1411 1500	-149	12	46.8	-170	5	0.000	64	P1/D1/B12 from 2206 to 0900. Acquisition late due to Maser 1 frequency drift; retuned maser. TFR-111952.
137	42	118	0759	1500	0903 0924 0929 1411	0924 0929	0759 0903 1411 1500	-151	12	39.8	-171.5	0			P0/D1/B12 from 0759 to 1500. Record only. No IAPS, DIS Alpha memory problems. TFR-111379. Maser 2 down. No JPL Voice on FR-1400 recorders. Track 1 due to TIC mode.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time	1-Way	2-Way	3-Way	Loop BW (Hz)	Temp Post (-°K)	Thres Pre/Post (dbm)				
137	62	118	1400	2300		1400 1410	1410 2032	2032 2300	12	45.81	-171.8	4	0.017/ 0.010	64/256	P1/D1/B12 from 1400 to 2300.
137	11	118	2159	0900		2159 2231	2231 0900		12	46.9	-171	2	0.000/ 0.147	64/256	P1/D1/B12 from 2159 to 0900. Maser 2 system temperature out of specification, 62.5°K. TFR-111967.
138	42	119	0758	1500		0902 0922 0928 1416	0922 0928 1416 1500	0758	12	40.9	-172.5	0			P0/D1/B12 from 0758 to 1500. Record only. Maser 2 cool down completed. Stability run to start after track. No IAPS, DIS Alpha computer down. TFR-111379. No JPL Voice on FR-1400 recorder Track 1 due to TIC mode.
138	62	119	1400	2300		1400 1417 2032 2221	1417 2032	2221 2300	12	50.46	-171.8	4	0.000/ 0.020	64/256	P1/D1/B12 from 1400 to 2300.
138	11	119	2159	0900		2200 2235	2235 0900		12	46.4	-171	4	0.000/ 0.123	64/256	P1/D1/B12 from 2159 to 0900. Loss of vacuum on Maser 2. TFR-111967 and 111968.
139	42	120	0756	1500		0903 0926 0934 1500	0926 0934	0756 0903	12	43.6	-172.5	0			P0/D1/B12 from 0756 to 1500. Record only. No JPL Voice on FR-1400 recorder Track 1 due to TIC mode.
139	11	120/ 121	2159	0700		2159 2234	2234 0700		12	47.5	-171	5	0.000/ 0.209	64/256	P1/D1/B12 from 2159 to 0700.
140	42	121	0553	1500		0704 0728 0732 1500	0728 0732	0553 0704	12	39	-172.45	0			Record only. P0/D1/B12 from 0553 to 1500. TXR VCO counter inoperative from start of track to 0625 due to faulty triggering. TFR-111388. Unable to confirm quality of recorded telemetry due to low signal level. No FR-1400 recorder Track 1 due to TIC mode. FR-1400 Reels 1B and 3A tapes stretched. Reel 3B (backup) included in data package. TFR-111389. Recorder servo system under investigation.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
140	11	121	2200	0700	2202 0219	0219 0700		-149.3	12	47.6	-171	12	0.000/ 0.156	64/256	P1/D1/B12 from 2200 to 0700. Record only from 2200 to 0200. Intermittent high level spikes and system temperature increase at times but settled down at 0300. CMD mod increase at 0459 from 700 mv to 3.5v. Comm personnel adjusted wrong amplifier gain; back to normal at 0511 and required retransmitting CMD 006.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmts	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (*K)	Thres Pre/Post (dbm)				
141	42	122	0554	1500	0703 0726 0730 1424	0726 0730	0554 0703 1424 1500	-150.5	12	43	-171.46	0			P0/D1/B12 from 0554 to 1500. Record only.
141	61	122	1359	2300	1359 1425	1425 2300		-148.2	12	47.52	-170.64	7	0.000/ 0.125	64/256	P1/D1/B12 from 1359 to 2300 (TFR-123003). TDH data erroneous from 201016 to 212802 due to incorrectly seated TDH patch board after switching from format 07 to 15. Delay in solving problem due to time required to play back 1-second TDH data.
141	11	122	2159	0700	2353 0209	0209 0700	2200 2353	-148.9	12	46.6	-171	13	0.000/ 0.279	64/256	P1/D1/B12 from 2159 to 0700. Record only from 2159 to 0200.
142	61	123	1356	2300	1356 1422	1422 2300		-149.4	12	48.42	-171.63	18	0.000/ 0.112	16/64/ 256	P1/D1/B12 from 1356 to 2300. From 1512 to 1521, time tags on engineering and science data reading all zeros, caused by loose wire in back of timing generator (TER-118401). At 1808, vacuum motor on Beta tape unit of DIS computer failed, and was replaced unit without loss of data (TFR-123008).
143	42	124	0557	1500	0557 0622 0628 1422	0622 0628	1422 1500	-151.5	12	39.5	-172.5	0			P0/D1/B12 from 0557 to 1500. Record only. DIS Beta memory fault (TFR-111397). Receiver 1 out of lock from 072713 to 072852 for no apparent reason (TFR-111400). Receiver 1 out of lock from 082404 to 082440 for investigation of problem. Ground Operating Equipment (GOE) in use for engineering evaluation.
143	61	124	1357	2300	1357 1424	1424 2300		-149.5	12	47.69	-171.63	12	0.000	64	P1/B1/B12 from 1357 to 2300. At 1537, the AFS program dropped out; reloaded program (TFR-118344).
144	42	125	0552	1500	0552 0618 0624 1417	0618 0624	1417 1500	-151.5	12	45.7	-171.4	0			P0/D1/B12 from 0552 to 1500. Record only. No Interim Monitoring Program (IMP) DIS Beta memory fault (TFR-111397). GOE in use for engineering evaluation.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm): D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
144	61	125	1357	2300	1357 1415 2249 2300	1415 2249		-149.3	12	47.58	-170.64	22	0.000/ 0.609	64/256	P1/D1/B12 from 1357 to 2300.
144	11	125	2202	0701	2300 0043	0043 0701	2202 2300	-149.9	12	47.8	-170	3	0.000/ 0.373	64/256	P1/D1/B12 from 2202 to 0701. No IMP or APS function due to ECO 66-204.
145	42	126	0553	1500	0701 0728 0732 1420 1420	0728 0732	0553 0701 1420 1500	-151.5	12	45.5	-172.5	0			P0/D1/B12 from 0553 to 1500. Record only. DIS Beta memory fault (TFR-111397). GOE in use for evaluation only. U-Bus failure for 5 minutes at 1258 due to overload trip for no apparent reason (TFR-111402).
145	61	126	1354	2300	1354 1420 2213 2300	1420 2213		-150	12	56.79	-170.64	6	0.000/ 0.921	64/256	P1/D1/B12 from 1354 to 2300. Maser 2 down for scheduled maintenance at 2000. ETO 128/1700.
145	11	126	2206	0701	2213 0013	0013 0701	2206 2213	-150.1	12	48	-170	2	0.000	64	P1/D1/B12 from 2206 to 0701. At 2200, TXR 1 became inoperative due to ruptured coolant line; switched to TXR 12 (TFR-111715).
146	42	127	0555	1500	0701 0725 0733 1500	0725 0733	0555 0701	-151.2	12	40.2	-171.4	0			P0/D1/B12 from 0555 to 1500. GOE in use for engineering evaluation only. Record only.
146	11	127	2159	0700	2159 2220	2220 0700		-150.4	12	51.5	170	9	0.000	64	P1/D1/B12 from 2159 to 0700. At 0255, (TFR-105424) excessive TCP dropouts at DSS 14 — investigation after track.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
147	42	128	0556	1500	0700 0725 0756 1500	0725 0756	0556 0700	-152	12	39.0	-172.5	0			P0/D1/B12 from 0550 to 1500. Record only. (1) GOE in use for engineering evaluation only. (2) Received receiver glitches after two-way acquisition on channel 6. Also excessive ground receiver dynamic phase error when tuning exciter vco at rates considerably less than 6°/Hz/min - noise spikes present throughout TXR spectrum. (3) Bit drive to west low speed tachometer removed to clear oscillating valve current fault (TFR-111408). (4) IMP typewriter page print lost from 1440 to 1500 due to jammed paper feed (TFR-111409).
147	11	128	2159	0700	2159 2231	2231 0700		-150.4	12	44.2	-171	3	0.000	64	P1/D1/B12 from 2159 to 0700. (1) DSS 14 TCP dropouts still open halted nine times, (TFR-105424). (2) Maser 2 down due to warm up (TFR-111721). ETO 127/0500. (3) From 2200 to 0234, the DIS Alpha computer magnetic tape unit was inoperative due to defective photo cell. No doppler printout on IMP. (4) From 2200 to 0054, the IMP and AFS problems on DIS Alpha computer cleared by adjusting the capstans and reloading the program.
148	42	129	0556	1500	0700 0727 0743 1438	0727 0743	0556 0700 1438 1500	-152.3	12	36.9	-172.5	0			P0/D1/B12 from 0556 to 1500. GOE equipment in use for engineering evaluation only.
148	61	129	1352	2300	1352 1438 2034 2221	1438 2034	2221 2300	-149.0	12	45.46	-171.63	5	0.000/ 0.243	64/256	P1/D1/B12 from 1352 to 2300.
148	11	129	2159	0700	2159 2222	2222 0700		-150.5	12	44.9	-171	1	0.000	64	P1/D1/B12 from 2159 to 0700 (TFR-111669). No doppler processed due to bad Beta tape unit.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (*K)	Thres Pre/Post (dbm)				
149	42	130	0552	1500	0701 0723 0728 1500	0723 0728	0552 0701	-152.3	12	38.6	-172.5				P0/D1/B12 from 0545 to 1500. Record only.
149	61	130	1351	2300	1351 1417	1417 2300			12	49.49	-170.64	5	0.000/ 0.267	64/256	P1/D1/B12 from 1351 to 2300. TFR-123021. Magnetic tape unit hung-up computer, momentarily took tape unit off line. No IMP data from 1710 to 1904.
150	42	131	0553	1500	0553 0624 0629 1418	0624 0629	1418 1500	-152.8	12	40.4	-170.5	0			P0/D1/B12 from 0545 to 1500. TDH Tape 2 (back-up) broke twice and had to be spliced (TFR-111417).
150	61	131	1351	2300	1350 1418	1418 2300		-149.0	12	48.12	-170.64	4	0.000	64	P1/D1/B12 from 1350 to 2300.
151	42	132	0552	1500	0553 0616 0621 1420	0616 0621	1420 1500	-152.7	12	39.6	-172.5	0			P0/D1/B12 from 0545 to 1500.
151	61	132	1349	2300	1349 1420 2033 2223	1420 2033	2223 2300	-149.5	12	46.97	-171.63	3	0.000	64	P1/D1/B12 from 1349 to 2300.
151	11	132	2158	0700	2158 2223	2223 0700		-151.3	12	48.4	-170	1	0.000	64	P1/D1/B12 from 2000 to 0700.
152	42	133	0550	1500	0703 0727 0733 1415 1416 1443	0727 0733	0551 0703 1415 1416 1443 1500	-153.0	12	37.9	-172.5	0			P0/D1/B12 from 0545 to 1500. Numerous receiver glitches and loss of lock while DSS 42 was three-way with DSS 61 and the spacecraft.
152	61	133	1347	2300	1347 1442 2033 2220	1442 2033	2220 2300	-149.0	12	44.9	-171.63	6	0.000	64	P1/D1/B12 from 1347 to 2300.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
152	11	133	2158	0700	2158 2220	2220 0700		-151.3	12	46.6	-171	1	0.000	64	P1/D1/B12 from 2200 to 0700.
153	42	134	0551	1500	0703 0720 0727 1419	0720 0727	0551 0703 1419 1500	-153.0	12	39.0	-171.5	0	0.000	64	P0/D1/B12 from 0545 to 1500. Telemetry data to line for engineering evaluation only.
153	61	134	1346	2300	1346 1432 2033 2222	1432 2033	2222 2300	-149.2	12	46.05	-170.25	3	0.000	64	P1/D1/B12 from 1346 to 2300. CEC recorder stopping intermittently from 1512 to 1625 (TFR-123033). Dropped lock several times during data point acquisition - cause unknown; investigating.
153	11	134	2158	0700	2158 2222 0612 0700	2222 0612		-151.0	12	45.0	-171	0			P1/D1/B12 from 2200 to 0700. Record only. No APS until 2343 due to wrong predict set used to make drive tape; reformatted new tape.
154	42	135	0600	1459	0613 0633 0639 1417	0633 0639	0600 0613 1417 1459	-153.4	12	42.8	-172.5	0	0.000	64	P0/D1/B12 from 0600 to 1459. Record only. GOE equipment and data for engineering evaluation only.
154	61	135	1345	2300	1345 1417 2038 2218 2233 2300	1417 2038	2218 2233	-149.9	12	48.02	-170.25	3	0.000	64	P1/D1/B12 from 1345 to 2300. From 2249 to 225309, receiver out of lock due to APS driving antenna off point; went to Aided Track (TFR-118344).
154	11	135	2158	0700	2158 2219 2233 0700	2219 2233		-151.7	12	46.7	-171	0			P1/D1/B12 from 2200 to 0700. Record only.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time	1-Way	2-Way	3-Way	Loop BW (Hz)	Temp Pre/Post (*K)	Thres Pre/Post (dbm)				
155	42	136	0553	1459	0553 0616 0621 1413	0616 0621	1413 1459		12	37.5	-172.5	0	0.000	64	Record only. P0/D1/B12 from 0553 to 1459. GOE in use for engineering evaluation. (1) DIS A down from start of this pass until 0622 (TFR-111425). (2) TCP R down from start of pass until 1255 (TFR-111426). (3) IAFS has constant +0.008' offset in Hour Angle (TFR-111427).
155	61	136	1344	2300	1344 1414 2035 2217	1414 2035	2217 2300		12	47.42	-170.25	6	0.000	64	P1/D1/B12 from 1344 to 2300. (1) From 1454 to 1459, the CEC paper jammed (TFR-123033). (2) At 1816, 1819 and 1820, the commands (CMD) (6/112, 6/101, and 6/061) transmitted with CMD MOD off - operator error. The commands were retransmitted at 1934, 1937, and 1938.
155	11	136	2159	0700	2159 2219	2219 0700			12	45.9	-171	8	0.000	64	P1/D1/B12 from 2200 to 0700. Defective Receiver 1 Iso-amp in RCV in/out lock circuit causing bad data (lag on TDH); replaced Iso-amp (TFR-120505).
156	42	137	0552	1458	0703 0723 0729 1425	0723 0729	0552 0703 1425 1458		12	41.1	-171.5	0			P0/D1/B12 from 0552 to 1458. TCP Alpha printout spurious incorrect commands (TFR-111429). TCP Beta printout excessive telemetry bit errors (TFR-111430).
156	61	137	1400	2300	1400 1426	1426 2300			12	48.21	-170.25	3	0.000	64	P1/D1/B12 from 1400 to 2300. Unable to initialize Beta DIS computer due to bad run-idle switch; replaced defective switch - lost all IMP until 1706 (TFR-123039).
157	42	138	0551	1457	0551 0617 0623 1404	0617 0623	1404 1457		12	43.1	-172.3	0	0.000	64	P0/D1/B12 from 0551 to 1457. Record only. GOE in use for engineering evaluation only.
157	61	138	1344	2300	1344 1404	1404 2300			12	47.6	-170.25	3	0.000	64	P1/D1/B12 from 1344 to 2300. AFS program drops out occasionally (TFR-118344).

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
158	42	139	0552	1456	0552 0626 0632 1419	0626 0632	1419 1456	-153.8	12	58	-171.5	0	0.000	64	P0/D1/B12 from 0552 to 1456. Record only. GOE in use for engineering evaluation only.
158	61	139	1343	2300	1343 1419 2033 2216	1419 2033	2216 2300	-148.9	12	46.29	-171.25	3	0.000	64	P1/D1/B12 from 1343 to 2300.
158	11	139	2200	0700	2200 2219	2219 0700		-150.8	12	50.7	-172	1	0.000	64	P1/D1/B12 from 2200 to 0700. Maser 1 down (TFR-120500).
159	42	140	0553	1455	0703 0730 0736 1415	0730 0736	0553 0703 1415 1455	-153.2	12	37.2	-171.5	0	0.000	64	P0/D1/B12 from 0553 to 1455. Record only. GOE in use for engineering evaluation only. DSS Beta IMP time readouts incorrect at each 10 minute update until 1120 (TFR-111436).
159	61	140	1342	2300	1342 1415 2033 2222	1415 2033	2222 2300	-150	12	48.09	-170.25	3	0.000	64	P1/D1/B12 from 1342 to 2300. APS program inoperative, track spacecraft in Aided Track (TFR-123041).
159	11	140	2200	0700	2200 2222	2222 0700		-150.5	12	50.1	-171	1	0.000	64	P1/D1/B12 from 2200 to 0700. (1) Maser 1 down. (2) TDH doppler bad from 2200 to 2320; reset trigger levels on resolver counter. (3) IMP printing out AGC voltage vice signal level due to incorrect entry on AGC curve fit pretrack calibration.
160	42	141	0553	1450	0704 0726 0734 1413	0726 0734	0553 0704 1413 1450	-154	12	37.2	-171.5	0	0.000	64	P0/D1/B12 from 0553 to 1450. Record only. GOE in use for engineering evaluation only. Antenna Hour Angle drive motors chatter - ing at 1200. East tachometer drive belt removed as temperature stabilize (TFR-111441).

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
160	61	141	1342	2207	1342 1419 1943 2207	1419 1943		-150	12	48.53	-170.25	3	0.000	64	P1/D1/B12 from 1342 to 2210. APS program inoperative, antenna in Aided Track.
160	11	141	2135	0700	2135 2209 0604 0604 0625 0632 0700	2209 0604	0625 0632	-152	12	45.9	-171	1	0.000	64	P1/D1/B12 from 2135 to 0700. Maser 2 down (TFR-120512).
161	42	142	0552	1450	0603 0623 0632 1412 1412	0623 0632	0552 0603 1412 1450	-153.4	12	46.7	-171.58	0	0.003	64	P0/D1/B12 from 0552 to 1450. GOE in use for engineering evaluation only. IAPS hang-up at 0703, restarted program and the memory stack temperature was noted to be 96°F (TFR-111446).
161	61	142	1341	2158	1341 1412 1934 2158	1412 1934		-149.8	12	44.71	-170.25	3	0.000	64	P1/D1/B12 from 1341 to 2158.
161	11	142	2134	0700	2134 2158	2158 0700		-151.5	12	45.4	-171	5	0.000	64	P1/D1/B12 from 2134 to 0700. IMP AGC curve fit erroneous.
162	42	143	0553	1450	0703 0724 0729 1408 1450	0724 0729	0553 0703 1408 1450	-153.5	12	37.8	-172.55	0	0.000	64	P0/D1/B12 from 0553 to 1450. Record only. GOE in use for engineering evaluation only.
162	61	143	1342	2200	1342 1408 2018 2200	1408 2018		-150	12	46.21	-171.25	3	0.000	64	P1/D1/B12 from 1342 to 2200. APS program dropping out causing receiver out-of-lock for 1 minute and 20 seconds - servo to Aided Track (TFR-118344).
162	11	143	2135	0700	2135 2218	2218 0700		-152.1	12	45.3	-171	1	0.003	64	P1/D1/B12 from 2135 to 0700. Incorrect 10 minute of printout on IMP, problem cleared by reset of BP-3.
163	42	144	0602	1450	0703 0724 0729 1407	0724 0729	0602 0703 1407 1450	-153	12	39.9	-171.96	0	0.000	64	P0/D1/B12 from 0602 to 1450. GOE in use for engineering evaluation only. Receiver out of lock at 115834, because the IAPS panel program option 1 reset button was accidentally pressed.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
163	61	144	1340	2158	1340 1406 2018 2158	1406 2018		-150.2	12	46.97	-170.25	3	0.000	64	P1/D1/B12 from 1340 to 2158. Loss of IMP data from 2015 to 2150 due to bad magnetic tape – regenerated new magnetic tape.
163	11	144	2134	0700	2136 2211	2211 0700		-152.5	12	45.2	-171	1	0.005	64	P1/D1/B12 from 2134 to 0700. Servo tracking in Aided Track, APS down (TFR-120526).
164	42	145	0554	1450	0703 0718 0823 1410	0718 0823	0554 0703 1410 1450	-154	12	49	-172.5	0	0.000	64	P0/D1/B12 from 0554 to 1450. GOE in use for engineering evaluation only. Maser 1 down for maintenance Receiver 2 SFE Iso-amp noisy – replaced Iso-amp (TFR-111455).
164	61	145	1342	2210	1342 1410 2019 2204	1410 2019	2204 2210	-149.8	12	46.75	-170.25	3	0.000	64	P1/D1/B12 from 1342 to 2210.
164	11	145	2135	0700	2137 2222	2222 0700		-152.5	12	47.6	-171	1	0.000	64	P1/D1/B12 from 2135 to 0700.
165	42	146	0554	1450	0703 0720 0724 1411 1411	0720 0724	0554 0703 1411 1450	-153.1	12	47.8	-172.46	0	0.003	64	P0/D1/B12 from 0554 to 1450. Maser 1 down.
165	61	146	1337	2210	1337 1411	1411 2210		-150.4	12	46.17	-170.25	3	0.003	64	P1/D1/B12 from 1337 to 2210.
166	42	147	0555	1449	0555 0628 0633 1410	0628 0633	1410 1449	-154.4	12	47.3	-171.48	0	0.003	64	P0/D1/B12 from 0555 to 1449.
166	61	147	1338	2208	1338 1409	1409 2208		-151	12	45.32	-170.25	6	0.000	64	P1/D1/B12 from 1338 to 2208.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					1-Way	2-Way	3-Way		Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
167	42	148	0535	1430	0535 0600	0600 1430		-154	12	38.7	-172.45	5	0.000	64	P0/D1/B12 from 0535 to 1430. (1) TCP late in locking up due to wrong S/C bit rate indicated on prepass instructions. (2) Punch 2 sticking caused missing characters on TDH printout - replaced punch (TFR-111459).
167	61	148	1338	2240	1430 1511 2033 2203	1511 2033 2203	1338 1430 2203 2240	-151.5	12	46	-170.25	1	0.000	64	P1/D1/B12 from 1338 to 2240.
167	11	148	2140	0640	2140 2221	2221 0640		-152.2	12	45.0	-171	2	0.000	64	P1/D1/B12 from 2140 to 0640. At 215040, the TXR went on 40 seconds late - operator error.
168	42	149	0535	1430	0643 0706 1333 1402	0706 1333	0535 0643 1402 1430	-153.4	12	40.5	-171.5	4	0.000	64	P0/D1/B12 from 0530 to 1430. At 090400, the TCP engineering printout showed CMD 160 not permissive. The CMD was re-entered and verified that the CMD did not get into the S/C first time and had to be retransmitted at 093023.
168	61	149	1337	2240	1337 1402 2013 2230	1402 2013	2230 2240	-151.2	12	45.05	-171.25	1	0.000	64	P1/D1/B12 from 1337 to 2240.
168	11	149	2206	0640	2207 2245	2245 0640		-153	12	45.4	-170	3	0.000	64	P1/D1/B12 from 2206 to 0640. Acquisition was 26 minutes late due to inoperative high speed control on Declination axis of the antenna (TFR-111877).
169	42	150	0535	1430	0643 0705 1333 1400	0705 1333	0535 0643 1400 1430	-154.5	12	37.6	-172.5	3	0.000	64	P0/D1/B12 from 0530 to 1430.
169	61	150	1336	2240	1336 1400	1400 2240		-151	12	55.45	-171.25	7	0.000	16/64	P1/D1/B12 from 1336 to 2240.
170	61	151	1336	2240	1336 1404 2018 2159	1404 2018	2159 2240	-151.3	12	44.15	-172.25	6	0.000/ 0.000	16/64	P1/D1/B12 from 1336 to 2240.

Table 48 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode			Signal Strength Avg (dbm) D/U	Configuration			No. of Cmds	Average PER	Bit Rate	Comments
					Start/Stop Time				Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)				
					1-Way	2-Way	3-Way								
170	11	151	2141	0640	2141 2200	2200 0640		-153	12	44.6	-171	7	0.000	64	P1/D1/B12 from 2141 to 0640. TDH Punch 2 inoperative (TFR-120553).
171	42	152	0525	1430	0643 0706 0712 0720 0720 1428 1430	0706 0712 0720 1428	0525 0643	-154.5	12	38.5	-172.5	3	0.000	64	P0/D1/B12 from 0525 to 1430. (1) Receiver dropped lock while tuning to Track Synfrq - cause unknown. (2) TCP program hang-up at 1005 and had to be reloaded (TFR-111471).
171	61	152	1336	2240	1430 1501 2014 2156	1501 2014 2156 2240	1336 1430 2156 2240	-152.0	12	41.4	-171.3	1	0.000	64	P1/D1/B12 from 1336 to 2240.
171	11	152	2140	0640	2140 2156	2156 0640		-151.5	12	46.2	-171	1	0.000	64	P1/D1/B12 from 2140 to 0640.

While meeting these broad objectives, the Project can also achieve other, more specific objectives. For example: the trajectory of *Pioneer VIII* (as of *Pioneer VII*) was so designed that the spacecraft passed through the geomagnetospheric tail within about 600 earth radii. Particle and field measurements could thus be made in this region.

It is the responsibility of the Tracking and Data System to provide efficient and sufficient support to collect the aforementioned valuable data by its resources during both the near-earth and deep space phases of each mission.

B. Near-Earth Phase

The near-earth phase support portion of the TDS for the *Pioneer VIII* mission included selected resources of the AFETR, the MSFN, NASCOM, the data operations branch of GSFC, and the DSN.

The overall performance of the TDS during the near-earth phase of flight was satisfactory. The most significant deficiency was the difficulty encountered in acquiring tracking and telemetry data from the third stage after solar-orbit injection.

Table 49 gives the TDS near-earth phase support configuration for *Pioneer VIII*. The in-flight events are listed in Table 50.

1. Air Force Eastern Test Range. The elements and facilities of the AFETR supported the near-earth phase of the *Pioneer VIII* mission with a satisfactory performance. The information given below provides some understanding of how this was accomplished.

a. Tracking. Estimated and actual radar coverages are shown in Fig. 58. All Class I metric coverage requirements were met, with the actual coverage equalling or exceeding the estimate at most stations. Valid third-stage tracking data were difficult to obtain. It is believed that this was caused by tumbling of the third stage following third-stage-spacecraft separation.

Station 1.16 radar at Cape Kennedy experienced a short signal dropout during its coverage interval. Redundant coverage was available during this period. It was established later that the 1.16 radar dropout was caused by a tube failure in the range tracker circuit. The Ascension 12.18 radar was about a minute late in acquiring track. This was attributed to a drift in the pulse-code

Table 49. TDS configuration for near-earth support of *Pioneer VIII*

Station	Metric tracking	VHF telemetry	S-band telemetry
Kennedy Space Center	X	X	X
Cape Kennedy	X	—	—
Patrick AFB	X	—	—
Grand Bahama Island	X	X	X
Grand Turk	X	—	X ^a
Antigua	X	X	X
Ascension	X	X	X
RIS Twin Falls	X	X	X
RIS Pretoria	X	X	X
Bermuda	—	X	—
Tananarive	X	X	—
Carnarvon	X	X	—
Guam	—	X	—
Hawaii	X	X	—
Guaymas	—	X	—
DSS 71	—	—	X
DSS 51	X	—	X
DSS 41	X	—	X

^aEngineering test basis.

Table 50. *Pioneer VIII* in-flight events

Mark	Event	Time (GMT)	Elapsed time, s
—	Liftoff	1408:00.265	—
1	Solid motor jettison	1409:10.55	70.28
2	Main engine cutoff	1410:30.14	149.87
3	Second-stage ignition	1410:35.71	155.04
4	Shroud jettison	1411:08.39	188.11
5	Sustainer engine cutoff	1416:56.8	536.53
6	Third-stage spinup	1438:42.8	1841.81
7	Second-third-stage separation	1438:45.1	1844.73
8	Third-stage ignition	1439:32.5 ^a	1891.77
9	Third-stage burnout (injection)	1440:18.1 ^a	1937.73
10	Third-stage-spacecraft separation	1440:20	1939.83
11	Spacecraft boom deployment	1440:20	1939.83

^aReadout of retransmitted launch-vehicle telemetry at Hangar AE indicated that Mark 8 occurred at 1438:58.1 and Mark 9 at 1439:31.7.

generator. The *Pretoria* radar experienced intermittent track, probably caused by tumbling.

b. S-band telemetry. Actual S-band telemetry coverages are shown in Fig. 59. Usable data were obtained

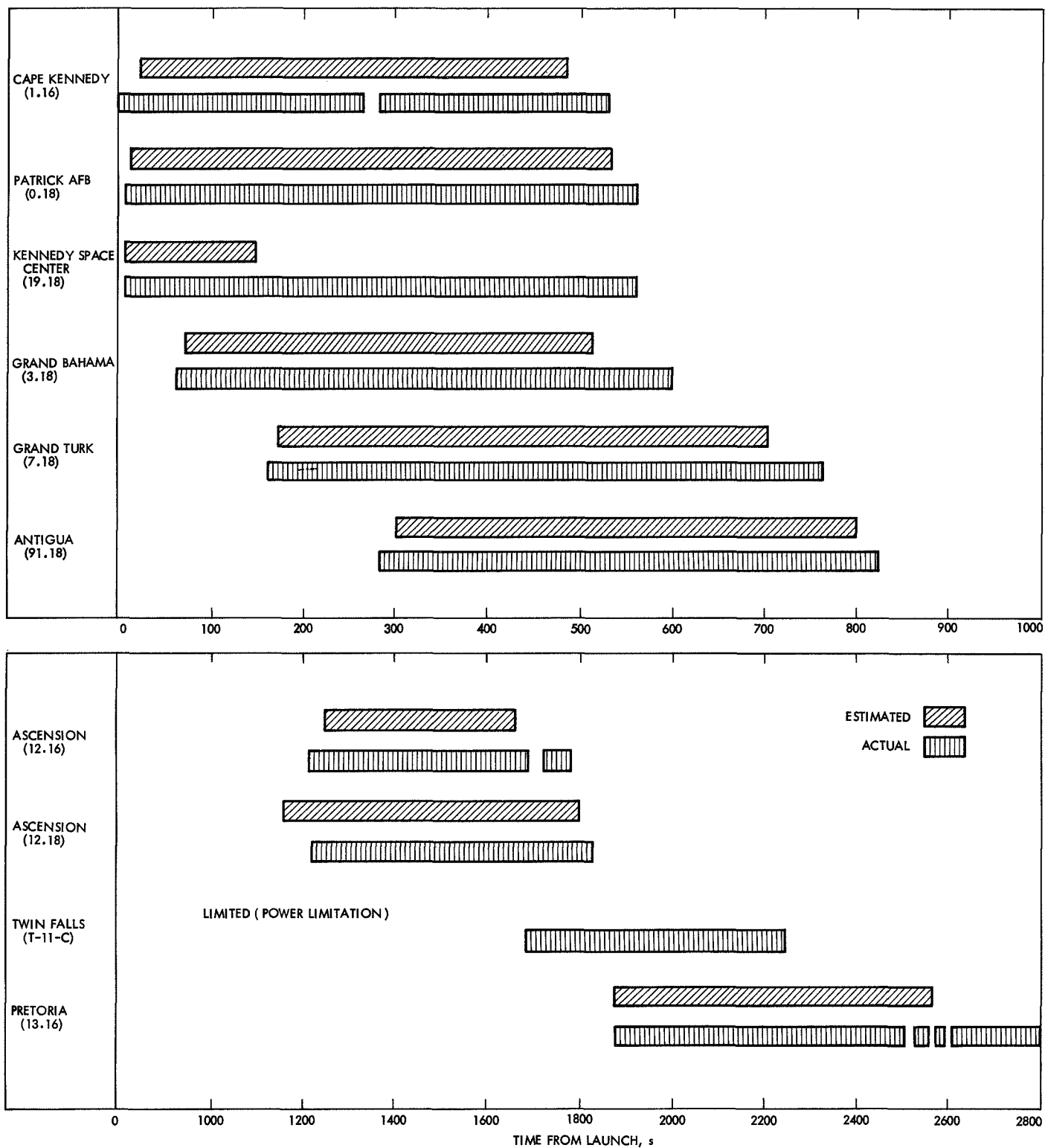


Fig. 58. AFETR radar coverage

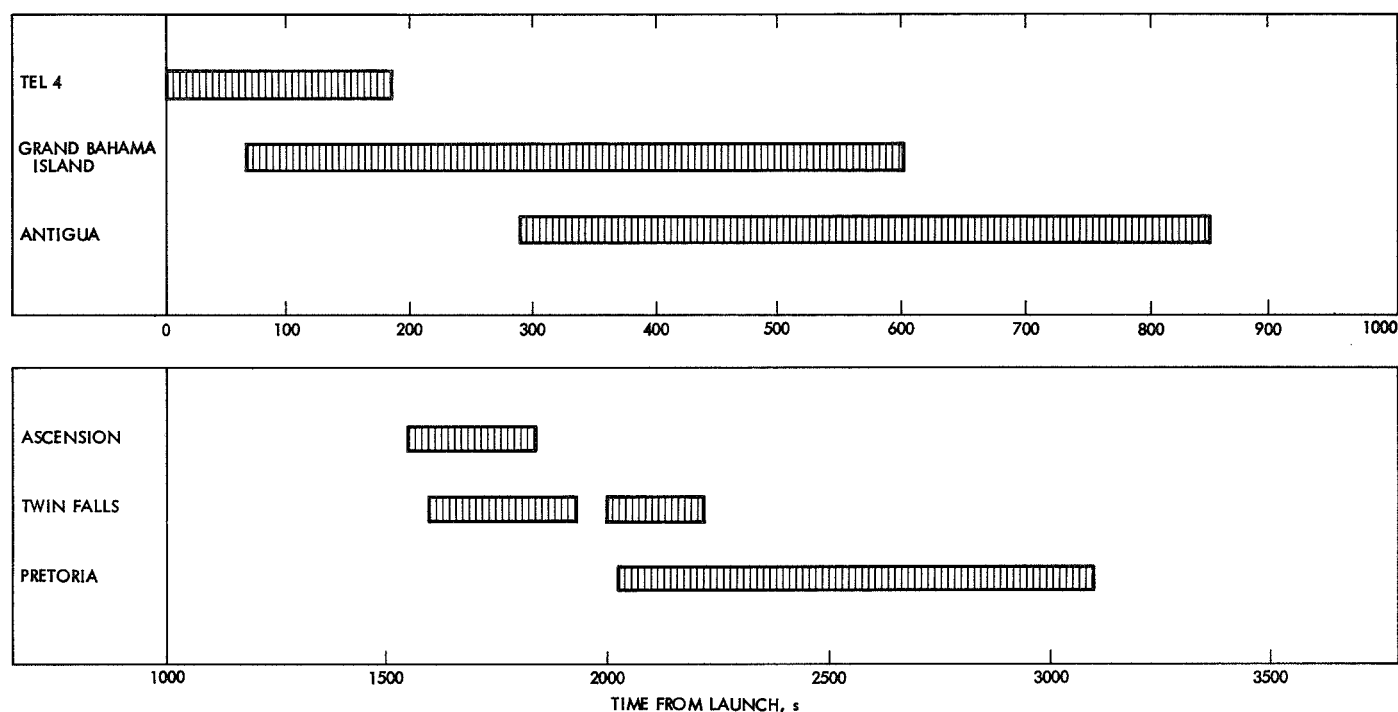


Fig. 59. AFETR S-band telemetry coverage (actual)

by Tel-4, Antigua, Ascension, Grand Bahama Island, and the RISs *Twin Falls* and *Pretoria*.

The gap in the *Twin Falls* S-band coverage occurred when the spacecraft was switched to the TWT amplifier, and was caused by the delay required for the TWT filament to reach operating temperature.

c. *VHF telemetry*. Estimated and actual VHF telemetry coverages are shown in Fig. 60. In general, good VHF telemetry coverage was provided. Grand Bahama Island acquisition of the 234-MHz link was approximately 5 min late because of operator error. Redundant, overlapping coverage from Tel-4 and Antigua was available during this period.

Mark event times that were received and read out by AFETR stations are shown in Table 50. The third-stage burn time mark event readouts from the RIS *Twin Falls* proved to be erroneous.

d. *Real Time Computing Facility*. Metric tracking and computed data flow are illustrated in Fig. 61. The RTCF orbital computations for *Pioneer VIII* are listed in Table 51 and discussed below.

A parking orbit was computed using Antigua free-flight data. This solution indicated an almost nominal parking orbit. An interrange vector, standard orbital parameter message, orbital elements, and look angles for Guam, Hawaii, Guaymas, and Tananarive were provided from this solution.

A theoretical transfer orbit was computed by the RTCF using Antigua data plus nominal third-stage burn parameters. An IRV, SOPM, orbital elements, and DSN predicts for DSSs 51 and 41 were computed from this solution. The SFOF reported that these predicts agreed closely with the nominal predicts. Third-stage look angles for Tananarive and Carnarvon were also computed from this solution.

An initial transfer orbit was computed by the RTCF using a 2-min span of *Pretoria* data. An IRV, SOPM, orbital elements, and solar mapping were provided from this computation. The RTCF also computed DSN predicts for DSS 41 and updated look angles for Carnarvon. A second transfer-orbit solution, based on *Twin Falls* data, was computed to verify the *Pretoria* solution. This computation agreed closely with the *Pretoria* solution.

The Tananarive and Carnarvon radars were scheduled to provide metric tracking data during the transfer orbit.

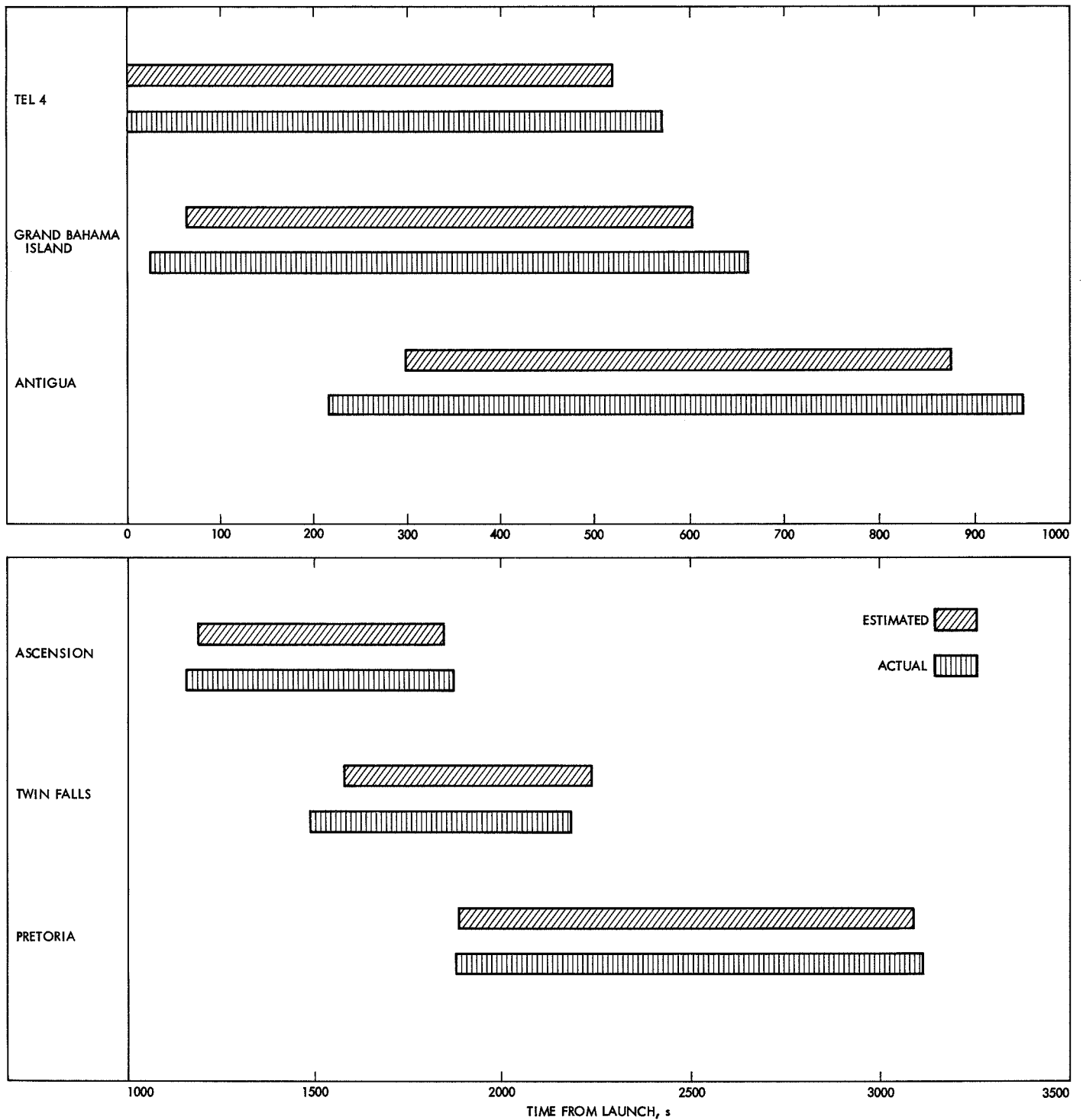
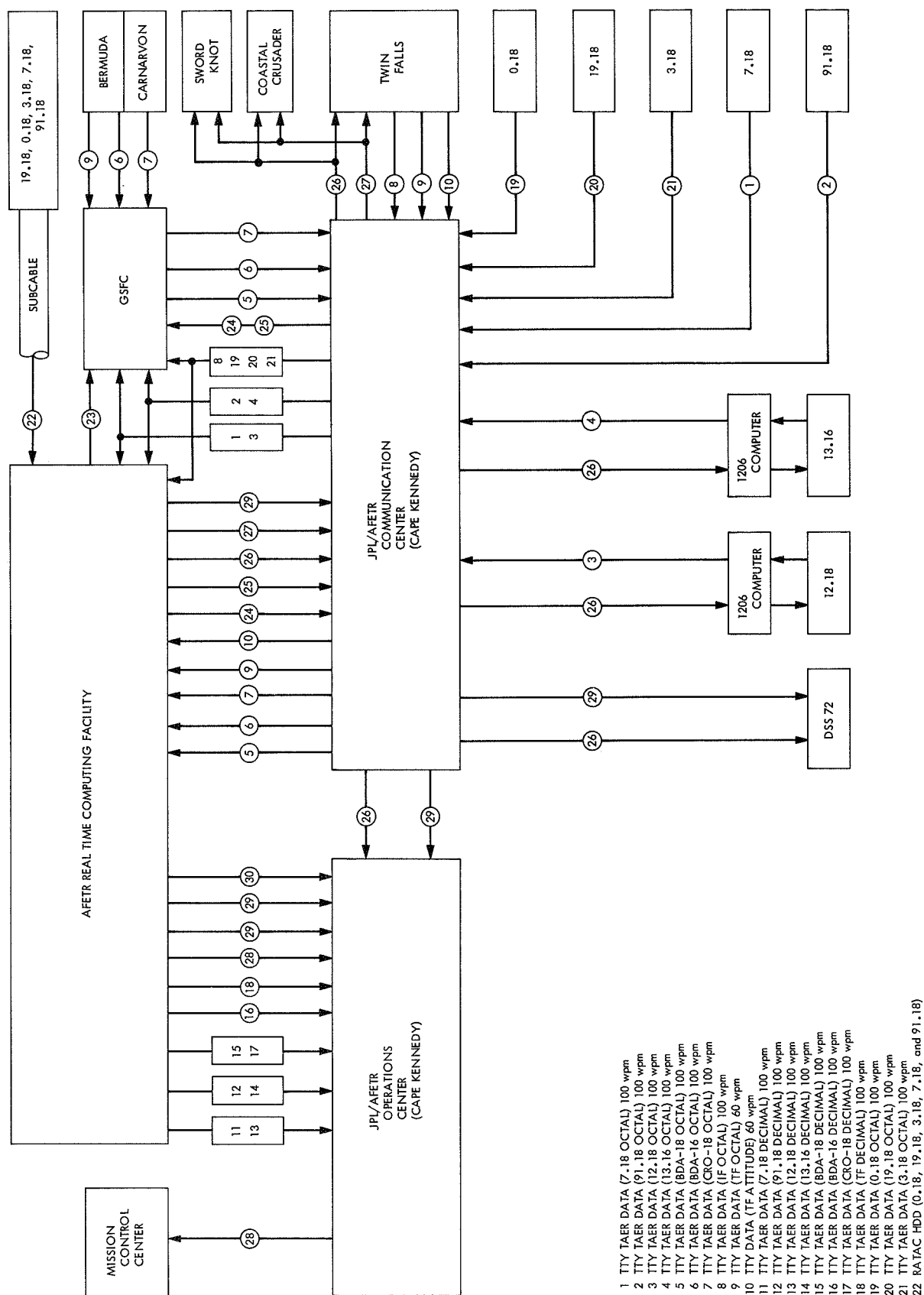


Fig. 60. AFETR VHF telemetry coverage



- 1 TTY TAER DATA (7.18 OCTAL) 100 wpm
- 2 TTY TAER DATA (91.18 OCTAL) 100 wpm
- 3 TTY TAER DATA (12.18 OCTAL) 100 wpm
- 4 TTY TAER DATA (13.16 OCTAL) 100 wpm
- 5 TTY TAER DATA (BDA-18 OCTAL) 100 wpm
- 6 TTY TAER DATA (BDA-16 OCTAL) 100 wpm
- 7 TTY TAER DATA (CRO-18 OCTAL) 100 wpm
- 8 TTY TAER DATA (IF OCTAL) 100 wpm
- 9 TTY TAER DATA (TF OCTAL) 60 wpm
- 10 TTY TAER DATA (TF ATTITUDE) 60 wpm
- 11 TTY TAER DATA (7.18 DECIMAL) 100 wpm
- 12 TTY TAER DATA (91.18 DECIMAL) 100 wpm
- 13 TTY TAER DATA (12.18 DECIMAL) 100 wpm
- 14 TTY TAER DATA (13.16 DECIMAL) 100 wpm
- 15 TTY TAER DATA (BDA-18 DECIMAL) 100 wpm
- 16 TTY TAER DATA (BDA-16 DECIMAL) 100 wpm
- 17 TTY TAER DATA (CRO-18 DECIMAL) 100 wpm
- 18 TTY TAER DATA (TF DECIMAL) 100 wpm
- 19 TTY TAER DATA (0.18 OCTAL) 100 wpm
- 20 TTY TAER DATA (19.18 OCTAL) 100 wpm
- 21 TTY TAER DATA (3.18 OCTAL) 100 wpm
- 22 RATAO HDD (0.18, 19.18, 3.18, 7.18, and 91.18)
- 23 MODEL 70 BUFFER DATA
- 24 TTY MSFN L/A (TANANARIVE)
- 25 TTY MSFN L/A (CARNARVON)
- 26 INTERANGE VECTORS 100 wpm
- 27 INTERANGE VECTORS 60 wpm
- 28 JPL ORBITAL ELEMENTS AND SOPM
- 29 DSN PREDICTS
- 30 PLANETARY MAPPING AND I-MA TRIX

Fig. 61. Metric tracking and computed data flow

Tananarive did not acquire track, and no usable Carnarvon data were provided to the RTCF for orbital computations.

The RTCF used 10 min of DSS 41 data to compute an actual spacecraft transfer orbit. This solution was considered only fair. An IRV, orbital elements, SOPM, and solar mapping were provided from this solution.

A second actual spacecraft orbit based on 45 min of DSS 41 data was computed by the RTCF. This solution was considered good. An IRV, orbital elements, SOPM, solar mapping, and an I-matrix were provided from this solution. Deep Space Network predicts for DSSs 41 and 51 were also provided.

The RTCF also provided near-real-time metric data in decimal format during the near-earth phase. Data in decimal format were provided from Grand Turk Island, Antigua, Ascension (TPQ-18), Pretoria, Tananarive, and Carnarvon.

2. Manned Space Flight Network. The MSFN configuration to support the *Pioneer VIII* mission performed satisfactorily.

a. Radar. Table 52 gives information relative to MSFN radar evaluation. Estimated and actual C-band tracking coverages are shown in Fig. 62. Tananarive, which was committed on a best-obtainable basis, did not acquire track. This was attributed, again, to probable tumbling of the third stage.

Carnarvon also failed to acquire third-stage track. The station reported poor beacon returns and severe count-down. Second-stage track was achieved through use of the acquisition-aid bus because neither the GSFC acquisition message nor the AFETR look angles were received (although generated and transmitted as required) and the nominal pointing data were unusable (see Subsection A-2-c, below).

The Hawaii station also did not receive its acquisition message before AOS. The station acquired second-stage track through the use of nominal pointing data.

Spacecraft two-way acquisition at DSS 41 (the prime DSN acquisition station) was delayed because of side-band and sidelobe lock-on problems.

b. Telemetry. Table 53 gives an evaluation of MSFN telemetry support. Estimated and actual VHF telemetry coverages are shown in Fig. 63. Good second-stage telemetry data were received by the MSFN stations; however, third-stage data were poor and unusable because of severe signal fluctuations.

Bermuda reported that strong RF interference from a local TV station caused a 2-min dropout of second-stage data shortly after initial AOS. The station confirmed mark event 5 (SECO). The requirements for retransmission of launch-vehicle telemetry data to Building AE at Cape Kennedy were cancelled before launch because of the removal of sensor connections from the third stage.

c. Computer. The real-time acquisition messages were delayed because of GSFC 7094/494 computer-interface problems. Subsequent investigation revealed an incompatibility between the on-line computer hardware and the software at the input of the 494 communications processor. These incompatibilities have since been resolved. Table 54 describes the *Pioneer VIII* computer support.

Regarding the reported lateness (or lack of) acquisition messages for the MSFN stations, investigation revealed the following:

- (1) The acquisition messages generated by the GSFC data operations branch were delayed because of the 7094/494 computer-interface problems.
- (2) The RTCF was required to prepare Carnarvon look angles for the third stage only, not the second stage. An IRV for the second stage was computed, transmitted, and received on time.
- (3) Although the GSFC acquisition message for Hawaii was late (because of the aforementioned computer-interface problems), the RTCF computed and transmitted second-stage look angles on time, and Hawaii acquired the second stage using these look angles.
- (4) Tananarive, Guam, and Guaymas received their RTCF look angles on time.

d. Ground communications. NASCOM supported the *Pioneer VIII* mission with the circuits listed in Table 55.

A requirement was placed with the AFETR for use of both voice and teletype circuits to DSS 51 via facilities

Table 51. RTCF orbital computations for Pioneer VIII

Orbit	Epoch, s	Time of computation, s	Data source	Quality
Initial parking orbit	L+559	L+840	Antigua	Good
Theoretical transfer orbit	L+1890	L+1140	Antigua plus nominal third-stage burn	Good
Transfer orbit	L+1890	L+3360	Pretoria	Fair
Actual spacecraft transfer orbit (1)	L+1890	L+6840	DSS 41 (10 min)	Fair
Actual spacecraft transfer orbit (2)	L+1890	L+9630	DSS 41 (45 min)	Good

Table 52. Pioneer VIII C-band radar

Station	Requirements	Predicted AOS-LOS, min:s	Actual AOS-LOS, min:s	Remarks
Tananarive	During pass 1, beacon track <i>Delta</i> third stage on best-obtainable basis from AOS to LOS and transmit real-time low-speed data to GSFC and RTCF During pass 2, beacon track <i>Delta</i> second stage on best-obtainable basis from AOS to LOS and transmit real-time data to GSFC and RTCF	Pass 1 (third stage): 34:30 to 80:20 Pass 2 (second stage): 137:00 to 145:30	None	Did not acquire; <i>Delta</i> third stage had a yo-yo weight released shortly after third-stage-spacecraft separation, which caused a high tumble rate of third stage. This was a probable cause for lack of acquisition. Station was committed on best-obtainable basis
Carnarvon	During pass 1, beacon track <i>Delta</i> third stage on best-obtainable basis from AOS until directed to switch to beacon track <i>Delta</i> second stage. Carnarvon was to transmit real-time data to GSFC and RTCF. When directed to switch and beacon track <i>Delta</i> second stage to LOS, Carnarvon was to transmit real-time data to GSFC and RTCF	Third-stage <i>Delta</i> : 43:50 to 94:00; second-stage <i>Delta</i> : 52:40 to 63:00	None (third stage); 55:26 to 61:36 (second stage)	Valid track was not received on <i>Delta</i> third stage because of poor beacon returns and severe countdown. Neither GSFC acquisition message nor AFETR look angles were received, and nominal pointing data were unusable; therefore, Carnarvon radar was forced to use acquisition-aid bus to acquire second stage. Achieved 270 s of valid track on second stage
Hawaii	During pass 1, beacon track <i>Delta</i> second stage from AOS to LOS and transmit low-speed data to GSFC	81:00 to 88:00	78:53 to 86:24	Acquisition messages were not received before AOS; therefore, nominal pointing data were used for acquisition. Obtained 444 s of valid track on second stage. Lost 42 s because of radiation limits

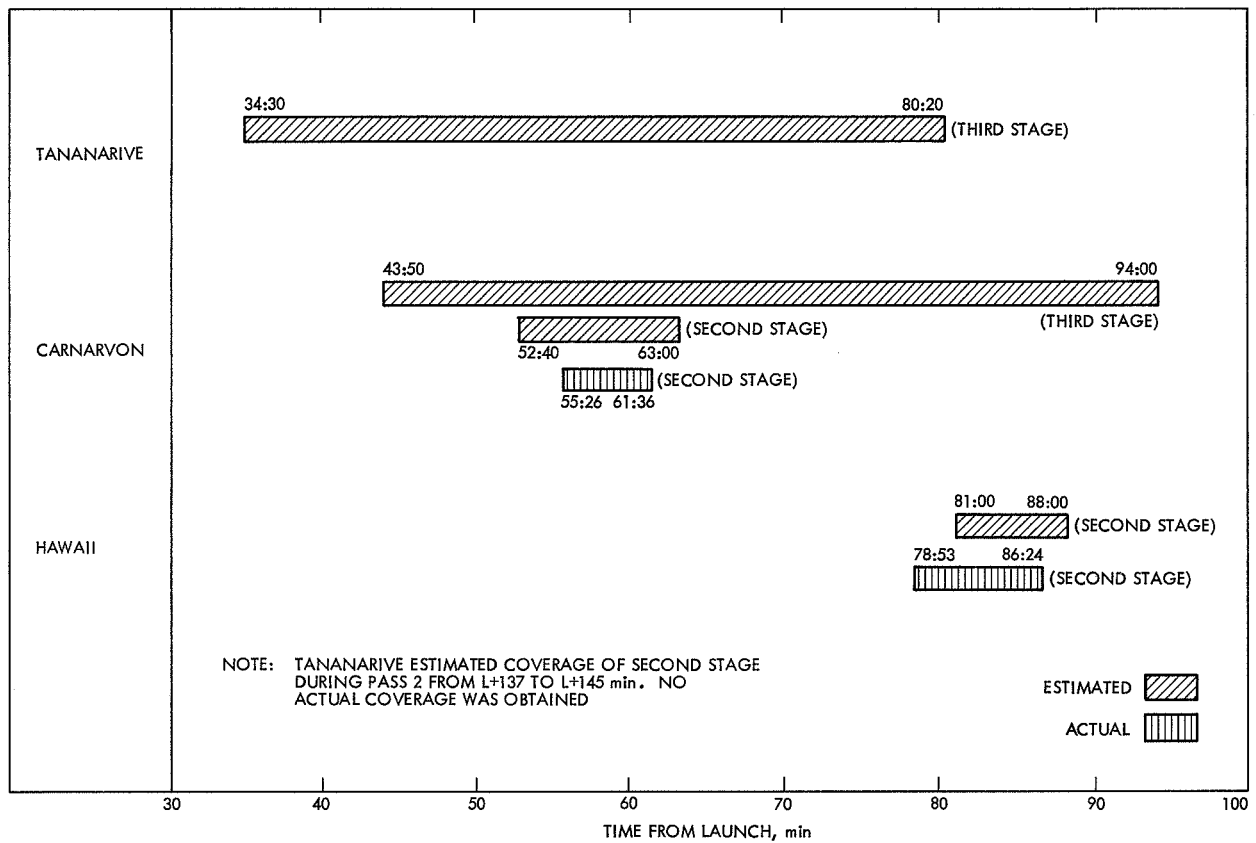


Fig. 62. MSFN radar coverage

Table 53. Pioneer VIII VHF telemetry

Station	Requirements	Predicted AOS-LOS, min:s	Actual AOS-LOS, min:s	Remarks
Bermuda	Receive and record <i>Delta</i> second-stage 234.0-MHz and <i>Delta</i> third-stage 256.2-MHz links on pass 1. Provide real-time readout of mark event 5 (SECO)	None	Pass 1 (second stage): 2:52 to 12:13; pass 1 (third stage): 2:13 to 12:12	Strong RFI ^a was received from local TV station, causing a 120-s dropout of second-stage data shortly after AOS on pass 1. Good signals were reported for remainder of pass. Mark event 5 (SECO) was confirmed at 1416:59
Tananarive	Receive and record <i>Delta</i> second-stage 234.0-MHz link and <i>Delta</i> third-stage 256.2-MHz link on pass 1 on a best-obtainable basis. Receive and record <i>Delta</i> second-stage 234.0-MHz link on pass 2	Pass 1 (second stage): none; pass 1 (third stage): none; pass 2 (second stage): 136:20 to 147:00	Pass 1 (second stage): none; pass 1 (third stage): 34:10 to 72:10; pass 2 (second stage): 134:50 to 144:25	Real-time telemetry transmission requirements to Hangar AE were cancelled during minus count on launch day (reason unknown). Poor, unusable signals were reported from <i>Delta</i> third stage on pass 1. No signals were received from second-stage link during pass 1 because that stage was out of view of telemetry antenna. Good signals were reported from <i>Delta</i> second stage during pass 2
Carnarvon	Receive and record <i>Delta</i> second-stage 234.0-MHz link and <i>Delta</i> third-stage 256.2-MHz link on pass 1 (256.2-MHz link was committed on a best-obtainable basis)	Pass 1 (second stage): 52:20 to 63:20; pass 1 (second stage): none	52:20 to 62:17 41:20 to 80:20	Real-time telemetry transmission requirements to Hangar AE were cancelled before AOS. Hangar AE reported data scheduled for retransmission had been received from other stations. Unusable data were received from <i>Delta</i> third stage because of severe signal fluctuations. Good telemetry data were received from <i>Delta</i> second-stage link
Guam	Receive and record <i>Delta</i> second-stage 234.0-MHz link on pass 1	66:10 to 75:10	64:54 to 74:12	Excellent signals were received from <i>Delta</i> second stage
Hawaii	Receive and record <i>Delta</i> second-stage 234.0-MHz link on pass 1	80:30 to 88:20	—	Fair signals were received from <i>Delta</i> second stage
Guaymas	Receive and record <i>Delta</i> second-stage 234.0-MHz link on pass 1	92:20 to 101:00	90:03 to 99:58	Good signals were received from <i>Delta</i> second stage

^aRFI = radio-frequency interference.

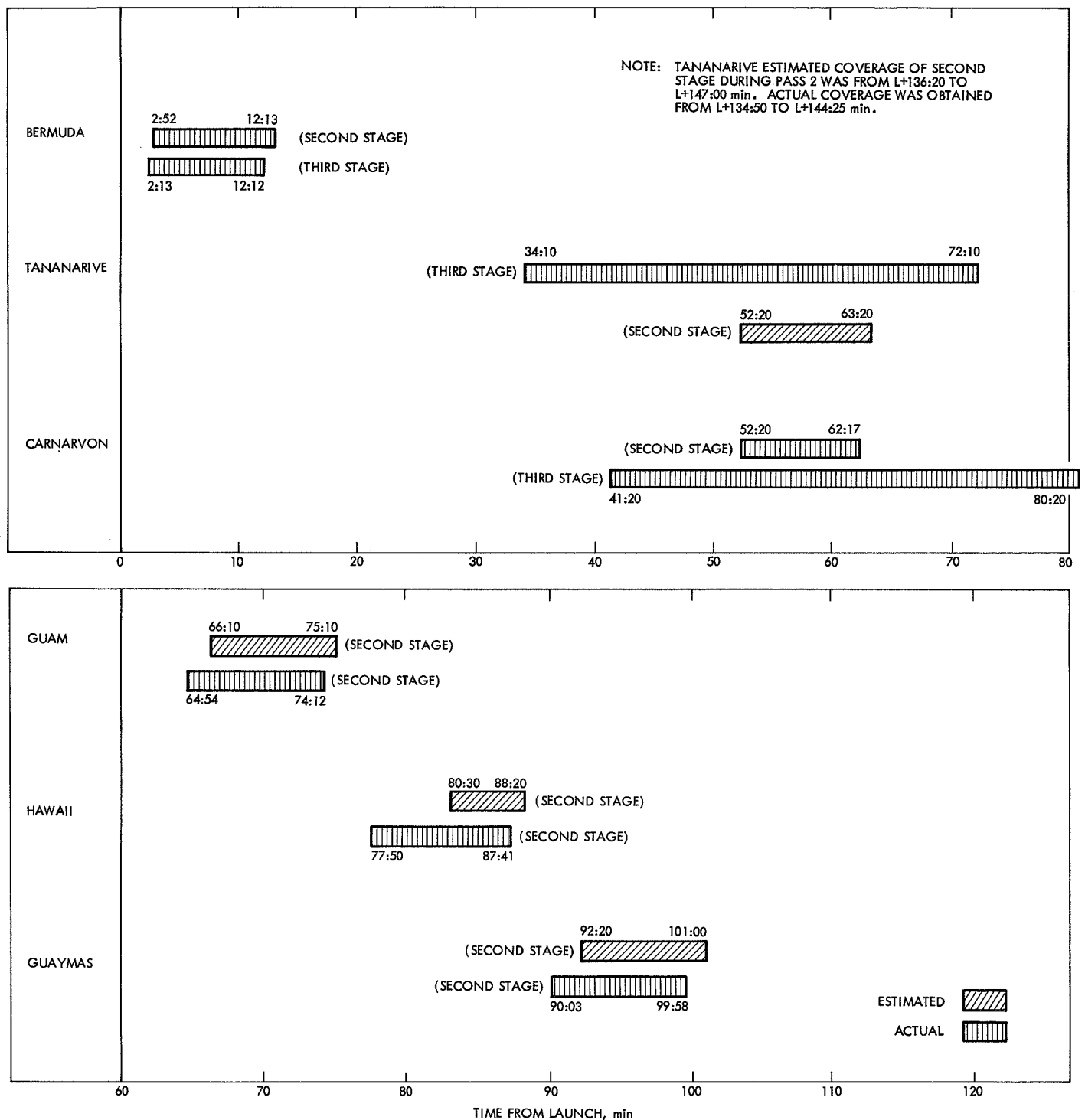


Fig. 63. VHF telemetry coverage at MSFN

Table 54. Pioneer VIII computer support at GSFC data operations branch

Requirements	Support
Provide nominal pointing-data printouts to be used for mission planning purposes and committing MSFN station coverage	Provided
Generate and transmit <i>Delta</i> third-stage pointing data to Tananarive and Carnarvon before L-5 days	Provided
Generate and transmit <i>Delta</i> second-stage pointing data to Tananarive, Carnarvon, Guam, Hawaii, and Guaymas before L-5 days	Provided
Generate and transmit radar-simulation tapes to Tananarive, Carnarvon, and Hawaii	Provided
Receive launch-trajectory data from AFETR via launch trajectory data system, and use data to drive displays at GSFC operations control	Provided
Generate and transmit real-time acquisition messages to participating MSFN sites based on <i>Delta</i> second- and third-stage tracking data	During first operational readiness test, acquisition message for Tananarive was transmitted approximately 6 min after predicted AOS because of problems in calculating nominal <i>Delta</i> third-stage burn maneuver During second operational readiness test, acquisition messages to Tananarive were again delayed because of 7094/494 computer-interface problems 7094/494 computer-interface problems again caused untimely transmission of acquisition messages
Reformat Carnarvon radar data to standard 38-character radar data format for transmission to RTCF at AFETR	1401 computer was used during operational readiness tests and launch because DDP-24 was down for modification. This resulted in approximately 10 min delay in retransmission of Carnarvon data to RTCF
At Hawaii LOS on pass 1, furnish STADAN ^a representative operations control with final orbital vector of <i>Delta</i> second stage for transmittal to NORAD ^b Space Defense Center duty officer at Ent AFB, Colo.	Provided

^aSTADAN = Space Tracking and Data Acquisition Network.
^bNORAD = North American Air Defense Command.

Table 55. Pioneer VIII NASCOM support

Station	Teletype circuits	Voice circuits
Building AO	3	4
DSS 71	3	1
DSS 51	4	1
DSS 41	4	1
DSS 42	2	1
DSS 62	4	1
ARC	7	1
TRW	1	—
Stanford	1	—

of the AFETR and the communication satellite. High-frequency propagation forecasts were provided on all HF radio circuits commencing at L-8 h. NASCOM circuit coverage (long lines and equipment) was furnished on all circuits scheduled to support *Pioneer VIII*.

The low-speed teletype circuits from both DSSs 41 and 51 were patched around the 418/494 communications processors; speed was changed from 60 to 100 wpm at GSFC, and extended to JPL. Three low-speed teletype lines from Building AO were patched around the 494 CP at GSFC, and extended to JPL at 60 wpm.

STADAN used the AFETR-provided voice circuit to Johannesburg in support of the TTS project. The quality was reported to be very good.

Good communication support was realized throughout the near-earth phase, with no significant problems encountered. The overall MSFN ground-communication configuration for *Pioneer VIII* is shown in Fig. 64.

e. Summary. With the exception of the failure of Tananarive to acquire C-band radar and difficulties with the *Delta* third-stage telemetry at Tananarive and Carnarvon, all requested MSFN support was provided.

Carnarvon reported poor C-band beacon returns and severe countdown of the *Delta* third stage, which resulted in their failure to obtain valid track.

Carnarvon reported that neither AFETR look angles nor GSFC DOB acquisition messages were received for the second stage. The station used the acquisition-aid bus for C-band acquisition.

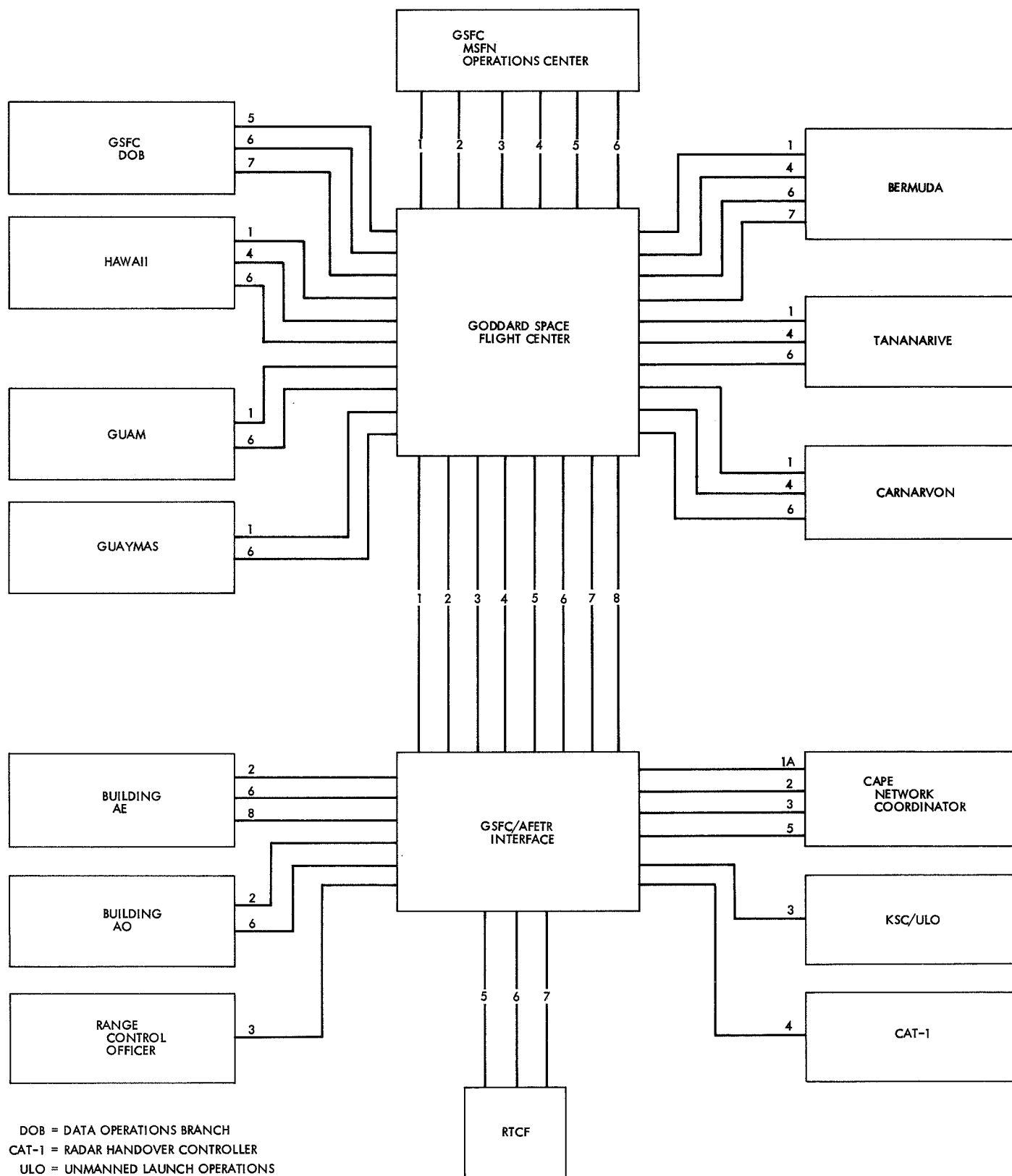


Fig. 64. MSFN ground communications

1. MSFN conference loop between MSFN operations center, Bermuda, Tananarive, Carnarvon, Guam, Hawaii, and Guaymas.
- 1A. "Monitor only" capabilities were extended on MSFN conference to GSFC Cape network coordinator RCC at Cape Kennedy Air Force Station (CKAFS).
2. Status loop between MSFN operations center, CNC, and Buildings AE and AO at CKAFS.
3. Range control officer (RCO) loop between MSFN operations center, CNC, RCO, and KSC/ULO at range control center.
4. Radar handover loop between MSFN operations center, Bermuda, Tananarive, Carnarvon, Hawaii, and radar handover controller CAT-1 at CKAFS.
5. Computer loop between MSFN operations center, GSFC/DOB, CNC, and RTCF at CKAFS.
6. Full-duplex TTY circuits were available between MSFN operations center, Bermuda, Tananarive, Carnarvon, Guam, Hawaii, Guaymas, GSFC/DOB, Building AE, and Building AO. These circuits were used to transmit low-speed radar data and operational traffic. Four full-duplex TTY circuits were available between GSFC and RTCF for transmission of low-speed radar data, interrange vectors, and look angles.
7. One high-speed data circuit was available between Bermuda, GSFC/DOB, and RTCF, and was used for transmission of Bermuda multiplexed FPQ-6 and FPS-16 radar data (2400 bits/s) to GSFC/DOB and RTCF.
8. Voice/data circuit between GSFC and GSFC/AFETR interface building. This circuit was patched to Building AE and at GSFC for Tananarive transmission of velocity-meter readout data. Because only two voice/data circuits were available at Tananarive, and one of these was used for radar handover, it was necessary to use send side of remaining circuit for transmission of Tananarive velocity-meter readout data to Building AE. Receive side of this circuit was to be used by MSFN NC for transmission in blind to Tananarive should need arise.

Fig. 64 (contd)

Both Tananarive and Carnarvon reported poor third-stage telemetry signals (with severe fluctuations) and unusable data on pass 1.

The *Delta* second-stage telemetry was reported by MSFN supporting stations to have good to excellent signals.

During launch minus count, the Cape network controller advised the MSFN network controller that Building AE could not use Tananarive velocity-meter data postpass because inputs had been disconnected. Tananarive was requested to receive and record the data.

During missions such as *Pioneer*, with more than one stage or vehicle to be tracked, it is felt that acquisition messages and look angles should indicate for which stage or vehicle these messages apply.

3. Deep Space Network.

a. Metric data. The trajectory was such that little or no two-way metric data could be obtained by DSS 51. Thus, DSS 41 was the prime acquisition station, and was responsible for obtaining good two-way metric data during the near-earth phase. It was planned that DSS 41 would remain in the one-way mode for the first 5 min after initial acquisition, then go to the two-way mode.

Deep Space Station 41 obtained one-way receiver lock at 1455:42, which was 67 s earlier than predicted. At 1503:59, the transmitter was turned on and the up-link acquisition started. Two-way lock occurred at 1510:52;

however, the station encountered sideband and sidelobe lock-on problems. At 1519:30, DSS 41 again performed the up-link acquisition sequence, and obtained good two-way lock at 1528:12.

b. S-band telemetry. Prelaunch spacecraft telemetry data were transmitted to the SFOF via the GOE and telemetry and command processor at DSS 71 as required. The postlaunch near-earth phase requirements for DSSs 71 and 51 were on a best-obtainable basis only. Deep Space Station 71 received 9 min and 10 s of postlaunch telemetry data; DSS 51 received 11 min and 10 s of data. The initial-acquisition station (DSS 41) was to receive 5 min of telemetry data in the one-way mode before going to the two-way mode with the spacecraft.

The number of telemetry data frames received from each station is listed in Table 56. Twenty frames were missing because of a 10-s communication outage.

Table 56. Near-earth phase, DSN telemetry data received

Station	Number of frames sent to SFOF by TCP ^a	Number of frames received at SFOF	Percent
DSS 71	256	252	98.44
DSS 51	42	42	100.00
DSS 41	908	884	97.36

^aTCP = telemetry and command processor.

C. Deep Space Phase

The main objective of the DSN during the near-earth portion of the *Pioneer VIII* mission was to acquire the spacecraft S-band signals as early as possible to determine orbit parameters, and to acquire telemetry information continuously, with the highest SNR and lowest bit-error rate possible.

Before launch, antenna-pointing and frequency-prediction data, based on an assumed nominal launch and parking-orbit conditions, were provided to the stations as preliminary acquisition data. After launch, predictions based on AFETR tracking data for the first- and second-stage flights, parking orbit, and an assumed nominal third-stage performance were supplied to the DSN stations in near-real-time to make possible the initial acquisition of *Pioneer VIII* by DSSs 51, 41, and 72.

It was the intent of the DSN to furnish all tracking and data-acquisition services that were required by the *Pioneer* Project. However, network capabilities and Project priorities, in general, make it impossible to furnish support that meets all requirements.

The DSN is composed of the DSIF, the GCF, and the SFOF. This configuration is essential for tracking and data acquisition during the deep space phase of each mission.

1. Deep Space Instrumentation Facility. The *Pioneer VIII* spacecraft was launched on December 13, 1967, from the Cape Kennedy facility of the AFETR. Liftoff occurred at 1408:00.265 at a launch azimuth of 108 deg. Injection to solar-transfer orbit was accomplished, and the escape trajectory was attained at 1439:28.552.

2. Deep Space Station performance. This subsection covers the activities of the Deep Space Stations and their performance status from the launch phase through pass 171, inclusive.

a. Data performance.

Launch through pass 15. The Type II orientation maneuver (pass 3 at DSS 12) was performed to establish a spin-axis orientation normal to the plane of the ecliptic. The spacecraft spin axis is positioned to maintain a right angle to the line joining the spacecraft and the sun. When successfully completed, this maneuver provides a 360-deg scan in the ecliptic plane for the on-board in-

struments. The final spacecraft attitude creates a reference well suited for scientific interrogation. Because special equipment is located at DSS 12, it is intended that all Type II orientation maneuvers be conducted and controlled from Goldstone. The best-lock frequency test (pass 9 at DSS 12) is designed to determine the best values of frequencies to which the on-board receivers will most readily respond.

Pass 16 through pass 30. From the time of launch, *Pioneer VIII* was tracked by the Deep Space Stations for real-time telemetry coverage. During this period, the spacecraft was tracked by DSSs 12, 41, and 62 at a telemetry bit rate of 512 bits/s. Low parity error rates obtained indicated that telemetry quality was good. The majority of all passes tracked involved transfers (handovers); consequently, few pure acquisitions were recorded. Special data-point acquisitions performed by DSS 12 were an exception. In brief, performance of all subsystems was exceptional, and data recovery was excellent. The significant events that occurred during this report period are as follows: Goldstone (DSS 12) performed seven special data-point-acquisition tests during pass 24 through pass 30, inclusive. These tests were performed to determine the best values of frequencies to which the on-board receivers would most readily respond. The results of each test are given below in the tracking data summary.

Pass 31 through pass 45. During this period, the spacecraft was tracked by DSSs 12, 41, 51, 62, and (on occasion) 14. Telemetry coverage was at 512 bits/s. Low parity error rates obtained indicated that telemetry quality was good. The majority of all passes tracked involved station transfers (handovers); consequently, few pure, two-way RF acquisitions were recorded. In brief, performance of all subsystems was nominal, and data recovery was exceptionally good.

Pass 46 through pass 79. The spacecraft was tracked during this period by DSSs 11, 12, 14, 41, 42, 51, 61, and 62. Several record-only passes were tracked by DSSs 42, 51, and 61. After launch, most passes involved direct station transfers (handovers); therefore, few pure, two-way RF acquisitions were recorded. The amount of data recovered was excellent, and, because of the relatively few anomalies occurring during this report period, a large percentage of these data was good. Telemetry coverage was at 512 bits/s. The low parity error rates obtained indicated that the telemetry quality was exceptional.

Pass 80 through pass 110. During this period, the spacecraft was tracked by DSSs 11, 14, 41, 42, 61, and 62. Several record-only passes were tracked by DSS 42. The telemetry coverage during this reporting period was predominantly at 512 bits/s. Toward the end of the month, however, the telemetry bit-rate mode was at both 512 and 256 bits/s. (The particular bit-rate mode is selected by the *Pioneer* Project.) The low parity error rate readings (less than 0.116 dBm) obtained for this report period indicated that the telemetry quality was good. Data recovery was excellent, and the amount of good tracking data obtained was very satisfactory. Significant events occurring within this report period are as follows: (1) cosmic-ray detection checks (pass 105 at DSS 11), and (2) Type I and partial Type II orientation maneuver (pass 108 at DSS 62).

Pass 111 through pass 140. The spacecraft was tracked during this period by DSSs 11, 42, 62, and (on occasion) 61. Deep Space Station 42 tracked in a record-only configuration; consequently, a large number of one-way passes were reported for this period. These passes are enumerated and listed below in the telemetry summary. In addition, activity at DSS 42 included several channel 6 data-point-acquisition tests. Limited tracking (three passes) was performed by DSS 61. The prime *Pioneer VIII* tracking stations were DSSs 11 and 62.

Telemetry coverage during this report period was at 16, 64, 256, and 512 bits/s, but predominantly at 256 bits/s. All telemetry bit-rate modes (except 16 bits/s) are covered below. In addition to their discussion, plots of the different bit rates vs day of year are included. Analysis of the bit rate of 16 bits/s is omitted because tracking at that particular rate was practically negligible. In summary, the low parity error rate readings obtained indicated that the telemetry quality was good.

Data recovery was excellent for this period. The percentage of good tracking data obtained was very high—higher than that received during the preceding period. More accurate predicts generated for this period contributed to the improvement. Aside from the data-point-acquisition tests, no significant events occurred during this period.

Pass 141 through pass 171. During this report period, the spacecraft was tracked by DSSs 11, 42, and 61. Beginning with pass 164, DSS 42 tracked for the first time in a two-way configuration; however, before the configuration change, several engineering telemetry tests

for GOE evaluation were performed. Activity at DSS 42 also included several channel 6 data-point acquisitions while in a record-only station ground mode. Deep Space Stations 12 and 62 provided the telemetry GOE and TCP support for DSSs 11 and 61. Spacecraft acquisitions and RF tracking were performed at DSSs 61 and 11. Data recovery by all Deep Space Stations was good for this period. Telemetry coverage was at 16, 64, and 256 bits/s, but predominantly at 64 bits/s. All telemetry bit-rate modes (except 16 bits/s) are presented below. Plots of the different bit rates vs day are also supplied. In general, low parity error rate values were obtained, indicating that the telemetry quality was good.

b. Operational performance. The down-link receiver signal strength, the predicted signal strength, and the receiver bandwidth are given for the respective stations. The predicted signal strength is listed for the purpose of comparing station performances.

Launch through pass 15. The Deep Space Station performances were, in most cases, within an average of ± 5 -dBm range of the predicted down-link receiver signal-strength values.

As reported in the engineering telemetry data, the up-link signal strength for channel 6 had an average maximum of -120 dBm for 10-kW ground-transmitter power. The engineering data processed by the TCP had an assigned up-link value of -153 dBm for one-way passes. This value was consequently neglected in computing the total average up-link signal strength.

Actual minutes tracked were 29,603 as compared with 29,621 min scheduled; as a result, the actual tracking time was only 18 min less than the scheduled time.

The ground transmitter was on for 21,083 min. Because several record-only passes were tracked during this period, any deficit between the transmitter-on time and total time tracked is accountable. In addition, a few transmitter failures were recorded (see Table 57).

Receiver one-, two-, and three-way lock was maintained for 29,467 min. This time represents approximately 99.7% of the actual tracking time. The high percentage indicates that data recovery was very good for this period.

Pass 16 through pass 30. The Deep Space Station performances were, in most cases, within an average of ± 2.0 -dBm range of the predicted down-link receiver signal-strength values.

Table 57. Pioneer VIII telemetry, RF, and command summary

Day	Station	Pass	Monitor		TX Power (KW)	Uplink SS	Downlink SS	RX Number	PER/BR				Frame			TK Data %	CMD TXed	Remarks
			Start (GMT)	Stop (GMT)					8	16	64	256	512	To Bufr	Rc'd	%		
61	41	80	0800	1700	10	-130.04	143.4	2					0.000	2332	2327	99.79	3	GSFC comm processor
61/62	62	80	1600	0100	10	-135.3	143.0	2					0.000	1431	1233	86.16	1	
62	11	80	0000	0900	10	-130.1	143.1	2					0.000	2936	2934	99.93	4	
62	41	81	0800	1700	10	-139.4	143.0	2/1					0.000	2095	2090	99.76	1	
62/3	62	81	1544	0100	10	-130.0	143.1	1					0.000	1434	1423	99.23	1	Record only.
63	11	81	2359	0900	10	-130.8	144.0	1					0.000	2901	2897	99.86	1	
63	42	82	0749	1630	10	-131.0	144.0	1					0.000	1468	1459	99.39	0	
63/4	62	82	1600	0100	10	-128.4	144.2	1					0.004	3713	3710	99.92	1	
63/4	11	82	2352	0900	10	-128.4	144.0	1					0.007	1576	1494	94.97	2	Record only.
64	42	83	0300	1600	10	-130.7	144.4	1					0.001	3754	3749	99.87	0	
64/5	62	83	1500	0100	10	-129.9	142.6	1					0.001	1517	1493	98.41	3	Tuning and London co sor problems.
65	11	83	0000	0900	10	-132.03	144.6	1					0.003	3966	3958	99.80	1	
65	42	84	0800	1600	10	-138.8	143.6	1					0.013	1595	1577	98.87	1	Record only.
65/6	62	84	1500	0100	10	-131.1	142.8	1					0.004	3573	3555	99.50	3	
66	11	84	0001	0900	10	-136.5	144.3	1					0.002	1609	1603	99.63	11	Receiver dropped lock
66	42	85	0800	1600	10	-138.4	143.9	2					0.010	3540	3485	98.44	3	
66/7	62	85	1459	0100	10	-140.7	145.1	2					0.005	1524	1456	95.54	1	Record only.
67	11	85	0000	0900	3	-139.5	144.3	1					0.018	3493	3471	99.32	3	
67	42	86	0800	1600	3	-136.5	143.9	2					0.007	1616	1610	99.63	1	GSFC comm processor
67/8	62	86	1503	0120	3	-138.4	145.8	1					0.018	1632	1507	92.34	1	
68	11	86	0000	0900	1	-142.0	143.6	2					0.004	2637	2628	99.66	3	Record only.
68	42	87	0800	1600	1	-138.2	145.2	2					0.007	1355	1343	99.11	3	
68/9	62	87	1500	0120	1	-140.7	144.1	1					0.007	1355	1343	99.11	3	Record only.
69	11	87	0000	0900	1	-142.6	143.9	2					0.004	1632	1507	92.34	1	
69	42	88	0800	1600	1	-140.3	146.0	2					0.007	1616	1610	99.63	1	GSFC comm processor
69/70	62	88	1500	0110	1	-138.2	145.2	2					0.018	1355	1343	99.11	3	
70	11	88	0027	0900	1	-142.6	143.9	2					0.004	2637	2628	99.66	1	Record only.
70	42	89	0800	1600	1	-140.3	146.0	2					0.007	1616	1610	99.63	1	
70/1	62	89	1500	0101	1	-142.6	143.9	2					0.004	2637	2628	99.66	1	Record only.
71	11	89	2258	0900	1	-140.3	146.0	2					0.007	1616	1610	99.63	1	

Note: Uplink S/S is computed using two-way readings only.

Table 57 (contd)

Day	Station	Pass	Monitor		TX Power (KW)	Uplink SS	Downlink SS	RX Number	PER/HR				Frame			TK Data %	CMD TXed	Remarks
			Start (GMT)	Stop (GMT)					8	16	64	256	512	T ₀ Buff	Rc'd %			
71	42	90	0800	1600	1	-141.9	144.9	1					0.010	1692	1651	93.42	1	Record only
71/2	62	90	1500	0100	1	-139.7	144.3	2					0.046	4156	4151	88.37	3	Record only.
72	11	90	0800	0900	1	-137.49	148.2	2					0.005	1536	1482	89.04	3	Record only.
72/3	42	91	0800	0100	1	-137.49	144.2	1/2					0.006	1536	1438	95.81	0	Record only.
73	42	92	0800	1600	1	-137.59	146.5	1/2					0.001	306	306	100.00	9	Record only.
73/4	62	92	1455	0132	0.1/0.2	one-way only	133.5	1					0.004	1692	1583	93.56	0	Record only.
74	14	92	0800	1000	1	-137.9	144.4	1					0.004	485	444	25.21	2	Linear diplexer configuration antenna to ultracone bypass.
74/5	42	93	0830	1600	1	-137.9	146.1	1/2					0.017	1615	1512	92.34	6	Record only.
75	14	93	0730	1124	1	-123.0	131.6	1	0.000				0.085	3816	3774	94.76	1	Record only.
75/6	62	94	1500	0100	1	-134.8	144.7	1/2					0.023	1632	1551	95.04	3	Record only.
76	11	94	0800	0900	1	-138.7	146.1	1					0.128	3747	3661	94.82	1	Record only.
76/7	42	95	0800	0100	1	-135.0	145.6	1					0.024	1632	1582	96.62	7	Record only.
77	11	95	2358	0900	1	-138.2	146.9	1					0.023	1333	1294	91.22	6	Maser failure
77/8	42	96	0800	1600	1	-133.0	146.3	1					0.646	363	212	58.90	0	Record only.
78	62	97	1430	0000	1	-136.6	145.5	1/2					0.000	2433	2424	99.63	1	Record only.
78/9	11	97	2306	0145	1	-136.6	148.5	1/2					0.058	1525	1473	95.06	9	Record only.
79	14	97	0030	0800	1	-131.8	134.8	2/1					0.063	893	875	93.02	5	Record only.
79/80	42	98	0657	1530	1	-138.0	147.0	1/2					0.040	2143	2097	97.85	0	Record only.
80	11	98	0350	0800	1	-139.6	145.6	1/2					0.197	2024	1909	94.32	7	Record only.
80/1	42	99	0700	1530	1	-137.0	146.7	1/2					0.078	1502	1445	96.21	6	Record only.
81	11	99	0058	0755	1	-137.4	146.5	1/2										
81	42	100	0700	1530	2	-136.5	Not Available	1/2										
81	62	100	1430	0000	2	-136.5	146.1	1/2										

Note: Uplink S/S is computed using two-way readings only.

Table 57 (contd)

Day	Station	Pass	Monitor		TX Power (KW)	Uplink SS	Downlink SS	RX Number	PER/BR				Frame		TK Data %	CMD TXed	Remarks
			Start (GMT)	Stop (GMT)					8	16	64	256	512	To Huff			
81/82	11	100	2309	0800	2	-137.4	147.0	1/2	0.000		0.001	0.457	3516	3269	92.97	7	Record only.
82	42	101	0700	1530	2	-137.0	147.6	1/2			0.001	0.186	576	553	96.01	0	
82/83	61	101	2030	0000	2	-137.0	146.7	1/2			0.008		2154	2100	97.49	3	
83	42	102	0700	1530	2	-137.1	146.6	1/2								0	Record only.
83	62	102	1430	0000	1	-138.0	146.3	1/2			0.006	0.085	1417	1359	95.91	5	
83/84	11	102	2258	0800	2	-137.2	148.2	1/2			0.006	0.383	3406	3358	98.59	3	
84	42	103	0700	1530	1	-138.5	147.2	1/2			0.007	0.089	1511	1434	94.90	0	Record only.
84	62	103	1430	0000	1	-138.5	146.5	1/2								5	
85	42	104	0800	1500			148.0	1/2								0	
85/86	62	104	1420	0100	2	-136.1	146.7	1/2			0.023	0.116	1668	1565	93.82	5	Record only. Cosmic ray detection checks. Record only.
86	11	104	0000	0904	1.2	-137.4	148.3	1/2			0.008	0.273	2123	2117	99.72	12	
86	42	105	0800	1500	2	-136.3	147.2	1			0.009		2027	2014	99.36	0	
87	11	105	0000	0900	2	-136.3	148.5	1								132	
87	42	106	0800	1500			150.0	1/2								0	
87/88	62	106	1416	0100	2	-136.3	147.0	1/2			0.059	0.218	1220	1123	92.05	72	DSS TCP problems. Record only.
88	11	106	0000	0900	2	-138.2	148.4	1/2			0.020		2201	2191	99.55	7	
88	42	107	0800	1500	2	-137.3	148.3	1/2			0.024	0.360	1679	1544	91.96	0	
88/89	62	107	1416	0100	2	-137.3	146.9	1/2								7	Record only. Spacecraft reorientation antenna pointing problems.
89	42	108	0800	1500			149.1	1/2								0	
89/90	62	108	1415	0100	2	-134.5	146.3	1			0.050	0.143	1597	1127	70.57	17	
90	11	108	0000	0900	2	-137.1	147.3	1/2			0.033	0.753	2168	2091	96.44	1	Record only. GOE failure.
90	42	109	0800	1500	2	-135.4	148.3	1/2			0.025	0.088	1440	1327	92.15	0	
90/91	62	109	1412	0100	2	-135.4	146.3	1/2			0.001	0.109	1661	1551	93.38	9	
91/92	62	110	1411	0100	2	-137.0	146.5	1/2	0.000							11	

Note: Uplink S/S is computed using two-way readings only.

Table 57 (contd)

DSIF	Pass	Day	Monitor		TX Power (kw)	Uplink SS Two Way Only	Downlink SS	RX Number	P _{ET} /Dr				Frame			CMD TXcd	TK Data %	Remarks
			Start (GMT)	Stop (GMT)					8	16	64	256	512	To Buff	RC'd	%		
62	111	096	1411	0000	2	-137.7	-147.2	1/2		0.000		0.004	0.179	1567	1520	97.00	94.06	Record only. Spacecraft Receiver 2 to high gain antenna at 0430.
62	112	093	1412	0000	2	-137.1	-147.2	1/2		0.004		0.007	0.198	1548	1417	91.53	96.95	
62	113	094	1412	0000	2	-137.2	-147.2	1/2		0.004		0.003		1519	1431	94.20	95.80	
62	114	095	1415	0000	2	-137.0	-147.2	1/2		0.000		0.008		1413	1387	98.16	97.15	
11	114	096	0000	0900	2	-137.1	-149.5	1/2				0.059		2123	2038	95.99	94.06	Record only. Spacecraft Receiver 2 to high gain antenna at 0430.
42	115	096/097	0800	1500	2	-137.9	-148.7	1/2		0.005		0.052		1728	1530	88.54	80.89	
61	115		1423	0100														
11	115	097	0000	0900	3	-129.8	-150.4	2		0.119		0.119		1944	1733	89.14	97.94	
42	116	097	0800	1500	3/1	-126.1	-148.0	1/2		0.007		0.007	0.416	1551	1499	96.65	97.07	Record only.
62	116	097	1415	0000														
11	116	098	0000	0900	1	-122.1	-147.0	2		0.001		0.001		2254	2248	99.73	96.01	
42	117	098	0800	1500	3/1	-126.9	-148.5	1/2		0.017		0.017		1557	1552	99.68	94.04	
62	117	098	1415	0000	1	-122.3	-146.5	2		0.001		0.001	0.329	2455	2427	98.86	97.53	Record only.
11	117	099	0000	0900	1	-135.8	-149.3	1/2				0.012		1485	1431	96.36	96.20	
42	118	099	0757	1500	3/1	-126.3	-147.7	1/2		0.000		0.157		1806	1722	95.35	94.20	
62	118	099	1415	0000	0.2	-134.4	-148.7	2				0.001	0.478	1511	1492	98.74	95.87	
11	118	100	0000	0900	0.1	-134.7	-145.8	1/2				0.001	0.034	1489	1467	98.52	93.84	Record only. Operator command problems, DSS 12 GOE.
42	119	100	0743	1500	3/0.1	-137.4	-147.8	1/2				0.005		2178	2167	99.49	98.00	
62	119	100	1415	0000	0.1	-135.8	-149.3	1/2										
11	119	101	0000	0900	0.1	-134.7	-145.8	1/2				0.001	0.034	1489	1467	98.52	93.84	
42	120	101	0743	1500	0.1	-134.7	-145.8	1/2				0.005		2178	2167	99.49	98.00	Record only - Receiver 1 problems. TDH Punch 1 fail; AFS problem.
62	120	101	1415	0000	0.1	-134.7	-145.8	1/2				0.005		2178	2167	99.49	98.00	
11	120	102	0000	0900	0.1	-131.4	-146.4	2										
42	121	102	0754	1500	3/0.1	-131.9	-149.2	1/2		0.011	Bad			1740	1602	92.07	89.40	
61	121	102/103	1416	0100														TDH DCC problem. Record only - Receiver 1, FTS, IMP, and AFS problems. Record only. Receiver 1 failure.
11	121	103	0000	0919	0.1	-132.0	-147.4	2		0.000		0.002		3476	3451	99.28	89.16	
42	122	103	0755	1500														
11	122	104	0000	0900	0.1	-133.1	-148.4					0.011		2010	1991	99.05	96.93	
42	123	104	0751	1500	0.1	-138.9	-146.4	2		0.034		0.034	0.128	1536	1340	87.24	91.17	Record only. Receiver 1 failure.
62	123	10	1415	0000														

Table 57 (contd)

DSIF	Pass	Day	Monitor		TX Power (kw)	Uplink SS Two-Way Only	Down-link SS	RX Number	Per/Br				To Buff	Frames		CMD TXed	TK Data %	Remarks
			Start (GMT)	Stop (GMT)					8	16	64	256	512	RC'd	%			
11	123	105	0000	0090	0.1	-135.2	-147.7	1/2				0.013	0.926	2178	99.50	2	95.80	Record only.
42	124	105	0750	1500			-149.5									0		Recorder problem.
62	124	105	1415	2300	0.1	-138.0	-146.2	1/2				0.006	0.133	1359	95.56	5	93.16	
11	124	105/106	2208	0904	0.1	-134.2	-147.7	2				0.073		2323	94.66	1	96.70	Record only.
42	125	106	0747	1500			-148.8									0		
62	125	106	1400	2100	0.1	-138.4	-146.5	1/2				0.007	0.186	930	97.68	5	96.32	
11	125	106/107	2207	0901	0.1	-134.2	-147.7	2			0.000	0.011		4464	97.63	5	96.99	Record only.
42	126	107	0755	1500			-149.4					0.035	0.131	1117	97.14	5	93.36	
62	126	107	1400	2100	0.1	-129.4	-146.7	1/2				0.016		1085	98.97	8	93.73	
11	126	107/108	2205	0900	1.0	-124.2	-147.4	2			0.000			4238				
42	127	108	0758	1500	0.1/3		-148.8	1/2								0		Record only - Data point acquisition channel 6.
62	127	108	1400	2100	0.1	-134.9	-147.1	1/2				0.018	0.181	1088	96.05	5	94.08	
11	127	108/109	2203	0900	0.1	-125.1	-147.9	2				0.041		3769	96.23	7	95.41	
42	128	109	0755	1500	3		-148.4	1/2								0		Record only - Data point acquisition channel 6.
62	128	109	1400	2100	0.1	-124.6	-147.4	2				0.010		1056	1007	4	93.82	
11	128	109/110	2217	0900	1	-125	-148.7	1/2				0.001	0.029	3546	98.99	8	94.52	Duty cycle store.
42	129	110	1400	2100	0.1	-123	-147.3	1/2				0.004		1079	98.89	6	92.18	
11	129	110/111	2205	0900	0.1	-125.6	-149.2	1/2	0.000			0.055		3302	96.32	1	94.09	
42	130	111	0754	1500	3		-150.3											Record only.
62	130	111	1400	2100	3.1	-127.2	-147.4	1/2				0.016	0.290	1116	96.78	5	89.82	
11	130	111/112	2200	0902	0.1/1	-125.7	-148.7	1/2				0.057		2626	95.73	2	94.25	
42	131	112	0754	1500	3	-125.2	-150.0					0.003	0.005	1102	95.91	4	91.23	Record only. *Changed to receiver 1 at end of pass.
62	131	112	1400	2100	3	-125.2	-147.5	1/2*										Record only.
11	131	112/113	2200	0900	0.01/1	-125.2	-148.8	1/2				0.000	0.094	2880	94.65	2	91.39	
42	132	113	0756	1500	3		-151.0											Record only.
62	132	113	1400	2300	0.1/1	-125.36	-147.5	1/2				0.015	0.008	1440	97.99	4	96.98	
11	132	113/114	2203	0900	0.1/1	-125.1	-148.5	1/2				0.000	0.141	3581	94.45	6	93.96	
42	133	114	0756	1500	3		-152.8											Record only.
62	133	114	1359	2300	0.1/1	-125.1	-147.8	1/2				0.002	0.006	1418	98.73	1	91.89	
11	133	114/115	2202	0900	0.1/1	-126	-149.5	1/2				0.000	0.117	3322	92.56	2	94.71	
42	134	115	0756	1500	5		-151.4											Record only.
62	134	115	1359	2259	0.2/1	-132	-147.8	1/2				0.008		1422	98.75	1	93.71	
11	134	115/116	2201	0900	0.2/1	-126	-149.3	1/2				0.000	0.172	3061	93.07	2	93.30	Record only.
42	135	116	0800	1500	5		-151.2											
62	135	116	1359	2300	0.2/1	-132	-148.3	1/2				0.009		1518	99.21	4	92.06	

Table 57 (contd)

DSIF	Pass	Day	Monitor		TX Power (kw)	Uplink SS Two Way Only	Down-link SS	RX Number	Per/BR				Frames			CMD TXed	TK Data %	Remarks	
			Start (GMT)	Stop (GMT)					8	16	64	256	512	To Buff	RC'd				%
11	135	116/117	2200	0900	0.2/1	-126.0	-149.2	1/2			0.012	0.156		3301	3070	93.00	4	87.27	Servo hydraulic problem from 0350 to 0421. Record only - Data point acquisition, DIS, LNA, and FR-1400 problems.
42	136	117	0756	1500	5		-150.8	1/2									0		
61	136	117	1400	2300	0.2/1	-127.5	-150.2	1/2			0.001	0.649		1387	1336	96.32	9	95.31	Maser drift problem. Record only - Data point acquisition, DIS, LNA, and FR-1400 problems.
11	136	117/118	2206	0900	0.2/1	-126.1	-149.3	1/2			0.000	0.200		3106	3047	98.10	5	90.86	
42	137	118	0800	1500	5		-151.5	1/2									0		
62	137	118	1400	2300	0.2/1	-125.5	-147.5	1/2			0.004	0.016		1422	1350	94.93	4	95.17	Maser 2 down. Record only - Data point acquisition, DIS, LNA, and FR-1400 problems.
11	137	118/119	2200	0900	0.2/1	-126.2	-149.1	1/2			0.000	0.221		2753	2447	88.88	2	93.36	
42	138	119	0758	1500	5		-151.3	1/2									0		
62	138	119	1400	2300	0.2/1	-126.1	-147.2	1/2			0.000	0.020		1440	1431	99.37	4	94.98	Record only - Data point acquisition and FR-1400 problems.
11	138	119/120	2200	0900	0.2/1	-126.0	-149.5	1/2			0.001	0.276		3734	3461	92.69	4	94.25	
42	139	120	0756	1500	5		-151.6	1/2									0		
11	139	120/121	2200	0700	0.2/1	-126.1	-149.6	1/2			0.000	0.324		3008	2968	98.67	5	96.53	Record only - Data point acquisition and FR-1400 problems. Tape was also damaged.
42	140	121	0554	1500	5		-150.6	1									0		CMD MOD comm problems
11	140	121/122	2200	0700	0.2/1	-126.0	-149.3	1/2			0.000	0.210		2287	2278	99.61	12	91.69	

Table 57 (contd)

DSIF	Pass	Day	Monitor		TX Power (kw)	Uplink SS Two Way Only	Downlink SS	RX Number	Per/Br					Frames			CMD TXed	TK Data %	Remarks
			Start (GMT)	Stop (GMT)					8	16	64	256	512	To Buff	RC'ed	%			
42	141	122	0555	1500	5		-150.5	1/2									0		Record only. Data point acquisition.
61	141	122	1400	2300	0.2	-125.3	-148.2	1/2			0.001	0.104		1402	1352	96.43	7	71.08	IDH problems from 2010 through 2128.
11	141	122/123	2200	0700	0.2	-126.2	-148.9	1/2			0.001	0.229		2348	2300	97.96	13	92.63	Record only from 2200 through 0200.
61	142	123	1400	2300	0.2	-125.8	-149.4	1/2			0.001	0.002	0.130	1318	1249	94.76	18	96.90	TCP timing: from DIS problems.
42	143	124	0558	1500	5		-151.5	1									0		Record only. Channel 6 data point. IMP/DIS; Rx 1 problems.
61	143	124	1358	2300	0.2/1	-125.1	-149.5	2			0.003			1371	1363	99.42	12	92.12	APS program drop out.
42	144	125	0553	1500	5		-151.3	1									0		Record only. Channel 6 data point. IMP/DIS problems.
61	144	125	1358	2300	0.2/1	-126.8	-149.3	2			0.002	0.637		1293	1231	95.20	22	90.31	Channel 7 data point.
11	144	125/126	2202	0701	0.2/1	-126.4	-149.8	2			0.005	0.351		3052	3017	98.85	3	82.75	IMP and APS out to ECO.
42	145	126	0554	1500	5		-151.5	1									0		Record only. Channel 6 data point. IMP/DIS problems U-bus failure.
61	145	126	1354	2300	0.2/1	-125.7	-150.0	2			0.001	0.865		1344	1285	95.61	6	94.86	Maser 2 scheduled down.
11	145	126/127	2206	0700	0.2/1	-126.0	-150.1	2			0.001			2664	2656	99.69	2	88.58	Transmitter failure, SFOF problems.
42	146	127	0555	1500	5		-151.2	1									0		Record only. Channel 6 data point. IAPS problems three doppler (11) problems.
11	146	127/128	2158	0700	0.2/1	-127.2	-150.4	2			0.001			2635	2454	93.13	9	96.54	TCP dropouts excessive.
42	147	128	0556	1500	5		-152.2	1									0		Record only. Channel 6 data point.

Table 57 (contd)

DSIF	Pass	Day	Monitor		TX Power (kw)	Uplink SS Two Way Only	Down-link SS	RX Number	Per/Br					Frames			CMD Tx'ed	TK Data %	Remarks
			Start (GMT)	Stop (GMT)					8	16	64	256	512	To Suff	RC'ed	%			
11	147	128/129	2159	0700	0.2/1	-127.0	-150.5	2			0.000			2651	2553	96.30	3	92.07	TCP problems, Maser 2 down, DIS "A" tape problems - IMP/APS. Record only. Channel 6 data point. Transmitter, antenna, and DIS problems.
42	148	129	0557	1500	10		-152.0	1									0		
61	148	129	1353	2300	0.2/1	-126.7	-149.1	2			0.000	0.230		1300	1251	96.23	5	92.59	GSFC comm processor problems and DIS problems. Channel 7 data point. TDH tape guides. Record only. Channel 6 data point.
11	148	129/130	2200	0700	0.2/1	-127.0	-150.4	2			0.000			4006	4005	99.98	1	93.00	Channel 7 data point. TDH tape guides. Record only. Channel 6 data point.
42	149	130	0553	1500	10		-152.3	1			0.001	0.297		1344	1307	97.25	5	89.49	Channel 7 data points Record only. Data point Channel 6. TDH punch problems.
61	149	130	1352	2300	0.2/1	-125.8	-149.6	2									0		
42	150	131	0554	1500	10		-152.8	1									0		
61	150	131	1351	2300	0.2	-126.1	-149.0	2			0.001			1344	1302	96.88	4	92.59	Comm problems. Record only. Data point Channel 6.
42	151	132	0553	1500	10		-152.7	1									0		
61	151	132	1350	2300	0.2	-126.2	-149.5	2			0.001			1210	1206	99.67	3	89.71	Data point Channel 7.
11	151	132/133	2159	0700	0.2	-127.8	-151.3	2			0.001			3058	3045	99.57	1	95.76	Record only. Rx glitches during 61 APS point Channel 6.
42	152	133	0551	1500	10		-153.0	1									0		
61	152	133	1349	2300	0.2	-126.1	-149.1	2			0.001	0.368		1427	1332	93.34	6	84.13	Problems with Channel 7 data point. Comm problems.
11	152	133/134	2200	0700	0.2	-127.9	-151.3	2			0.001			4167	4156	99.74	1	95.21	Record only. Data point Channel 6. *TLM to line for Engineering evaluation.
42	153	134	0552	1500	10		-153.0	1			0.002			*1426	1413	99.08	0		Transmitter or VCO potentiometer and CEC problems. Record only. APS problems.
61	153	134	1347	2300	0.2	-127.5	-149.2	2			0.000			1375	1328	96.58	3	93.35	
11	153	134/135	2159	0700	0.2		-151.0	2									0		

Table 57 (contd)

DSIF	Pass	Day	Monitor		TX Power (kw)	Uplink SS Two Way Only	Down-link SS	RX Number	Per/Br				Frames		CMD Tx'ed	TK Data %	Remarks
			Start (GMT)	Stop (GMT)					8	16	64	256	512	To Buff			
42	154	135	0601	1500	10		-153.4	1			0.012		*1656	1645	99.34	0	Record only. Data point Channel 6. *TLM to line for engineering evaluation. APS; GCF Comm problems.
61	154	135	1346	2300	0.2	-125.2	-149.9	2			0.001		1404	1369	97.51	3	86.53
11 42	154 155	135/136 136	2159 0554	0700 1459	0.2 10		-151.7 -153.4	2 1			0.015		*1202	1150	95.67	0	Record only. Data point Channel 6. *TLM for engineering evaluation. DIS, TCP, and APS problems.
61	155	136	1346	2300	0.2	-127.5	-148.7	2			0.001		1455	1440	98.97	*3	88.01
11 42	155 156	136/137 137	2159 0553	0700 1458	0.2 10	-128.0	-151.4 -154.1	2 1			0.000		2882	2837	98.44	8	93.36
61	156	137	1400	2300	0.2	-126.7	-148.9	2			0.007		1156	1149	99.39	3	93.25
42 61	157 157	138 138	0554 1347	1457 2300	10 0.2		-153.4 -149.0	1 2			0.005 0.001		*2219 1435	2209 1408	99.55 98.12	0 3	88.59
42	158	139	0552	1457	10		-153.8	1			0.010		*1875	1804	96.21	0	Data point Channel 6. TLM to line at 0709.
61	158	139	1343	2300	0.2	-126.9	-148.9	2			0.002		1370	1355	98.91	3	93.93
11 42	158 159	139/140 140	2200 0553	0700 1500	0.2 10	-128.0	-150.7 -153.2	2 1			0.001 0.002		2636 *2008	2633 2002	99.89 99.70	1 0	93.72
61	159	140	1342	2300	0.2	-127.0	-149.9	2			0.003		1355	1350	99.63	3	91.76

^a Record only. TLM to line for engineering evaluation only.

Table 57 (contd) .

DSIF	Pass	Day	Monitor		TX Power (kw)	Uplink SS TwoWay Only	Down-Link SS	RX Number	Per/Br					Frames		CMD TXed	TK Data %	Remarks
			Start (GMT)	Stop (GMT)					8	16	64	256	512	To Buff	RC'd %			
11	159	140/141	2200	0700	0.2	-128.2	-150.6	2			0.001			2858	2847	99.62	1	TWM 1 inoperative. Doppler resolver problems. Data point Channel 6, TLM to line HA tachometer problems. At 0921.
42	160	141	0553	1450	10		-154.0	1			0.004			^a 1233	1231	99.84	0	
61	160	141	1343	2207	0.2	-127.0	-150.1	2			0.001			1259	1226	97.37	3	Data point Channel 7, APS hits.
11	160	141/142	2135	0700	0.2	-128.6	-152.0	2			0.001			3007	2983	99.20	1	Maser 2 inoperative, Data point Channel 7.
42	161	142	0553	1450	10		-153.5	1			0.002			^a 1225	1216	99.27	0	Data point Channel 6, APS and IMP problems. TLM to line at 0917.
61	161	142	1342	2158	0.2	-126.5	-149.9	2			0.001			1157	1151	99.48	3	Data point Channel 7, APS fixed.
11	161	142/143	2135	0700	0.2	-128.9	-151.5	2			0.000			2894	2872	99.24	5	IMP problems, Data point Channel 7.
42	162	143	0553	1450	10		-153.5	1			0.001			^a 2052	2038	99.32	0	Data point Channel 6, TLM to line at 0653.
61	162	143	1342	2200	0.2	-127.0	-150.0	2			0.001			1254	1227	97.85	3	Data point Channel 7, APS not fixed.
11	162	143/144	2135	0700	0.2	-128.9	-152.2	2			0.003			2796	2777	99.32	1	Data point Channel 7, IMP problems.
42	163	144	0602	1450	10		-153.0	1			0.002			^a 2302	2284	99.22	0	Data point Channel 6, APS operator error.
61	163	144	1341	2157	0.2	-127.1	-150.2	2			0.003			1248	1236	99.03	3	IMP magnetic tape problems.
11	163	144/145	2135	0700	0.2	-128.9	-152.5	2			0.002			2791	2781	99.64	1	Maser 1 scheduled down.
42	164	145	0555	1450	10		-154.1	1			0.029			^b 321	307	95.64	0	Rx 2 lno amplifier problems - TLM from 0600 through 0914.
61	164	145	1346	2210	0.2	-127.4	-149.9	2			0.003			1274	1271	99.76	3	
11	164	145/146	2135	0700	0.2	-129.0	-152.5	2			0.001			^b 2780	2667	95.93	1	Comm problems.
42	165	146	0554	1450	10	Ch. 6	-153.1	1			0.010			2454	2447	99.71	0	Maser 1 scheduled down.
61	165	146	1337	2210	0.2	-127.0	-150.4	2			0.002			^b 1257	1252	99.60	3	
42	166	147	0556	1449	10	D.P.A. Ch. 6	-154.2	1			0.005			1955	1946	99.54	0	Maser 2 prime.

^a Record only. TLM to line for engineering evaluation only.^b TLM to line for GOE evaluation only.

Table 57 (contd)

DSIF	Pass	Day	Monitor		TX Power (kw)	Uplink SS Two-way Only	Down-link SS	RX Number	Per/Br				Frames			CMD TXed	TK Data %	Remarks	
			Start (GMT)	Stop (GMT)					8	16	64	256	512	To Buff	RC'ed				%
61	166	147	1338	2208	0.2	-127.2	-151.1	2			0.002			1344	1341	99.78	6	94.34	Prepass TWX bps in error. Punch 2 problem. First full GOE. Two-way acquisition problems. Transmitter operator error - 40 seconds. CMD verify problems. SFOF comm problems. *Antenna Hi-Speed drive problems. Acquisition problems. Doppler resolver problems. TCP problems. TDH Punch problems, TCP problems. Rx drop after two-way. Ames Research Center GOE mod at DSS 62 record only from 1335 through 1634. Doppler resolver problem track.
42	167	148	0549	1430	10	-132.7	-154.0	1			0.002			2016	2009	99.65	5	97.28	
61	167	148	1339	2240	0.2	-127.0	-151.1	2			0.000			1344	1304	97.02	1	92.33	
11	167	148/149	2140	0640	0.2	-129.0	-152.2	2			0.000			2628	2620	99.70	2	95.85	
42	168	149	0535	1430	10	-133.2	-153.5	1			0.004			2016	2011	99.75	4	94.59	
61	168	149	1340	2240	0.2	-127.1	-151.1	2			0.001			1307	1269	97.09	1	91.34	SFOF comm problems. *Antenna Hi-Speed drive problems. Acquisition problems. Doppler resolver problems. TCP problems. TDH Punch problems, TCP problems. Rx drop after two-way. Ames Research Center GOE mod at DSS 62 record only from 1335 through 1634. Doppler resolver problem track.
11	168	149/150	*2206	0640	0.2	-129.0	-152.9	2			0.001			2736	2714	99.20	3	86.32	
42	169	150	0535	1430	10	-133.3	-154.5	1			0.002			2153	2150	99.86	3	92.91	
61	169	150	1339	2240	0.2	-127.2	-151.0	2			0.001			1336	1316	98.50	7	95.05	
61	170	151	1337	2240	0.2	-127.6	-151.4	2			0.000			1247	1194	95.75	6	90.22	
11	170	151/152	2142	0640	0.2	-129.0	-153.1	2			0.002			2765	2750	99.46	7	91.85	SFOF comm problems. *Antenna Hi-Speed drive problems. Acquisition problems. Doppler resolver problems. TCP problems. TDH Punch problems, TCP problems. Rx drop after two-way. Ames Research Center GOE mod at DSS 62 record only from 1335 through 1634. Doppler resolver problem track.
42	171	152	0526	1430	10	-133.4	-154.5	1			0.001			2771	2700	97.44	3	88.64	
61	171	152	1335	2240	0.2	-127.5	-151.8	2			0.001			898	894	99.55	1	89.35	
11	171	152/153	2140	0640	0.2	-129.0	-151.5	2			0.001			2622	2602	99.24	1	92.63	

The up-link signal strength for channel 6 had an average maximum of -121 dBm for 10-kW ground-transmitter power. The engineering data processed by the TCP had an assigned up-link value of -153 dBm for one-way passes. This value was consequently neglected in computing the total average up-link signal strength.

Actual minutes tracked were 24,263 as compared with 24,214 min scheduled; as a result, the actual tracking time was greater than the scheduled time by 49 min.

The ground transmitter was on for 21,023 min. Because most passes involved direct station transfers (handovers), the somewhat low transmitter-on time indicated is accountable. Normally, a station transfer requires that the incoming station acquire in the three-way mode, and maintain that configuration for $\frac{1}{2}$ h. The transferring process is then undertaken. In general, the transferring station stays in the three-way mode for $\frac{1}{2}$ h after transfer, and terminates tracking immediately afterwards. On the average, therefore, the transmitter is off for a total of 1 h during those passes involving transfer to and from a station. In addition, special data-point-acquisition tests cause periodic transmitter on and off intervals when acquisition on both channels is attempted. When DSS 12 performed such tests during this period, DSS 62 turned off its transmitter 2 h before the end of track in preparation for the test by DSS 12. Acquisition on channel 7 was accomplished by DSS 12; the transmitter was then turned off for approximately 10 min to enable preparation for channel 6 acquisition.

Receiver one-, two-, and three-way lock was maintained for 24,241 min. This time represents 99.9% of the actual tracking time. The high percentage indicates that data recovery was very good for this period. Good data were received for 92.74% of actual tracking time.

Pass 31 through pass 45. The Deep Space Station performances were, in most cases, within an average of ± 2.0 -dBm range of the predicted down-link receiver signal-strength values.

The up-link signal strength for channel 6 had an average maximum of -122 dBm for 10-kW ground-transmitter power. The engineering data processed by the TCP had an assigned up-link value of -153 dBm for one-way passes. This value was consequently neglected in computing the total average up-link signal strength.

Actual minutes tracked were 24,142 as compared with 24,299 min scheduled; as a result, the actual tracking time was less than the scheduled time by 157 min. The most distinguishing factor attributing to the discrepancy is that, on pass 33, DSS 62 terminated actual track $2\frac{1}{2}$ h before the scheduled end of track to provide support for *Lunar Orbiter E*.

The ground transmitter was on for 21,476 min or 88.9% of actual track time. Because most passes involved direct station transfers (handovers), the somewhat low transmitter-on time indicated is accountable. Normally, a station transfer requires that the incoming station acquire three-way lock, and maintain that configuration for approximately $\frac{1}{2}$ h. The transferring process is then undertaken. In general, the transferring (outgoing) station stays in three-way lock for approximately $\frac{1}{2}$ h after transfer, and terminates tracking immediately thereafter. On the average, therefore, the transmitter is off for a total of 1 h during those passes involving transfer to and from a station.

Receiver one-, two-, and three-way lock was maintained for 24,139 min, which is 3 min less than actual tracking time. This time represents 99.9% of the actual tracking time. The high percentage indicates that data recovery was excellent for this period.

Pass 46 through pass 79. The Deep Space Station performances were, in most cases, within an average range of ± 2.0 dBm of the predicted down-link receiver signal-strength values.

The up-link signal strength for channel 6 had an average maximum of -122 dBm for 10-kW ground-transmitter power. The engineering data processed by the TCP had an assigned up-link value of -153 dBm for one-way passes. This value was consequently neglected in computing the total average up-link signal strength.

Pass 80 through pass 110. See Table 57 for the down-link receiver signal strength recorded for each pass by the Deep Space Stations. The signal-strength values are plotted in Fig. 65 to graphically illustrate the characteristic trends (if any) of individual station performances. The predicted down-link signal-strength curve is shown superimposed over the actual down-link signal-strength values to establish the accuracy of the predictions. Figure 65 indicates that, with the exception of DSS 11, all stations seem to have been consistent with their own

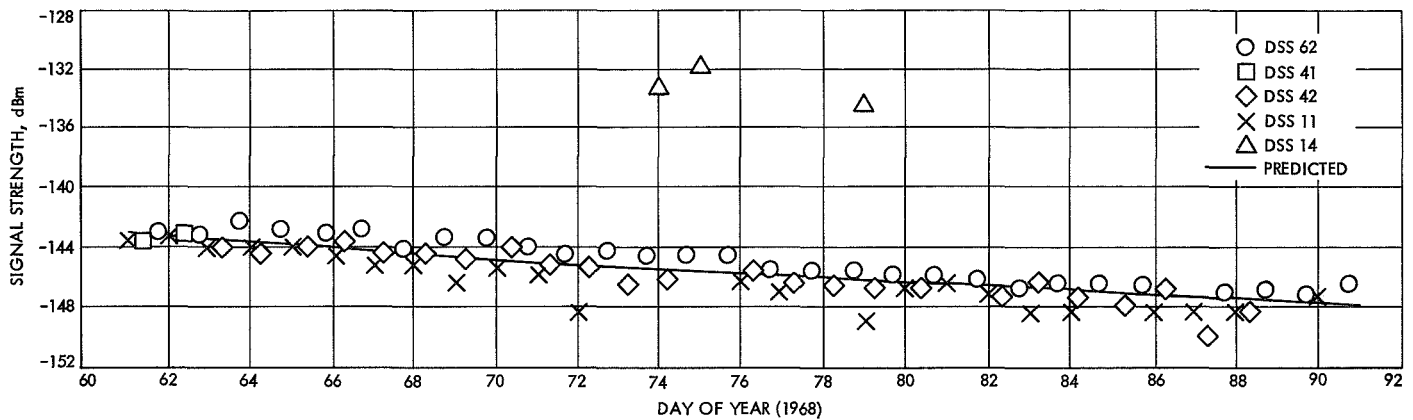


Fig. 65. Down-link signal strength vs time, pass 80 through pass 110

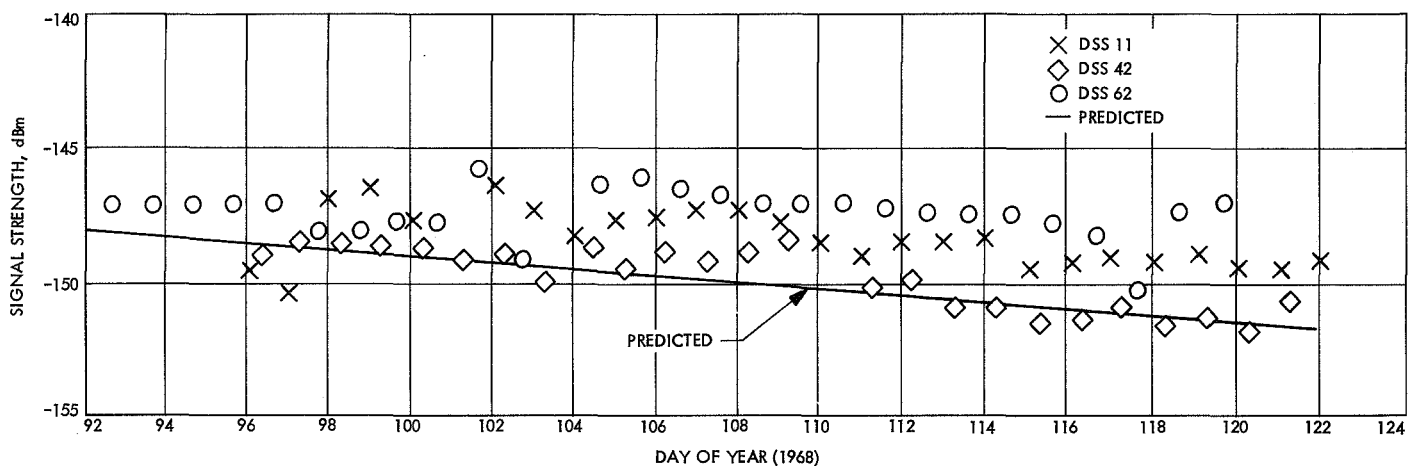


Fig. 66. Predicted vs actual down-link signal strength, pass 111 through pass 140

signal-strength performances. According to the values plotted in this figure, the values recorded for DSS 11 deviate—at times substantially—between consecutive passes. It is suspected that the pretrack calibration procedures performed at DSS 11 might have been somewhat different from those taken at the other Deep Space Stations.

The up-link signal-strength values recorded on the engineering telemetry printout are listed in Table 57, along with the corresponding transmitter power applicable to each signal-strength value. The engineering data processed by the TCP had an assigned up-link value of -153 dBm for one-way passes. The assigned up-link value of -153 dBm is of no consequence and, therefore, is not listed for one-way passes.

Pass 111 through pass 140. See Table 57 for the down-link receiver signal strength recorded for each pass by the

Deep Space Stations. The signal-strength values are plotted in Fig. 66 to graphically illustrate characteristic trends (if any) of individual station performances. The predicted down-link signal-strength curve is shown superimposed over the actual down-link signal-strength values to establish the accuracy of the predictions. Figure 66 indicates that the trend of the true data points is actually sloping downward, as predicted. However, near the end of the period, the predicted curve descends at a slightly faster rate than the actual values.

The up-link signal-strength values recorded on the engineering telemetry printout are listed in Table 57, along with the corresponding transmitter power applicable to each signal-strength value. The engineering data processed by the TCP had an assigned up-link value of -153 dBm for one-way passes. The assigned up-link value of -153 dBm is of no consequence and, therefore, is not listed for one-way passes.

Pass 141 through pass 171. See Table 57 for the down-link receiver signal strength recorded for each pass by the Deep Space Stations. The signal-strength values are plotted in Fig. 67 to graphically illustrate the characteristic trends (if any) of individual station performances. The predicted down-link signal-strength curve is shown superimposed over the actual down-link signal-strength values to show the accuracy of the predictions. Figure 67 indicates that DSS 61 signal-strength values are very optimal—stronger than the expected signal levels. It should be noted that the antennas at DSSs 11 and 61 have linear-to-circular polarization. The antenna at DSS 42 did not yet have this capability. The data points plotted for DSS 11 lie about 1.5 dB below the expected value. The signal-strength performance of a station is considered self-consistent only if these values lie within 1 dB on succeeding passes. The signal-strength values at DSSs 11 and 61 apparently did not meet this condition; consequently, the operation engineering group initiated an investigation of the possible cause. Indications were that the fault lay in the manner in which the pretrack calibrations were taken at these stations. Values recorded from the different stations should be within 1.5 dB of each other for good performance. The DSS 42 signal-strength performance for this period was good.

The up-link signal-strength values recorded on the engineering telemetry printout are listed in Table 57,

along with the corresponding transmitter power applicable to each signal-strength value. The engineering data processed by the TCP had an assigned up-link value of -153 dBm for one-way passes. The assigned up-link value of -153 dBm is of no consequence and, therefore, is not listed for one-way passes.

The telemetry, RF, and command summary for *Pioneer VIII* is given in Table 57. The column headings in this table are as follows:

- (1) Day: 1968 day number; if day crosses 0000 GMT, both day numbers are given (e.g., 096/097).
- (2) Station: number of Deep Space Station tracking.
- (3) Pass: applicable pass number (or number of times spacecraft has passed over station).
- (4) Monitor Start (GMT): time at which data monitor began.
- (5) Monitor Stop (GMT): time at which data monitor ended.
- (6) TX Power (KW): power setting of ground transmitter.
- (7) Uplink SS: average up-link signal-strength value, dBm.

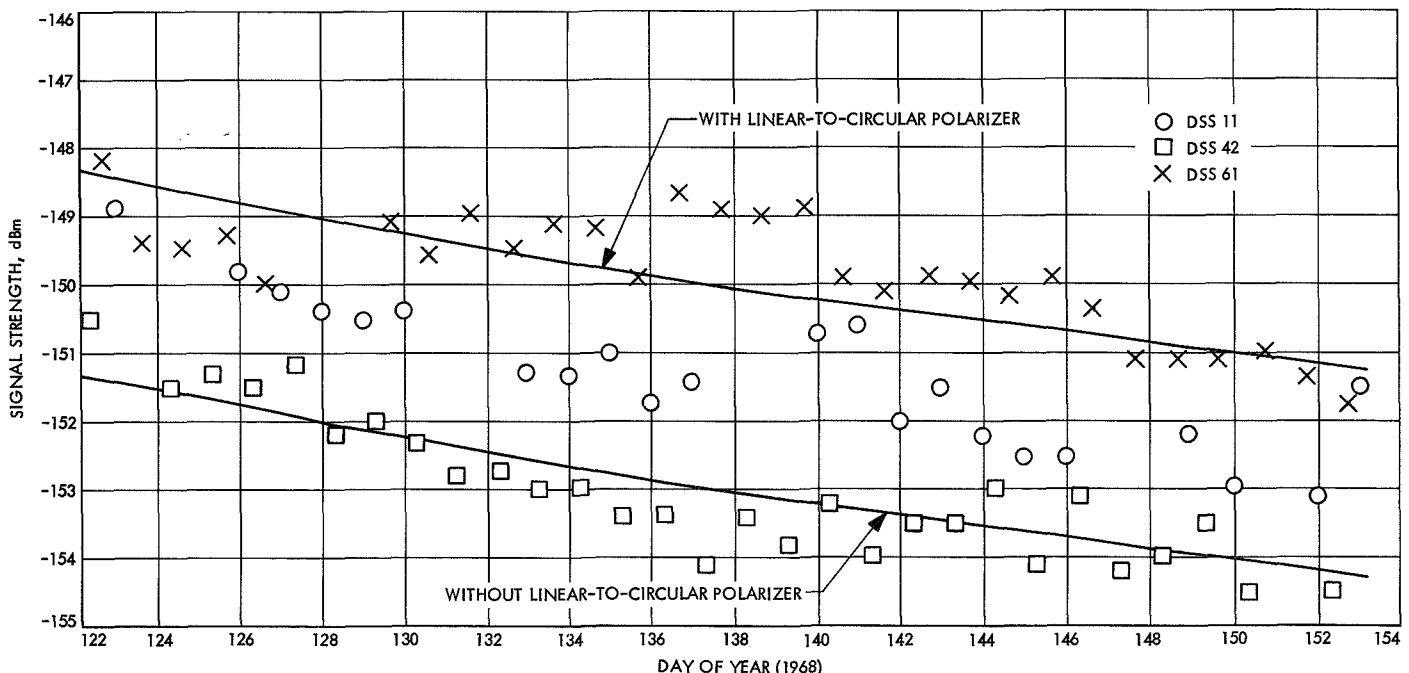


Fig. 67. Down-link signal strength vs time, pass 141 through pass 171

- (8) Downlink SS: average down-link signal-strength value, dBm.
- (9) RX Number: applicable receiver (1 or 2) used for tracking.
- (10) $\overline{\text{PER}}/\text{BR}$: average parity error rate over applicable telemetry mode (8, 16, 64, 256, or 512 bits/s) of spacecraft.
- (11) Frame To Buff: number of telemetry frames requested to go to computer buffer.
- (12) Frame Rc'd: number of telemetry frames actually received at computer buffer.
- (13) Frame %: percentage of number of telemetry frames received over number requested.
- (14) TK Data %: percentage of good tracking data received.
- (15) CMD TXed: total number of commands transmitted per pass.
- (16) Remarks: significant events, anomalies, etc. (anything affecting data quality).

c. Tracking performance. The tracking data performance is a summary by passes of all good tracking data available for *Pioneer VIII* trajectory analysis and orbit determination.

Launch through pass 15. The total number of minutes of good data obtained by the Deep Space Stations from launch through pass 15 is 27,570 (Table 58).

Pass 16 through pass 30. The total number of minutes of good data obtained by the Deep Space Stations from pass 16 through pass 30 is 22,503 (see Table 58).

Pass 31 through pass 45. The total number of minutes of good data obtained by the Deep Space Stations from pass 31 through pass 45 is 21,950 (see Table 58). This figure constitutes 90.9% of the total actual tracking time.

Pass 46 through pass 79. The total number of good tracking samples obtained by the Deep Space Stations from pass 46 through pass 79 is 77,764. Most of these tracking points were taken at a sample rate of 60 s, some at 10 s, and a few at 1 s. The total number of tracking samples recorded for this period was 81,230, which means that good data were obtained for 95.73% of the total amount of data recovered. It should be noted that the tracking data taken in record-only passes constitute no part in the value of the above figures.

Table 58. *Pioneer VIII* scheduled and actual tracking data

Overall performance	Minutes	Percentage
Passes 1 through 15		
Scheduled	29,621	100.0
Actual	29,603	99.93
Transmitter on	21,083	71.21 ^a
Receiver in lock (one- and two-way)	29,467	99.54 ^a
Good tracking data	27,570	93.13 ^a
FR-1400 in lock	29,467	99.54 ^a
TCP in lock	29,265	98.85 ^a
Demodulator in lock	29,467	99.54 ^a
Passes 16 through 30		
Scheduled	24,214	100.0
Actual	24,263	100.2
Transmitter on	21,023	86.64 ^a
Receiver in lock (one-, two-, and three-way)	24,241	99.90 ^a
Good tracking data	22,503	92.74 ^a
FR-1400 in lock	24,241	99.90 ^a
TCP in lock	24,241	99.90 ^a
Demodulator in lock	24,241	99.90 ^a
Passes 31 through 45		
Scheduled	24,299	100.0
Actual	24,142	99.3
Transmitter on	21,476	88.9 ^a
Receiver in lock (one-, two-, and three-way)	24,139	99.9 ^a
Good tracking data	21,950	90.9 ^a
FR-1400 in lock	24,139	99.9 ^a
TCP in lock	24,129	99.9 ^a
Demodulator in lock	24,139	99.9 ^a
^a The indicated percentages are calculated with the actual time used as reference.		

Pass 80 through pass 110. Tracking was performed per specification at a 60-s sample rate until meridian crossing. After meridian crossing ($358 \text{ deg} \leq \text{HA} \leq 001 \text{ deg}$), the Deep Space Stations were requested to take 12 min (approximately) of 1-s data at least once a week.

Figure 68 plots the percentage of good tracking data received per pass by the individual stations. It should be noted that a greater percentage of good tracking data was recovered at the beginning of the period. Tracking was done on channel 6 during the first part of March; acquisitions on both channels 6 and 7 were performed later in the month, thereby accounting for the larger amount of bad tracking data. Overall, good tracking data were obtained for 84.58% of the total actual tracking time.

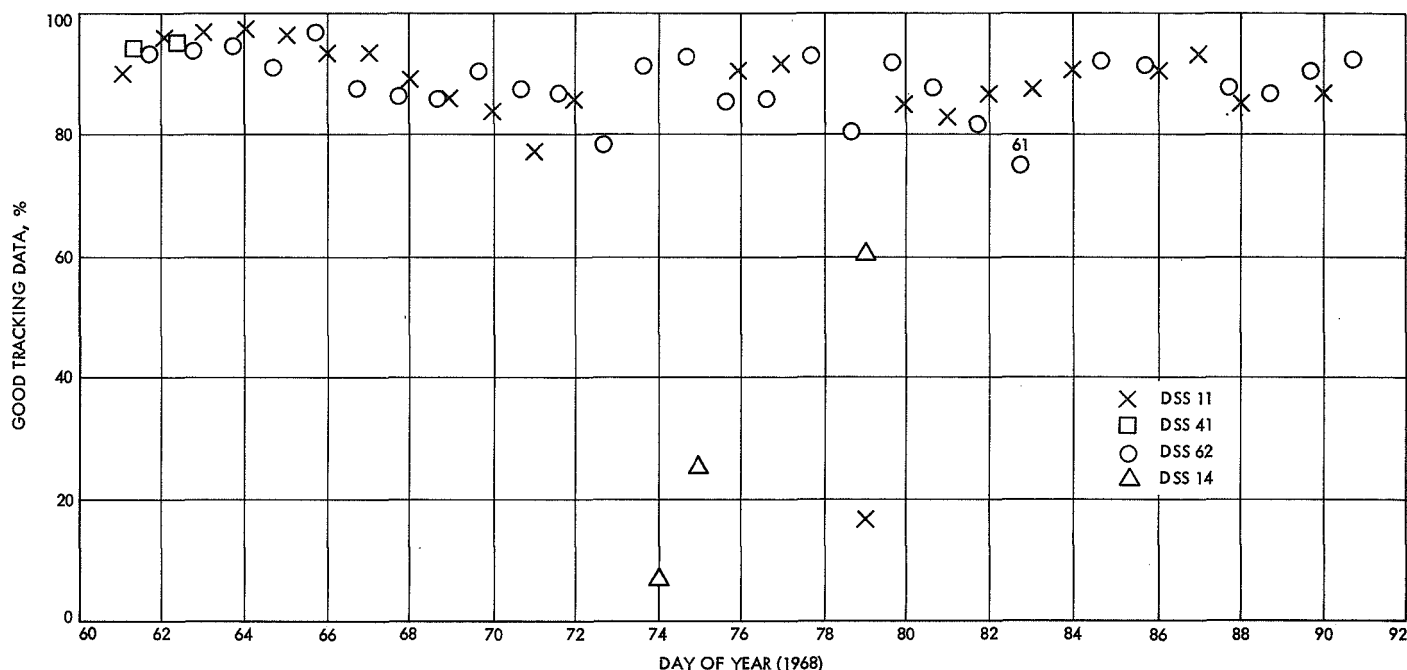


Fig. 68. Percentage of good tracking data vs time, pass 80 through pass 110

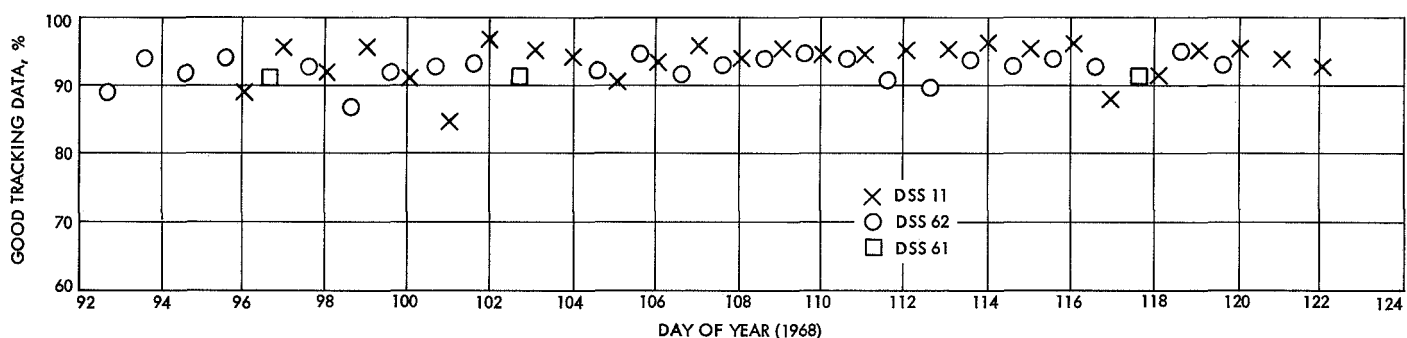


Fig. 69. Percentage of good tracking data vs time, pass 111 through pass 140

Pass 111 through pass 140. Tracking was performed per specification at a 60-s sample rate at all times; at least once a week, each two-way station was required to go to a 1-s sample rate at meridian crossing ($358 \text{ deg} \leq \text{HA} \leq 001 \text{ deg}$). The two-way stations were requested to take 12 min (approximately) of 1-s data.

Figure 69 plots the percentage of good tracking data received per pass by the individual stations. As reported, the overall percentage of good tracking data obtained in April was very high—higher than the March percentage. Acquisition tests performed on channels 6 and 7 to determine the best-lock frequency for each channel were frequent during this period. Several tests on channels 6 and 7 were undertaken by DSSs 11, 61, and 62 (DSS 42

performed the data-acquisition tests on channel 6 only). Results of frequency tests enabled the generation of better predicts, thereby increasing the amount of good data received during this period. Overall, good tracking data were obtained for 92.83% of the actual tracking time. In contrast, the percentage for the previous period was 84.58%. It should be noted that reduction of one-way passes is not given in this presentation.

A low percentage of good tracking data was received on pass 121 at DSS 11. The TDH was reading out a bad data condition code when the data were in effect good. If the data had been considered bad, the percentage of good data would have been 76%; however, because the data can be considered good, the percentage of good data increases to 95.74%.

Pass 141 through pass 171. Tracking was performed per specification at a 60-s sample rate at all times; at least once a week, each two-way station was required to go to a 1-s sample rate at meridian crossing ($358 \text{ deg} \leq \text{HA} \leq 001 \text{ deg}$). At that time, the stations were requested to take approximately 12 min of 1-s data.

Figure 70 plots the percentage of good tracking data received per pass by the individual stations. Except for three instances, the percentage of good data obtained

was very high in all cases. The three instances in which the amount of good data received was somewhat lower than the monthly overall average are discussed below. The overall percentage of good data obtained for this period was 92.82%, which indicates that a large amount of good tracking data was obtained during this period by the Deep Space Stations.

The following formulates two methods of percentage computations:

$$\begin{aligned} \text{DSN percentage} &= 100 \times \frac{\text{total samples recorded} - (\text{total good DCC}^{11} \text{ samples} - \text{garbled good DCC samples})}{\text{total samples recorded}} \\ &= 100 \times \frac{\text{total usable samples}}{\text{total samples recorded}} \\ \text{SDA}^{12} \text{ percentage} &= 100 \times \frac{\text{total minutes of good tracking data}}{\text{total minutes of tracking}} \end{aligned}$$

Therefore, the DSN percentage is a point (sample) percentage and the SDA percentage is a time percentage.

d. Telemetry performance.

Launch through pass 15. The quality of real-time telemetry is indicated by the PER printout on the engineering telemetry data sheet. A PER of 0.116 is equivalent to 1 error in 1000 consecutive bits of information, and is regarded as the threshold value.

The telemetry bit-rate mode was constant at 512 bits/s. It should be noted that error rates diminish in significance as the time of recording becomes greater from the time of spacecraft maximum elevation. The desired situation is achieved when the time of recordings is bounded by a limit of $\pm 3 \text{ h}$ from maximum elevation time. The average monthly PER for the combined stations was 0.003 for this report period.

The percentage performance for the analog tape recorder (FR-1400), TCP, and GOE demodulator was itemized above (see Table 58). The operation of the preceding subsystems indicates that the FR-1400 recorders were functioning normally throughout the receiver in-lock periods at all stations. On pass 3 at DSS 62, various spurious interruptions were experienced at different por-

tions of the pass. Another problem was that the station, while in three-way track, was not informed that the bit-rate mode was changed from 512 to 16 bits/s. The TCP was out of lock for a total of 130 min during pass 3. On pass 9 at DSS 12, the TCP failed twice, and was taken off line temporarily; 72 min of lost data resulted. Consequently, the TCP was out of lock for 98.85% of actual tracking time for this report period (see Table 58).

Figure 71 is a plot of the spacecraft receiver temperatures vs time from launch. This graph shows the initial temperature to be 78°F for both of the *Pioneer VIII* receivers. This temperature was maintained by receiver 1 for 90 min after liftoff. Receiver 2 had a temperature change at $L+85 \text{ min}$. Both receiver temperature curves eventually sloped downward. At $L+270 \text{ min}$, the difference between the two temperatures was 2°F . For purposes of comparison, the temperatures of both *Pioneer VII* receivers are also plotted.

Pass 16 through pass 30. The telemetry bit-rate mode was constant at 512 bits/s. The average PER for the combined stations was 0.0006 for this report period.

The percentage performance for the FR-1400 recorder, TCP, and GOE demodulator was itemized above (see Table 58). The operation of the preceding subsystems indicates that the FR-1400 recorders were functioning normally throughout the receiver in-lock periods at all

¹¹DCC = data condition code.

¹²SDA = systems data analysis.

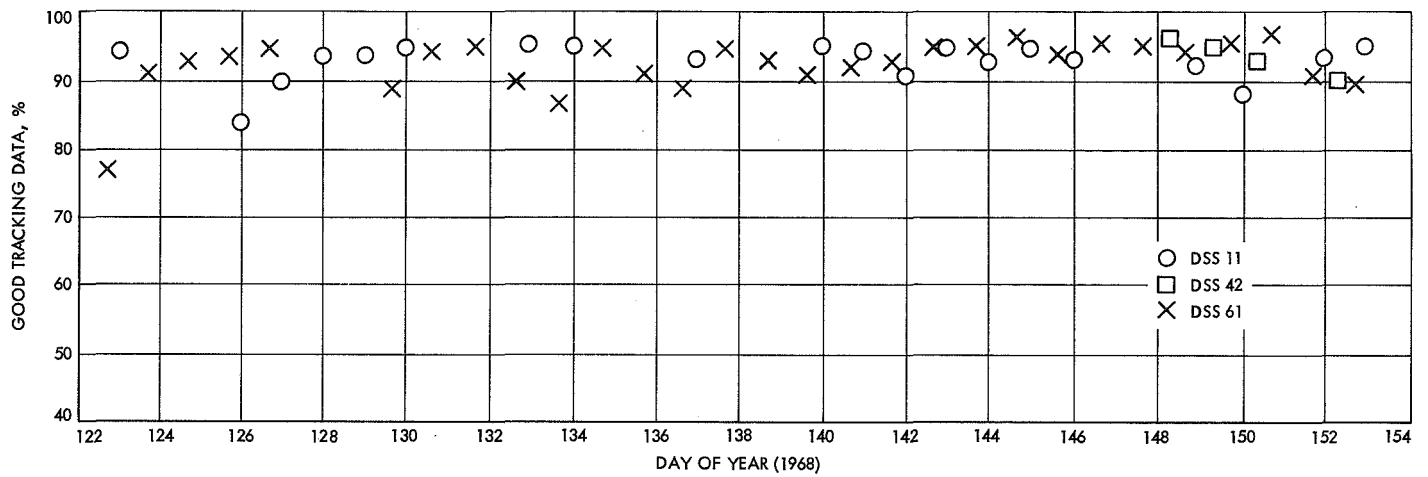


Fig. 70. Percentage of good tracking data vs time, pass 141 through pass 171

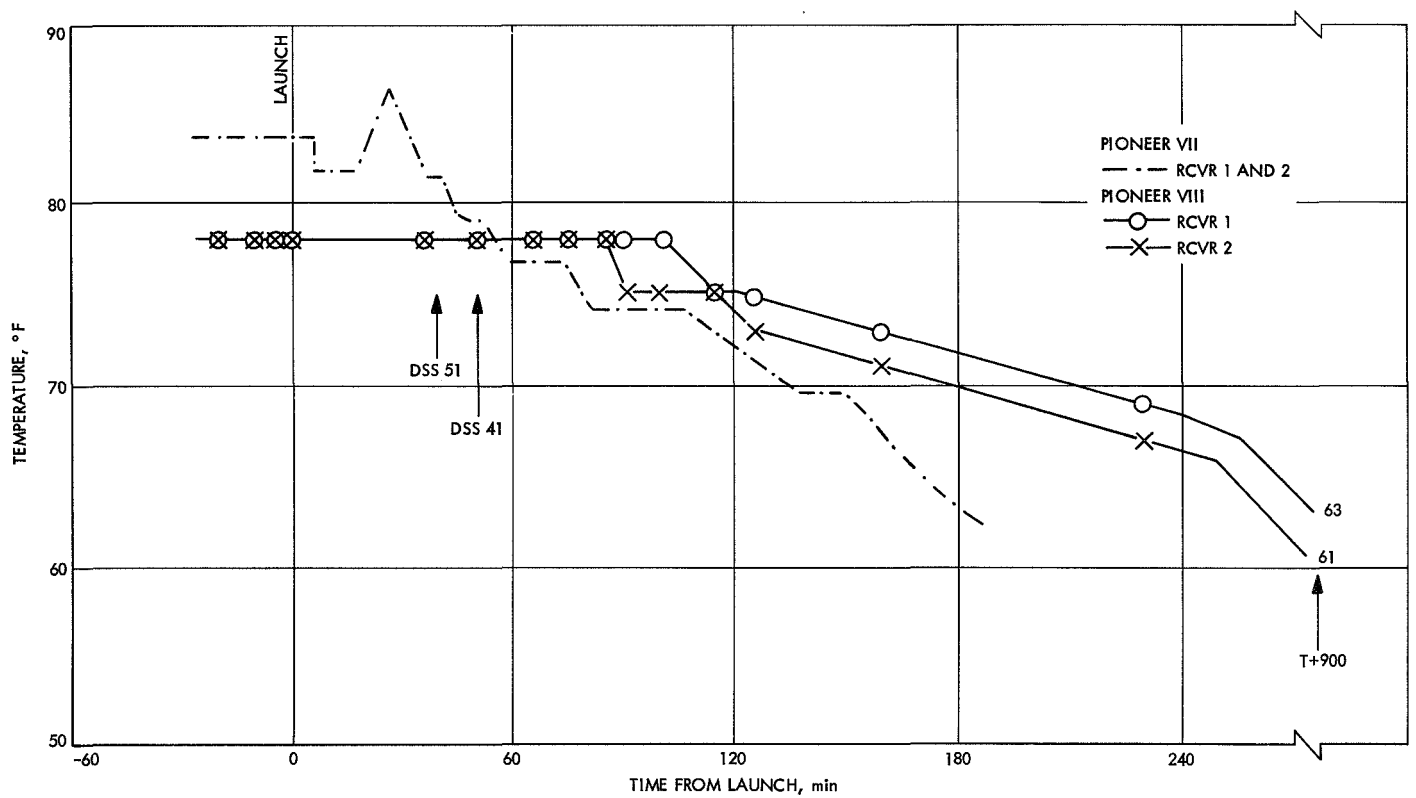


Fig. 71. Receiver temperature vs time from launch

stations. The TCP and the GOE demodulator were in lock for 99.90% of actual tracking time for this report period (see Table 58). There were no anomalies.

Pass 31 through pass 45. The telemetry bit-rate mode was constant at 512 bits/s. The average PER for the combined stations was 0.0006 for this report period.

The percentage performance for the FR-1400 recorder, TCP, and GOE demodulator was itemized above (see Table 58). The operation of the preceding subsystems indicates that the FR-1400 recorders were functioning normally throughout the receiver in-lock periods at all stations. The GOE demodulator did not experience any malfunctions. A commercial-power malfunction caused the digital instrumentation system and TCP at DSS 12 to lose its programs on pass 45. The TCP was down for 10 min. (See Table 58 for individual performance percentages of these subsystems.)

Pass 46 through pass 79. The telemetry bit-rate mode was constant at 512 bits/s. The average PER for the combined stations was 0.0002 for this report period.

The performance of the FR-1400 recorder, TCP, and GOE demodulator is subject to the same limitations with respect to accuracy as the posttrack reports, station mission logs, and network controller logs. These print-

outs indicate that no FR-1400 or GOE demodulator failures were experienced during this period. The TCP outages were confined to a total loss of 20 min of data.

Pass 80 through pass 110. The PERs for this period, along with their applicable bit-rate modes, are graphically presented in Fig. 72. The telemetry bit-rate mode was predominantly 512 bits/s, but was at both 512 and 256 bits/s toward the end of this reporting period. The PER at DSS 11 (see Fig. 72) was generally higher than the PER at DSS 62. The path traced by the DSS 11 PER values seems to be reconstructed by the DSS 62 PER values 6 days or so later. The reason that the DSS 11 values are high is that this station sent the RF signal to the GOE at DSS 12 via microwave for processing. The extra signal transmission from DSS 11 to DSS 12 introduced additional noise, thereby degrading the telemetry quality and yielding a higher PER.

The performance of the FR-1400 recorder, TCP, and GOE demodulator is based on the following assumptions: the TCP performance is based on the ratio of the number of telemetry frames received to the number of frames requested; the GOE demodulator and FR-1400 recorder are functioning normally. If there should be a malfunction, a TFR would be written. Anomalies resulting in no loss of data are of minor importance in evaluating data performance.

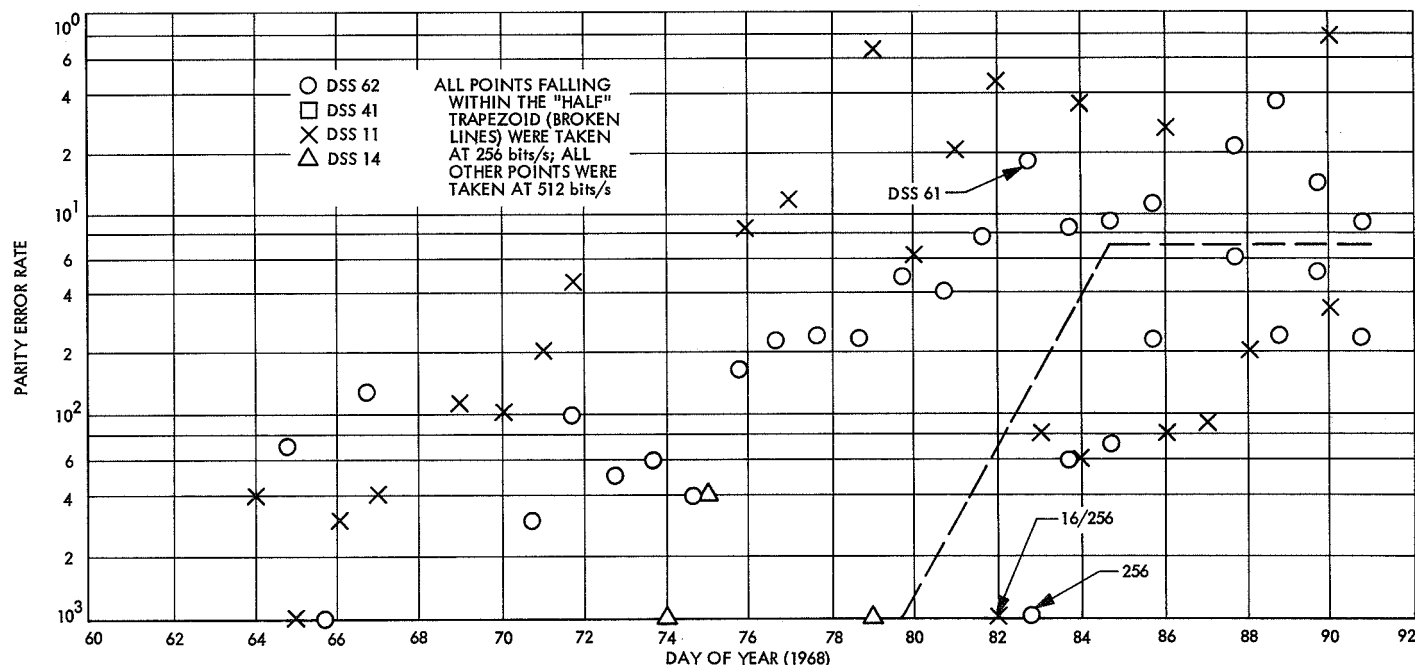


Fig. 72. Parity error rate vs time, pass 80 through pass 110

Pass 111 through pass 140. The PERs, along with their applicable bit-rate modes, are graphically presented in Figs. 73 through 75 according to bit-rate mode. The PERs for DSSs 11 and 61 were generally higher than those for DSS 62. The reason for the difference is that the RF signal received at DSSs 11 and 61 is sent via microwave to DSSs 12 and 62 for processing by the GOE. The extra signal transmission introduced additional noise, thereby degrading the telemetry quality and yielding a higher PER.

Investigation of the PER plots in Figs. 73 through 75 indicates that several PERs seem to be rather inconsistent with the remainder of the data points. Such is the case for all of the DSS 11 PER points occurring before day 98. From day 98 to the end of this report period, all of the DSS 11 PER points are linearly coherent except the value received on day 101. The reason for this is that DSS 11 started to use its polarizer on day 98, and continued to use it (except on day 101) until the termination of this report period. On day 101, the polarizer was not used; therefore, an abnormal (inconsistent) value resulted.

Deep Space Station 62 started using its polarizer in tracking for the first time on day 101, and continued to use the polarizer through the end of this report period. The dispersal of the PER value points is not totally uniform; nevertheless, no great irregularity is indicated. If the polarizer had been used on days 92, 93, and 97, the PERs received on those days (see Fig. 74) would probably have decreased appreciably in value. A drop in the numerical value of the PER is equivalent to an improvement in the telemetry quality.

Pass 141 through pass 171. The PERs, along with their applicable bit-rate modes, are graphically presented in Figs. 76 and 77 according to bit-rate mode. These figures also illustrate that all stations recorded nominal values at the telemetry bit-rate mode of 64 bits/s; however, the few values recorded at 256 bits/s were generally high. Tracking at 256 bits/s normally yields a higher PER because of the range of the spacecraft. (It is anticipated that tracking at this higher bit-rate mode will be discontinued.)

e. Command performance.

Launch through pass 15. The total number of commands sent during this report period was 368. During

DSS 14 tracking, the commands were generated at DSS 12 and sent via a microwave link to DSS 14 for transmission to the spacecraft.

Pass 16 through pass 30. The total number of commands sent during this report period was 117. During DSS 14 tracking, the commands were generated at DSS 12 and sent via a microwave link to DSS 14 for transmission to the spacecraft. The cumulative total of commands transmitted from the time of launch was 485.

Pass 31 through pass 45. The total number of commands sent during this report period was 103. During DSS 14 tracking, the commands were generated at DSS 12 and sent via a microwave link to DSS 14 for transmission to the spacecraft. The cumulative total of commands transmitted from the time of launch was 588.

Pass 46 through pass 79. The total number of commands sent during this report period was 245. During DSS 11 or 14 tracking, the commands were generated at DSS 12 and sent via microwave link to DSS 11 or 14 for transmission to the spacecraft. The cumulative total of commands transmitted from the time of launch was 833.

Pass 80 through pass 110. The total number of commands sent during this report period was 345. During DSS 11 or 14 tracking, the commands were generated at DSS 12 and sent via microwave link to DSS 11 or 14 for transmission to the spacecraft. The cumulative total of commands transmitted from the time of launch was 1178.

Pass 111 through pass 140. The total number of commands sent during this report period was 263. During DSS 11 or 61 tracking, the commands were generated at DSS 12 or 62 and sent via microwave link to DSS 11 or 61 (as applicable) for transmission to the spacecraft. The cumulative total of commands transmitted from the time of launch was 1441.

Pass 141 through pass 171. The total number of commands sent during this report period was 229. During DSS 11 or 61 tracking, the commands were generated at DSS 12 or 62 and sent via microwave link to DSS 11 or 61 (as applicable) for transmission to the spacecraft. The cumulative total of commands transmitted from the time of launch was 1670.

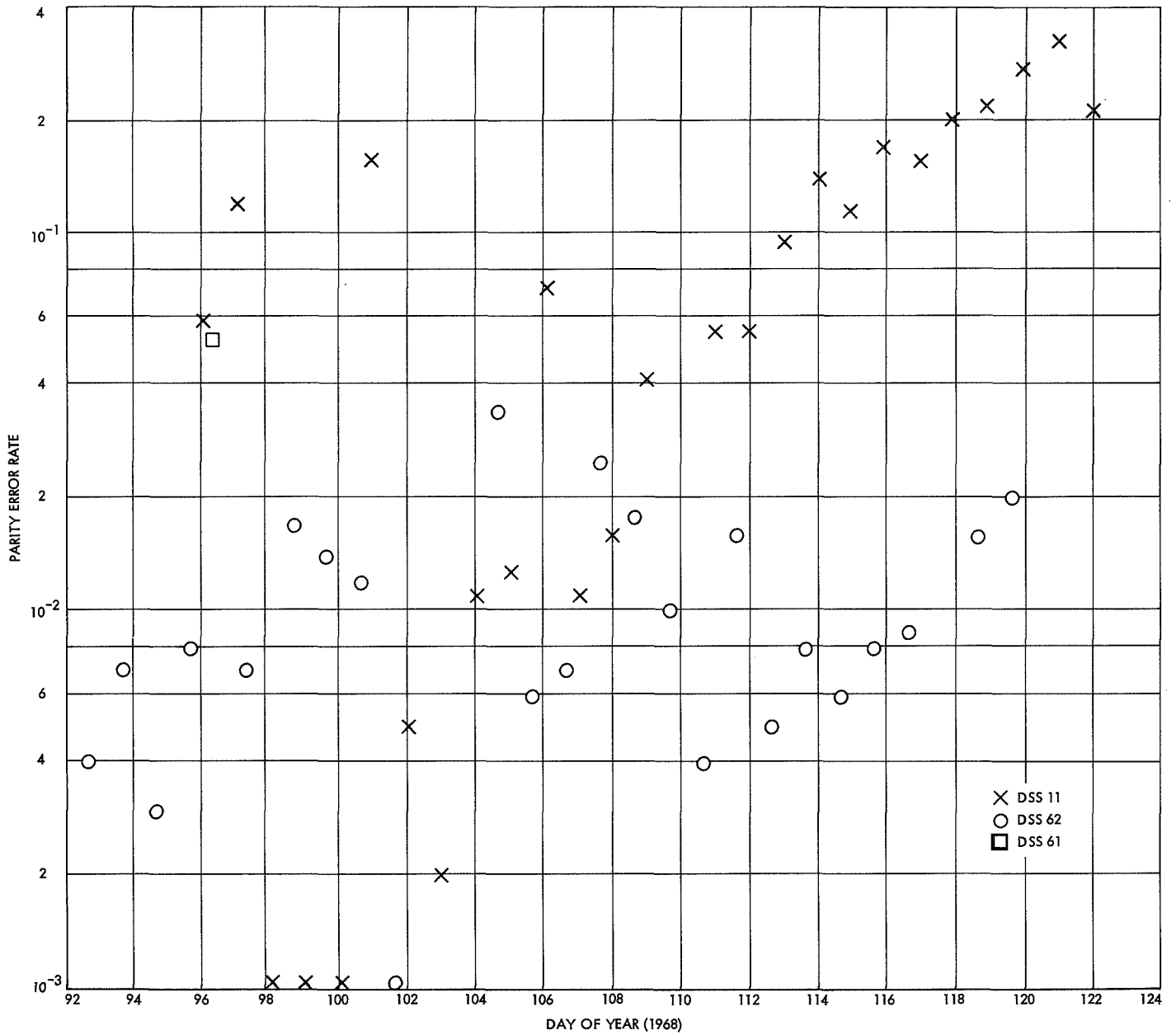


Fig. 73. Parity error rate vs time (256 bits/s), pass 111 through pass 140

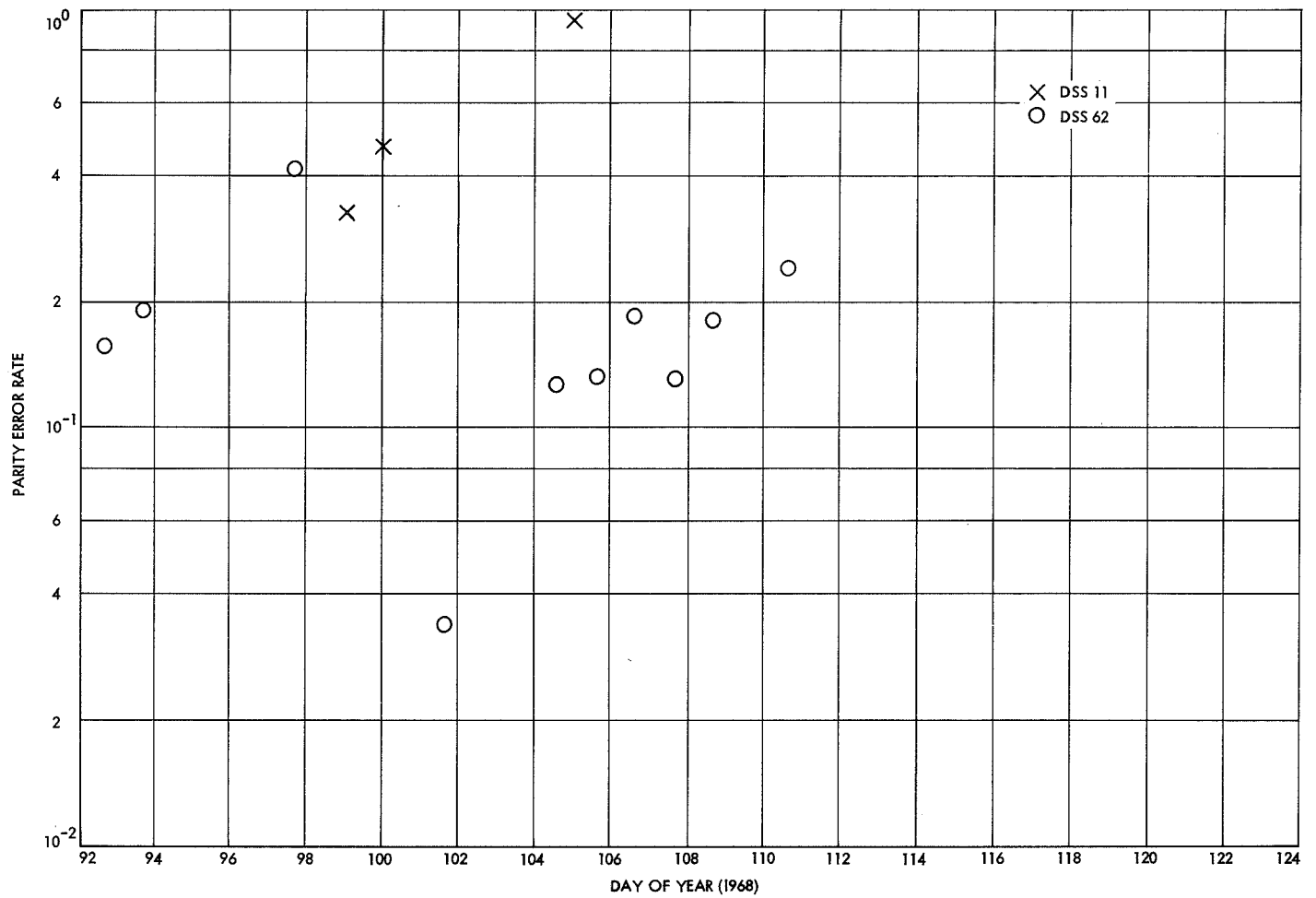


Fig. 74. Parity error rate vs time (512 bits/s), pass 111 through pass 140

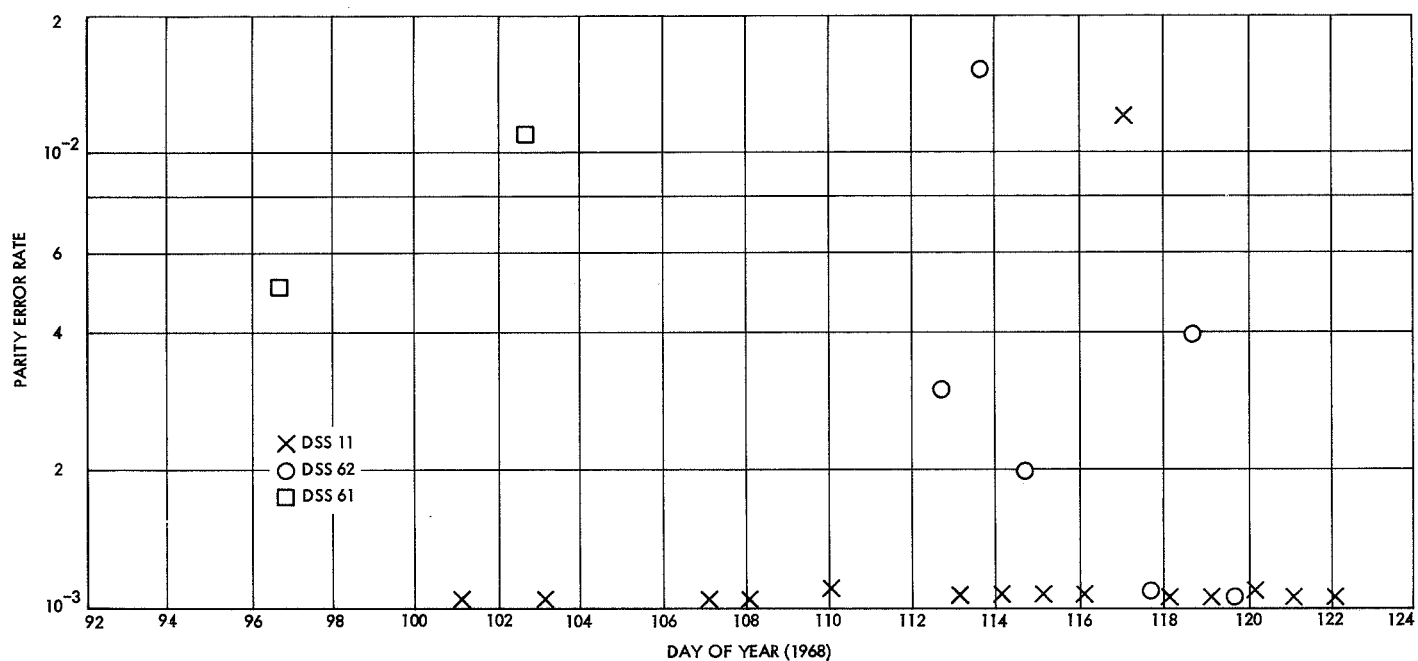


Fig. 75. Parity error rate vs time (64 bits/s), pass 111 through pass 140

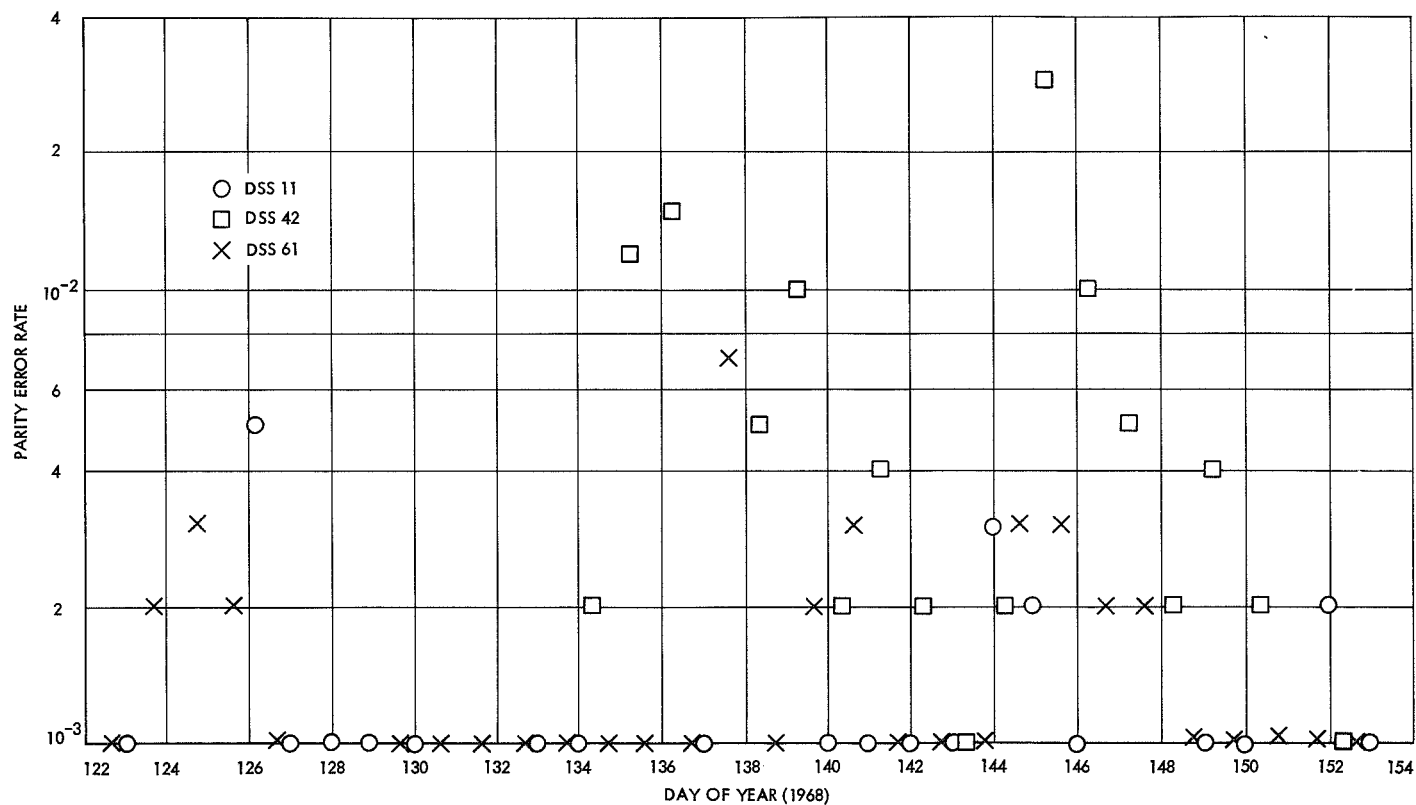


Fig. 76. Parity error rate vs time (64 bits/s), pass 141 through pass 171

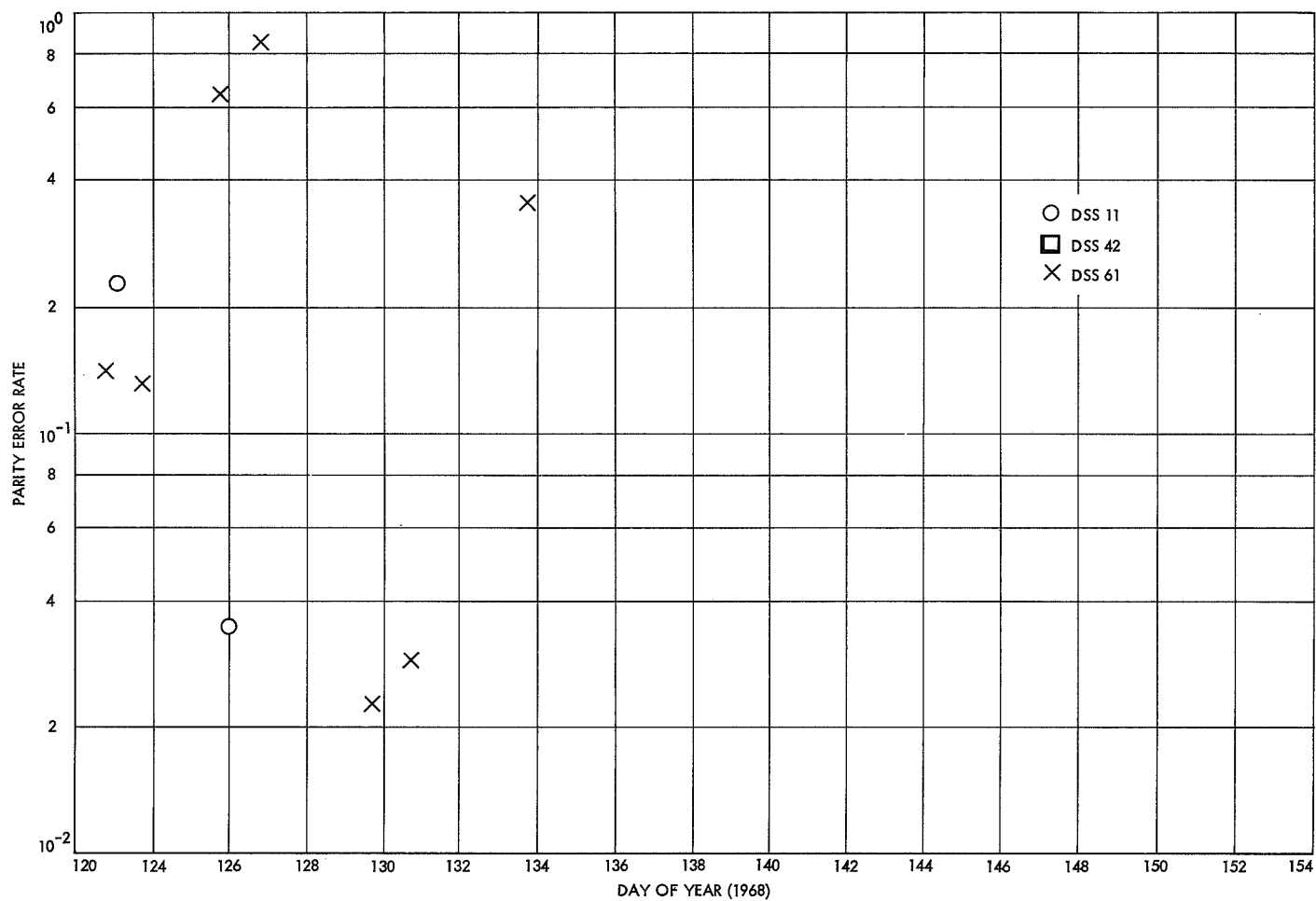


Fig. 77. Parity error rate vs time (256 bits/s), pass 141 through pass 171

Glossary

AFB	Air Force Base	GCF	Ground Communications Facility
AFETR	Air Force Eastern Test Range	GCS	Ground Communication System
AGC	automatic gain control	GDA	General Dynamics Astronautics
AOS	acquisition of signal	GOE	ground operational equipment
APC	automatic phase control	GRCSW	Graduate Research Center of the Southwest (later known as Southwest Center for Advanced Studies)
APS	antenna pointing subsystem	GSFC	Goddard Space Flight Center
ARC	Ames Research Center	<i>H</i>	horizon (plus time)
ASR	automatic send–receive	HA	hour angle
az	azimuth	HDX	half duplex
CCF	Central Computing Facility	HSDL	high-speed data line
CDU	command distribution unit	IBM	International Business Machines
CEC	Consolidated Electrodynamics Corporation	ICS	Internal Communication System
CKAFS	Cape Kennedy Air Force Station	IMP	Interim Monitoring Program
CNC	Cape network coordinator	INTELSAT	communications satellite
CP	communications processor	IRV	interrange vector
CPCC	communications processor control console	JPL	Jet Propulsion Laboratory
CRF	central receive frequency	KSC	Kennedy Space Center
DCC	data condition code	KSR	keyboard send–receive
dec	declination	<i>L</i>	launch (plus time)
DIS	digital instrumentation system	LOS	loss of signal
DOB	data operations branch (GSFC)	MCC-K	mission control center, Cape Kennedy
DOD	Department of Defense	MDC	Mission Director's Center
DPS	data processing system	MECO	main engine cutoff
DSIF	Deep Space Instrumentation Facility	MOIS	Mission Operations Intercommunication System
DSN	Deep Space Network	MOPS	mission operations paging system
DSS	Deep Space Station	MSA	mission support area
DTU	data transmission unit	MSFN	Manned Space Flight Network
EGSE	electrical ground support equipment	MUX	multiplexer
el	elevation	M&O	maintenance and operations
ESSA	Environmental Sciences Service Administration	NASCOM	NASA Communications Network
FDX	full duplex	NC	network controller
FM	frequency-modulated	NORAD	North American Air Defense Command
FPAA	flight-path analysis area	NRZ-C	nonreturn-to-zero computer
FPAC	flight-path analysis and command	NST	network support team
GBI	Grand Bahama Island	OSSA	Office of Space Science and Applications

Glossary (contd)

OVCS	operational voice communications subsystem	SFOF	Space Flight Operations Facility
PDM	pulse-duration-modulated	SMX	simplex
PER	parity error rate	SNR	signal-to-noise ratio
PLIM	postlaunch instrumentation message	SOPM	standard orbital parameter message
PT&T	Pacific Telephone	SRO	Superintendent of Range Operations
RCC	range control center	SSAC	space science analysis and command
RCO	range control officer	STADAN	Space Tracking and Data Acquisition Network
RCVR	receiver	TAER	time-azimuth-elevation-range
RFI	radio-frequency interference	TCP	telemetry and command processor
RIS	Range Instrumentation Ship	TDA	tracking and data acquisition
RO	receive only (teletype)	TDH	tracking data handling
RTCF	Real Time Computing Facility	TDS	Tracking and Data System
SAA	S-band acquisition aid (antenna system)	TETR	<i>Test and Training Satellite</i>
SAF	Spacecraft Assembly Facility	TFR	Trouble/Failure Report
S/C	spacecraft	TPS	telemetry processing station
SCAMA	signaling, conferencing, and monitoring arranging	TSS	teletype switching system
SCM	S-band cassegrainian monopulse (antenna system)	TTS	<i>Target Tracking Satellite</i>
SDA	systems data analysis	TVM	television monitor
SDCC	Simulation Data Conversion Center	TWM	traveling-wave maser
SECO	sustainer engine cutoff	TWT	traveling-wave tube
SEIG	sustainer engine ignition	TWX	teletypewriter exchange
SFOD	Space Flight Operations Director	ULO	unmanned launch operations
		VCO	voltage-controlled oscillator
		XMTR	transmitter

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