N71-13298

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Memorandum 33-426

Volume IV

Tracking and Data System Support for the Pioneer Project

Pioneer IX. Prelaunch Through June 1969

N. A. Renzetti

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

November 15, 1970

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Memorandum 33-426

Volume IV

Tracking and Data System Support for the Pioneer Project

Pioneer IX. Prelaunch Through June 1969

N. A. Renzetti

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

November 15, 1970

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, Manned Space Flight Network, and by the NASA Communications Network of the Goddard Space Flight Center. This volume, the fourth in a series of four, covers the Tracking and Data System support for (1) the *Pioneer IX* mission from prelaunch; i.e., spacecraft arrival at Cape Kennedy, Fla., October 6, 1968, through pass 235, June 30, 1969, and (2) the *Pioneer E* mission from prelaunch, July 18, 1969, to the end of the flight, August 27, 1969. Some information is also included on planning activities and the Project background.

Volumes I, II, and III of this series presented similar documentation relative to *Pioneer VI, VII,* and *VIII,* respectively. For *Pioneer VI* and *VII,* the period documented was from prelaunch to the end of the nominal mission. For those missions, the *nominal mission* was ended when the data transmission by the Deep Space Network 85-ft-diam antenna system exceeded a bit-error rate of 1 error in 1000. However, because spacecraft trajectories and improved Deep Space Network design extended the use of the 85-ft-diam antenna stations beyond convenient reporting periods, the term *nominal mission,* as previously used, was not applicable to *Pioneers VIII* and *IX.* What would have been the end of the nominal mission has been replaced by arbitrarily set dates.

Acknowledgment

The author acknowledges the considerable assistance of W. R. Barton, R. Santiestevan, R. H. Grace, A. J. Siegmeth, R. E. Purdue, A. D'Amore, W. J. Ross, and D. D. Hubiak. The author also acknowledges the support in the form of reports and other types of information from the staffs of the various networks; i.e., Air Force Eastern Test Range, Manned Space Flight Network, NASA Communications Network, and the Deep Space Network of the Jet Propulsion Laboratory. Information relative to the launch vehicle and spacecraft was obtained from reports generated by the Ames Research Center and the Goddard Space Flight Center. The author is indebted for the support of A. C. Belcher and M. E. Binkley of the Office of Tracking and Data Acquisition, NASA Headquarters.

Contents

Contents (contd)

Contents (contd)

Contents (contd)

Contents (contd)

Tables

Contents (contd)

Tables (contd)

Figures

Contents (contd)

Figures (contd)

Contents (contd)

Figures (contd)

Contents (contd)

Figures (contd)

Contents (contd)

Figures (contd)

Contents (contd)

Figures (contd)

Abstract

The *Pioneer IX* mission (inward trajectory and heliocentric orbit) employed seven scientific instruments to accumulate information relative to interplanetary high-energy particles, solar phenomena, and plasma. The launch vehicle carried aloft a "piggyback" satellite called the *Test and Training Satellite* (TETR) to be used for *Apollo* ground station crew training and mission simulation. The spacecraft also served as a celestial mechanics experiment reference point. In addition, a convolutional coding experiment was conducted. The Tracking and Data System (Air Force Eastern Test Range, JPL 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 the mission, launch-vehicle, and range requirements. For deep space tracking, the Deep Space Network responded to the tracking, telemetry, command, monitoring, simulation, and operations control requirements.

The *Pioneer E* mission (near the earth for 900 days, then heliocentric) was intended to investigate interplanetary phenomena. After 438 s of flight on August 27, 1969, a destruct signal was transmitted because of a loss of hydraulic pressure in the first stage. This was the fifth spacecraft in the second *Pioneer* generation and the only failure (launch vehicle failed).

Tracking and Data System Support for the *Pioneer* Project

Pioneer IX. Prelaunch Through June 1969

I. Introduction

The *Pioneer* Project was designed and developed to collect scientific data relative to interplanetary phenomena within a region of 0.75 to 1.20 AU from the sun. The characteristics of the magnetic field, plasma, cosmic rays, high-energy particles, electron density, electric fields, and cosmic dust were the phenomena of particular interest to the Project. Analyses of the data collected through the *Pioneer* Project have added to the understanding of the mechanisms relating to the propagation through space of solar disturbances and the relationship between solar and galactic fields. Near-real-time data reduction and analyses were part of a *Pioneer* space weather report teletyped regularly to U.S. Space Disturbance Centers.

In a generation of five flights that began with the *Pioneer A* spacecraft, all except one were successfully placed into orbit. *Pioneers VI, VII, VIII,* and *IX* continue to return valuable scientific data at the time of this report. *Pioneer E* was destroyed shortly after launch because of a faulty mechanism in the launch vehicle. *Pioneer E* is covered in Part II of this document. (All *Pioneer* spacecraft are first designated by letter and become known by Roman numeral only after a successful flight.)

Unless otherwise stated, all times referred to in this report will use the Greenwich Mean Time (GMT) convention.

A. Tracking and Data Acquisition (TDA) Support

1. Near-earth phase. Tracking support of the *Pioneer VI, VII, VIII,* and *IX* missions during the near-earth phase (launch until the beginning of Deep Space Station two-way communication with the spacecraft) was a function of the Tracking and Data system (TDS). This system was made up of the Air Force Eastern Test Range (AFETR), the Manned Space Flight Network (MSFN), the NASA Communications System (NASCOM), and the Deep Space Network (DSN). The radars tracked the first, second, and third stages of the booster vehicle. Linked with central computing facilities as required, they provided and processed data in real-time. Acquisition information, parking, and *Delta* postretro and solar-injection orbits were computed on an as-available basis. The Deep Space Station (DSS) at Johannesburg, South Africa (DSS 51) also furnished near-earth data within the tracking rate limitation of the station. The Deep Space Network station designations and locations are presented in Table 1. The existing AFETR and NASCOM communication circuits provided the necessary ground communications support.

a. Telemetry data. The AFETR and MSFN acquired VHF launch vehicle telemetry data. The AFETR acquired S-band spacecraft telemetry data for the missions. When available, and within the constraints of excessive tracking rates, the Johannesburg station provided S-band

Table 1. 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. (Pioneer)	11	35.38950°N	243.15175°E	1037.5	35.20805°N	243.15080°E	6372.0341
Goldstone, Calif. (Echo)	12	35.29986°N	243.19539°E	989.5	35.11861°N	243.19445°E	6372.0176
Goldstone, Calif. (Venus)	13	35.24772°N	243.20599°E	1213.5	35.06662°N	243.20507°E	6372.2599
Goldstone, Calif. (Mars)	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
Tidbinbilla, 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

telemetry coverage. The station at Cape Kennedy, Fla. (DSS 71) provided S-band telemetry monitoring from launch to loss of signal. The station also provided prelaunch checkout and calibration, as well as necessary frequency reports. Again, the AFETR and NASCOM provided ground communication support.

Johannesburg (DSS 51), as the initial two-way acquisition station for *Pioneer IX*, was required to provide the two-way S-band operation for at least 4 h after initial acquisition to complete the near-earth phase of the support. Tidbinbilla, Australia (DSS 42), with Woomera, Australia (DSS 41), for emergency, was the backup prime acquisition station.

b. Metric data. The Real Time Computing Facility (RTCF) at the AFETR used the best available metric data from AFETR radars to compare acquisition data. The RTCF converted radar data to decimal form, transmitted the data to DSN/SFOF as required, and also generated trajectory predictions for Johannesburg and Tidbinbilla (when possible).

All AFETR stations provided launch-vehicle mark event reports. The existing AFETR and NASCOM communication circuits provided ground communication support.

2. *DSN flight responsibilities.* The DSN had the greatest responsibility for the *Pioneer* flight projects, being the principal tracking support throughout the lifetime of the missions after the launch. In support, the DSN simultaneously performed advanced engineering on components and systems, integrated proven equipment and methods into the network, and provided direct support of each Project through the TDS for that Project.

By tracking the spacecraft, the DSN was involved in the following data types:

(1) Metric: generate angles, one- and two-way doppler, and range.

(2) Telemetry: receive, record, and retransmit engineering and scientific data.

(3) Command: send coded signals to spacecraft to activate equipment to initiate spacecraft functions.

The DSN operation was characterized by six functions: (1) tracking, (2) telemetry, (3) command, (4) monitoring, (5) simulations, and (6) operations control. The network comprised the Deep Space Instrumentation Facility (DSIF), the Ground Communications Facility (GCF), and the Space Flight Operations Facility (SFOF).

3. *Deep space phase.* The primary DSN stations used for the support of all *Pioneers* remaining within the threshold of the 85-ft-diam antenna network were as follows: (1) Goldstone, Calif. (DSS 12); (2) Tidbinbilla, Australia (DSS 42); and (3) Madrid, Spain (Robledo) (DSS 61). These Deep Space Stations were equipped with *Pioneer* ground operations equipment (GOE), whereas the *Pioneer* stations at Goldstone, Calif. (Pioneer) (DSS 11) and Cerebros, Spain (DSS 62) provided support by connecting to Echo and Robledo, respectively, using microwave links and the multimission support area configuration. (*Pioneer* GOE was transferred from Cerebros to

Robledo in December 1968, reversing the role of the stations.)

The Echo station provided Type II orientation maneuver support. Woomera—not having *Pioneer* GOE—only recorded the received telemetry data for postflight data reduction. As had all other DSN stations, Woomera had the capability to demodulate uncoded S-band spacecraft telemetry up to a bit rate of 256 bits/s using the multiple-mission telemetry configuration. All *Pioneer* missions beyond the 85-ft-diam antenna DSN stations are supported jointly from the Mars station (DSS 14) at Goldstone. The Mars station is equipped with a 210-ft-diam antenna.

The DSN 85-ft-diam antenna stations gave continuous tracking coverage for $L+30$ days. From $L+31$ days to the end of the mission, the stations covered two passes each day (coverage period 16 h or greater) and at least one horizon-to-horizon metric data mission each week (not on the same day of the week) for two-way doppler measurement only. These requirements could be superseded by the need to cover specific scientific events. When the spacecraft required the 210-ft-diam antenna station, 3 to 4 h of coverage were provided each day to the end of the mission, or as conditions varied, 6 to 8 h each day of coverage.

The spacecraft telemetry was received and processed at the Deep Space Station using the *Pioneer* GOE. The existing NASCOM and Ground Communications Facility (GCF) circuits were used for ground communications.

B. Project Requirements and TDA Performance

1. ***Significant changes in Project requirements.*** There were no significant changes in Project requirements from those for *Pioneers VI, VII,* and *VIII.*

2. ***Synopsis of significant events.*** The following significant events occurred:

(1) Inferior conjunction—syzygy (January 30, 1969).

(2) Solar flares (most active in March 1969).

3. ***Overall performance of TDA.*** The TDA fulfilled all of its commitments to the Project for the *Pioneer IX* flight through the period covered by this report.

4. ***Support beyond the minimum commitment.*** Based on past performance by other *Pioneer* spacecraft and the DSN, *Pioneer IX* would have passed beyond the capabilities of the 85-ft-diam antenna stations by May or June 1969, and only the 210-ft-diam antenna at DSS 14 would have maintained satisfactory tracking and telemetry performance. However, the convolutional coding and sequential decoding engineering experiment conducted with *Pioneer IX* resulted in support beyond the minimum commitment by the 85-ft-diam stations of the DSN.

With the convolutional coding and sequential decoding, the 85-ft-diam antenna stations were expected to maintain contact with the spacecraft into 1970. This change permitted greater use of the 210-ft-diam antenna for *Pioneers VI* and *VII,* which were beyond the range of the 85-ft-diam stations, and also greater coverage for *Pioneer IX* because of the additional facilities available to it.

Special horizon-to-horizon coverage was provided by the 85-ft-diam stations between May 8 and May 15, 1969, when *Pioneer IX* had a zero declination crossing. Analyses of the data improved the station location solutions for the *Apollo 11* mission and the *Mariner Mars 69* encounter.

II. *Pioneer IX* Tracking and Data System Requirements

The plans, requirements, configurations, and data and performance analyses for the TDS support for *Pioneer IX* from the beginning of the prelaunch readiness phase through launch (November 8, 1968 to June 30, 1969) are reported herein.

A. Mission Definitions and Information Areas

1. ***Mission definitions.*** Previous reports were issued at the end of the nominal mission phase. The nominal mission was defined as the period when the DSN could receive telemetry satisfactorily using the 85-ft-diam antennas with a bit-error rate of 1 error or less in 1000 bits. When this rate was exceeded, the spacecraft had entered an extended mission.

The 210-ft-diam antenna of the Mars station (DSS 14) at Goldstone became the tracking instrument for the extended mission. Through the use of new engineering procedures, *Pioneer IX* was expected to remain within the capability of the 85-ft-diam antennas into 1970. Thus, this report concerns only the first 8 mo of flight. The terms *nominal mission* and *extended mission* will not be used in connection with *Pioneer IX.*

Future reports on the TDS support of *Pioneer IX* will be issued on an annual basis.

2. ***Information areas.*** This document is primarily concerned with the activities of the DSN as managed by the Jet Propulsion Laboratory, Pasadena, Calif., in support of the *Pioneer IX* flight. Required by the *Pioneer* Project to establish down-link signal acquisition and telemetry demodulation not later than $L+1$ h, the DSN maintained support responsibility throughout the lifetime of all of the *Pioneer* spacecraft.

3. ***Facilities and systems.*** This report includes information on the following facilities, systems, and activities (not necessarily in that order):

(1) Ames Research Center (ARC): manager of *Pioneer* Project.

(2) TDA requirements.

(3) MSFN: managed by Goddard Space Flight Center.

(4) AFETR.

(5) NASCOM: managed by GSFC.

(6) Mission preparations of participating agencies.

(7) Tracking operations and related GOE.

(8) Spacecraft and launch vehicle.

(9) Flight objectives.

(10) Major events and time of occurrence.

(11) Spacecraft and scientific test programs.

Managed by the ARC for the NASA Office of Space Science and Applications, the *Pioneer* Project was supported by four major administrative and functional systems. These were as follows:

(1) Launch Vehicle System (LVS).

(2) Spacecraft System (SS).

(3) TDS.

(4) Mission Operations System (MOS).

B. TDS Support

The TDS near-earth phase support for the *Pioneer IX* spacecraft was furnished by the committed facilities of AFETR, MSFN, and DSN. The DSN with the MSFN furnished all of the support for the deep space phase. The DSN furnished all of the support for the deep space phase with the MSFN 85-ft-diam antenna stations providing support of the command and telemetry exchange when needed because of DSN conflicts or priorities. The TDS requirements and support evolve from the demands and restrictions of the *Pioneer IX* mission, the launch vehicle, and range safety.

Acquisition support was classified by the *Pioneer* Project Office as Class I, Class II, or Class III. These were as follows:

(1) Class I requirements reflected the minimum essentials that ensured the accomplishment of primary test objectives that are mandatory and, if not met, may result in a decision not to launch.

(2) Class II requirements reflected those needed to accomplish all the stated objectives.

(3) Class III requirements reflected the ultimate in desired support: such support provided capability to achieve objectives earlier in the program than required.

C. *Pioneer* History

Pioneer VI, launched December 16, 1965, was the first of a second generation of *Pioneers*. (The last of the first generation was *Pioneer V*, which was launched on March 11, 1960. Radio communication was maintained with *Pioneer V* until June 26, 1960, when the spacecraft was 3.75×10^7 km from the earth. This established a record for long-distance communication that stood for several years. Among its achievements, *Pioneer V* confirmed the existence of previously theorized interplanetary magnetic fields.)

Pioneer VI ended its nominal mission on June 16, 1966, and began an extended mission. Similar to all *Pioneers* in its generation, it was placed in a heliocentric orbit. *Pioneers IX* and *VI* were launched to move ahead of the earth with increasing time as opposed to *Pioneers VII* and *VIII*, which were launched to move behind the earth with increasing time (Fig. 1). The trajectories of *Pioneers VII* and *VIII* were designed so that repeated measurements could be taken in the geomagnetic wake.

All spacecraft equipment and scientific instruments aboard the *Pioneer* spacecraft have continued to operate normally through the period covered by this report; no malfunctions or anomalous performances affected the mission objectives.

Relative *Pioneer* spacecraft positions are illustrated in Fig. 2. Figure 3 gives the *Pioneer IX* fixed sun–earth line trajectory. Data on *Pioneers VI* through *IX* as of July 1, 1969, are shown in Table 2.

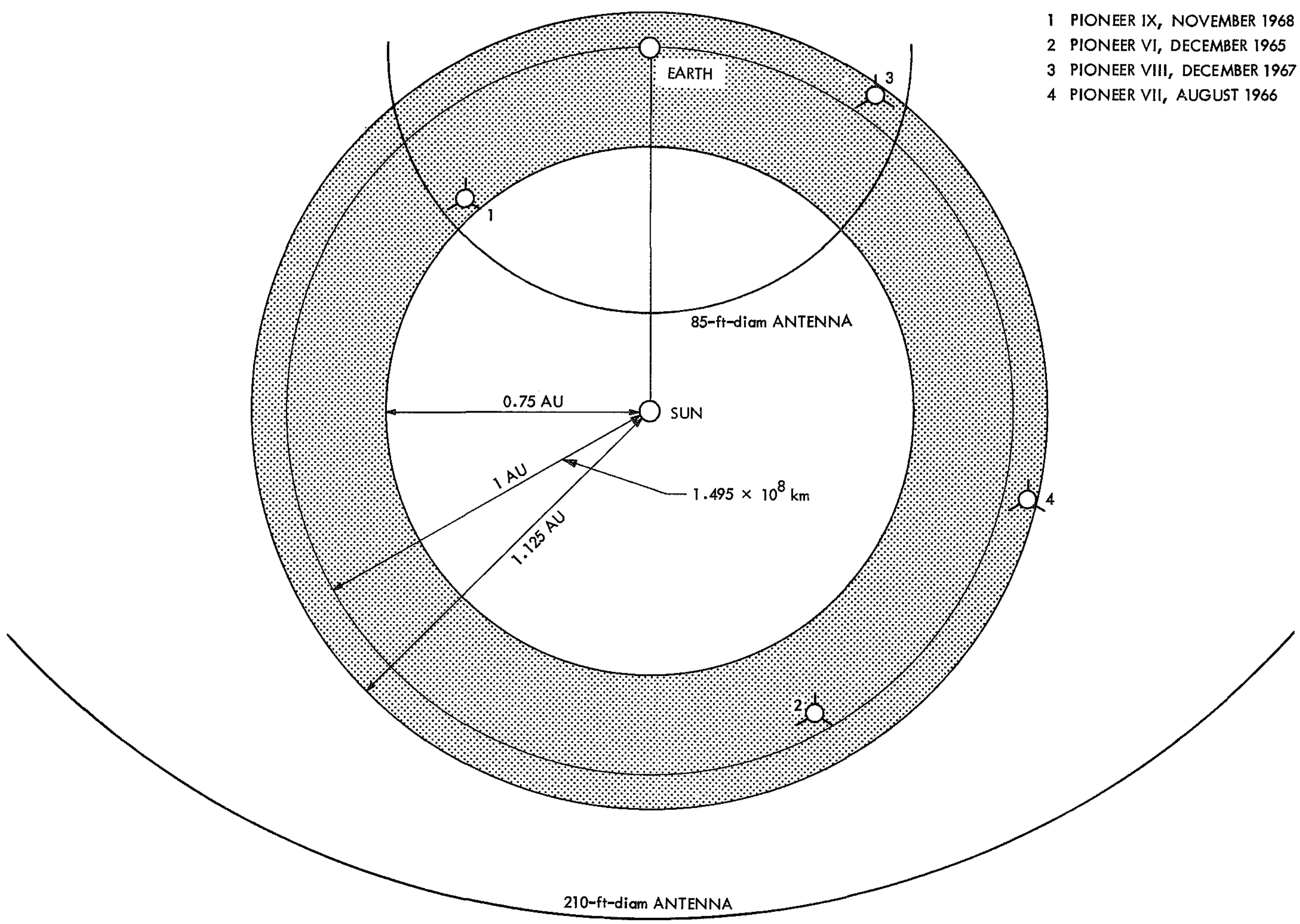


Fig. 1. May 1969 status of *Pioneer* spacecraft positions

Table 2. History data of *Pioneer* spacecraft

Event	*Pioneer VI*	*Pioneer VII*	*Pioneer VIII*	*Pioneer IX*
Launch date	12/16/65	8/17/66	12/13/67	11/8/68
Trajectory	Inward	Outward	Outward	Inward
Perihelion, AU	0.80	1.01	0.98	0.75[a]
Distance from earth, km $\times 10^6$	284	252	88	154.84720
Distance from sun, km $\times 10^6$	143	164	135	136.62087
Aphelion, AU	0.98	1.12	1.08	0.99

[a]*Pioneer IX* achieved a perihelion of approximately 0.75 AU on April 7, 1969. The velocity of *Pioneer IX* relative to the sun was 29.979102 km/s and to the earth, 28.750660 km/s at the end of June 1969. There had been a total of 3658 commands and the spacecraft had been tracked for 4569 h. The telemetry bit rate was 64 bits/s at the end of the period.

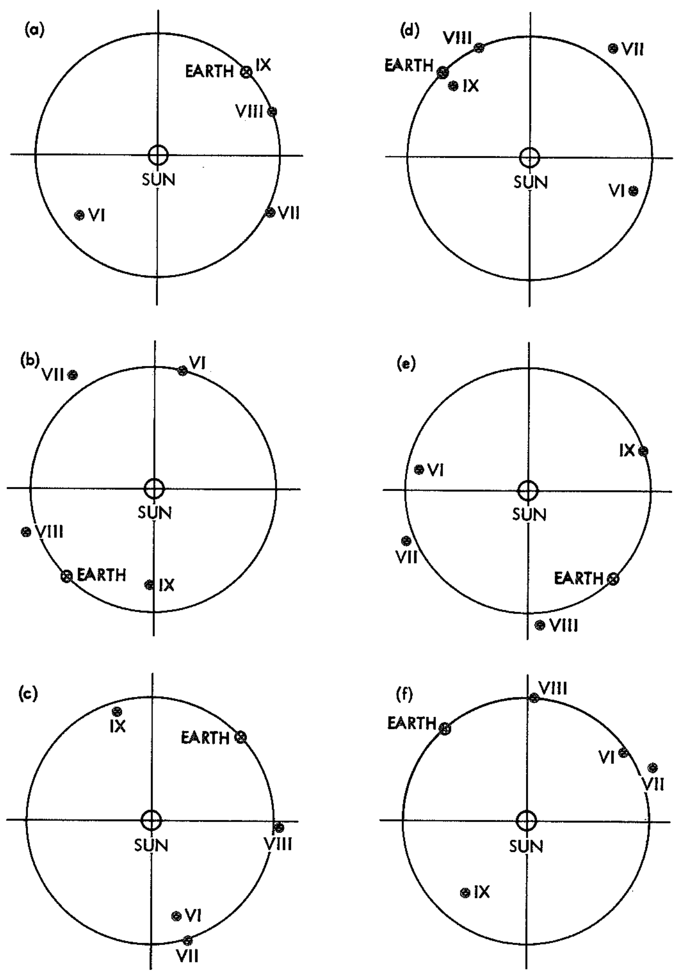


Fig. 2. *Pioneers VI, VII, VIII,* and *IX* relative spacecraft positions: (a) November 8, 1968; (b) May 7, 1969; (c) November 3, 1969; (d) February 6, 1969; (e) August 5, 1969; (f) February 1, 1970

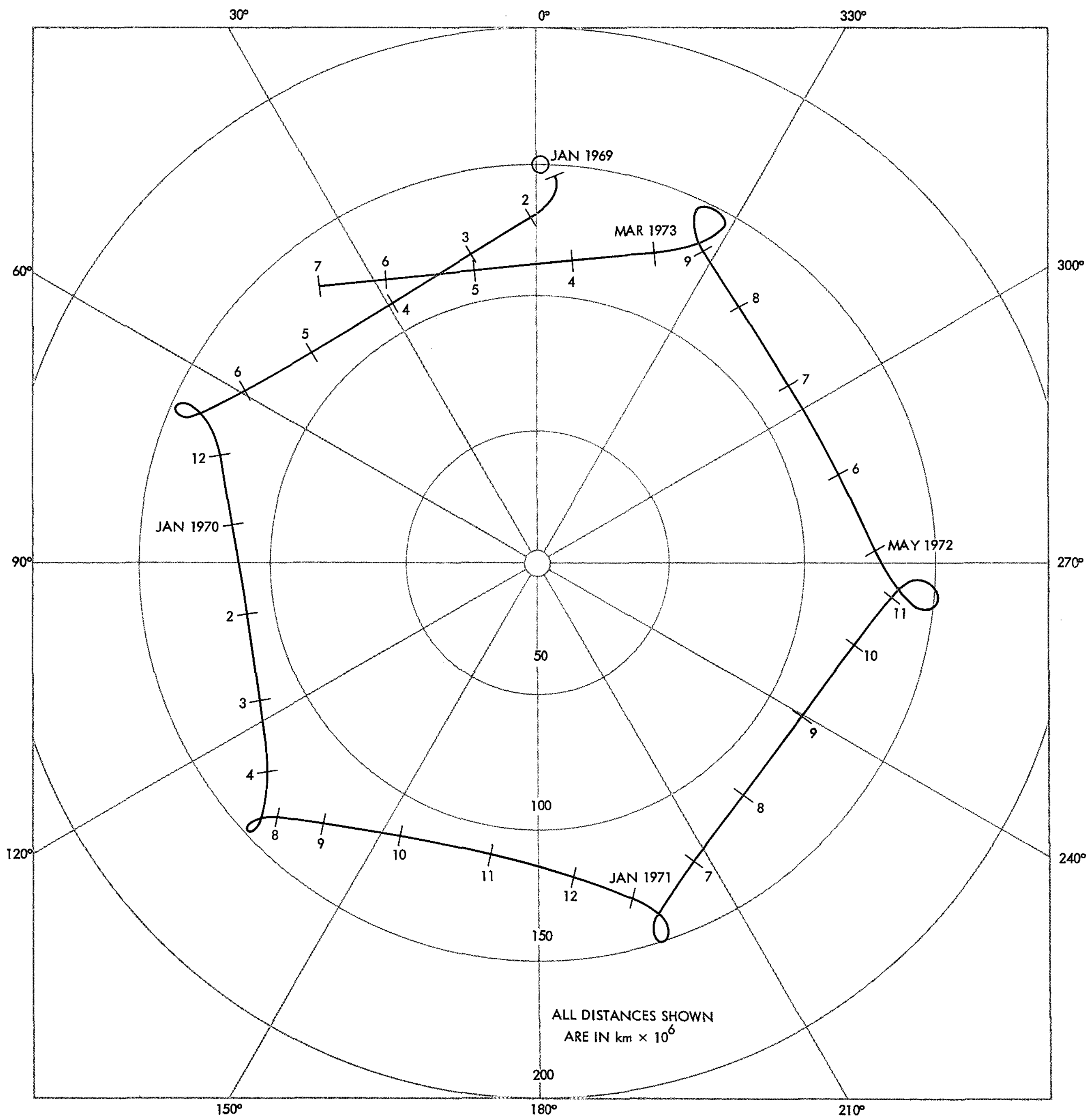


Fig. 3. ***Pioneer IX*** **fixed sun–earth line trajectory**

III. Experiments and Scientific Instruments

A. Introduction

The purpose of *Pioneer IX* was to collect scientific data on interplanetary phenomena. These phenomena include characteristics of magnetic fields, plasma, and cosmic dust. The effect of solar and galactic changes on these characteristics was of particular interest.

The spacecraft carried seven scientific instruments weighing less than 40 lb, and was capable of conducting nine experiments (Table 3). Thus, after the DSN established two-way lock to make possible the directing of commands to the spacecraft, the *Pioneer* Project mission control directed proper orientation of the spacecraft spin axis and commanded the spacecraft experiments on.

With a perihelion of approximately 0.75 AU, the inward trajectory of *Pioneer IX* was designed to minimize the time to superior conjunction and to produce a heliocentric orbit with multiple solar occultation characteristics.

1. Spatial probes. The Pioneer mission scientific observations provided a better understanding of 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. On a large time scale, they are believed to be influenced by the magnitude of the 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 *Pioneer* Project was also to determine the temporal and spatial variation of the interplanetary phenomena. To accomplish the objectives, the spacecraft were launched at intervals of approximately 8–12 mo to cover the period from near-minimum to maximum solar activity. The need to observe spatial effects was the reason for launching the spacecraft both ahead of and behind the earth.

2. Magnetosheath and bow-shock definition. Similar to the other *Pioneer* spacecraft, *Pioneer IX* was designed for magnetosheath and bow-shock definition and for solar-event analysis in general. To perform the magnetosheath and bow-shock definition investigation, the *Pioneer IX* plasma and magnetometer on-board instruments had to be operating and the resultant scientific

Table 3. *Pioneer IX* experiments

Experiment/scientific instrument	Managed by	Principal investigator
Triaxial fluxgate magnetometer	NASA/ARC	C. P. Sonett
Quadrispherical plasma	NASA/ARC	J. H. Wolfe
Radio propagation detector	Stanford University	V. R. Eshleman
Cosmic ray anisotropy detector	Southwest Center for Advanced Studies	K. McCracken
Cosmic ray gradient	University of Minnesota	W. R. Weber
Cosmic dust detector	NASA/GSFC	O. Berg
Electric field detector	TRW Systems	F. Scarf
Celestial mechanics investigation[a]	JPL	J. Anderson
Convolutional coding and sequential decoding[b]	NASA/ARC	D. Lumb

[a]Required no on-board instrumentation; used two-way doppler tracking as data source.

[b]Convolutional coding and sequential decoding gave capability to transmit coded or uncoded telemetry data; transmission of convolutional coded data provided (1) an effective increase in information communication characteristics in terms of spacecraft–earth distance, and (2) an increase in useful range for a given bit rate. Use of the 85-ft-diam antenna stations for *Pioneer IX* was extended into 1970.

data received by $L + 3$ to 3½ h or 8–10 earth radii attitude. *Pioneer IX* entered the magnetospheric bow-shock boundary about 8 h after liftoff, and exited during the first pass over Goldstone.

3. Solar event analysis. When a solar event of high scientific value occurred (e.g., solar flare, Class III or above), the spacecraft required continuous tracking coverage from 30 to 50 h following the event. Depending upon the location and characteristics of the specific event, this coverage could be shared by other *Pioneer* spacecraft, as determined by *Pioneer* Project management at the time of the event.

Traveling to within 70×10^6 mi of the sun—closest of all *Pioneer* spacecraft—*Pioneer IX* observed the quantity of solar particles to be almost double that found on the earth.

Solar flares, the most cataclysmic form of solar activity, are rapid brightenings observed at the chromospheric level in the light of the Balmer red line of hydrogen (H-alpha). The Balmer lines are accompanied by other prominent lines, such as those of neutral and singly ionized iron, and an enhancement of the white-light continuum. Sometimes the flare releases energy on the order of 10^{32} ergs distributed over a wide range of electromagnetic and particle radiations. The importance of a flare has traditionally been expressed in terms of its area. Class III designates the largest class (10^{-3} of the area of the solar disk), and the letters *B*, *N*, or *F* are appended to signify bright, normal, or faint, respectively. Nearly all of the great flares are in the Class III category. For the largest flares, the total optical energy output is about 1/80th of the total energy radiated per second by the entire sun (3.8×10^{33} ergs/s). The H-alpha burst is accompanied by prompt ionization, X-rays, and ultraviolet radiation. Flare surges eject large masses of solar plasma (also called solar wind) and are followed by magnetic storms on earth.

All *Pioneer* spacecraft cooperated to fulfill the requirements of the *Pioneer* space weather monitoring project. The Environmental Sciences Service Administration (ESSA) used the *Pioneer* space weather reports daily in its analysis of solar weather at its Space Disturbance Laboratory, Boulder, Colo.

4. Celestial mechanics. The support of the celestial mechanics experiment required the two-way doppler tracking data of the precision data source of *Pioneer*, with a readout capability of one data sample every minute. Accumulated tracking data were required for the life of each *Pioneer* mission. The computer program of the experimenter performed a least-squares reduction of the tracking-data residuals to obtain design-parameter estimates and statistics. The residuals were obtained by determining the difference between observed and computed values of tracking data. The computed values were a function of the initial parameter estimates, the integrated equations of motion, and the lunar and planetary ephemerides. Whereas the same S-band doppler data as an in-orbit determination of the spacecraft was used, this experiment required a priority accumulation of tracking data throughout the mission lifetime. The DSN furnished the necessary support.

5. Spin-rate measurement. The measurement of the *Pioneer IX* spacecraft spin rate (nominal: 60 rev/min), a Project requirement, was furnished by JPL once a month. The DSN/SDA personnel at JPL were instrumental in developing the method of measuring the spin rate using the spin ripple of the doppler tracking data. The measurement could be made only on missions tracked regularly in a two-way mode. Because the available facilities and software were not designed for the spin-rate measurement, the analysis runs had to be repeated to acquire reliable and acceptable data.

6. Convolutional coding and sequential decoding. An advanced concept for the DSN spacecraft support was tested for the first time during the flight of *Pioneer IX*. This concept—convolutional coding and sequential decoding—made possible corrected, errorless data flow from the spacecraft to the earth with the primary goal a coding gain of at least 3 dB for the mission over the previous *Pioneer* missions.

Through the use of convolutional coding and sequential decoding, the spacecraft, upon ground command, had the capability to transmit coded or uncoded data. The transmission of convolutionally coded data provided an effective increase in information-communication characteristics, or, in terms of spacecraft–earth distance, an increase in the useful range for a given bit rate.

The *Pioneer* digital communication data source was a single pulse-code-modulated bit stream formatted into 224-bit blocks of data consisting of time-multiplexed information from each of the scientific experiments and spacecraft engineering data. The pulse-code-modulated data were biphase or phase-shift-keyed modulated onto a subcarrier, which was phase-modulated with a 0.9-rad modulation index, onto a 2292 MHz carrier. The received carrier was tracked by the standard Deep Space Station phase tracking receivers, and the subcarrier from the receiver telemetry phase detector was processed by the *Pioneer* subcarrier-demodulator/bit-synchronizer units.

7. Communications satellite. *Pioneer IX* carried the second *Test and Training Satellite* (TETR-2), an MSFN test and training communications satellite, and successfully placed it into an earth orbit from a piggyback location on the second stage. The TETR-2 satellite was an 11-in. octahedral Environmental Research Satellite (ERS) containing a unified S-band transponder, solar cells, batteries, stabilization for attitude control, and VHF and telemetry dipoles. The TETR-2 satellite was used for S-band system checkout and training exercises with the MSFN.

8. Scientific observations. The DSN successfully supported the *Pioneer IX* scientific observations. On January 30, 1969, during the inferior conjunction of the spacecraft (a position directly between the earth and the sun), the DSN furnished continuous support from Deep Space Stations 12, 42, 61, and 62, and the MSFN control room, Pioneer station at Goldstone. No signal dropouts were experienced during the predicted 20-h radio blackout caused by the close vicinity of the Deep Space Station antenna beam to the sun. (The prediction was based on the SNR measurements made in 1964 when the spacecraft was in the close vicinity of the sun.

a. Sun–earth–spacecraft angle. The telemetry bit rate used during the closest approach to the sun was 64 bits/s, with a system noise temperature of 700°K. At this closest point, the heliocentric sun–earth–spacecraft angle was 0.78 deg. The assumption was that resurfacing of the 85-ft-diam antennas improved the sidelobe performance and resulted in the success of the antenna in picking up less noise from the sun than in 1964, when the old antenna surfaces were in use.

The collection of uninterrupted telemetry and precision two-way tracking data during sun–spacecraft–earth syzygy of *Pioneer IX* made possible a detailed analysis of the fields and particles traveling from the sun toward the earth (at an approximate distance from the earth of 1.7×10^7 km).

b. Solar activity. Solar activity was at a high level during most of March 1969, with numerous small flares occurring. On March 30, 1969, after the most active of the flare regions had rotated behind the west limb of the sun and could no longer be observed from the earth, there occurred the largest 10-cm radio burst in the corona ever recorded by terrestrial radio telescopes. Within 2 h, the cosmic-ray instruments aboard *Pioneer IX* (also *Pioneers VI* and *VIII* and the earth satellites) were recording a marked increase in the intensity of low- and high-energy protons. From these measurements, it was assumed that a large solar proton flare had occurred on the far side of the sun. During this time, the neutron monitors on earth showed a slight enhancement with gradual onset, so the effects at the surface of the earth were slight. A day later, cosmic-ray instruments aboard *Pioneer VII* showed increases in intensity.

The particle detectors aboard *Pioneer IX* (also aboard *Pioneer VIII* and the earth satellites) began to indicate reduced intensity within a few days after the March 30 event. During the period from March 31 through April 9, solar activity on the visible side of the sun, as recorded by terrestrial observatories, was at an extremely low level, with only minor subflares reported.

By April 10, the active region that had produced the earlier proton flare had rotated on the far side of the sun to a position of about 20 deg behind the east limb. On this date, it again erupted, producing a large proton flare. Within a half hour, cosmic-ray intensities recorded by *Pioneers VI* and *VII* jumped by more than an order of magnitude, but the instruments aboard *Pioneers VIII* and *IX* and those on the earth showed essentially no change.

Two days later, cosmic-ray detectors aboard *Pioneers VIII* and *IX* and those on the earth satellites were indicating large increases in proton intensities, and protons began showering into the region of the polar caps of the earth. By April 13, severe polar-cap absorption was in progress, and the geomagnetic field was moderately disturbed. Radio communications in the arctic regions became virtually impossible for almost a week as this solar proton storm ran its course.

These scientific observations have contributed to the progress toward near-real-time distribution of space weather data. Also, metric data from *Pioneer IX*, along with data from the other spacecraft in the series, have provided improved navigational accuracy for *Apollo* and *Mariner* spacecraft. From the individual spacecraft data and correlation of data from all or part of the spacecraft, the varying plasma ion content, plasma angular distribution, plasma-temperature anisotropy, and cosmic-ray anisotropy have been researched.

B. Spacecraft

1. General requirements. The *Pioneer* spacecraft general requirements were the following:

(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 less than 1 γ ($\gamma = 10^{-5}$ G) 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 the 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. The structure met the strength and rigidity requirements to withstand the vibration and acceleration loads of the launch vehicle.

2. ***Subsystems.*** The telemetry and command communication subsystems were compatible with the DSN requirements and the need for long-distance communication. The communication subsystem operated at S-band frequencies. When the subsystem operated in a coherent mode, the frequency transmitted from the spacecraft was a fixed ratio of that received by the spacecraft. As a result, accurate doppler measurements could be made so that the spacecraft velocity relative to the earth, and hence the trajectory, could be determined. The telemetry communication subsystem also operated at a frequency governed by an on-board oscillator to provide for the occasions when the ground stations were not transmitting to the spacecraft or when the doppler measurements were not required.

3. ***Pioneer IX spacecraft.*** The *Pioneer IX* spacecraft was a cylinder 35.14 in. high and 37.30 in. in diameter with a weight of 148 lb, including 39.5 lb of experimental equipment. Constructed principally of durable, lightweight aluminum, the spacecraft contained five basic subsystems: thermal control, orientation control, communications, data handling, and power supply. Figure 4 shows an exploded view of *Pioneer IX,* which is made up of 56,000 parts.

a. Power supply. Electrical power was provided by a solar array consisting of 10,368 N-P type solar cells mounted on the outer surface of the cylindrical spacecraft body. Altogether, the solar cells could generate 80 W of power at the distance of the earth from the sun and more when nearer the sun. A narrow, circular band divided the solar array and contained apertures for experiment viewing and orientation sun sensors.

During the launch and initial orientation phases, power was provided by a rechargeable battery that was also used throughout the remainder of the mission to provide peak power requirements for the instruments and equipment. Figure 5 is a simplified block diagram of the spacecraft.

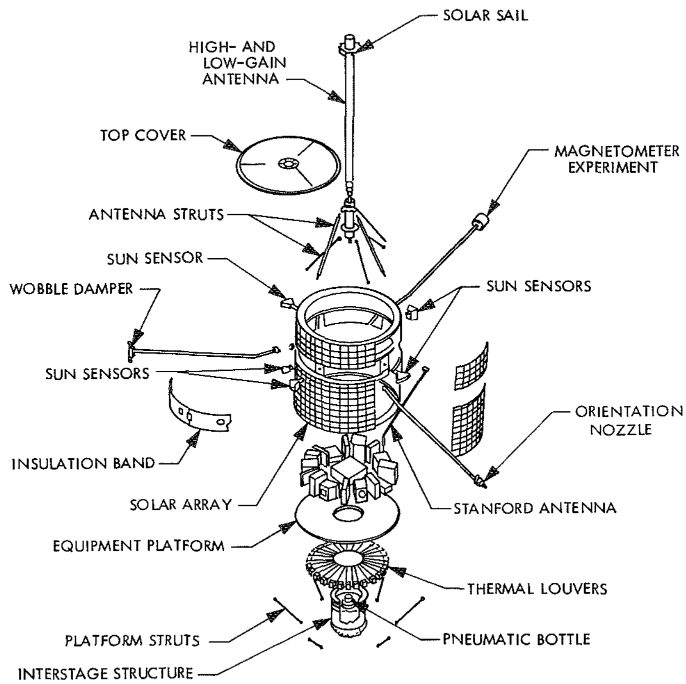
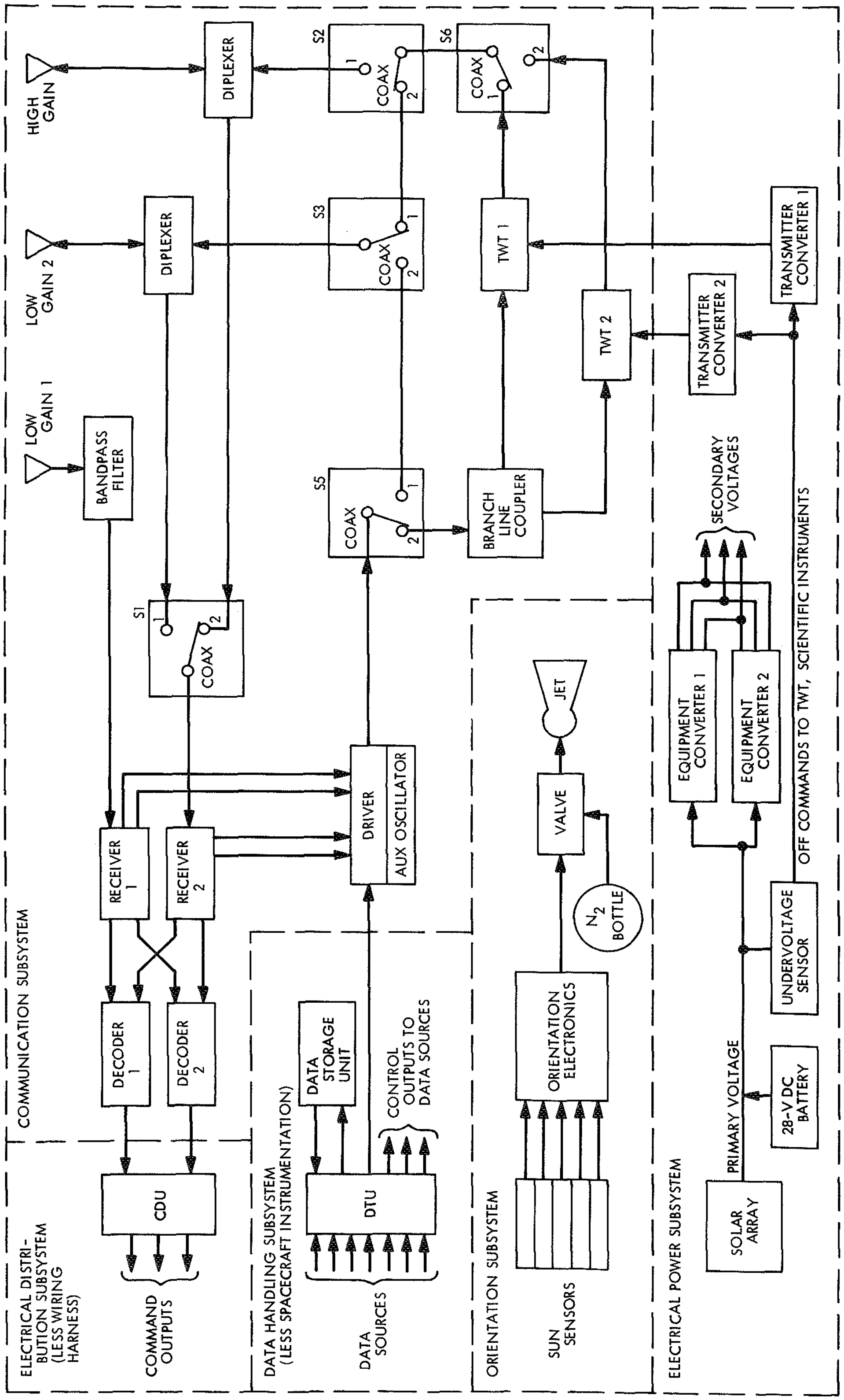


Fig. 4. Exploded view of *Pioneer* spacecraft

Power to the scientific instruments was supplied directly from the spacecraft primary bus; therefore, each instrument has its own converter. Power to all instruments was turned off by a single ground command; each instrument could be turned on individually by ground command. The power required for the instruments, when one plasma detector was operating in its low-power mode, was 9 W; when in the high-power mode, 18 W was required (approximately 18 and 35%, respectively, of the total *Pioneer IX* power).

b. Orientation and thermal control. The spacecraft had three radial booms 5 ft, 4 in. long; 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 the Stanford University scientific experiment. Except for a small viewing band provided for the scientific instruments, the curved surface of the cylinder was covered with solar cells to supply the on-board power. Within the cylinder was a single platform on which all of the electronic equipment for the spacecraft and scientific instruments was located. Thermal louvers aft of the equipment platform covered a portion of the platform area and controlled the amount of heat radiated from that surface. These components are shown in Fig. 6.



CDU = COMMAND DISTRIBUTION UNIT
DTU = DATA TRANSMISSION UNIT

Fig. 5. Simplified functional block diagram of *Pioneer* spacecraft

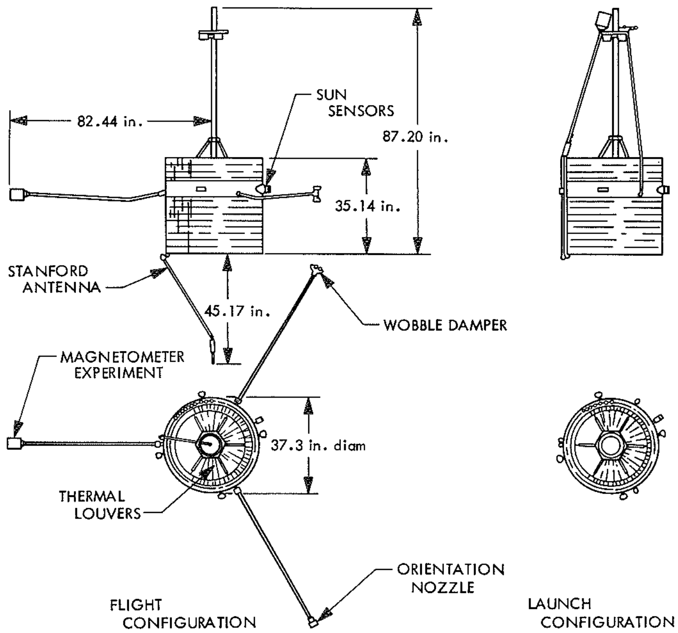


Fig. 6. *Pioneer* spacecraft configuration

The booms could be folded against the antenna mast and the Stanford antenna against the cylinder so that the spacecraft could fit within the launch-vehicle fairing. After separation from the third stage, the booms and the Stanford antenna were automatically deployed. The three booms augmented the spacecraft moment of inertia about the spin axis to achieve the gyroscopic stabilization required for the mission.

For magnetic cleanness, the magnetometer was placed at the end of one of the booms, as far as possible from the spacecraft equipment that induced magnetic fields. (Magnetic-compensation design techniques were also used.) Another boom had a nozzle that, as part of the nitrogen gas jet system, provided the torque for attitude control of the spacecraft. The third boom had a wobble damper at its end. The wobble damper consisted of two small balls floating inside a fluid-filled cylinder. Friction of the balls moving through the fluid converted the kinetic energy of the wobble to heat, which was dissipated into space. The wobble resulted from the single cold gas jet, which operated in brief spurts during powering orientation maneuvers.

c. Communications. To provide the required communication capabilities within the constraints imposed by the electrical power subsystem, the antenna mast was a high-gain antenna with a disk-like pattern axially symmetric with respect to and perpendicular to the spin axis. Because the spin axis was perpendicular to the ecliptic plane, and the earth and the spacecraft were in the ecliptic plane, there was assurance that the earth would be illuminated by radiation from the spacecraft without a separate antenna-pointing system.

C. Launch Vehicle

The three-stage, thrust-augmented improved *Delta* (DSV-3E) of *Pioneer IX* had three attached solid-propellant motors to augment the first-stage thrust. The components of the *Delta 60* and their principal dimensions are shown in Fig. 7.

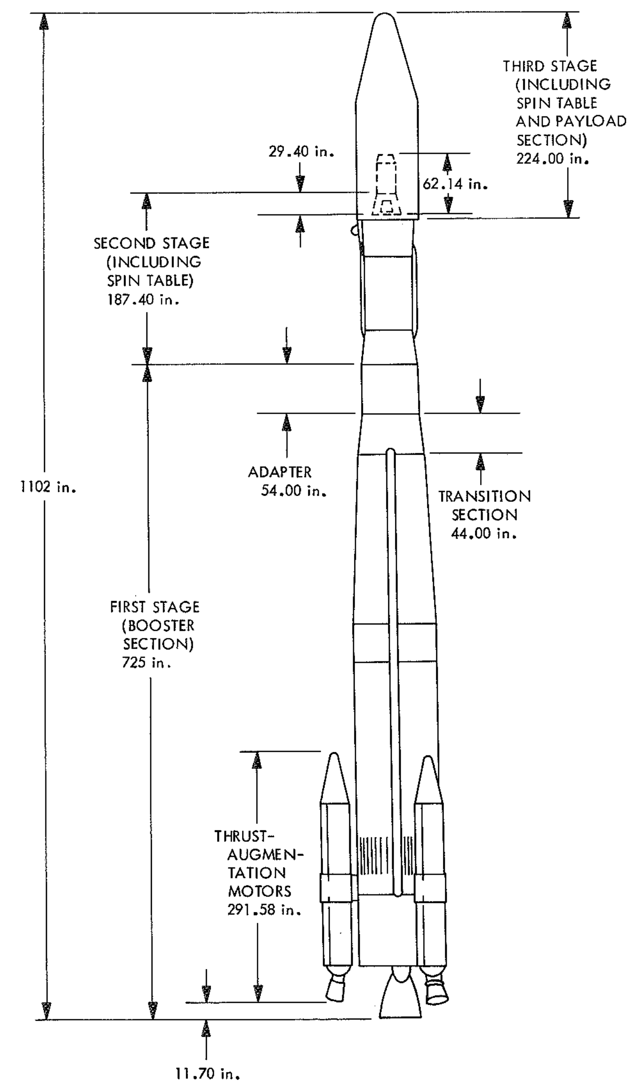
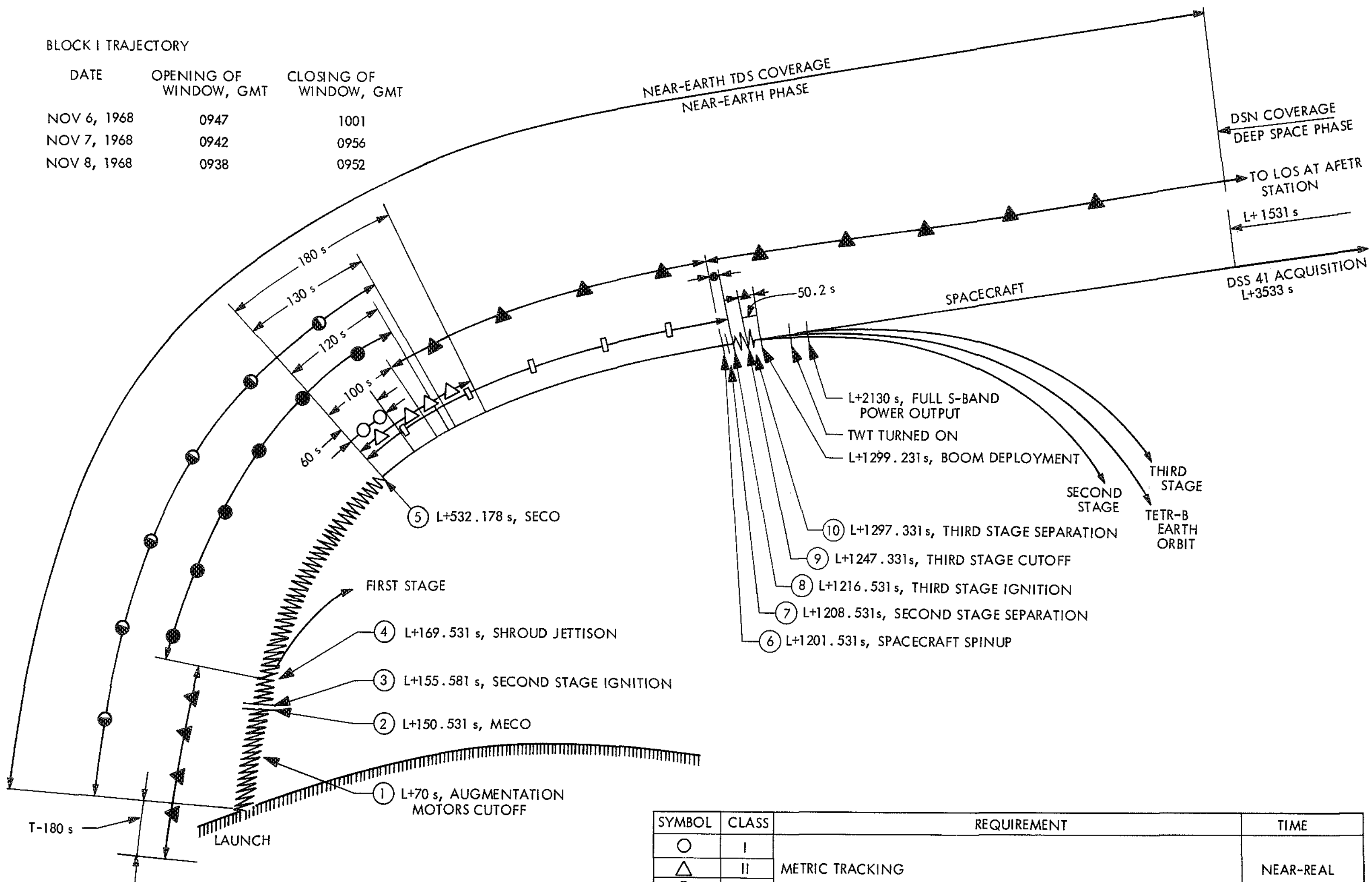


Fig. 7. Thrust-augmented improved *Delta* (DSV-3E) launch vehicle

BLOCK I TRAJECTORY

DATE	OPENING OF WINDOW, GMT	CLOSING OF WINDOW, GMT
NOV 6, 1968	0947	1001
NOV 7, 1968	0942	0956
NOV 8, 1968	0938	0952



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

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

NOTES

1 ALL EVENT TIMES ARE TYPICAL.

2 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.

3 ENCIRCLED NUMBERS INDICATE MARK EVENTS.

Fig. 8. Typical *Pioneer* trajectory profile

1. First stage. The first stage of *Pioneer IX* was a modified liquid-propellant MDAC *Thor* booster, powered by a Rocketdyne MB-3 Block III engine system. The engine system was rated at 172,000 lbf thrust at sea level, and it was augmented by three Thiokol solid-propellant motors, each of which was rated at 52,000 lbf thrust at sea level. The liftoff weight was approximately 150,000 lb, and the liftoff thrust was 325,000 lbf. Of the latter, the *Thor* supplied -175,700 lbf. The fuel was RP-1 kerosene and the oxidizer for the *Thor* stage was liquid oxygen.

2. Second stage. The second-stage thrust was supplied by a pressure-fed Aerojet General Corporation AJ10-118E liquid-propellant propulsion system. The weight at ignition was approximately 14,000 lb. The thrust was rated at 7800 lbf in a vacuum. The fuel was unsymmetrical dimethylhydrazine (UDMH) and the oxidizer was inhibited red fuming nitric acid (IRFNA).

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

The third-stage propulsion was provided by a UTC FW-HD solid-propellant rocket motor. The weight at ignition including the spacecraft was about 735 lb. The thrust was 6000 lbf at 100,000-ft altitude. The spacecraft was mounted on an X-258 motor.

D. Solar Orbit

The DSN plans for the *Pioneer* Project called for a medium accuracy solar orbit based upon two-way tracking data received from the Deep Space Stations. The minimum accuracy required of the *Pioneer IX* was 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.

1. Trajectory. The *Pioneer IX* trajectory (Fig. 8) was designed to minimize the time to reach superior conjunction (a position directly behind the sun in relation to the earth) and to produce a heliocentric orbit with characteristics of solar occultation (spacecraft eclipsed by the sun). At $L+770$ days, the spacecraft was to reach solar occultation. An early prediction of possible multiple occultation was not fulfilled.

Prior to and following the superior conjunction, *Pioneer IX* was to perform the analyses of the solar corona and the solar atmosphere near the solar disk as the spacecraft was occulted. Near-continuous coverage within the capability of the 210-ft diam antenna of the DSN was required from October 1970 to January 1971. Actual dates were obtained as a result of orbit determination from two-way doppler tracking. Continuous support was provided January 30, 1969, during the inferior conjunction. For lunar occultation, *Pioneer IX* required 24-h continuous tracking coverage from syzygy -5 days to syzygy $+15$ days.

2. Launch block study. The *Pioneer IX* launch block study had produced a series of three blocks, with a minimum daily window of 30 min and a maximum deviation in perihelion of ± 0.005 AU. Block I ran from August 21, 1968, to October 8, 1968; Block II ran from October 3, 1968, to November 15, 1968; and Block III ran from approximately November 10, 1968, to December 3, 1968. The objective was to achieve a heliocentric orbit with a nominal perihelion of 0.76 AU, an inclination of 0.00 deg, a lunar occultation, a launch azimuth of 108 deg, and to maximize the time interval of the spacecraft close to the superior conjunction.

To achieve the planned heliocentric orbit for *Pioneer IX*, the guidance system of the launch vehicle provided both inertial and radio guidance. The first and second stages were inertially guided by precise preprogrammed autopilots. In addition, for trajectory refinements, a ground-based guidance system was used during the first- and second-stage powered flights. The second-stage autopilot supplied five discrete steering commands and six flight sequences. The third stage was spin-stabilized before firing and had a fixed direction in space.

IV. Preflight Testing and Launch Readiness

A. Prelaunch Event Synopsis

Prelaunch preparation began October 6, 1968, upon arrival of the *Pioneer* spacecraft at AFETR. Approximately 20 working days were required to set up the spacecraft and to begin system tests. The launch vehicle had been erected on September 1, 1968. The spacecraft was integrated with the third stage, and then the third-stage–spacecraft combination was placed on launch pad 17-B.

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* spacecraft with a typical Deep Space Station.

*1. **Operational readiness test.*** Two operational readiness tests were performed 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. Following the operational readiness tests and the final launch operation checks, a launch readiness review was conducted where all areas of responsibility for the launch operations and the 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 to provide the mission director with background for his decision of *go* or *no-go.*

Following the final operational readiness test, Deep Space Stations 51, 42, 62, and 12 underwent *Pioneer* configuration control.

*2. **Countdown.*** During the countdown, the Deep Space Stations calibrated the station and mission-dependent equipment. Also, during the countdown, the spacecraft was supplied with external power to conserve the spacecraft battery in case of orientation difficulties after injection. The spacecraft was put on internal power (battery) exclusively at $L-5$ min. Because of the necessity to conserve battery power, the spacecraft was launched with all travelling-wave tubes (TWTs) off. During the final stages of the launch operations countdown, the transmitter driver was commanded to low-gain antenna 2 for the 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 dropped after the TWT had 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.

Since scientific instruments are not 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.

The initial activity at JPL/SFOF consisted of establishing and checking voice and teletype circuits, and the assessment of spacecraft condition with particular emphasis on the rest frequencies of the receiver and transmitter, and the initializing of all computer facilities. A sequence of significant prelaunch events follows:

(1) July 10: final experiment calibration.

(2) July 25: FPAC[1] acceptance at SFOF.

(3) August 2: SPAC[2]/SSAC[3] acceptance at SFOF.

(4) October 2: receive EGSE[4].

(5) October 6: receive spacecraft at AFETR.

(6) October 9: SFOF integration 2.

(7) October 23: mate spacecraft third stage to *Delta.*

(8) October 24: operational readiness test 1.

(9) October 31: operational readiness test 2.

(10) November 5: countdown initiation.

(11) November 7: third-stage servicing.

(12) November 7: second-stage propellant servicing.

(13) November 7: first-stage fueling.

(14) November 8: tower removal.

(15) November 8: LOX fill.

B. Preflight Tests

*1. **DSN system readiness test.*** The Cape Kennedy (Building AO) communications and operations personnel participated in the DSN system readiness test on October 14, 1968. The purpose of this test was to exercise the data flow paths to be used in future tests and the launch. The simulated tracking data, prepared earlier by the RTCF at AFETR, were transmitted from the Building AO communications center. The DSN spacecraft telemetry data were *back fed* from the SFOF to Building AO. The problems encountered during this test were of a minor nature and were corrected by the operational readiness test of October 24, 1968.

---

[1]FPAC = flight-path analysis and command.

[2]SPAC = spacecraft performance analysis and command.

[3]SSAC = space science analysis and command.

[4]EGSE = electronic ground support equipment.

2. ***AFETR compatibility tests.*** On October 16, 1968, with the spacecraft in Cape Kennedy Building AM and the roof antenna directed toward DSS 71, Merritt Island telemetry station (Tel 4) locked its data receiver on the spacecraft signal and recorded the 2048-Hz subcarrier. Data from this magnetic tape was successfully received during the following week by DSS 71.

During this same interval, with the spacecraft on the launch pad, Tel 4 reacquired the spacecraft signal. The station then transmitted the 2048-Hz subcarrier via a wideband line to Building AM where the telemetry was successfully recovered. These compatibility tests verified: (1) the RF interface between the AFETR and the spacecraft, (2) the data record and recovery capability between the AFETR and the range user, and (3) the real-time data transmission interface between Tel 4 and Building AM.

Although the *Pioneer* Project had requested magnetic tape originals recorded at 60 in./s, it was learned during the compatibility test that AFETR planned to provide 60-in./s dubs made from originals recorded at 30 in./s. It was subsequently decided the AFETR method was acceptable.

3. ***Operational readiness tests.*** An operational readiness test, the first in preparation for launch, was performed on October 24, 1968. Elements of the AFETR, the MSFN, and the DSN participated in this test. A launch of November 6, 1968, with a liftoff of 0947 GMT on a launch azimuth of 108.0 deg was simulated. *Pioneer* Project personnel participated from Cape Kennedy Building AE Mission Director's Center (MDC). The near-earth TDS experienced several problems during this test. The more significant ones are summarized as follows:

a. AFETR RTCF.

(1) The heliocentric orbital parameter message was not provided.

(2) Orbital elements, predicts, and I-matrices were delivered late.

(3) Computed data messages lacked end of message (EOM) coding. Previous launch support had included this item.

(4) In the preparation of predicts for DSS 51, the wrong antenna type was used—az–el instead of hour angle–declination (HA–dec).

(5) Titles of the orbital elements messages were wrong (e.g., *Postretro* appeared on some).

b. MSFN. The simulated data from the Ascension USB site were for the *Delta* second stage instead of the *Pioneer* spacecraft. Also, the times were in ground elapsed time instead of GMT.

c. DSN.

(1) The DSS 51 tracking data handling subsystem punch test sent to Building AO was a moving point rather than a static point.

(2) The message sent to update the inputs to the AFETR predicts was lost because it was addressed to GKYA, the spacecraft science telemetry line. The final update message, which was due before $T-0$, arrived at $T+6$ min.

(3) Miscellaneous problems were encountered with the voice levels in the cross-country communication nets.

4. ***Correctional measures.*** As required, the necessary correctional measures were coordinated with each element.

a. Test resumption and count. Because of the problems experienced during the operational readiness test of October 24, the test was rescheduled for October 28, with the AFETR and the MSFN participating. In this second test, trouble was encountered in transmitting the parking orbit elements that arrived late at Building AO and the EOMs were still missing from the data. Power and air-conditioning problems were reported by the RTCF at $T+63$ min. Because of the poor plus-count, the test was recycled to $T-5$ min and held until the RTCF was fully operational.

The count was resumed at $T-5$ min; however, at $T-3$ min, the RTCF 3600 computer was not ready to operate. The test was again recycled to $T-5$ min, and held for 168 min until the computer was ready to operate. The problem with the computer was thought to be in the hardware interface with the communications lines.

After resuming count, it was necessary to shorten the plus count because of other scheduled use for the RTCF. This run proceeded smoothly, with all computed items except the heliocentric orbital parameter message delivered on time. The heliocentric orbital parameter message was not provided, and the EOMs were again missing.

The format of the Ascension USB site data was also questioned because of the presence of zeros instead of spaces in the last two characters; however, it was later determined that this was acceptable.

b. Outstanding problems. The main problems from this test were as follows:

(1) Nonavailability of the heliocentric orbital parameter message.

(2) Absence of EOMs on the predict and I-matrix messages.

(3) Difficulty in evaluating the Ascension USB site data.

Since the delivery of the data was good, no additional tests were scheduled prior to the test on October 31, 1968.

c. Final operational readiness test. For the final operational readiness test, the voice nets were initially established with levels considered adequate, but as the test progressed there were reports of sound levels that were too high. These problems were corrected. The tracking data handling subsystem (TDH) punch tests from the DSN were satisfactory. The address GKYA still appeared in the routing indicator for the update to the AFETR predicts message; however, a proper heading of GKAP was used as well.

At $T-5$ min, the Superintendent of Range Operations (SRO) reported that another test required the use of the radars at Ascension and *Pretoria* as well as the data lines to Cape Kennedy. There was no hold; the test progressed and was reasonably successful. The simulation conditions were the same as those used on the first operational readiness test. Because of the conflicting requirements of the test, the communication line assignments between Building AO and the RTCF were not necessarily valid.

The first set of predicts transmitted for DSS 51 was garbled. The set was retransmitted later. The garbling occurred between Cape Kennedy and GSFC, but the cause was never clearly established. The RTCF also experienced problems computing an orbit using the DSN data. The EOMs were provided during this test; however, the heliocentric orbital parameter message was again missing. Retransmission of the vehicle telemetry data from downrange to Building AE was exercised successfully. Although problems were encountered, no further testing was scheduled prior to launch.

V. Near-Earth Phase Requirements

A. Launch Phase Major Events

1. Initial preparation. During the launch phase of any space mission (from launch to the initial Deep Space Station acquisition), several events occur which have a major influence upon mission success. Examples are powered flight and separation events that lead to the injection of the spacecraft into its deep space trajectory and the subsequent final separation of the spacecraft from the launch vehicle third stage. Information gathered from tracking and telemetry during the period of these events was used to continually evaluate and update the status of the flight.

Acquisition support by the AFETR was important to the successful initial acquisition by the first-viewing committed DSN station. This AFETR acquisition support effort was primarily directed toward evaluating the performance of the launch vehicle including the third-stage burn because the DSN acquisition occurred subsequent to the third-stage burn. In addition to being vital to the acquisition effort, the near-real-time evaluation of the launch vehicle performance was of concern to spacecraft operations personnel. For example, if the launch vehicle performance had been nonstandard during any portion of powered flight, early indication of the degree of abnormality of the flight would have presented an opportunity to change the command sequence of the spacecraft event to meet flight test objectives.

2. Evaluation methods. There were two general methods of evaluating the launch vehicle performance in near-real-time. One method involved comparing the actual mark times of the significant launch vehicle events from telemetry with the predetermined nominal times and analyzing the differences. This method called for general evaluation of all available telemetry. The second method required metric data in order to calculate the resultant trajectory subsequent to the first- and second-stage burn. A comparison of the actual trajectory with the anticipated nominal gave an evaluation of the launch vehicle performance. By employing both of these methods, one could be used to determine the validity of the conclusions derived from the other.

Actual launch vehicle mark times for the *Pioneer* launches were determined by the AFETR from telemetry received at their sites and reported by the SRO over the AFETR communications network matrix operating programming system. In the launch vehicle telemetry laboratory, the telemetry data were analyzed and the mark times were validated. The mission analyst also provided current reports to JPL regarding the launch vehicle performance based on all information available to him in real-time including the mark times.

The accuracy to which the first and second stages injected the combination third stage–spacecraft into the parking orbit was evaluated by tracking the *Delta*-stage C-band beacon by the AFETR and the MSFN radars subsequent to injection into the parking orbit. Based on this tracking data, trajectory calculations performed by the AFETR at the RTCF established the degree of normality of the parking orbit. The flight path analysis group at the SFOF made this evaluation after receiving the parking orbit elements and the injection conditions from the RTCF. Determining the performance of the third stage by the AFETR in near-real-time was a much more difficult task since this stage was not equipped with a radar tracking beacon. Two methods were conceived, however, which provided some indication of the third-stage ignition and burn duration. One method involved examining the doppler in the RF signal on the carrier of the spacecraft S-band telemetry. The second method depended upon receiving a signal from the beacon installed on the third stage and retransmitting this signal for display and analysis of the doppler frequencies.

Table 4. Near-earth TDS support requirements

Station	Metric tracking C-band radar	VHF telemetry	S-band telemetry
AFETR			
Merritt Island	Third stage	X	X
Cape Kennedy	Second stage	—	—
Patrick AFB	Second stage	—	—
Grand Bahama Island	Second stage	X	X
Grand Turk	Second stage	—	X
Antigua	Third stage	X	X
Coastal Crusader	—	X	X
Twin Falls	—	X	X
Ascension	Third stage	X	X
Pretoria	Third stage	X	X
MSFN			
Bermuda	—	X	—
Ascension	—	X	X
Tananarive	Second stage	X	—
Carnarvon	Second stage	X	—
Guam	—	X	—
Hawaii	Second stage	X	—
Guaymas	—	X	—
Grand Canary Island	—	—	X
Merritt Island	—	—	X

B. TDS Support Program; Class I Tracking Requirements

The overall near-earth TDS support requirements are shown in Table 4; the near-earth TDS Class I requirements are illustrated by Fig. 9.

The minimum requirement for tracking coverage[5] was from SECO to SECO+60 s. Since SECO was considered as the injection point into the parking orbit, this tracking coverage constituted 60 s of the parking orbit.

The Class I C-band, VHF, and S-band overall tracking coverage requirements during the *Pioneer IX* mission near-earth flight phase are presented in Table 5 and illustrated in Fig. 10.

Table 5. Class I requirements for *Pioneer IX* near-earth flight phase

Data	Coverage interval
C-band radar	SECO to SECO+60 s
	Third-stage burnout to third-stage–spacecraft separation[a]
VHF telemetry	Second stage:
	$L-2$ 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]A Class II requirement, but shown here because of its relative importance.

C. Orbit Establishment

Pioneer Project requirements for metric data during the near-earth phase were for information to establish the orbit and normalcy of spacecraft solar injection in real-time as well as for launch vehicle evaluation. These were obtained by tracking the third stage. Since the

[5]*AFETR Project Requirements Document 2500.*

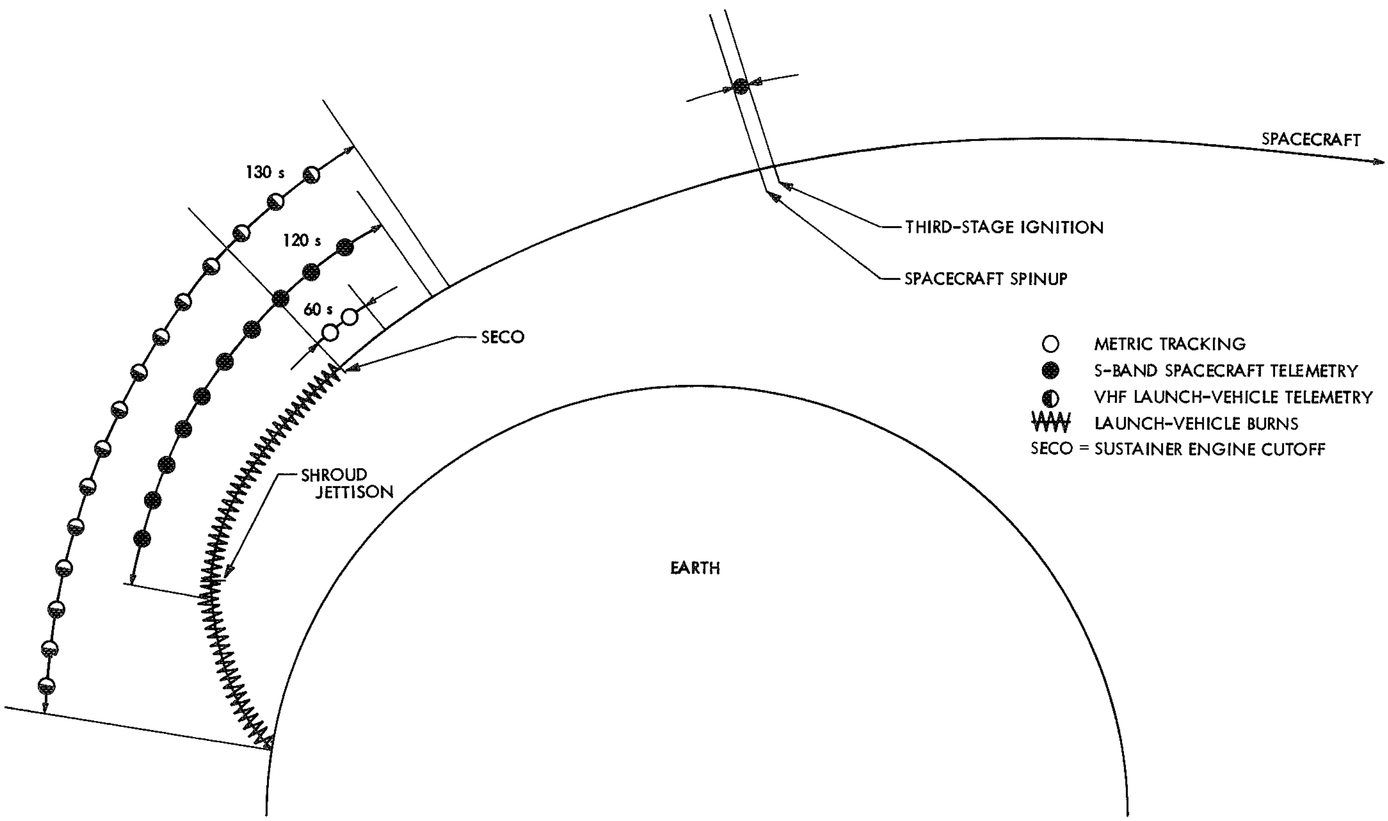


Fig. 9. Near-earth TDS Class I requirements

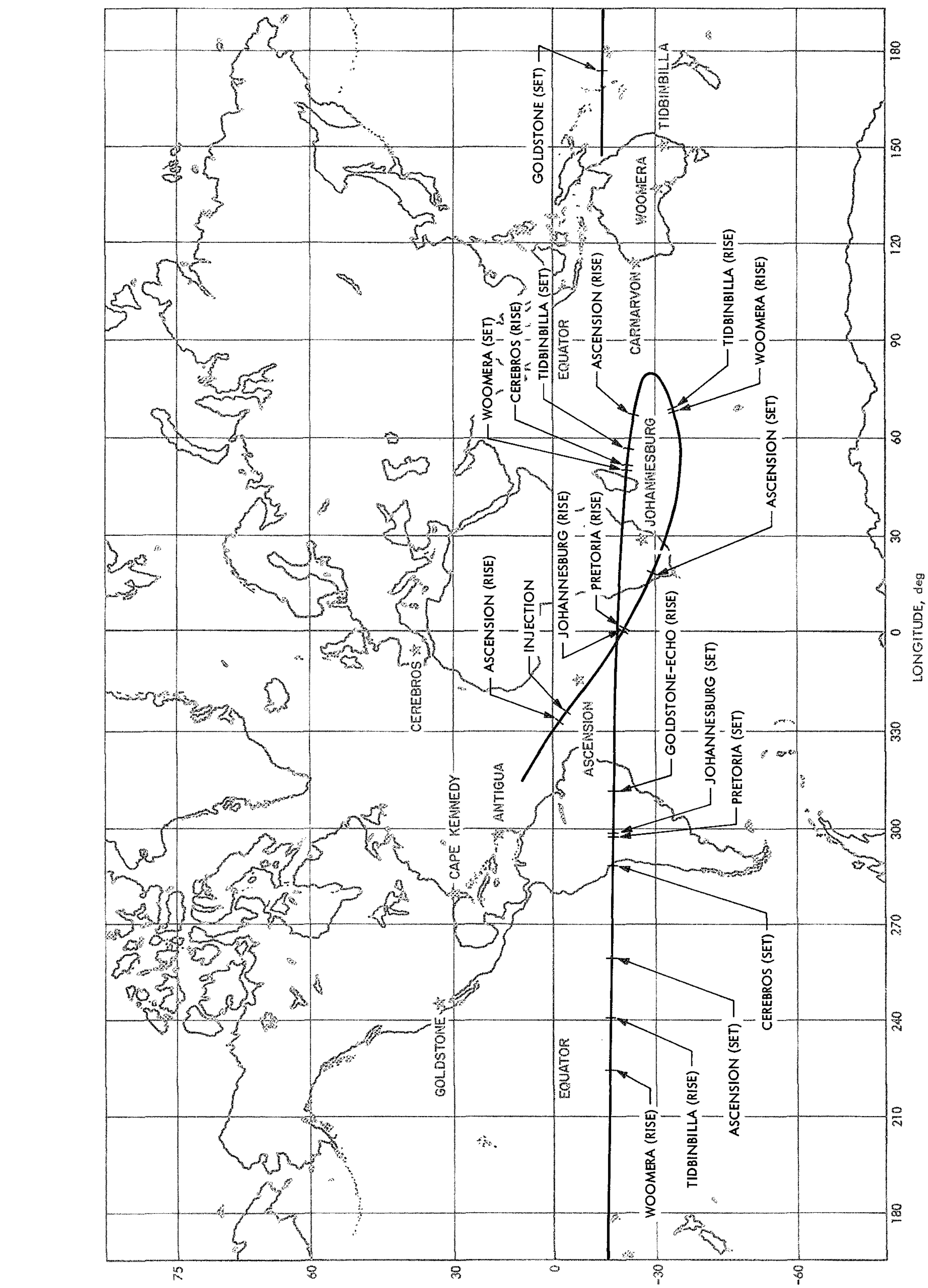


Fig. 10. *Pioneer IX* earth track and station view periods

separation velocity was small, tracking of the third stage, both prior to and subsequent to separation, had great value in determining an early orbit.

The metric data supplied by the uprange AFETR and the MSFN radars were processed by the RTCF at AFETR. The station predicts were generated in real-time for the AFETR, MSFN, and Deep Space Stations farther downrange. In addition, the AFETR forwarded metric data directly to the GSFC for use in generating prediction data for the MSFN stations. These data were also relayed to the SFOF at Pasadena for use with the Deep Space Station data in calculating the spacecraft orbit. The AFETR retransmitted its raw metric data and that of the MSFN stations to the SFOF in near-real-time.

D. AFETR

1. C-band tracking. The AFETR configured its radar support of the launch vehicle so that each radar was assigned to track a specific beacon and would switch to the other beacon only if its assigned beacon was not trackable.

The third-stage tracking was to be committed since the antenna patterns for the third-stage beacon were reliable when a correction in antenna gain was included. However, a portion of the Ascension radar commitment and all of the *Pretoria* commitment were best obtainable because the expected signal strength was low.

The *Pretoria* was requested to provide support until $L+70$ min, unless released earlier. The RIS *Twin Falls* was not configured for radar support because there was enough coverage overlap provided by the land-based stations. All Class I and II C-band requirements were expected to be covered by this support configuration.

2. Computed data. The RTCF was configured to provide the computed data requirements. (See Table 4.) The computation of the heliocentric orbital parameters was to be on a limited commitment basis because of lack of program certification. The RTCF also was to provide the MSFN with the acquisition data in the form of inter-range vectors and look-angles for Ascension, Tananarive, and Carnarvon to assist them in meeting their support requirements for second-stage and spacecraft track.

Data either from Grand Turk or Antigua were to be used for computing the parking orbit elements. Ascension data were to be used for computing the solar orbit. It was also planned to use any available data from the MSFN USB site at Ascension for an additional solution.

The S-band tracking data from the DSN also were to be used to determine a spacecraft orbit and predicts if required.

3. VHF telemetry. The VHF telemetry support was configured to give near-continuous coverage from liftoff through third stage–spacecraft separation. A small gap was predicted in the third-stage coverage (256.2 MHz link) during the coast phase. Also, a 30-s gap between the Ascension set and *Pretoria* rise was predicted for the 234.0 MHz link of the second stage.

The *Twin Falls* and the *Coastal Crusader* were to support in the area between Antigua and Ascension. Their test-support positions were: RIS *Twin Falls*—2°N lat, 33.6°W lon; RIS *Coastal Crusader*—3.2°S lat, 27°W lon.

Real-time retransmission to Cape Kennedy of second- and third-stage telemetry was to be accomplished by Antigua. Ascension and the RIS *Twin Falls* were to retransmit selected channels from the second- and third-stage telemetry links in real-time.

4. S-band telemetry. In addition to the recording of data at the stations (see Table 4), the AFETR telemetry station (Tel 4) on Merritt Island was to retransmit spacecraft telemetry in real-time. These data were to be routed to the spacecraft test area during the launch phase and first pass.

E. MSFN

1. C-band tracking. The MSFN was configured to provide C-band tracking of only the second stage. This was to be accomplished by Tananarive, Carnarvon, and Hawaii. The data were to be used at GSFC, and were not to be transmitted to the AFETR.

2. Computed data. The GSFC data operations branch was to generate and transmit 29-point acquisition messages based on inter-range vectors provided by the AFETR RTCF to Ascension, Grand Canary Island, and Merritt Island unified S-band sites for use in the support of the S-band correlation test. The second-stage tracking data from the AFETR radars were to be used in updating the acquisition messages for those MSFN sites tracking the *Delta* second stage.

3. ***VHF telemetry.*** Tananarive, Bermuda, Guaymas, Guam, Carnarvon, and Hawaii were to receive and record the *Delta* second-stage telemetry. Bermuda was to receive and record the *Delta* third-stage telemetry.

F. Deep Space Network

1. ***Minimum requirements.*** The following minimum requirements needed to be *go* for the DSN to meet Class I requirements:

(1) DSIF:

(a) DSS 71, at least one frequency measurement before $L-30$ min.

(b) DSS 51 in a *go* status.

(c) DSS 42 in a *go* status.

(d) DSS 12 in a *go* status by $L+9$ h (required for possible Type II orientation during first pass).

(2) SFOF:

(a) DSN operations control support in a *go* status.

(b) FPAC team and data processing system (including communications processor) or RTCF at AFETR in a *go* status.

(3) NASCOM/GCF:

(a) One voice and one teletype from RTCF to JPL/Building AO.

(b) One voice and one teletype to the SFOF from JPL/Building AO, DSSs 71, 51, and 42.

The DSN requirements and constraints for each DSN facility supporting the *Pioneer IX* launch, as well as the DSN requirements for the AFETR and the MSFN tracking and trajectory data, are presented in Tables 6 and 7.

2. ***Overall NASCOM requirements.*** Figure 11 shows the overall NASCOM requirements for support of the *Pioneer IX* launch. Launch constraints were as follows:

(1) DSN/GCF operational circuits (Class II):

(a) AFETR/SFOF: three voice circuits (AFETR circuit, status circuit, and mission decision

Table 6. SFOF requirements and constraints

DSN Class II launch requirements	DSN launch constraints
Communications processor	Go[b]
Data processing system[a]	Go[b]
DSN operations control support	Go[b]
FPAC area	Go[b]
Internal SFOF communications	Go[c]
Use of TV monitors	—
Simulation data conversion center support from $L-5$ to $L-3$ h	—

[a]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 for orbit determination, predict, and trajectory generation.

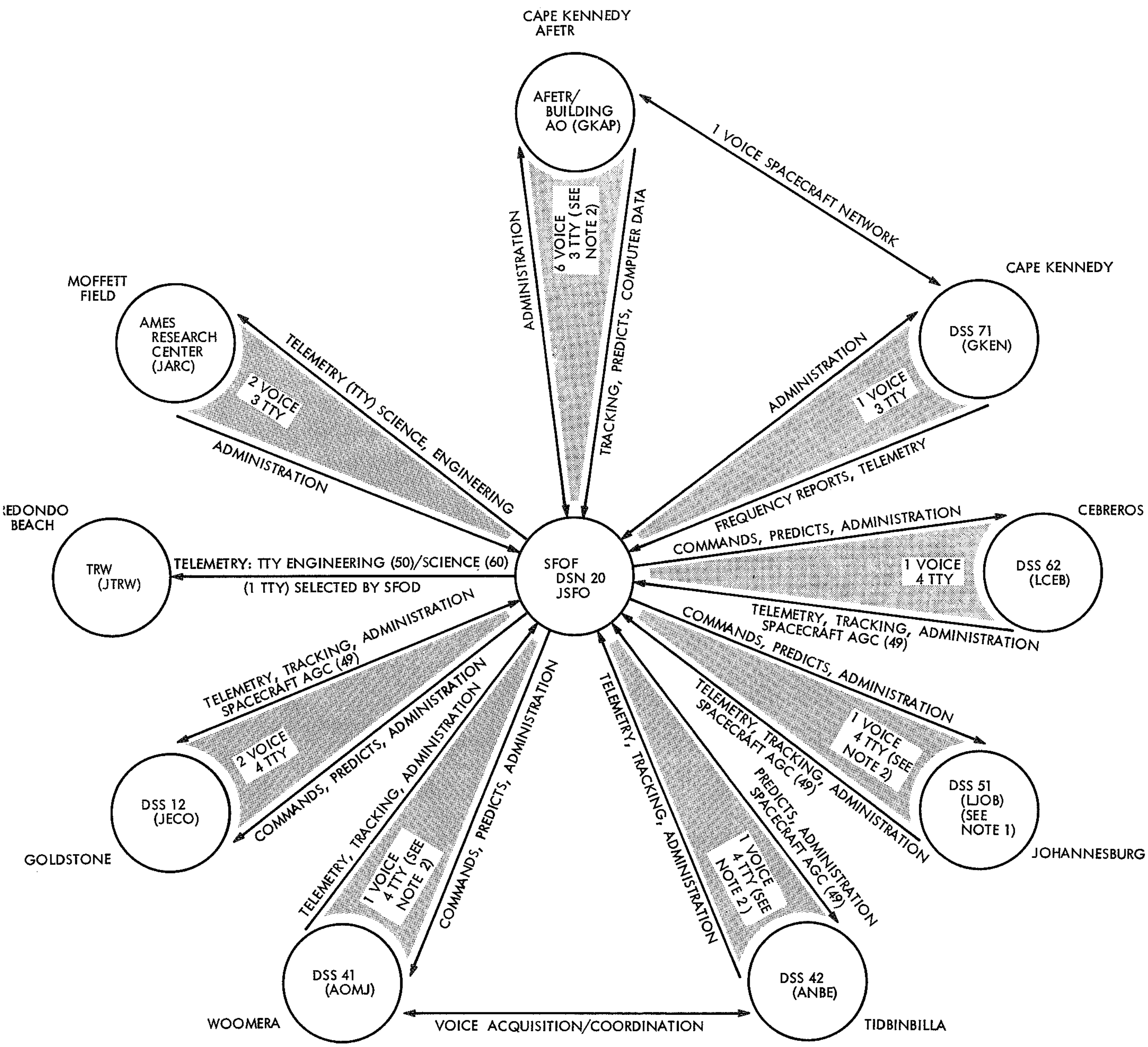
[b]Either the RTCF or FPAC team and data processing system in go status (refer to facility checklists). The communications processor is considered necessary to interface with the data processing system.

[c]Essential communications to operate in nonstandard mode.

Table 7. DSIF launch requirements and constraints

Class I requirements	Class II requirements	Launch constraints
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 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	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
DSS 51 able to provide tracking, telemetry, and command support during initial acquisition and subsequent passes	DSS 51 in a go status (see facility checklist) for initial acquisition	DSS 51 in a go status (see facility checklist) for initial acquisition
DSS 42 able to provide tracking, telemetry, and command support	DSS 42 and DSS 62 in a go status (see facility checklist)	DSS 42 in a go status (see facility checklist)
DSS 12 able to provide tracking, telemetry, and command support by $L+9$ h	DSS 12 in a go status (see facility checklist)	DSS 12 to be in a go status by $L+9$ h[a] (see facility checklist)

[a]DSS 12 was not expected to see the spacecraft until $L+12$ h. Since this station had to be prepared to support a Type II orientation maneuver during the first pass, it would have been considered a launch constraint only if a station problem occurred after $L+9$ h.



NOTES

1: DSS 51/DSS 42 PRIME ACQUISITION STATION

2: THESE TTY CIRCUITS (USING CP) TO HAVE HARDWIRE BACKUP

Fig. 11. DSN–GCF circuit requirements diagram for *Pioneer IX* (near-earth phase)

circuit) and three duplex teletype circuits (one for raw and two for computed data).

(b) SFOF/DSS 71: one voice circuit and two teletype circuits (frequency reports and telemetry data).

(c) SFOF/Deep Space Stations 42, 51, and 12: one voice circuit and two duplex teletype circuits (one for predicts and tracking data and one for telemetry data).

(d) SFOF/ARC: one voice circuit and one duplex teletype circuit (predicts for Stanford and Type II maneuver data).

(2) DSN/GCF operational circuits (Class I):

(a) AFETR/SFOF: one voice (AFETR circuit) and one teletype circuit (frequency reports).

(b) SFOF/DSS 71: one voice circuit and one teletype circuit.

(c) SFOF/DSS 42: one voice circuit and one teletype circuit.

(d) SFOF/DSS 51: one voice circuit and one teletype circuit.

(e) SFOF/DSS 12: one voice circuit and one teletype circuit.

(3) DSN requirements for AFETR and MSFN data:

(a) At least single station raw C-band tracking data from SECO (parking orbit injection) to SECO+60 s in decimal data format.

(b) Raw C-band radar tracking data from third-stage burnout (solar orbit injection) to third stage–spacecraft separation.

(c) Parking orbit elements, injection conditions, and inter-range vector based on actual parking orbit C-band radar tracking data.

(d) Theoretical solar orbit elements, injection conditions, and inter-range vector based on parking orbit and nominal third-stage performance.

(e) DSIF predicts for Deep Space Stations 51, 42, and 41 based on parking orbit and nominal third-stage performance.

(f) Actual solar orbit elements, injection conditions, and inter-range vector based on post-solar orbit-injection C-band radar tracking data.

(g) DSIF predicts for Deep Space Stations 51, 42, and 41 based on actual solar orbit.

(h) Actual solar orbit elements, injection conditions, and inter-range vector based on DSIF tracking data.

(i) DSIF predicts for any Deep Space Station and possibly Stanford based on actual solar orbit if required by FPAC director.

(j) If required by FPAC director, I-matrix for use as inputs for Type II orientation maneuver computation at ARC.

(k) Mark event time reports.

*3. **Prior approval.*** The following constraint was agreed to by the *Pioneer* Project and the TETR-2 Project (S-band only): prior to $L+10$ days, approval of the *Pioneer* Project must be obtained before turning on or tracking the TETR-2 transponder.

The Assistant Space Flight Operations Director represented the *Pioneer* Project on this coordination. The TETR operations manager was to inform the Assistant Space Flight Operations Director that the TETR-2 transponder would be turned on from approximately $L+93$ to $L+123$ min. From L to $L+10$ days, the TETR operations manager was to schedule the transponder on and use the tracking only during the periods when *Pioneer IX* was not in view.

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 (items 1 through 3 below only) during launch were to include:

(1) Spacecraft transmitter one-way frequency measurement.

(2) Spacecraft auxiliary oscillator temperature in degrees Fahrenheit measured coincident with item (1).

(3) GMT measurement of items (1) and (2).

(4) Spacecraft receiver–exciter subsystem (RCV) best-lock frequency.

(5) Spacecraft transmitter subsystem two-way frequency corresponding to spacecraft RCV best-lock frequency.

(6) Spacecraft RCV temperature at time of preceding measurement.

(7) Spacecraft RCV static phase error in volts, corresponding to spacecraft RCV best-lock frequency.

(8) Spacecraft RCV serial number.

(9) Auxiliary oscillator driver serial number.

The equipment listed in Table 8 was to be operational to declare the station in a *go* status to launch.

Table 8. Equipment required

Equipment	DSS 42	DSS 51	DSS 62	DSS 12
Paramp	X	X	X	X
Receiver 1 or 2	X	X	X	X
S-band cassegrain monopulse and microwave	X	X	—	—
S-band acquisition aid subsystem and microwave	X	X	X	X
Exciter	X	X	X	X
Transmitter	X	X	X	X
Servo	X	X	X	X
Tracking data handling	X	X	X	X
Doppler	X	X	X	X
Frequency and timing	X	X	X	X
Magnetic tape recorder, RF-1400	X	X	X	X
Magnetic tape recorder, FR-1400	X	X	X	X
Digital instrumentation Alpha	X	X	X	X
Digital instrumentation Beta	X	X	X	X
SDS-20 computer	X	X	X	X
Power	X	X	X	X
Equipment air conditioner	X	X	X	X
Pioneer GOE	X	X	X	X

VI. Deep Space Phase Requirements

A. TDA Deep Space Phase

1. Overall requirement. The collection of the interplanetary science data beginning with the deep space phase and ending with the termination of the mission required continuous 24 h/day tracking support by the 85-ft-diam antenna DSN stations. Fulfillment of this requirement was subject to constraints caused by the DSN facilities or manpower limitations particularly when flight missions coincided.

2. Support plan. The DSN planned continuous 24 h/day tracking and telemetry data acquisition coverage with three tracking missions each day and a minimum of 1 h of overlap during the first 30 days. From $L+31$ days until the spacecraft exceeded the range of the 85-ft diam antennas, the intent of the DSN was to continuously provide three tracking missions each day giving full 24 h/day coverage. The DSN was to call on the MSFN stations if it could not meet support requirements because of requirements from projects with higher priority. To support the Stanford University radio propagation experiment, the DSN was to make the selection of tracking stations with at least two tracking missions from the Goldstone area each week.

B. Resources and Facilities

Deep Space Stations 12, 42, and 62 with their GOE were to serve as primary support for *Pioneer IX* with the assistance of DSS 12. The backup stations were Deep Space Stations 51, 11, and 61. The latter two stations were connected with the *Pioneer* ground operations equipment via microwave link and multimission support area configuration to Deep Space Stations 12 and 62, respectively. Because DSS 41 was not equipped with *Pioneer* ground operations equipment, it could only operate in a recording mode. After the spacecraft had exceeded the range of the 85-ft diam antenna, DSS 14 with its 210-ft diam antenna was to be the support. Deep Space Station 14 used GOE built from DSS 12 spares.

Because the convolutional coding and sequential decoding experiment boosted information communication characteristics, the 85-ft diam antenna stations fulfilled the data acquisition requirements at a greater distance from the earth than on previous flights and the stations were still performing for *Pioneer IX* at the end of the report period. It was determined that these stations would be used into 1970. Without the convolutional coding and sequential decoding, these facilities would have been inadequate after $L+7$ mo.

The Deep Space Station configurations were as follows:

(1) Antenna: parabolic, 85-ft diam with equatorial mount, operating at 2290–2300 MHz in receive mode and 2110–2120 MHz in transmit mode. The exception was DSS 14, extended mission station, with 210-ft diam parabolic antenna, also operating at 2290–2300 MHz in receive mode and 2110–2120 MHz in transmit mode.

(2) Power: 120 V, 10%, 60 ± 1 Hz, with capacity sufficient for the Project-peculiar equipment; 120-V, 60-Hz power outlets for auxiliary equipment.

(3) Room temperature: 70 ±5°F.
Plenum air temperature: 55 ±5°F.
Humidity: 50 ±10% relative.

(4) Lighting: 100 ft-cd.

(5) Acoustic level: 65 dB above 10^{-16} W/cm^2 max.

(6) Data system hardware: one SDS-910 computer with 8192 words of memory. The computer remained integral to the digital instrumentation system at each station.

1. S-band tracking systems. The parabolic reflector antennas operated without radomes and used polar mounts at S-band frequencies. A cassegrainian feed system was used and the low-noise preamplifier was mounted in the cassegrainian cone assembly. Table 9 gives the characteristics for S-band tracking systems such as these. The gain of the antenna was approximately 53 dB when receiving and 51 dB when transmitting. The beamwidth was 0.35 deg.

The 210-ft diam antenna at DSS 14 was a parabolic reflector that used an azimuth–elevation mount. The gain was approximately 62 dB when receiving and 60 dB when transmitting. The beamwidth was 0.1 deg.

The Office of Tracking and Data Acquistion (OTDA)/DSN formula for use of DSS 14 was based on a yearly average targeting at 60% or more of the time for the coverage of all flight projects, 20% more or less of the time for maintenance, 15% or less of the time for the DSN system development, and 5% or less of the time for scientific research unless preempted by specific instructions from the OTDA.

Because NASA had only one 210-ft diam antenna TDA facility without backup, this station could only be committed for flight support which was not time-critical.

2. Power transmission. The DSS transmitters operated between approximately 0.2 and 10 kW. The maximum

Table 9. Characteristics for S-band tracking systems

Equipment	Characteristic	Equipment	Characteristic
Antenna, tracking		Transmitter	
Type	85-ft-diam parabolic	Frequency (nominal)	2113 Hz
Mount	Polar (HA–dec)[a]	Frequency channel	14b
Beamwidth ±3 dB	~0.4 deg	Power	10 kW, max
Gain, receiving	53.0 dB, +1.0, −0.5	Tuning range	±100 kHz
Gain, transmitting	51.0 dB, +1.0, −0.5	Modulator	
Feed	Cassegrainian	Phase input impedance	≥50 Ω
Polarization	LH[b] or RH circular	Input voltage	≤2.5-V peak
Max angle tracking rate[c]	51 deg/min ±0.85 deg/s	Frequency response (3 dB)	dc to 100 kHz
Max angular acceleration	5.0 deg/s/s	Sensitivity at carrier output frequency	1.0 rad peak/V peak
Tracking accuracy (1σ)	0.14 deg	Peak deviation	2.5 rad peak
		Modulation deviation stability	±5%
Antenna, acquisition-aid		Frequency, standard	Rubidium
Type	2 × 2-ft horn	Stability, short-term (1σ)	1×10^{-11}
Gain, receiving	21.0 dB ±1.0	Stability, long-term (1σ)	5×10^{-11}
Gain, transmitting	20.0 dB ±2.0	Doppler accuracy at F_{T0} (1σ)	0.2 Hz, ±0.03 m/s
Beamwidth ±3 dB	~16 deg	Data transmission	TTY and HSDL[d]
Polarization	RH circular		
Receiver	S-band		
Typical system temperature			
With paramp	270 ±50°K		
With maser	55 ±10°K		
Loop noise bandwidth	12, 48, or 152 Hz		
Threshold (2 B_{LO})	+0, −10%		
Strong signal (2 B_{LO})	120, 255, or 550 Hz +0, −10%		
Frequency (nominal)	2295 Hz		
Frequency channel	14a		

[a]HA = hour angle; dec = declination.
[b]Goldstone only.
[c]Both axes.
[d]HSDL = high-speed data line.

power was sufficient to transmit to the spacecraft whenever reception from the spacecraft was possible. The lower power could be used when the spacecraft was near the earth. Each Deep Space Station was equipped with a parametric amplifier and a helium-cooled traveling-wave maser. At 2295 MHz, the system noise temperature of the amplifier was 270 ±50°K and that of the traveling-wave maser was between 35 and 50°K.

3. ***Types of receivers.*** All Deep Space Station receivers were of the phase-lock-loop type and operated on S-band. These receivers locked to the carrier, detected the subcarrier signal, and supplied the signal to the mission-dependent equipment for demodulation and further processing.

Each Deep Space Station was equipped with two FR-1400 tape recorders and two SDS-910 or 920 computers for use by the flight projects. The recorders recorded telemetry data directly from the receivers and from the mission-dependent equipment and other information from the instruments at the ground station. The computers were used in the *Pioneer* system to perform functions associated with telemetry and command. Examples follow:

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

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

(3) Verifying commands transmitted to the spacecraft and determining that these commands had been executed.

4. ***Specific requirements and plans.***

a. Axis orientation. With command from the ground at DSS 12 and using other Deep Space Stations as alternates, it was necessary to orient the spin axis normal to the ecliptic within several days after launch. The purpose of this requirement was to establish the final reference orientation of the spacecraft spin axis. To furnish one complete Deep Space Station pass over approximately 8–10 h, the DSN planned to furnish mission control capabilities at DSS 12, where the *Pioneer* Space Flight Operations Director and his team were located for this support. The backup support was to be provided from the SFOF.

b. Large solar flares. This coverage had to provide the most useful scientific data. This requirement existed during Class III or greater solar flare events. The DSN planned continuous coverage for 30 to 50 h.

c. Lunar or solar occultation. The probability of a lunar occultation occurring had to be indicated from analysis of the nominal trajectory. Definite times had to be established from detailed analysis of the resultant trajectory. Simultaneous view-periods from Stanford University and Goldstone were also required to make possible simultaneous tracking between the Stanford 150-ft tracking system and the Deep Space Station 12 or 14 tracking system. Coverage was also required from the other stations in Australia, Spain, and South Africa if the solar occultation period occurred during overlap view with Goldstone and Stanford University. The DSN support intended to give continuous coverage from entrance to exit+10 h.

d. Celestial mechanics. The celestial mechanics experiment support was needed for at least 2 passes/wk in a two-way coherent mode. The appropriate longitudinal separation between passes would have been accomplished whenever possible. Plans were to furnish at least 2 passes/wk in a two-way coherent mode. The duration of these tracks was to be at least 9 h in length and were to be centered around the highest elevation points of the antenna beam.

e. Spacecraft spin axis. Support was requested for an orientation of the spacecraft spin axis as directed by the mission operations manager. During this horizon-to-horizon tracking mission, the ARC mission control was to be moved to DSS 12.

f. Spacecraft anomalies. For correction of spacecraft anomalies as determined by the mission operations manager, the DSN planned to furnish continuous 24 h/day coverage until the spacecraft anomaly had been corrected or it had been determined that it could not be corrected. The latter was to be determined by the mission operations manager. The operation period requirements were to be established in real-time by the manager. Whether mission control was to be moved to JPL/SFOF or to remain at NASA/ARC was to be decided by the mission control manager.

5. ***Command support.*** The efficient use of the *Pioneer IX* mission depended upon the proper scheduling of command tracks. Thus, the Deep Space Stations operated in a coherent two-way mode during the majority of the TDA support tracks. The one-way, receive-only configuration was used if the signal power received by

one of the spacecraft receivers dropped into the vicinity of the up-link threshold. During these phases of the mission, the DSN furnished the two-way coherent command mode capabilities either from a single station or from an additional appropriate station of the network.

VII. Near-Earth Support

A. Scope of Support

Actual support received by the *Pioneer IX* spacecraft from the committed facilities of the AFETR, the MSFN, and the DSN and the performance of systems from launch through the near-earth phase of the flight are reported in this section.

B. AFETR

1. C-band support. All Class I metric coverage requirements were met with the actual coverage equaling or exceeding the estimate at most stations. The estimated and actual radar coverages are shown in Fig. 12. Because the transmitter was intentionally turned off to provide a phasing slot for another radar, there was early termination of the Cape Kennedy radar (1.16) coverage.

The Antigua radar experienced a 5-s loss of track at $L+301$ s prior to the data commitment interval because of a primary power fluctuation of undetermined origin. Because of the range recycles, breaks in the track for the Ascension radar (12.16) were indicated.

The two Ascension radars and the *Pretoria* radar were committed for the latter portions of their estimated coverage intervals on a best-obtainable basis. It was anticipated that the signal strength would be below the level required for acceptable metric data recording. Although not indicated in Fig. 12, intermittent tracking by the *Pretoria* radar extended to $L+4650$ s.

2. Computed data support. A parking orbit was computed using the Antigua free-flight data and it indicated an almost nominal parking orbit. An inter-range vector, standard orbital parameter message, orbital elements, and look-angles for Carnarvon and Tananarive were provided from this solution of the orbit. The metric tracking and computed data flow are illustrated in Figs. 13 and 14. The RTCF orbital computations for *Pioneer IX* are shown in Tables 10 and 11.

A theoretical transfer orbit was computed by the RTCF using the Antigua data plus nominal third-stage burn parameters. The inter-range vector, standard orbital parameter message, orbital elements, and the DSN predicts for Deep Space Stations 51 and 42 were computed from this solution. The SFOF reported that these predicts agreed closely with the nominal predicts and that they were received at the Deep Space Stations.

An actual transfer orbit was computed by the RTCF using the Ascension data. The inter-range vector, standard orbital parameter message, orbital elements, I-matrix, and heliocentric parameters were provided from this computation. The RTCF also computed the DSN predicts for Deep Space Stations 51, 42, and 41. These predicts compared closely with the nominal predicts. Because of a message header error, the DSS 42 predicts were inadvertently transmitted to Deep Space Stations 51, 41, and 42. After the transmission started, the error was discovered and a correct transmission was restarted.

The DSS 51 data were used by the RTCF to compute an actual spacecraft orbit. This was considered to be a good solution. The inter-range vector, orbital elements, I-matrix and heliocentric parameters were provided from this solution. A final set of predicts was sent to Deep Space Stations 51, 42, and 41. These predicts matched the nominal predicts closely.

In support of the S-band correlation test, the RTCF also provided additional acquisition data from the DSS 51 data. Updated inter-range vectors and the DSN predicts were provided for the MSFN S-band sites at Ascension (GACN), Canary Island (LCYI), and Merritt Island (GMIL).

The RTCF also provided near-real-time metric data in the decimal format during the near-earth phase. Data in the decimal format were provided from Grand Turk, Antigua, Ascension (TPQ-18), and *Pretoria.*

3. VHF telemetry support. All Class I requirements were met with the actual coverage equaling or exceeding the estimate at most stations. The estimated and actual VHF telemetry coverages are shown in Fig. 15. Grand Bahama Island lost data for 18 s at $L+353$ s. The TAA-2 antenna of the station was slaved to the acquisition bus, which was necessarily switched from Cape Kennedy AFETR (CKAFS) station 1 origin to the Grand Bahama Island origin at a vehicle range of 1×10^6 yd from CKAFS. This caused the antenna to slew away from the vehicle.

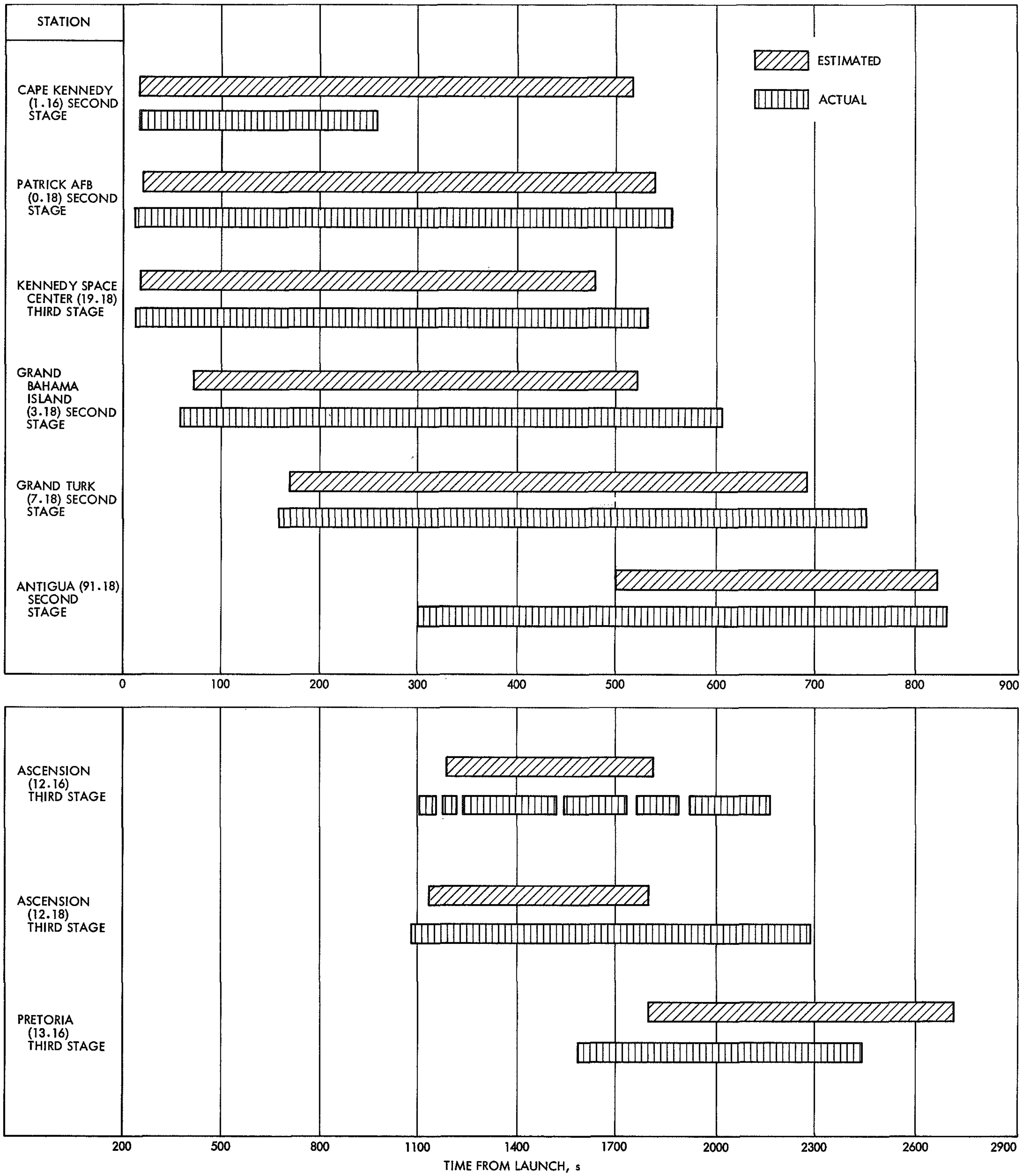


Fig. 12. AFETR radar coverage

Table 10. *Pioneer IX* RTCF orbital computations

Orbit	Epoch,s	Time of computation, min	Data source	Quality of solution
Initial parking orbit	$L+569$	$L+15$	Antigua	Fair
Theoretical transfer orbit	$L+1247$	$L+20$	Antigua plus nominal third-stage burn	Fair
Transfer orbit	$L+1247$	$L+38$	Ascension	Good
Actual spacecraft transfer orbit	$L+1247$	$L+105$	DSS 51 (25 min)	Good

Table 11. *Pioneer IX* orbital parameters from RTCF computations

Parameters		Parking orbit (based on Antigua data)	Parking orbit plus nominal third-stage burn	Actual transfer orbit (based on Ascension data)	Actual spacecraft transfer orbit (based on DSS 51 data)
Epoch time (GMT)		11/8/68 0955:58.7	11/8/68 1007:16.3	11/8/68 1007:16.3	11/8/68 1007:16.3
Earth-fixed sphericals	Radius, deg	6750.0	6845.0	6843.0	6833.0
	Latitude, deg	20.097	03.145	03.105	03.133
	Longitude, deg	299.937	336.386	336.329	336.375
	Velocity, km/s	07.434	10.637	10.631	10.639
	Path angle (gamma), deg	00.185	02.154	02.223	02.319
	Azimuth angle, deg	118.176	125.851	126.094	126.087

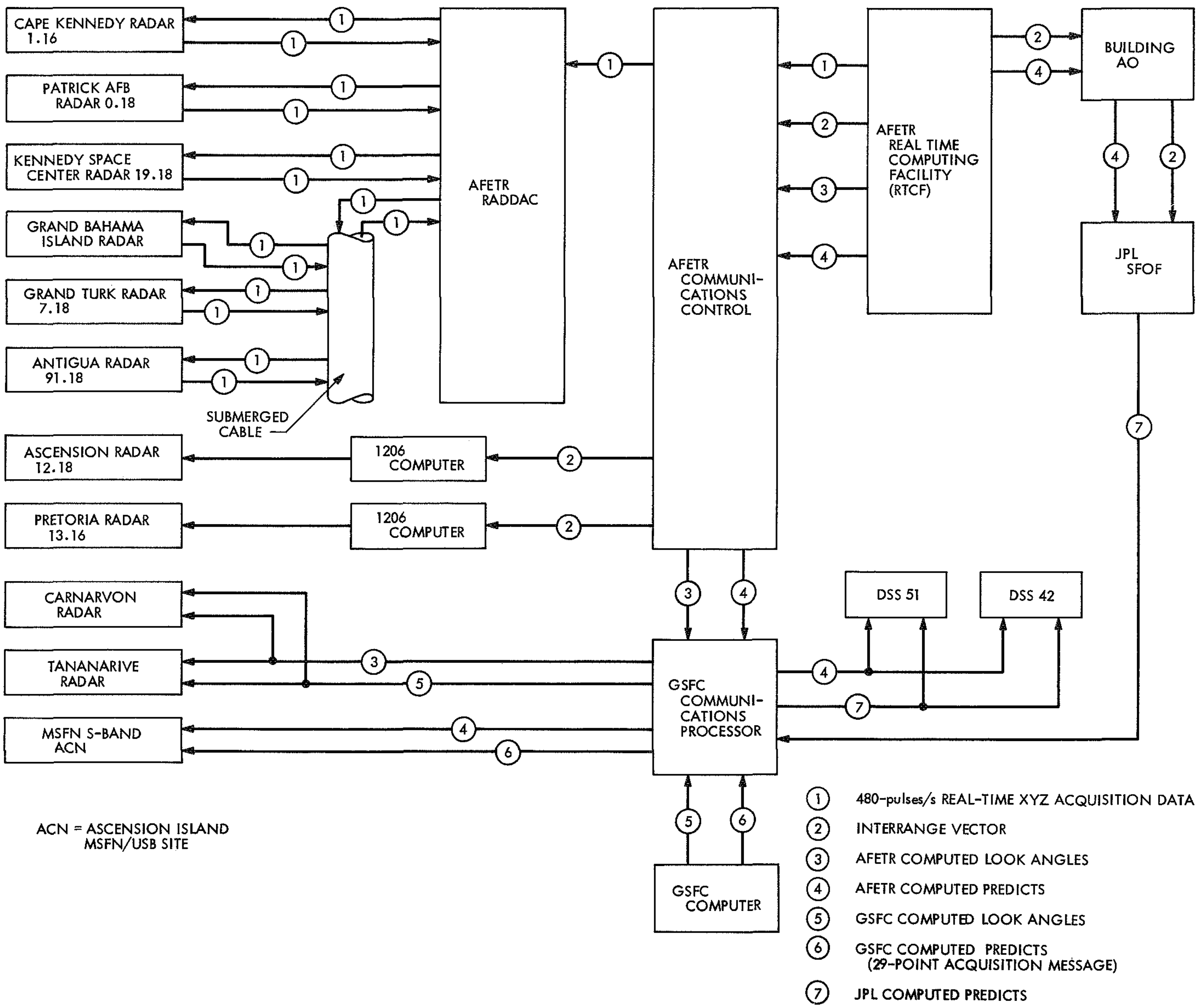


Fig. 13. Acquisition data flow

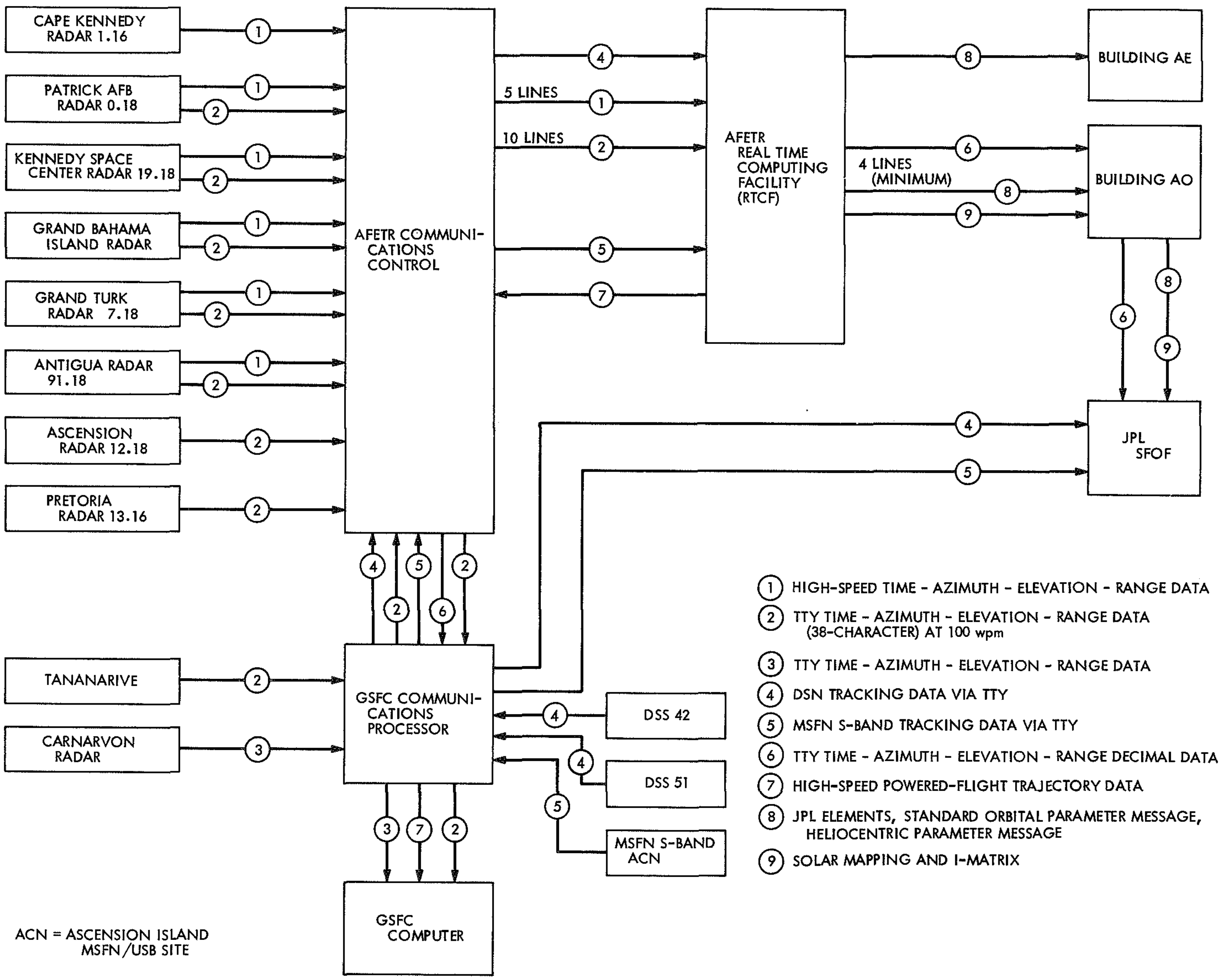


Fig. 14. Metric tracking data flow

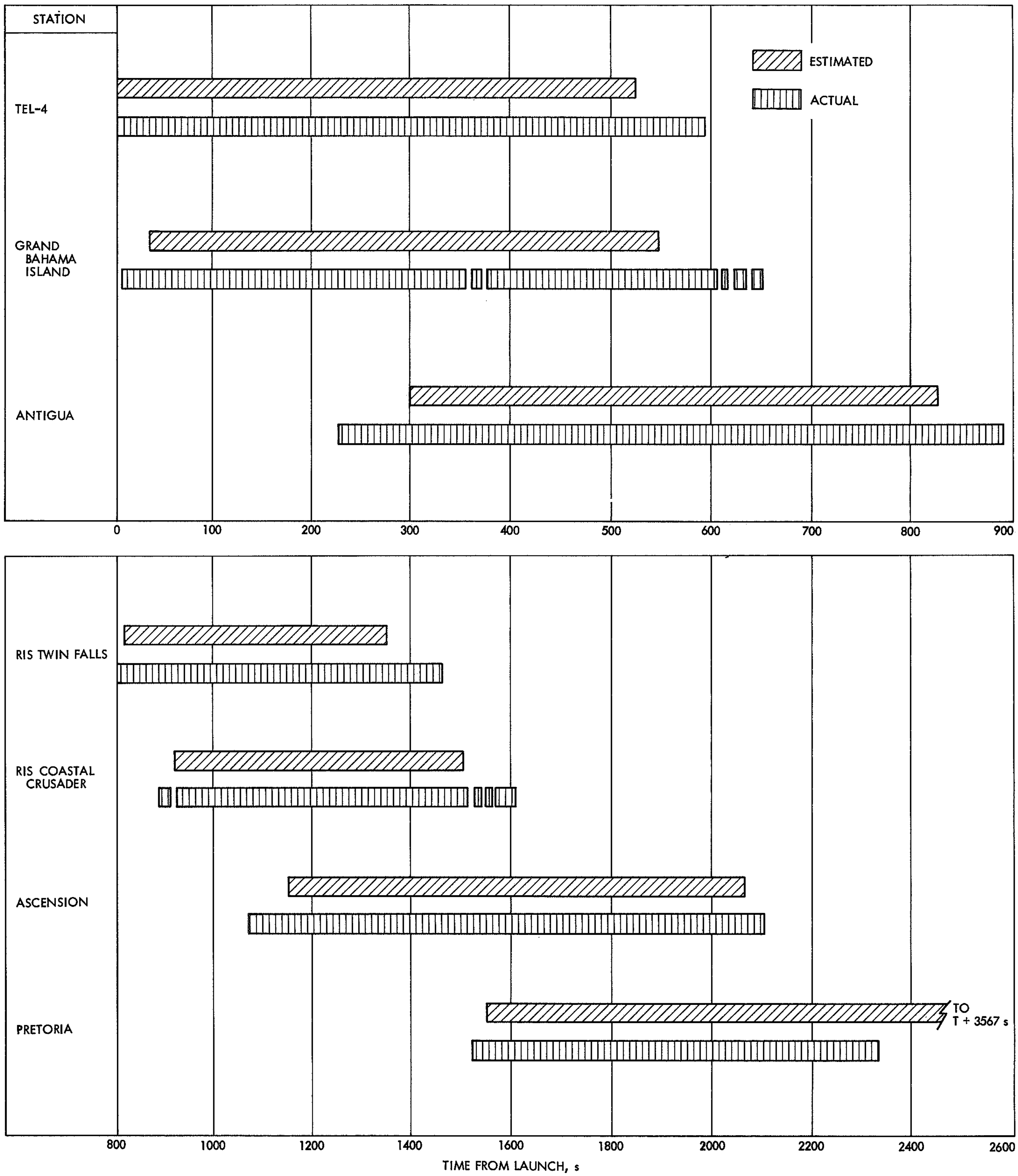


Fig. 15. AFETR VHF telemetry coverage

The RIS *Coastal Crusader* failed to make the near-real-time readouts on the 234.0 and 256.2 MHz links because of the failure of a recorder. An input selector switch short-circuited the common language bus. The *Pretoria* lost data on the 234.0 MHz link from $L+1820$ to 1842 s and from $L+2336$ to 2523 s because of loss of signal.

The RIS *Twin Falls* lost data on the 256.2-MHz link for 27 s at $L+1141$ s. No malfunctions were discovered. The near-real-time reports of the launch vehicle and spacecraft in-flight events (mark events) together with the nominal times of occurrence are shown in Table 12.

*4. **S-band telemetry support.*** The 2292 MHz link transmitter apparently shut down at $L+130$ s, terminating reception at DSS 71 and Grand Bahama Island. Grand Turk, Antigua, RIS *Twin Falls,* RIS *Coastal Crusader,* and Ascension did not observe the signal during the launch phase.

On the sudden loss of S-band signal at DSS 71 and Grand Bahama Island, it was noted that all stations were 18 dB or more above threshold until the moment of dropout. The S-band telemetry was not recovered by any other downrange stations. Deep Space Station 51 did not achieve a firm lock until 12 min after the expected lockup time and the signal level was 16 dB below the expected level at that time.

Five minutes after DSS 51 was in lock, the station transmitter was turned on; within 1 min, the down-link signal was lost, indicating that the spacecraft receiver had been acquired. The down-link signal was reacquired and was at the predicted signal level.

The *Pretoria* received the signal after the transmitter returned to operation at about $L+2400$ s; however, the signal was low and only intermittent phase-lock was achieved.

Table 12. *Pioneer IX* launch vehicle and spacecraft event times

Mark	Event	Nominal time, s	Near-real-time report, s			
			Cape Kennedy	Ascension	*Twin Falls*	*Coastal Crusader*
—	Nominal liftoff	0.000	—	—	—	—
1	Solid motor jettison	70.000	70.0	—	—	—
2	Main engine cutoff	150.531	151.4	—	—	—
3	Second-stage ignition	154.531	156.5	—	—	—
4	Shroud jettison	169.531	171.0	—	—	—
5	Sustainer engine cutoff (SECO)	534.721	—	—	—	—
6	Third-stage spinup	1201.531	—	1202.5	1202.7	1203.5
7	Second/third stage separation	1203.531	—	1214.2	1204.7	—
8	Third-stage ignition	1216.531	—	1218.3	1218.5	1219.3
9	Third-stage burnout (injection)	1247.331	—	1253.4	1251.5	1252.7
10	Third stage/spacecraft separation	1297.331	—	—	—	—
11	Spacecraft boom deployment complete	1299.231	—	—	—	—
—	Spacecraft TWT amplifier on	1299.231	—	—	—	—
—	Type I orientation initiated	1299.231	—	—	—	—
—	TETR separation	—	—	1264.3	1264.7	—

C. MSFN

1. C-band tracking support. Tananarive experienced two drop-outs and an early loss of signal. The first drop-out was caused by a check for sidelobe track; the second was attributed to weak signal strength. A poor aspect angle was reported as the probable cause for the early loss of signal. Carnarvon experienced four drop-outs during its coverage interval. These were also attributed to poor aspect angle. Hawaii acquired the signal approximately 5 min later than had been anticipated. Again a poor aspect angle was listed as the probable cause. The estimated and actual C-band tracking coverages are shown in Fig. 16.

2. Computed data support. The data operations branch provided all the required support.

3. VHF telemetry support. All requirements were met with the actual coverage equaling or exceeding the estimates at most stations. However, Guam did experience an unexplainable 4-min dropout at $L+66$ min. The estimated and actual VHF telemetry coverages are shown in Fig. 17.

D. DSN Near-Earth Support

1. Initial and actual acquisition. Deep Space Stations 12, 42, 51, 62, and 71 were called on to support the launch with DSS 51 the first acquisition station. A momentary signal was received by DSS 51 at 1012:32, but actual acquisition of the signal was not obtained until 1024:11. The auto-track began at 1025:47. The transmitter was turned on at 1029:06 at 10 km with two-way lock occurring at 1030:06 at an exciter voltage-controlled oscillator (VCO) frequency of 21.985792 MHz. The down-link S-band (one-way) frequency at initial acquisition was at 2292.047770 MHz and was computed on the pseudo-residual program output. Deep Space Station 51 had been predicted to acquire the spacecraft at 1002:53. Deep Space Station 71 and the AFETR stations had lost S-band signal at $L+130$ s.

Normal operation of the spacecraft communications subsystem was shown by a detailed examination of all data received during the first 130 s of flight. Examination of the data received by DSS 51 during the first 5-min period the station was in lock before the received power returned to normal showed the following conditions:

(1) TWT temperature was 11°F higher than predicted (vice nominal 100°F).

(2) TWT helix current was 1.4 mA instead of the normal 4.7 mA indicating the power input to the TWT was extremely low.

(3) Deep Space Station 51 received signal strength was 16 dB or more lower than predicted.

The loss of signal during the powered flight indicated a possible reduction in transmitter auxiliary oscillator output. Verification was by the low helix current at DSS 51 acquisition plus the increased temperature of the TWT. At reacquistion after up-link was established, the TWT helix current was nominal. The down-link signal strength was at predicted levels and the TWT temperatures began dropping towards predicted values. The only change on the spacecraft resulting from the up-link acquisition was that the frequency control of the transmitter auxiliary oscillator changed from a crystal-controlled oscillator to the spacecraft receiver. A detailed investigation and analysis led to the conclusion that a problem in the circuitry associated with the auxiliary oscillator was the most probable cause of the observed anomaly.

Good two-way data were received at 1040:42 approximately 38 min after expected initial acquisition. At 1047:00 ($L+62$ min), DSS 42 established three-way lock with DSS 51 and immediately transmitted the engineering and science telemetry data to SFOF as backup to DSS 51. A result of the late acquisition was the delay in the generation of an orbit based on the data. This caused a delay in the generation of predicts.

The pseudo-residual data reduction of DSS 51 metric data showed a problem in the leading digit of the doppler counter: every time it reached four, the doppler counter recycled causing the loss of a data point in the orbit data generator program. This problem happened on the order of 2½ times more often than normal for recycle. Deep Space Station 51 tried to correct the problem in real-time, but abandoned the effort because more data were being lost than if the doppler counter had been allowed to recycle periodically.

However, the final analysis was that the predicts sets to the DSIF were accurate enough for an initial acquisition. The cumulative effect of the problems was that DSS 51 received all the predicts sets at almost the same time near the initial acquisition. Despite this, the efforts of the station were satisfactory in acquiring the spacecraft.

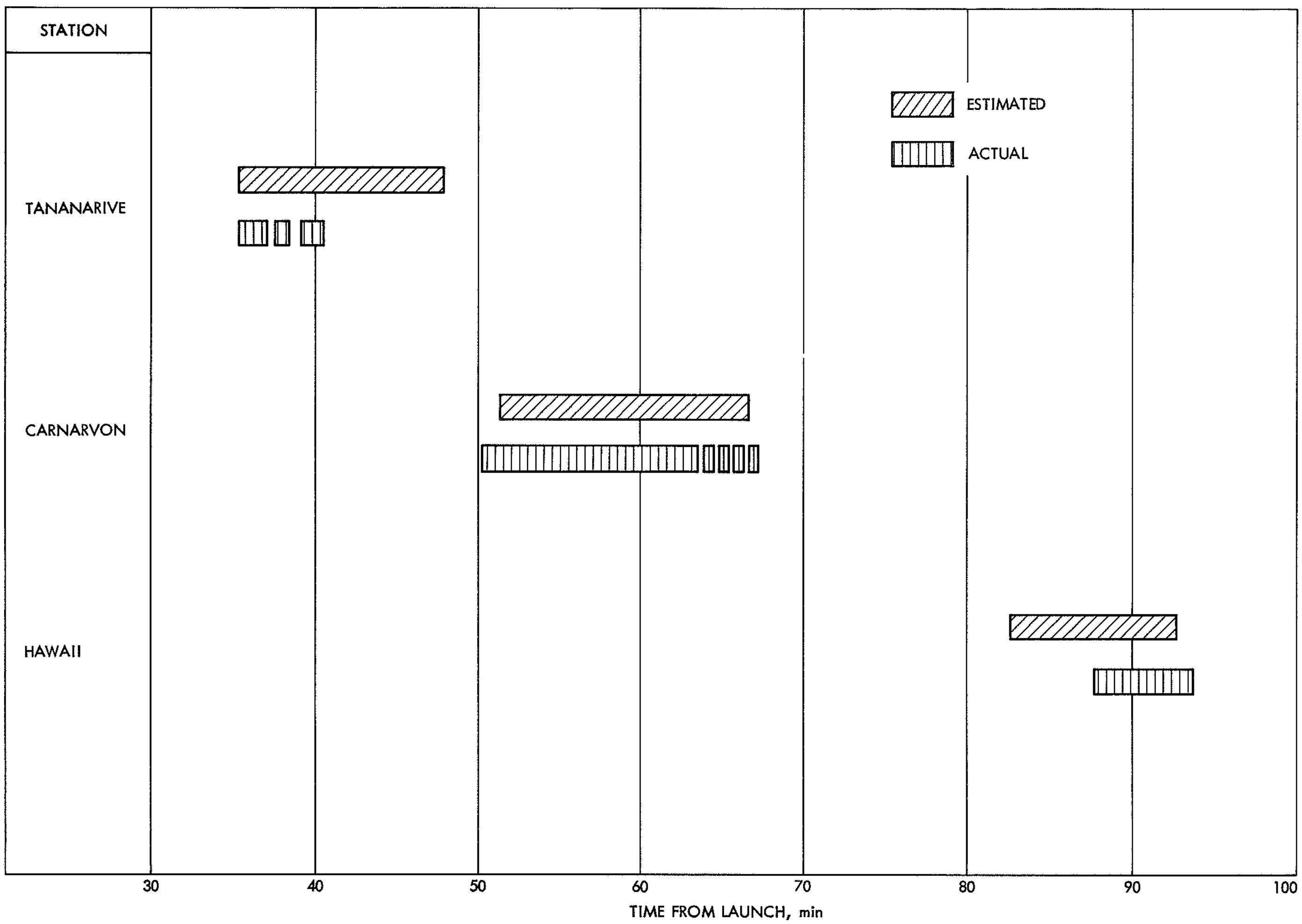


Fig. 16. MSFN radar coverage

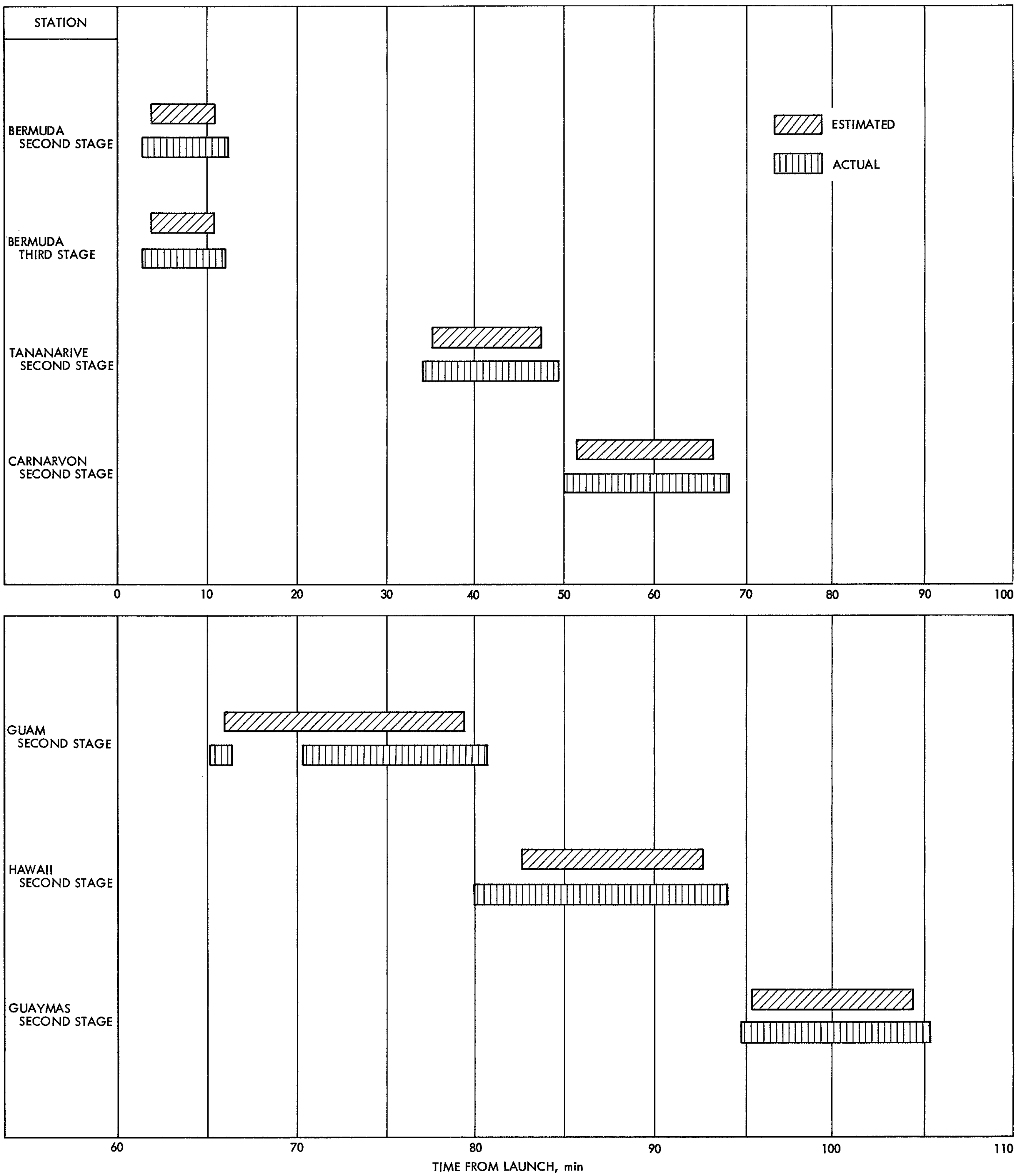


Fig. 17. MFSN VHF telemetry coverage

The scheduled vs the actual station coverage is illustrated in Fig. 18. The received carrier power at DSS 71 at launch is illustrated in Fig. 19. Following a successful two-way lock, DSS 51 reported that all station systems were in a *green* status to support the command activity. Since the spacecraft was launched at a bit rate of 64 bits/s, the first transmitted command was to increase the bit rate to 512 bits/s.

2. *Prelaunch and initial acquisition phase frequencies.*

a. Frequency measurements. The frequency measurements were determined at Cape Kennedy and sent to the SFOF where they were temperature corrected by the SPAC analysts. Subsequently these frequency measurements were sent to system data analysis (SDA)/FPAC for the AFETR and JPL predicts. These measurements included the following:

(1) Spacecraft auxiliary oscillator frequency.

(2) Spacecraft receiver 1 rest frequency.

(3) Spacecraft receiver 2 rest frequency.

(4) Temperature at initial acquisition.

The SDA in turn read the frequencies to the AFETR computer and sent a followup message with the same information.

b. Final frequencies (MHz) and temperature from SPAC. These data consisted of the following:

(1) Auxiliary oscillator frequency: 2292.035362.

(2) Spacecraft receiver 1: 21.985267.

(3) Spacecraft receiver 2: 21.988789.

(4) Temperature at initial acquisition: 75°F.

c. Frequencies (MHz) for AFETR predicts. These data consisted of the following:

(1) Auxiliary oscillator frequency: 2292.035362.

(2) Spacecraft receiver 1: 21.985267.

(3) The J (DSS 51) track synchronous frequency: 21.985550.

The J (DSS 51) frequency was the track synchronous frequency picked to minimize the spacecraft static phase error; it enabled the station to maximize the amount of good two-way data received.

d. Preflight nominal frequency. The temperature corrected frequencies (MHz) are listed below:

(1) Receiver 1: 21.985275.

(2) Receiver 2: 21.988820.

(3) Auxiliary oscillator: 2292.034985.

3. *Prelaunch and initial acquisition phase predicts.* In addition to the preflight nominal predicts generated weeks before launch, several predicts sets were generated by JPL for the spacecraft receivers, whereas the AFETR generated receiver 1 (channel 6) only. The predicts sets for channel 6 were labeled as XXE and for channel 7 as XXF.

After consultation with the Deep Space Stations, it was decided to run the predicts in GMT rather than in time for launch since the stations did not have countdown clocks. Also, it was felt that the preflight nominals[6] which included the time for launch nominals were close enough to the input frequencies to be used as predicts sets in case the launch slipped slightly. It was further agreed that in the event of a prolonged slip, a new set of predicts would be generated at $L-5$ min.

This sequence was followed in the countdown, but several problems occurred resulting in a confusion about the predicts at the stations. Table 13 lists chronologically the events involved in the predicts generation and transmission betwen $T-45$ min and $L+50$ min as observed by the SDA. The problems encountered were as follows:

(1) The trajectory run from which the predicts were to be generated was in error. This problem was not discovered until the predicts set 08E was run and checked. A total of three trajectory runs were made in an attempt to obtain a correct A6 tape for predicts. When these trajectory runs failed, the decision was made to run predicts from input injection conditions. This action delayed the predicts by over 30 min.

(2) When the injection conditions for predicts set 10E were input to the computer, a keypunch error was discovered. This also delayed the predicts by about 5 min.

(3) Predicts sets 10E and 10F were erroneously transmitted, once as data type 42 and once as data type 43.

[6] *DSN Operations Plan*, Vol. VIII.

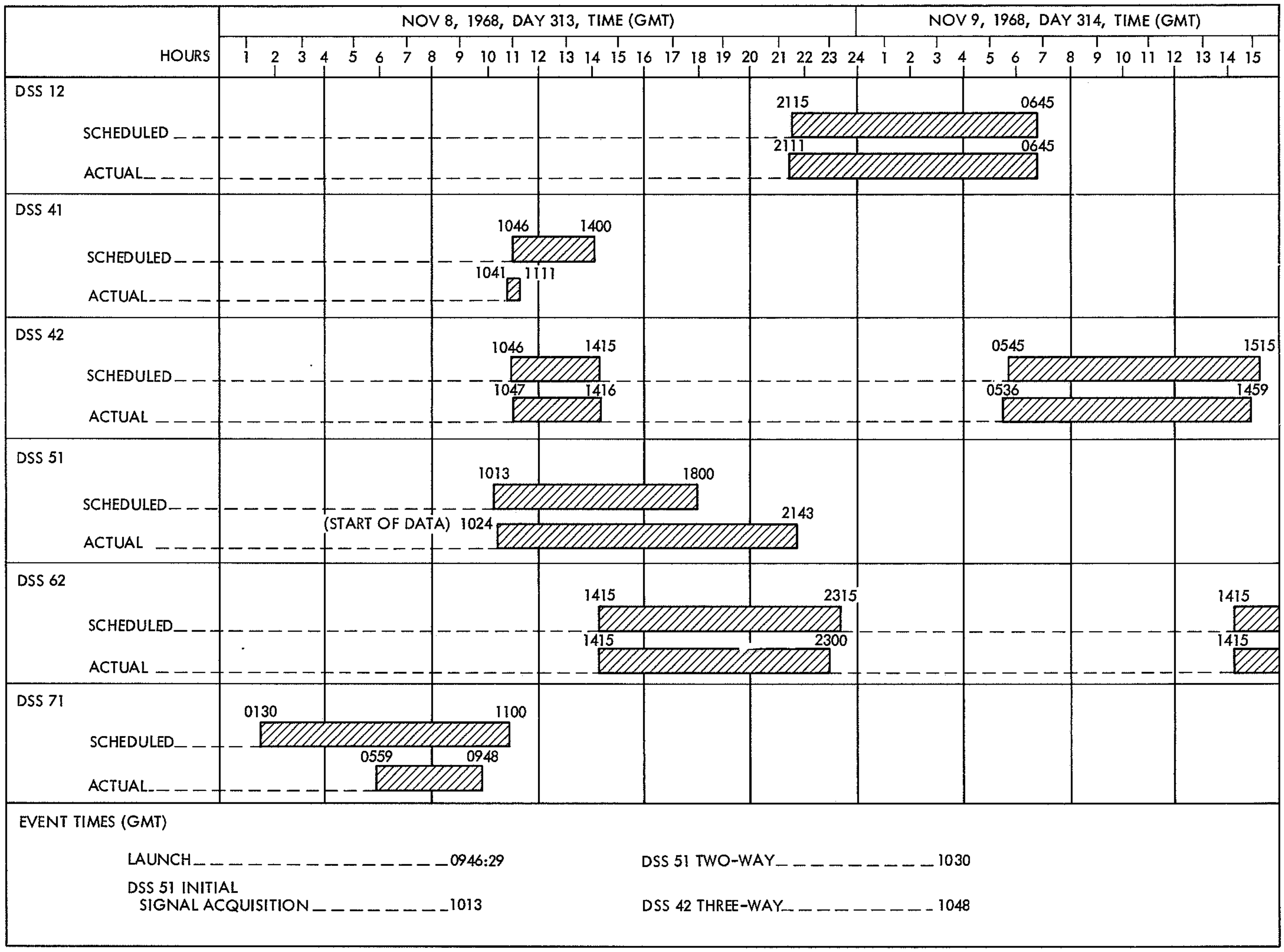


Fig. 18. Scheduled vs actual station coverage

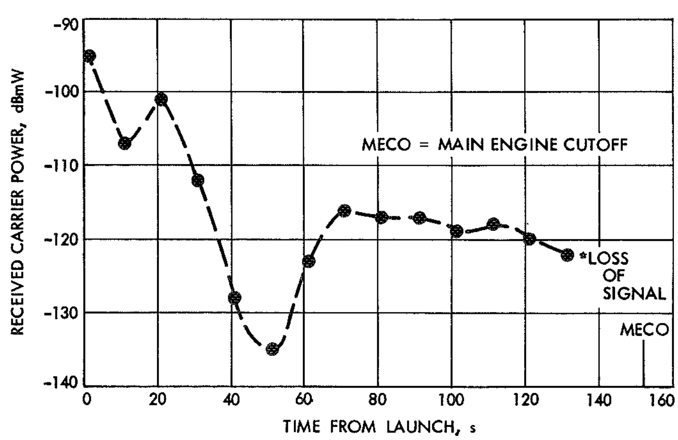


Fig. 19. Received carrier power at DSS 71 during launch

Table 13. Sequence of predicts operations

Time (GMT)	Launch time, min	Event
0800	$T-45$	Scheduled time for $T-45$ min predicts run
0820	$T-35$ hold	Trajectory program first run to generate A6 tape
0825	$T-35$ hold	Prediction program run for predicts sets 08E and 08F
0830	$T-35$ hold	Predicts sets 08E and 08F were found to be bad; error traced to A6 tape
0835	$T-35$ hold	Trajectory program second run to generate A6 tape
0840	$T-35$ hold	Prediction program run for predicts sets 09E and 09F
0845	$T-35$ hold	Predicts sets 09E and 09F were found to be bad; error traced to A6 tape
0850	$T-35$ hold	Trajectory program third run to generate A6 tape; the same problem occurred as in first and second runs. SDA decided to run trajectory from the injection condition cards
0858	$T-34$	Prediction program run for predicts sets 10E and 10F
0904	$T-28$	Prediction program aborted due to key-punch error in injection conditions. Restarted after card was corrected
0915	$T-17$	Prediction program off the computer. Predicts sets 10E and 10F checked. Instructions to transmit
0917	$T-15$	Predicts set 10E transmitted twice by data chief
0919	$T-13$	Predicts set 10F transmitted twice by data chief
0930	$T-5$ hold	Due to slip, predicts set 10E declared unusable by the SDA. Decided to run predicts set 12E as soon as count is picked up
0943	$T-3$	New launch time announced. SDA computed new injection time and asks trajectory engineer to confirm. Trajectory engineer does not concur
0951	$L+5$	Prediction program run for predicts set 12E started after trajectory engineer and SDA agree on new injection time
0956	$L+10$	Prediction program off the computer with predicts set 12E
1001	$L+15$	Predicts set 12E was transmitted by data chief after station reported predicts set 10F still incoming; therefore, track chief decided that the predicts set 12E should queue up behind it
1009	$L+23$	AFETR predicts set 01N (parking orbit) was transmitted
1026	$L+40$	AFETR predicts set 01A (transfer orbit) for DSS 42 was transmitted to all stations—stopped by AFETR after 15 lines
1028	$L+42$	AFETR predicts set 01A was retransmitted correctly
1030	$L+44$	DSS 51 was still receiving predicts set 12E

(4) When the launch time was slipped, the SDA decided to run a new predicts set and requested communications to clear the in-house predicts lines. When predicts set 12E was ready for transmission, it was queued up behind predicts set 10F at the sites. No action was taken to set an urgent precedence level on predicts set 12E because the SDA was unaware that predicts set 10F was still printing out at the Deep Space Stations.

(5) The AFETR transmitted predicts set 01A for DSS 42 to all Deep Space Stations. This erroneous transmission was stopped by the AFETR after about 15 lines. However, it caused confusion at DSS 51 where it was not noticed that the predicts set was for DSS 42.

(6) Because of the nonstandard initial acquisition conditions, the voice circuit to DSS 51 was heavily used for commands, and it took considerable time to straighten out the confusion about the predicts since communications on this subject were squeezed in between command instructions.

In general, all the predicts sets generated were fairly close to nominal and differed mostly in the adjusted GMT. Deep Space Station 51 ultimately acquired the spacecraft on the preflight nominal predicts and switched to predicts set 12E when they arrived after initial acquisition. Deep Space Stations 42 and 51 itemized all launch operation messages received during this crucial phase.

4. SPAC/SDA. The SPAC/SDA interface was the first attempt ever made during any *Pioneer* mission toward selecting proper spacecraft and ground frequencies for a smooth DSN initial acquisition. The prelaunch frequency measurements made on spacecraft receivers 1 and 2 served as a data base for predicting the best-lock frequency. In addition, the auxiliary oscillator frequency measurements appeared to be in agreement with the expected nominal values made by the thermal vacuum data curves.[7]

During launch operations, the initial acquisition frequencies (temperature corrected) were made from the $L-90$ min report, and no changes were deemed necessary based on the $T-45$ and $L+5$ min reports. However, it should be noted that the spacecraft auxiliary oscillator driver temperature indicated a much cooler temperature (5°F) than expected. This could account for a part of the difference of 6600 Hz between the predicts and the actual initial acquisition frequency for the auxiliary oscillator.

5. Conclusion and recommendations. In the final analysis, all the predicts sets sent to JPL were accurate enough for the initial acquisition. The cumulative effect of all the problems mentioned was that DSS 51 received all of the predicts sets almost at once, near their initial acquisition. Under these confused circumstances, DSS 51 did a commendable job with the preflight nominals in acquiring the spacecraft. In order to avoid the confusion and the problems encountered during the *Pioneer IX* launch, the following recommendations were made for future *Pioneer* missions:

(1) The Deep Space Stations should be provided with countdown clocks. This would obviate the need to rerun predicts just to update the GMT.

(2) The procedure for transmitting predicts should be streamlined to eliminate misunderstanding, such as the double transmission of predicts set 10E. The SDA should work with data control on rewriting the standard operating procedures.

(3) The trajectory engineer should be more responsive to the needs of the SDA in the area of trajectory definition. Too much time was consumed on this launch in trying to obtain accurate trajectory information to run predicts.

(4) The communications between the track chief and the SDA should be improved so that:

   (a) SDA will be aware of predicts arrival and completion at the station.

   (b) Track chief and SDA track can coordinate use of urgent precedence level on predicts when needed.

   (c) Track chief will be aware when AFETR predicts are transmitted to the stations.

(5) The sequence of events is such that, in the standard case, the stations will receive the predicts sets for the initial acquisition and the instructions for use before the spacecraft rise. This was the standard requirement for *Pioneer IX*, but was not adhered to because of the problems previously mentioned.

(6) Pseudo-residual telemetry output should be displayed on TV in order to give the SDA track visibility into the quality of the predicts and the data.

(7) The interface with AFETR predicts needs to be reviewed. This interface was riddled with problems throughout the operational readiness test and the launch. The AFETR should concentrate more heavily on providing prediction backup rather than trying to compete with the SFOF in orbit determination.

[7]*Pioneer DRF Equipment and Trajectory Information* (ARC), PC-196.

VIII. Deep Space Support

A. Introduction

This section presents details of the DSN support activity for the *Pioneer IX* spacecraft throughout a flight period beginning in November 1968 and ending June 30, 1969. The data summaries appear at the end of this section. An event of special interest during this period was an inferior conjunction (Fig. 20).

The DSN support in deep space began November 8, 1968, with 24 h/day support by three 85-ft diam antenna stations. When the period covered by this document ended, the spacecraft remained within the increased range of the 85-ft diam antenna network of stations and did not become the sole responsibility of the 210-ft diam antenna station as did the previous *Pioneer* spacecraft.

The prediction at launch was that the spacecraft would exceed the capabilities of the lesser-range antennas during May 1969. At the end of the time period of this document, the prediction was made that *Pioneer IX* would remain within the range of the 85-ft diam antenna stations into early 1970.

The extension of station range resulted from an upgrading of the DSN characteristics. (Figure 21 presents an illustration of the percentage of good tracking data.) These two engineering improvements, (1) and (2) below,

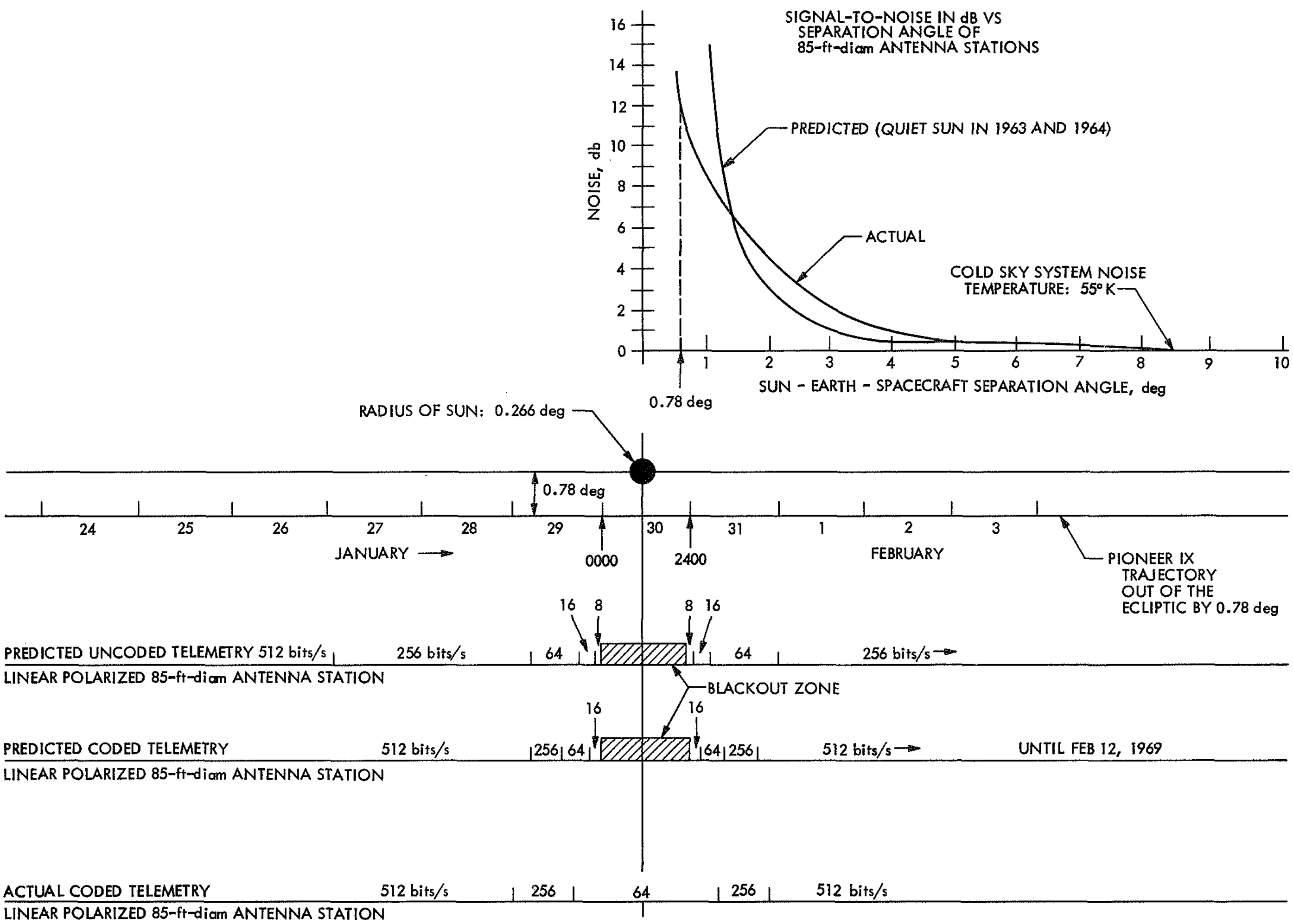


Fig. 20. *Pioneer IX* inferior conjunction, January 30, 1969

and the surpassing of a specification, (3) below, extended the range of the 85-ft diam antenna stations.

(1) Convolutional coding and sequential decoding.

(2) Design and installation of a 3-Hz loop bandwidth.

(3) Reduction of the signal-to-noise temperature from 55 to 40°K.

1. Convolutional coding and sequential decoding. The convolutional coding and sequential decoding experiment that required modification of the GOE as well as a change in the station data-handling methods successfully achieved a coding gain of 3 dB. The code rate for the convolutional coding and sequential decoding was ½, which means that for each bit transmitted, a coded parity was also transmitted. Thus, for the 512 bits/s information, the actual transmitted symbol rate was 1024 bits/s. The 512 bits/s rate covered the previously used 256 bits/s, and similarly, the 256 bits/s covered the 64 bits/s, the 64 bits/s covered the 16 bits/s, and the 16 bits/s covered the 8 bits/s rate.

The convolutional coding and sequential decoding assisted in extending the effective use of the 85-ft diam subnet for *Pioneer IX* into 1970. Also, the convolutional coding system was credited for the errorless real-time processed telemetry during the inferior conjunction of the earth, the spacecraft, and the sun in January 1969.

The coding scheme involved decoding in two directions on each frame of data (denoted forward and reverse). This two-way approach was used for error detection since errors committed in decoding in one direction were almost never committed in the opposite direction. Any words that disagreed between forward and reverse decoding were deleted.

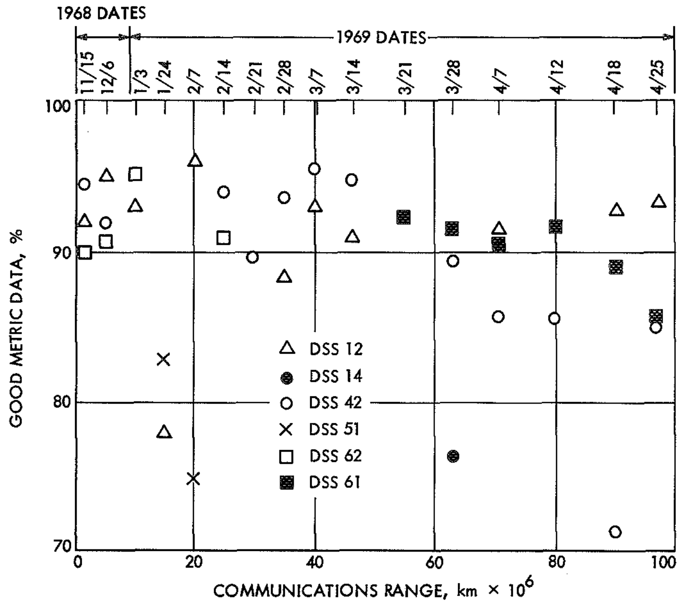


Fig. 21. Percentage of good metric data for communications range

a. Modifications. The real-time data processing of the received convolutional coding data required the use of two SDS 920/telemetry command processor computers at the Deep Space Station. The GOE modification was implemented by the personnel of the ARC/*Pioneer* Project. The DSN furnished all the necessary test equipment, facilities, and personnel required to implement all modifications. The DSN tested each subsystem individually and integrated the modified GOE. In addition, the DSN furnished all necessary engineering, planning, testing, training, and implementation support to the *Pioneer* Project to equip the Deep Space Stations with a new software package developed by the Project for coded and uncoded *Pioneer*/telemetry command processor operation.

b. Telemetry command processors. All Deep Space Stations were equipped with two telemetry command processor computers. One of these computers served as a backup for the operational unit. Because the *Pioneer* Project used both computers, with two different computer programs in the convolutional coding mode, a computer failure required an interruption of the TDA support. In such case, the computer operator reloaded the computer that was still operational with a *Pioneer* emergency program. This emergency program required the use of only one computer with limited data processing capabilities. Because of the necessary switching and computer program reloading actions, a 10-min dropout of telemetry data occurred.

During the third quarter of 1969, the *Pioneer* Project furnished a new *Pioneer* software package that used the increased 16^3word core memory capability of the SDS 920 computers; only one SDS/TCP 920 computer was needed to support the convolutional coding experiment. Since the second computer in the convolutional mode was not required, the second machine provided full backup of the operational unit, thus eliminating the prevailing support reliability risk.

c. Pass in convolutional coded mode. Figure 22 presents a DSS 12 pass with *Pioneer IX* operating in the convolutional coded mode.

2. Loop bandwidth, 3-Hz. The bandwidth tests performed during May employed the *Pioneer* simulator with a 2 B_{LO} of 3, 6, 9, and 12 Hz. These tests indicated that 3 Hz was the optimum tracking loop bandwidth. On pass 197 at DSS 12, a test was performed using spacecraft data to confirm the previous test results.

The test began in the 12-Hz 2 B_{LO} position, switching to 6 Hz for the first half of the pass, and then to 3 Hz for the remainder. The bit-error rates printed out every 12 min were averaged; the results are illustrated in Fig. 23. The figure also shows a direct relationship of signal-to-noise ratio (SNR) to probability of error. The equivalent error when the 2 B_{LO} was changed from 12 Hz to 3 Hz was 1.4 dB. When changed from 12 Hz to 6 Hz, the improvement was 0.9 dB and the improvement from 6 Hz to 3 Hz amounted to 0.5 dB.

Because signal strength readings, automatic gain control (AGC), were difficult to make near threshold, the DSS 14 readings were used as a reference, and 8 dB were added to give the value for an 85-ft diam antenna station. The 3-Hz loop bandwidth was made available to all stations.

3. Signal-to-noise temperature. The 55°K specification for the signal-to-noise temperature was exceeded with the performance being maintained at 40°K. The lower temperature proved an additional factor in extending antenna range.

4. Inferior conjunction. The DSN furnished continuous support during the January 30, 1969, inferior conjunction of *Pioneer IX* from Deep Space Stations 12, 42, 61/62, and the MSFN control room, Pioneer station at Goldstone. However, the planning forecast had predicted an approximate 20-h radio blackout resulting from the nearness of the sun to the Deep Space Station antenna beam.

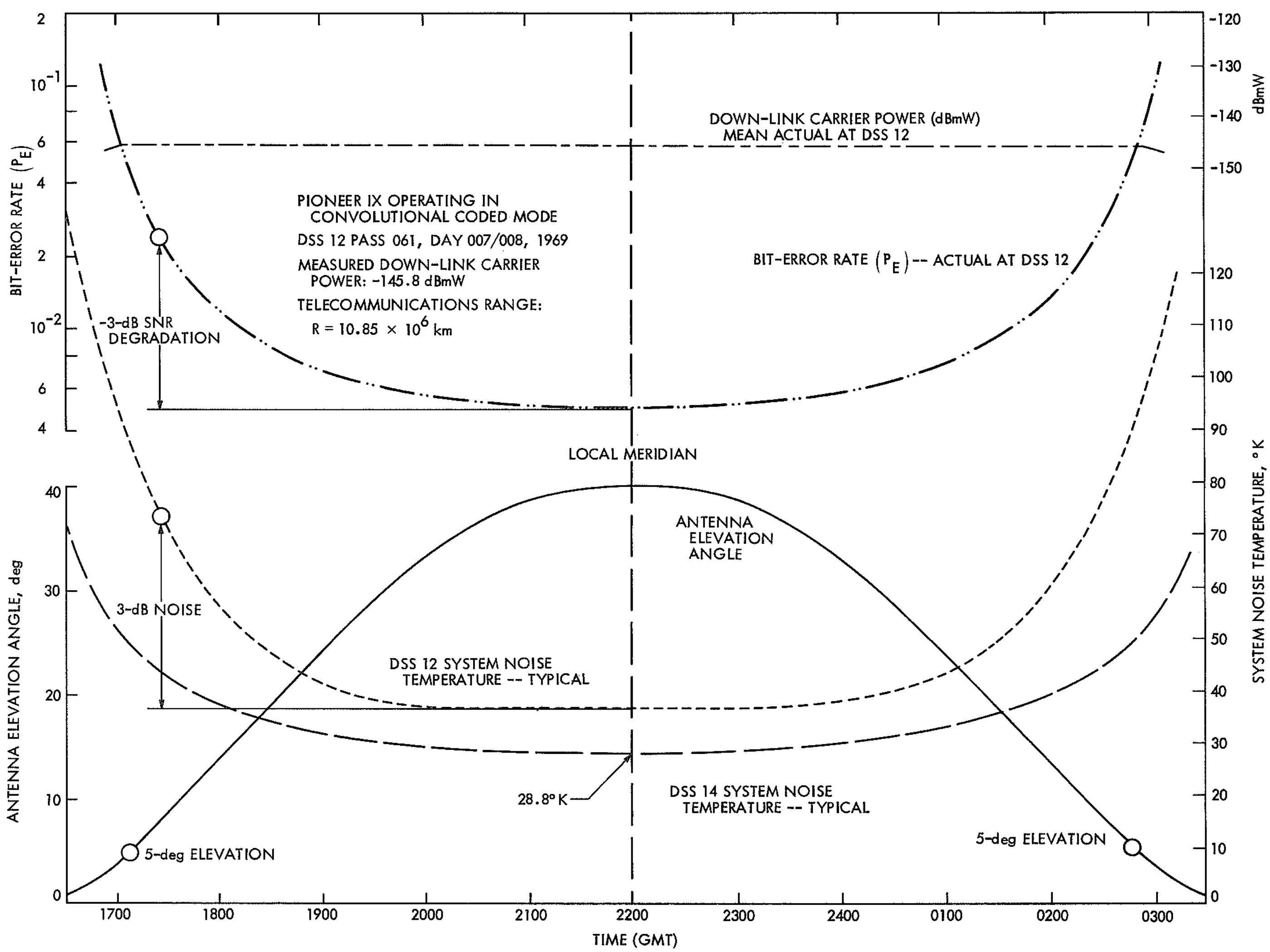


Fig. 22. DSS 12 pass with *Pioneer IX* operating in convolutional coded mode

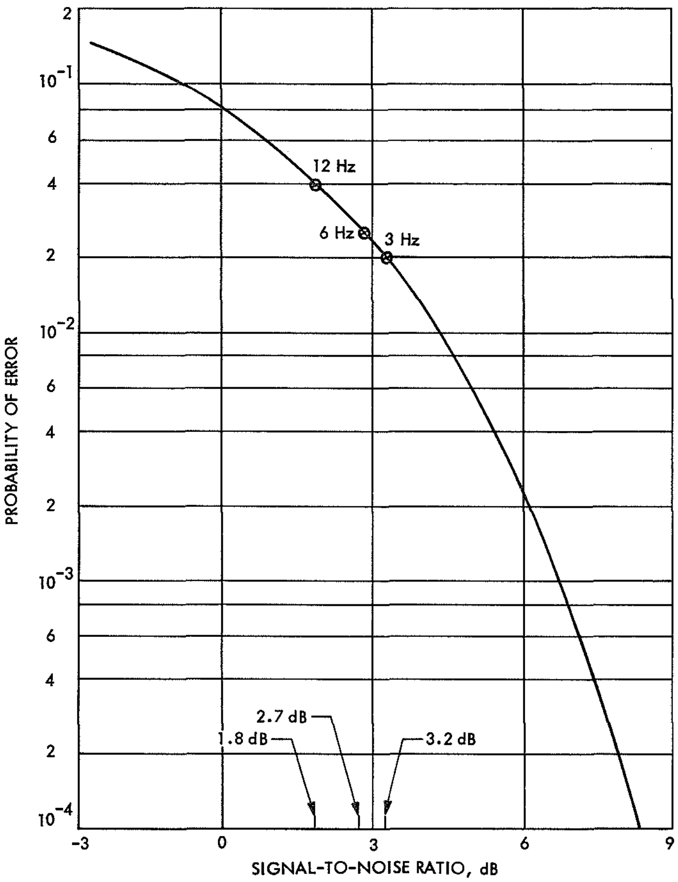


Fig. 23. Tracking loop bandwidth test results

The forecast was based on the SNR measurements made in the close vicinity of the sun in 1964 by the network.

Although a telemetry signal was not expected during the radio blackout, actual TDA support performance was continuous and there were no signal dropouts. The telemetry bit rate used during the closest approach to the sun was 64 bits/s with a system noise temperature of 780°K. At this closest point, the heliocentric sun–earth–spacecraft angle was 0.78 deg. Because of the success of the convolutional coding system, as previously noted, the real-time processed telemetry was errorless. Figure 24 illustrates the increase in the system noise temperature and the bit-error rate for 36 h during the conjunction.

The continuation of the telemetry signal is believed to be a result of the resurfacing of the 85-ft-diam antennas. This improved the sidelobe performance and the antennas did not pick up as much noise as they did in 1964 with the old surfaces.

The collection of uninterrupted telemetry and the precision two-way tracking data during the sun–spacecraft–earth syzygy of *Pioneer IX* made possible detailed analysis of the fields and particles travelling from the sun toward the earth at an approximate distance of 1.7×10^7 km.

B. Support Summaries

*1. **Passes, tracking commands, and telemetry.*** A summary of these is contained in Table 14.

*2. **Monitor data.*** A summary of the monitor data is contained in Tables 15 and 16.

a. Analog tapes. Information from the DSN monitor group weekly status report is presented here. After the analog tapes were validated through the passes covered, all tapes were sent to the project office at ARC.

b. Data frames. The data frames transmitted by the Deep Space Stations and the percentage of frames received by the SFOF are compiled here for the November–December 1968 period. The first and second quarters of 1969, with the exception of June, are also included. No data were made available for June because of a change in the method of recordkeeping.

Table 14. Passes, commands, and telemetry

Parameter	November, December 1969	First quarter 1969	Second quarter 1969	Totals
Passes	1–55	55–145	145–234	—
Number of passes covered	55	90	84	229
Tracking, h: min	1363:01	2051:36	1154:25	4569:02
Bit rate	16, 64, 256, 512	16, 64, 256, 512	8, 16, 64	—
Number of commands	1043	1379	1236	3658

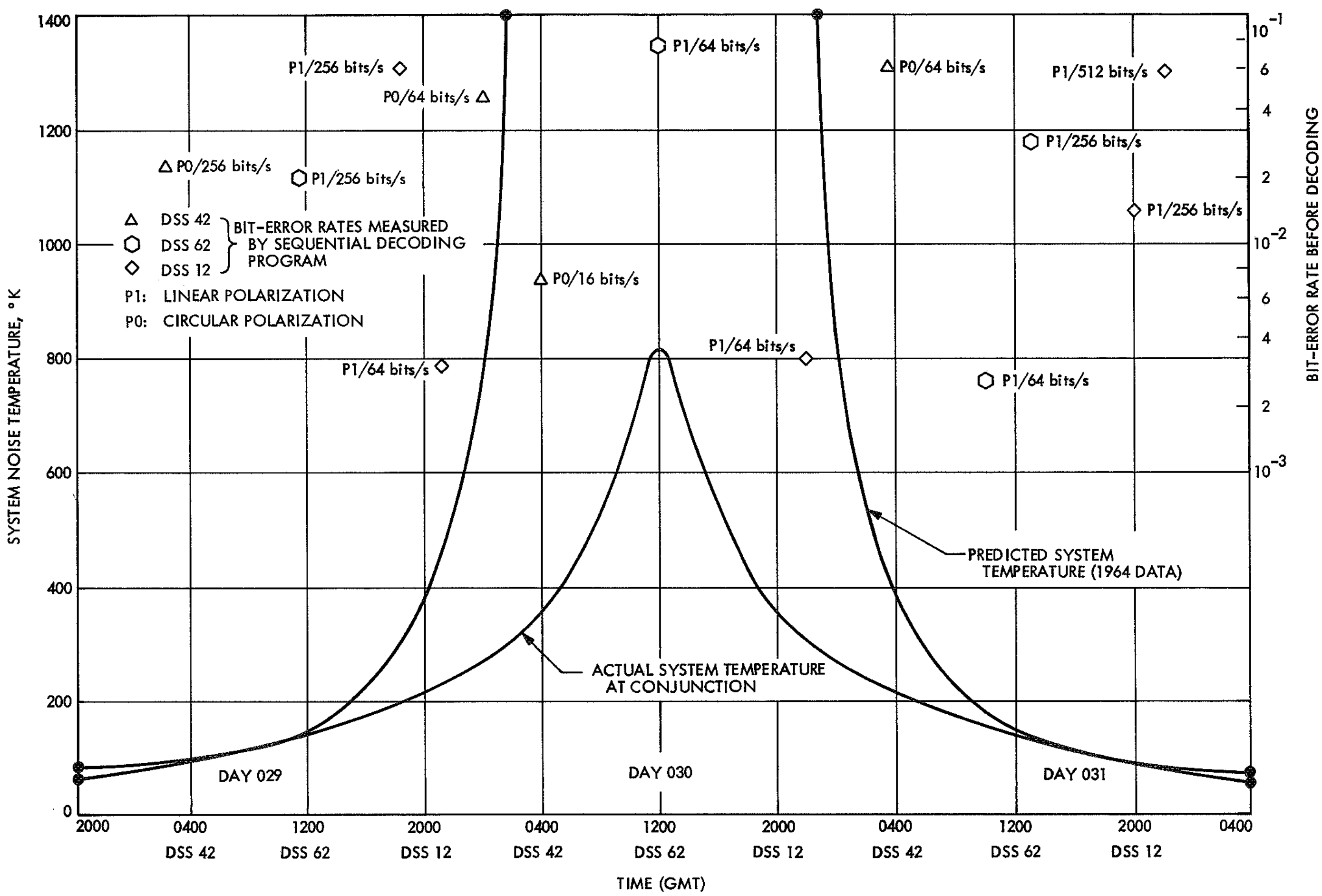


Fig. 24. System noise temperature and bit-error rate before decoding vs time during *Pioneer IX* inferior conjunction

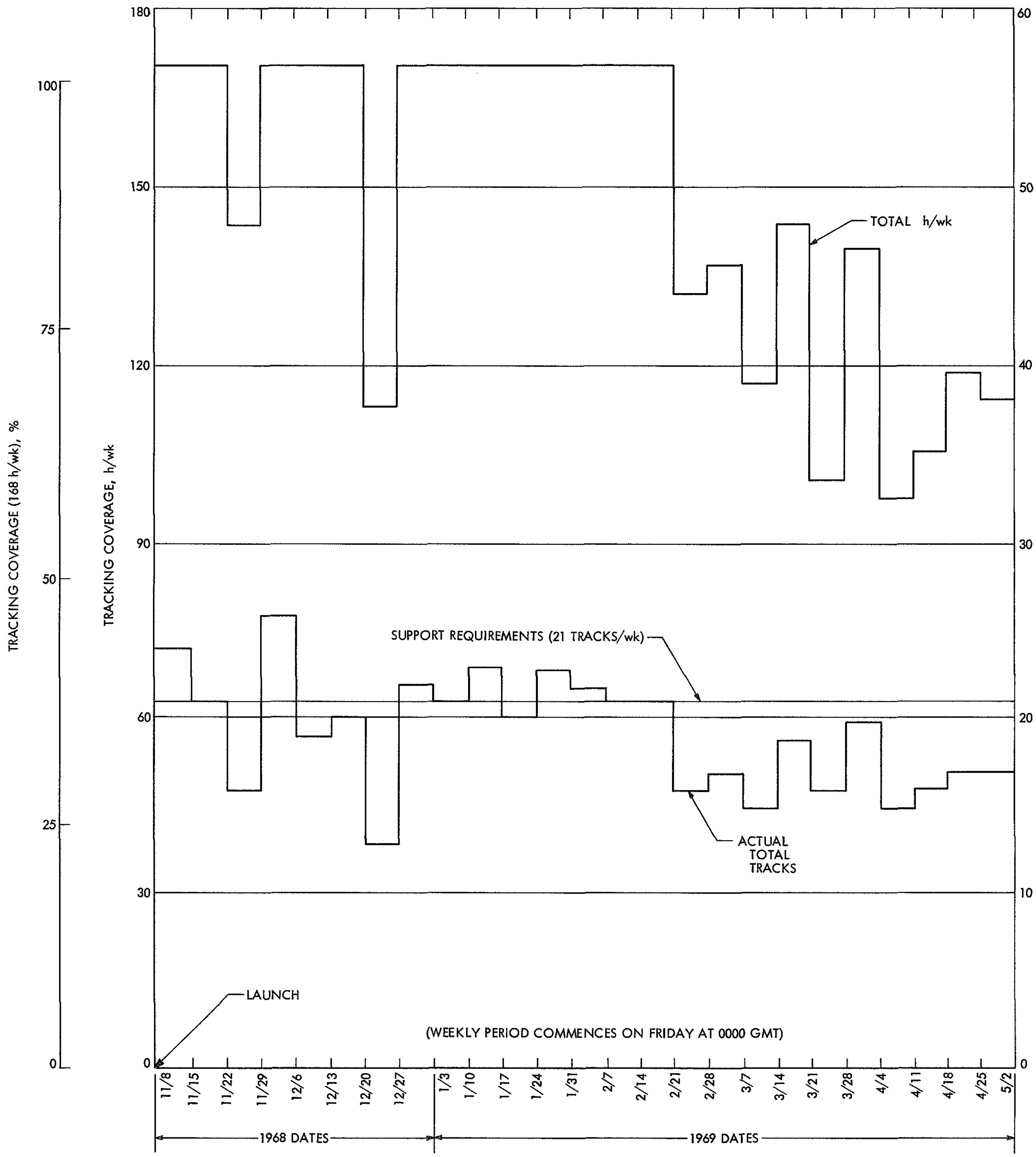


Fig. 25. DSN tracking and data support of *Pioneer IX*

Table 15. Data frames

Deep Space Station	November, December 1968		First Quarter 1969		April, May 1969	
	Frames transmitted	Percent	Frames transmitted	Percent	Frames transmitted	Percent
11/12/14	140,047	99.53	132,778	99.15	70,675	98.68
42	59,449	98.74	116,083	97.94	44,040	97.96
51	4,878	94.29	13,362	87.59	7,748	97.14
61/62	109,020	98.89	84,745	98.57	43,899	99.22
71	703	99.77	—	—	—	—
GD–SX	—	—	21,297	98.93	—	—
MA–DX	—	—	24,192	99.38	—	—
SD–SX	—	—	—	—	256	75.39

Table 16. Analog tapes

Deep Space Station	November, December 1968	First quarter 1969	Second quarter 1969
11	—	—	—
12	25	324	359
14	—	—	412
41	—	300	186
42	11	99	516
51	—	254	186
61	—	150	561
62	43	180	—

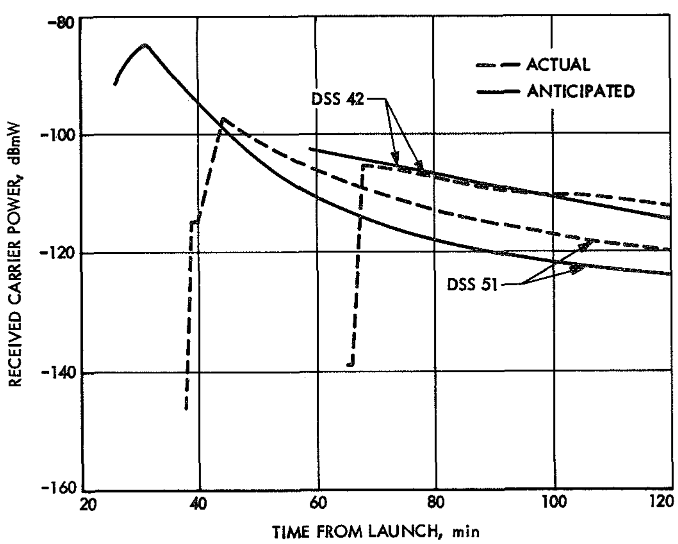


Fig. 26. Received carrier power by Deep Space Station for first 2 h after launch (passes 1 through 23)

C. Early TDA Support

Figure 25 illustrates the DSN tracking and data acquisition support of *Pioneer IX*. Figures 26 and 27 illustrate the received carrier power in the early hours of deep space flight. The support was based upon the application of the unified S-band system wherein a single coherent up-link and down-link carrier was used to provide both a two-way doppler and a data reference carrier. This carrier was modulated with command on the up-link and telemetry on the down-link.

Essentially, the tracking and telemetry system provided precision radio tracking related quantities by performing tasks such as data acquisition, handling, display, distribution, and validation. Some examples of metric data from the tracking were range angle, signal level, and doppler information. Telemetry data were defined as engineering and science information, including video received from the spacecraft via the telecommunications links. The telemetry data could consist of multiple data streams coded in a variety of ways.

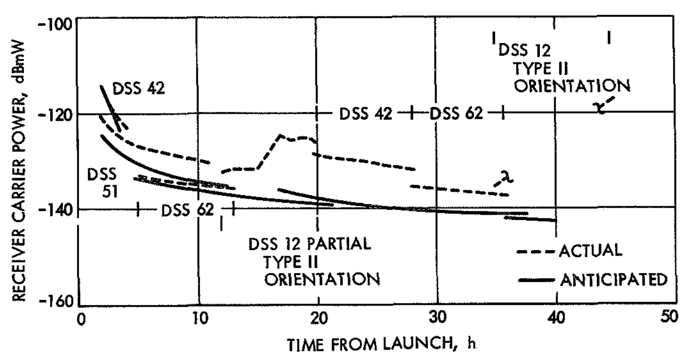


Fig. 27. Received carrier power at various Deep Space Stations during first 45 h after launch

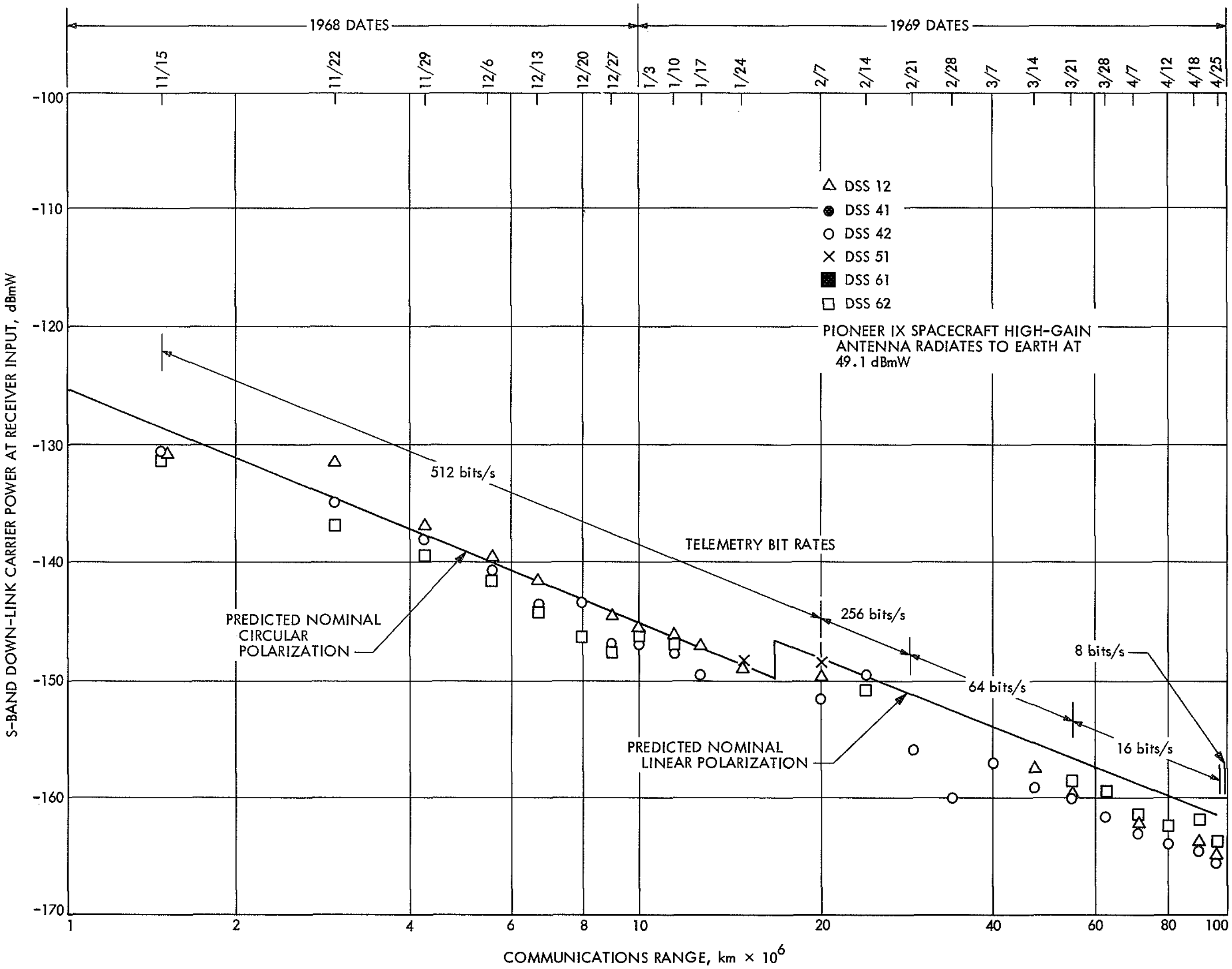


Fig. 28. Actual down-link performance of Deep Space Stations by communications range

The DSN continuously analyzed and upgraded its capabilities for *Pioneer* Flight Project support. The down-link signal strength continuously degraded as a function of the distance from the earth, as shown by the actual down-link performance of a Deep Space Station by communications range in Fig. 28. However, despite the degradation of the down-link signal strength, good usable data (for example, metric data) were consistently processed by the DSN. Using the same horizontal axis for comparison, the percentage of this usable data remained at a high percentage level. (See Fig. 28.)

D. DSN Tracking Activity

Table 17 shows the month-by-month Deep Space Station support.

Table 17. Station support

Month	Station
Nov 1968	12, 42, 62
Dec 1968	12, 41,[a] 42, 51, 62
Jan 1969	12, 41,[a] 42, 51, 61,[b] 62[c]
Feb 1969	12, 41,[a] 42, 51, 62[c]
Mar 1969	12, 14, 41,[a] 42, 61, 62[c]
Apr 1969	12, 42, 61
May 1969	12, 14, 41,[d] 42, 51, 61, 62[c]
Jun 1969	12, 14, 42, 61[e]

[a]DSS 41 tracked in the record-only mode.

[b]DSS 61 supported DSS 62 with the telemetry command processor and GOE.

[c]Support also provided by MSFN stations.

[d]DSS 41 furnished real-time data by use of multimission telemetry system.

[e]DSS 62 supported DSS 61 tracking activities. (GOE was moved to DSS 62 in May.)

IX. Flight Synopsis

A. Launch Through Initial Acquisition

1. ***Launch chronology.*** After two slippages, the *Pioneer IX* spacecraft was launched from AFETR, Cape Kennedy, Fla., November 8, 1968, at 0946:29.008, approximately 9 min after the opening of the launch window. The launch azimuth was 108.0 deg, as desired. A chronology of launch events is given in Table 18.

The original launch date of November 6, 1968, was slipped to November 8, 1968, because of an intermittent anomaly detected in the second-stage programmer of the two-stage, thrust-augmented improved *Delta* launch vehicle. The second slip, one of 9 min, was created by a high upper wind condition at Cape Kennedy.

Table 18. DSN launch event synopsis

Time (GMT)	Events
0800	All stations and systems reported green for launch
0805	Began built-in 52-min hold
0857	Resumed counting at $T-35$ min
0927	Began built-in 5-min hold
0932	Hold had been extended because of high altitude winds
0941:28	Resumed counting at $L-5$ min
0946:29.008	Liftoff
0948:40	DSS 71 and AFETR stations reported loss of S-band signal[a]
1012:32	DSS 51 reported momentary signal (predicted acquisition—1002:53)
1024:11	DSS 51 receivers in-lock. Receiver 1 at 115 dBmW S-band cassegrainian–monopulse and receiver 2 at 146 dBmW S-band acquisition aid subsystem
1025:47	DSS 51 switched to cassegrainian–monopulse automatic mode (auto-track)
1029:06	DSS 51 transmitter turned on at 10 kW
1030:18	DSS 51 reported receivers in-lock, two-way
1040:42	Good two-way data received
1045:23	Command: spacecraft to 512-bits/s rate
1046:23	Command: restart of Type I orientation maneuver
1047:00	DSS 42 established three-way lock with DSS 51
1100:23	Command: undervoltage protection turn-on
1105:20	Reduced transmitter power to 1.25 kW
1130	Command: first experiment turn-on

[a]Loss of S-band signal from the spacecraft could have been caused by a coaxial switch being vibrated into a nonstandard position. An investigation failed to determine the exact cause.

Official surface weather conditions at launch were: temperature, 60.4°F; visibility, 10 mi; wind, 5 knots from 330 deg; relative humidity, 93%; sea-level pressure, 1015.9 mbar; dew point, 58.1°F; and clouds, none.

2. ***Orientation maneuvers.*** The *Delta* boosted the third stage–spacecraft combination into an elliptical parking orbit. Near the end of the parking orbit coast period, the third stage–spacecraft combination was spun up, the second stage–third stage separation took place, and the third stage was ignited. One minute after the third-stage burnout, the spacecraft and the third stage separated, the spacecraft booms deployed, the TWT amplifier turned on, and the Type I orientation maneuver was initiated. This maneuver, controlled by the sun sensors, placed the spin axis of the spacecraft normal to the sun–spacecraft

line, and permitted maximum output from the solar panels located on the sides of the spacecraft.

The Type II orientation maneuver was accomplished during the second pass over DSS 12 at Goldstone and placed the spin axis of the spacecraft approximately normal to the ecliptic plane. This orientation allowed the high-gain antenna to maintain contact with the earth continuously throughout the mission.

3. Early spacecraft activity. Subsequent to the spacecraft separation, the booms and the Stanford antenna were deployed and latched into place. The power to the orientation system and the TWT was turned on automatically. The low-gain antenna was switched from the transmitter–driver output to the TWT output, and the transmitter–driver output was switched from the antenna to the TWT. Following the TWT warmup, the transmitted signal increased about 7.7 W. The Type I maneuver, alignment of the spin axis of the spacecraft perpendicular to the spacecraft-sun line, was automatically initiated following the orientation power turn-on.

4. Solar orbit parameters. Two hours after launch, *Pioneer IX* reached the solar orbit starting point at 1007:16.3, the DSN flight path determination group published the first set of solar orbit parameters as follows:

(1) Epoch: November 8, 1968, 1007:16.3.

(2) Geocentric equatorial coordinates:

$$X = -6812.889$$
$$Y = +504.74171$$
$$Z = -366.80790$$
$$\dot{X} = -0.74449804$$
$$\dot{Y} = -9.0561598$$
$$\dot{Z} = -6.7678175$$

(3) Inclination: 0.0893 deg.

(4) Longitude: 222.7024 deg.

(5) Argument of pericenter focus: 4.7224 deg.

(6) Sidereal period: 297.5397 days.

(7) Aphelion: 0.9904 AU.

(8) Perihelion: 0.754 AU.

(9) Time of perihelion passage: $L+150$ days.

(10) Time to spacecraft superior conjunction: 769 days.

(11) Time to spacecraft inferior conjunction: 82 days.

(12) Spacecraft-earth distance at superior conjunction: 1.7560 AU.

The solar orbit injection velocity vector of the spacecraft deviated only by a 1σ value from the nominal after launch. The orbit determination predicts generation tasks were completed on schedule and actual deviations from the predictions were within expected limits.

B. Flight Coverage

1. DSN activity reports.

a. Launch through pass 23. During November 1968, Deep Space Stations 12, 42, and 62 maintained 24-h/day coverage. Because of the questionable status of the spacecraft in the noncoherent mode of operation, two-way coherent operation was maintained by using the method of power-steal transfers between stations. This method was continued until the up-link was inadvertently chopped during the transfer from DSS 42 to DSS 62 on pass 5, day 317, November 12, 1968. On November 15, 1968, the transmitter at DSS 12 was turned on and off several times during pass 8 to observe the spacecraft operation. The data indicated the spacecraft was healthy and that normal transfers could be used. A continuing problem during the period was loss of word frame synchronization by DSS 62.

b. Passes 24 through 55. During December 1968 there was only one major network irregularity which entailed extensive investigation during this report period. This problem was indicated by occasional spurious interrupts in the telemetry command processor that caused loss of real-time data.

Because of the intermittent nature of the problem, it took more than 2 mo to isolate and correct the irregularity. The final determination was that there were spurious word parity errors on the decoded data caused by transients on the decoding computer parallel input lines. These transients generated excessive noise for the logic *one* state on the operational processing computer parallel input lines.

After the problem was isolated, the ARC sent modification 11 to all *Pioneer* GOE stations for the computer buffer. Modification 11 changed the timing on the decoded data clock to the center of the data period, triggering the interrupt to the operational processing computer. This ensured that both computers would not address the buffer simultaneously.

c. Passes 55 through 86. Several minor anomalies occurred during January, but they did not require extensive investigation. Modifications were completed during January in an effort to correct the spurious interrupt problem noted previously in the December report.

d. Passes 86 through 114. The engineering problems, all minor, and the solutions during February were the following:

(1) On pass 88 at DSS 62, approximately 8 min of data were lost because of the Klystron pump drift; this was readjusted.

(2) On pass 88 at DSS 12, a broken closed-cycle refrigeration line was replaced.

(3) On pass 99 at DSS 62, the GOE demodulator–synchronizer power supply failed and was replaced with a spare.

(4) During passes 103 and 104 at DSS 62, real-time telemetry data were lost because of a microwave failure. Channels were changed and tracking was resumed.

(5) On pass 113 at MSFN Goldstone Wing Site, the command modulation index was set incorrectly because of microwave problems. Correct amplitude was set and the command sequence continued.

The MSFN prime station at Cebreros supported the *Pioneer* Project for the first time by demonstrating its capability in tracking two-way during this period.

e. Passes 114 through 145. During March 1969, Deep Space Stations 14 and 51 each had only one pass and DSS 41 had one record-only type pass. The MSFN prime station at Goldstone attempted to track *Pioneer IX*, but because signals were below the threshold for satisfactory data, the station was not requested to track again. Four passes were tracked by the MSFN Wing Site at the Robledo Madrid station (DSS 61).

The operations engineering was involved with several anomaly investigations. Two were reported at DSS 62. On pass 114, the maser was in the cool-down mode, which was not completed until after the pass began, causing several AGC fluctuations and telemetry command processor losses of lock. The problem was corrected after the maser was stabilized. On pass 117, the telemetry command processor would not lock after initial acquisition. A loose 1-pulse/s cable was found and reconnected. On pass 121 at DSS 42, maser 1 was out of service because of excessive oil contamination. The backup maser was substituted. On pass 131 at DSS 51, the synthesizer was unstable.

f. Passes 145 through 175. There were no major problems during April 1969, with Deep Space Stations 12, 42, and 61 that provided all support. None of these stations required microwave support facilities. Minor problems and their solutions were as follows:

(1) On pass 150 at DSS 42, the signal level dropped by 1 dB. This problem was corrected by adjusting the maser compressor return regulator valve. Also, telemetry command processor alpha was down because of a bad clock generator card that was later replaced.

(2) On pass 151 at DSS 61, the telemetry command processor intermittently dropped lock after being switched to the coded mode. Upon resetting the bit-rate switch, the telemetry command processor held lock. The cause of the problem, which did not recur, was believed to be a faulty contact at the switch.

(3) On pass 155 at DSS 61, all data were lost for 11 min because of a governor failure on the power generator. The power was switched to a standby generator while the prime generator was being repaired.

(4) On pass 163 at DSS 61, the signal level was erratic throughout the pass because of a failed HA clutch solenoid. The clutch was manually adjusted to allow tracking.

(5) During several passes, DSS 42 experienced multiple received signal transients because of a faulty transmitter acquisition potentiometer.

g. Passes 175 through 206. The average signal strength ranged from -165.7 dBmW on May 1, 1969, to -167.5 dBmW on May 31, 1969. The 85-ft diam antenna sites maintained 16-bits/s telemetry coverage during passes 176–179 at -165.7 dBmW, and the same antenna sites maintained telemetry coverage at 8 bits/s between passes 180 and 206. In addition, the stations provided horizon-to-horizon tracking coverage between May 8 and May 15. This special coverage was requested and used for obtaining data when *Pioneer IX* had a zero declination crossing. This data served to tie all Deep Space Stations together in relative longitude and established their distances off the spin axis of the earth.

The improved station location solutions were supplied from an analysis of this tracking data for the *Mariner* Mars 1969 encounter and the *Apollo 11* mission. During May 1969, in which the MSFN Goldstone and Honeysuckle Creek, Australia wings also tracked, there were numerous receiver malfunctions caused by the spacecraft signal approaching what appeared to be threshold at that time. Because of this, the aforementioned tests were performed on the tracking loop bandwidth (2 B_{LO}) to determine optimum telemetry threshold.

Besides receiver malfunctions, other problems and solutions were as follows:

(1) On pass 177, DSS 42 lost the telemetry command processor data because of a computer buffer in GOE. The buffer was replaced with a spare unit; later a bad card was found.

(2) On pass 183, DSS 42 lost the transmitter power because of a heat exchanger. A faulty valve was located and corrected.

(3) On pass 183, DSS 62 lost the transmitter power because of focus magnet power supply failure. The beam voltage was reset and track continued without further problems.

(4) On pass 184, a DSS 51 maser warmed up; the unit was purged and recooled.

(5) On pass 197, the DSS 62 telemetry command processor alpha failed because of a memory parity; the correction was made by replacing the voltage regulator.

(6) On pass 204, the DSS 42 antenna HA was off because of a faulty power supply; the power supply was replaced.

h. Passes 206 through 236. A test in June 1969 determined that the difference between receiver 1 (with occultation equipment turned on) and receiver 2 (without occultation equipment) was between 1 and 2 dB. Therefore, it was suggested that receiver 2 be used or that the occultation equipment be turned off if receiver 1 was used.

During June 1969, a major problem for the 85-ft-diam antenna stations was the low received power from the spacecraft because of the extended range. The 3-Hz tracking loop bandwidth was installed because of the weak signal and this improvement increased the telemetry threshold by approximately 1.4 dB. Other significant problems and their solutions were as follows:

(1) On pass 211 at DSS 42, the data processing started 23 min late because of a faulty connection on the telemetry command processor interrupt patch panel.

(2) On pass 221 at DSS 14, the telemetry command processor output was bad because of a broken pin in the demodulator. Telemetry support was provided by DSS 12 and the broken pin was repaired after the pass.

(3) On pass 222 at DSS 61, the receivers were unable to acquire the spacecraft because of a faulty frequency shifter, which was replaced with a spare module.

(4) On pass 227 at DSS 14, the antenna rotation stopped because the film height lowered to the alarm stage. Cleaning dirt from the sensor solved the problem.

2. Operations data. The operations data are presented by pass number in Tables 19–26.

Table 19. Operations data by pass number (November 1968)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time: 1-Way	Ground Mode Start/Stop Time: 2-Way	Ground Mode Start/Stop Time: 3-Way	Signal Strength Avg (dbm)	Configuration: Loop BW (Hz)	Configuration: Temp Pre/Post (°K)	Configuration: Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
LAUNCH	71	313	0359	0948				-117		356	-160				
1	41	313	1041	1111			1041 1042	-113	48	40.9	-168				P0/D1/B48.
1	42	313	1047	1416			1047 1416	-114	48	37.4	-167.5				P0/D1/B48.
1	51	313	1024	2143	1024 1029	1030 2135	2135 2143	-126.5	48	40.7	-168	39	0.000	512	P0/D1/B12 from 1024 to 1036 and P0/D1/B48 from 1036 to 2143.
1	12	313	2111	0645		2130 0605	2111 2130 0605 0645	-128.0	48	633	-156	79	0.000	512	P0/D1/B48.
1	62	313	1415	2300			1420 2300	-133.6	48	36.1	-172		0.000	512	P0/D1/B48.
2	42	314	0536	1459		0600 1430	0536 0600 1430 1454	-130.1	48	39.1	-168.5	2	0.000	512	P0/D1/B48.
2	62	314	1415	2245		1433 2200	1415 1433 2200 2245	-133.5	48	34.5	-170	1	0.000	512	P0/D1/B48.
2	12	314	2138	0645		2200 0615	2138 2200 0615 0645	-132.9	12	34.8	-173	256	0.000	512	P0/D1/B12.
3	42	315	0507	1459		0615 1425	0507 0615 1425 1429	-120.9	48	37.7	-169.5	5	0.000	512	P0/D1/B12.
3	62	315	1400	2249		1428 2200	1400 1428 2200 2249	-125.1	48	34.8	-170.1	2	0.000	512	P0/D1/B48.

Table 19 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
3	12	315	2145	0645		2200 0600	2145 2200 0600 0645	-123.1	12	35.9	-173	12	0.000	512	P0/D1/B12.
4	42	316	0538	1458		0600 1420	0538 0600 1420 1458	-123.8	48	40.7	-169.5	1	0.000	512	P0/D1/B48.
4	62	316	1400	2218		1424 2205	1400 1424 2205 2218	-127.5	12	34.0	-169.1	7	0.000	512	P0/D1/B44. "B" computer used. Analog-to-digital (A/D) converter needs calibration.
4	12	316	2145	0645		2205 0600	2145 2205 0600 0645	-125.1	12	35.8	-173	13	0.000	512	P0/D1/B12.
5	42	317	0537	1455	1426 1443	0601 1426	0537 0601 1443 1455	-125.8	12	38.8	-167.5	1	0.000	512	P0/D1/B12. RCVR lost lock at XFR.
5	62	317	1400	2230	1427 1447	1420 1424 1447 2222	1400 1420 1424 1427 2222 2230	-129.2	12	35.9	-173.1	2	0.000	512	P0/D1/B12. At 1420, lost two-way lock.
5	12	317	2201	0645		2220 0600	2201 2220 0600 0645	-129.0	12	600	-160	7	0.000	512	P0/D1/B12. Maser and paramp failure occurred during precalibrations-late acquisition of spacecraft (AOS).
6	42	318	0535	1451		0605 1423	0535 0605 1423 1451	-127.1	12	39	-172.9	1	0.000	512	P0/D1/B12.

Table 19 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
6	62	318	1356	2245		1415 2203	1356 1415 2203 2245	-131.0	12	41.1	-173.1	3	0.000	512	P0/D1/B12. The Telemetry and Command Processor (TCP) had spurious interrupts.
6	12	318	2145	0645	0410 0427	2200 0410 0427 0600	2145 2200 0600 0645	-127.9	12	33.4	-173	6	0.000	512	P0/D1/B12. Maser klystron power supply bad. Lost commercial power.
7	42	319	0536	1447		0600 1420	0536 0600 1420 1447	-128.9	12	38.2	-173.4	1	0.000	512	P0/D1/B12.
7	62	319	1355	2245		1515 2205	1355 1515 2205 2245	-131.5	12	312	-164.2	2	0.000	512	P0/D1/B12.
7	12	319	2145	0645		2200 0301	2145 2200 0301 0645	-128.4	12	37.4	-172	13	0.000	512	P0/D1/B12. Command 5-06 delayed due to defective transmitter switch. At 0350,lost commercial power for 1 minute.
8	42	320	0242	1445		0300 1420	0242 0300 1420 1445	-130.1	12	39.7	-172	6	0.000	512	P0/D1/B12.
8	62	320	1355	2245	2223 2245	1417 2205	1355 1417 2205 2223	-131.5	12	313	-165.2	2	0.000	512	P0/D1/B12. ANT Dec. brake jammed.
8	12	320	2145	0645	2222 0047 0431 0605	2000 2222 0047 0431	2145 2200 0605 0645	-130.6	12	38.4	-172	7	0.000	512	P0/D1/B12.
9	42	321	0536	1440	0536 0605	0605 1400	1400 1430	-130.9	12	40	-173.4	1	0.000	512	P0/D1/B12.

Table 19 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
9	62	321	1345	2245		1401 2200	1345 1401 2200 2245	-132.5	12	34.4	-173	2	0.000	512	P0/D1/B12.
9	12	321	2145	0645	0450 0603	2200 0450	2145 2200 0603 0645	-130.9	12	35.6	-172	7	0.000	512	P0/D1/B12.
10	42	322	0536	1435	0536 0603 1240 1406	0603 1240	1406 1435	-132.0	12	40	-171.5	1	0.000	512	P0/D1/B12.
10	62	322	1340	2245	1340 1406 2045 2206	1406 2045	2206 2245	-133.4	12	34.9	-173.1	2	0.000	512	P0/D1/B12. TCP had spurious interrupts.
10	12	322	2145	0645	2145 2206 0448 0611	2206 0448	0611 0645	-132.0	12	35.1	-173	7	0.000	512	P0/D1/B12. Digital Instrumentation Subsystem (DIS) parity errors.
11	42	323	0538	1430	0538 0611 1230 1402	0611 1230	1402 1430	-132.8	12	39.2	-172.4	4	0.000	512	P0/D1/B12.
11	62	323	1336	2245	1336 1402 2045 2204	1402 2045	2204 2245	-134.5	12	34.0	-173.1	2	0.000	512	P0/D1/B12. TCP had spurious interrupts.
11	12	323	2145	0645	2145 2204 0504 0608	2204 0540	0608 0645	-131.8	12	34.8	-172	7	0.000	512	P0/D1/B12.

Table 19 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time			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)				
12	42	324	0541	1431	0541 0607 1232 1352	0607 1232	1352 1431	-134.5	12	41.7	-171	1	0.000	512	P0/D1/B12.
12	62	324	1332	2245	1332 1353 2045 2204	1353 2045	2204 2245	-135.9	12	320	-166	2	0.000	512	P0/D1/B12. TCP had spurious interrupts.
12	12	324	2145	0645	2145 2204 0540 0559	2204 0540	0559 0645	-132.4	12	35.2	-172	8	0.000	512	P0/D1/B12. DIS was not used.
13	42	325	0541	1426	0541 0559 1410 1424	0559 1410	1424 1426	-135.0	12	41.2	-172.5	1	0.000	512	P0/D1/B12.
13	62	325	1330	2245	2045 2213	1424 2045	1330 1424 2213 2245	-135.3	12	256.47*	-167.4	1	0.000	512	P0/D1/B12. *On paramp.
13	12	325	2145	0707	2145 2203 0501 0526	2203 0501	0526 0707	-133 -149*	12	37.8 289.7*	-173	9	0.000	512	*At 0533, on paramp for convolution coded unit (CCU) test. P0/D1/B12.
14	42	326	0436	1422	0500 0523 1405 1418	0523 1405	0436 0500 1418 1422	-135	12	40.0	172.5	1	0.000	512	P0/D1/B12.

Table 19 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
14	62	326	1325	2254	1405 1419 2045 2203	1419 2045	1325 1405 2203 2254	-135.8	12	272.5*	-167.4	9	0.004	512	* On paramp. P0/D1/B12. TCP restarts caused loss of real time data for 15 minutes. P0/D1/B12.
14	12	326	2145	0645	2145 2204 0540 0602	2204 0540	0602 0645	-133.0	12	36.6	-170	8	0.000	512	P0/D1/B12.
15	42	327	0538	1418	0540 0600 1400 1418	0600 1400	0538 0540	-135.0	12	39.6	-172	2	0.000	512	P0/D1/B12.
15	62	327	1321	2245		1423 2100	1321 1423 2100 2245	-137.0	12	34.5	-171	1	0.000	512	P0/D1/B12.
15	12	327	2200	0645	2200 2214 0535 0608	2349 0535	2214 2349 0608 0645	-131.7	12	35.2	-170	1	0.000	512	P0/D1/B12.
16	42	328	0541	1414	0541 0607 1355 1412	0607 1355	1412 1414	-136.0	12	35.0	-172	5	0.000	512	P0/D1/B12.
16	62	328	1317	2245	1355 1412 2045 2215	1412 2045	1317 1355 2215 2245	-137.1	12	35.7	-172	2	0.000	512	P0/D1/B12. "B" computer and A/D converter failures.
16	12	328	2145	0645	2145 2204 0430 0609	2204 0430	0609 0645	-132.4	12	35.2	-169	7	0.000	512	P0/D1/B12.

Table 19 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
17	42	329	0542	1413	0542 0609 1210 1339	0609 1210	1339 1413	-136.1	12	37.4	-172	1	0.000	512	P0/D1/B12.
17	62	329	1313	2245	1313 1338 2045 2209	1338 2045	2209 2245	-137.8	12	36.2	-172	2	0.000	512	P0/D1/B12. TCP spurious interrupt.
17	12	329	2145	0645	2145 2205 0400 0045	2205 0400		-133.9	12	37.4	-172	7	0.000	512	P0/D1/B12.
18	42	330	0519	1409	0517 0536 1210 1339	0536 1210	1339 1409	-137.0	12	33.5	-173	1	0.000	512	P0/D1/B12.
18	62	330	1309	2245	1309 1339 2045 2211	1339 2045	2211 2245	-138.3	12	35.18	-172	1	0.000	512	P0/D1/B12.
18	12	330	2145	0620	2145 2202 0359 0549	2202 0359	0549 0620	-137.0	12	34.5	-172	8	0.000	512	P0/D1/B12.
19	42	331	0519	1400	0519 0549	0549 1206	1206 1335	-137.5	12	33.8	-173	1	0.000	512	P0/D1/B12.
19	62	331	1305	2245	1305 1335	1335 2205	2205 2245	-138.6	12	34.2	-172	2	0.000	512	P0/D1/B12. Recorder levels on tapes 1A and 2A were low - backup tapes were included in data package.
19	12	331	2145	0620	0400 0535	2205 0400	2145 2205 0535 0620	-137.5	12	36.1	-172	7	0.000	512	P0/D1/B12.

Table 19 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
20	42	332	0438	1400	0438 0535 1200 1334	0535 1200	1334 1400	-137.5	12	33.9	-172.4	2	0.000	512	P0/D1/B12.
20	62	332	1301	2245	1301 1334 2045 2159	1334 2045	2159	-139.4	12	37.0	-172.1	2	0.000	512	P0/D1/B12. TCP had spurious interrupts. TCP stopped due to operators error.
20	12	332	2145	0620	2145 2159 0400 0606	2159 0400	0606 0620	-137.8	12	37.5	-172.0	8	0.000	512	P0/D1/B12.
21	42	333	0515	1357	0515 0606 1155 1329	0606 1155	1329 1357	-137.7	12	34.8	-172.4	1	0.000	512	P0/D1/B12. ANT runaway in Hour Angle (HA) position (TFR-106949).
21	62	333	1258	2245	1258 1329 2046 2203	1329 2046	2203 2245	-139.3	12	37.1	-172.1	1	0.000	512	P0/D1/B12. TCP had spurious interrupts.
21	12	333	2145	0620	2145 2204 0400 0535	2204 0400	0535 0620	-138.3	12	37.8	-172.0	8	0.000	512	P0/D1/B12. DIS magnetic pack failure.
22	42	334	0514	1353	0514 0535 1150 1353	0535 1150		-138.0	12	34.7	-173.4	1	0.000	512	P0/D1/B12.
22	62	334	1254	2245	1254 1323 2046 2203	1323 2046	2203 2245	-139.8	12	37.3	-174.0	1	0.000	512	P0/D1/B12. ICP had spurious interrupts.

Table 19 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
22	12	334	2145	0620	2145 2204 0420 0538	2204 0420	0538 0620	-137.7	12	37.1	-172.0	7	0.000	512	P0/D1/B12. No Tracking Data Handling Subsystem (TDH).
23	42	335	0516	1349	0516 0538 1200 1304	0538 1200	1304 1349	-138.7	12	34.3	-173.0	1	0.000	512	P0/D1/P12.
23	62	335	1250	2245	1250 1313 2045 2158	1313 2045	2158 2245	-139.5	12	35.4	-173.1	1	0.000	512	P0/D1/B12. Voltage control oscillator (VCO) counter misaligned.
23	12	335	2145	0620	2145 2200 0420 0540	2200 0420	0540 0620	-139.2	12	37.8	-172.0	7	0.000	512	P0/D1/B12.

Table 20. Operations data by pass number (December 1968)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
024	42	336	0512	1345	0512 0540 1200 1309	0540 1200	1309 1345	-139.3	12	34.3	-172.4	2	0.000	512	P0/D1/B12.
024	62	336	1246	2245	1246 1313 2045 2158	1313 2045	2158 2245	-140.4	12	37.3	-173.1	1	0.000	512	P0/D1/B12.
024	12	336	2145	0620	2145 2158 0247 0403	2158 0247	0403 0620	-138.8	12	36.6	-172.0	8	0.000	512	P0/D1/B12.
025	42	337	0338	1330	0338 0403 1200 1307	0403 1200	1307 1330	-138.7	12	34.0	-172.4	1	0.000	512	P1/D1/B12. DIS dropped out.
025	62	337	1245	2145	1245 1311 1920 2026	1311 1920	2026 2145	-140.7	12	35.8	-173.1	1	0.000	512	P1/D0/B12.
025	12	337	2000	0445	2000 2027 0246 0408	2027 0246	0408 0445	-138.8	12	37.2	-172.0	7	0.000	512	P0/D1/B12. DIS Inoperative.
026	42	338	0341	1337	0341 0408 1230 1337	0408 1230		-139.8	12	34.1	-171.4	2	0.000	512	P0/D1/B12.
026	62	338	1347	2130	1348 1413 1900 2018	1413 1900	2018 2130	-141.4	12	35.4	-173.1	5	0.000	512	P0/D1/B12.
026	12	338	2000	0445	2000 2018 0215 0403	2018 0215	0403 0445	-138.3	12	37.5	-172.0	8	0.000	512	P0/D1/B12.

Table 20 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
027	42	339	0344	1330	0344 0402 1310 1330	0402 1310		-141.0	12	35.5	-172.4	1	0.000	512	P0/D1/B12.
027	62	339	1245	2005	1245 1315 1920 2005	1315 1920		-141.7	12	36.0	-173.1	2	0.000	512	P0/D1/B12.
027	12	339	2000	0445	2000 2017 0336 0400	2017 0336	0400 0445	-138.3	12	35.8	-172.0	7	0.000	512	P0/D1/B12.
028	42	340	0340	1329	0340 0400 1145 1305	0400 1145	1305 1324	-140.1	12	33.7	-172.4	2	0.000	512	P0/D1/B12.
028	51	340	1240	2045	1240 1305 1642 1702 1730 2016	1305 1614 1702 1730	2031 2045	-140.5	12	40.5	-172.0	4	0.150 0.000	512 256	P0/D1/B12.
028	12	340	2000	0608	2000 2016 0336 0401	2016 0336	0401 0608	-139.2	12	36.3	-171.0	8	0.000	512	P0/D1/B12.
029	42	341	0341	1325	0341 0359 1150 1259	0359 1150	1259 1325	-140.9	12	43.9	-171.4	2	0.000	512	P0/D1/B12. Maser 1 down.
029	62	341	1245	2045	1245 1304 1950 2017	1304 1950	2017 2045	-141.1	12	35.7	-173.1	2	0.000	512	P0/D1/B12. TCP spurious interrupt.

Table 20 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/ Post (°K)	Thres Pre/ Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
029	12	341	2000	0445	2000 2017 0356 0427	2017 0356	0427 0445	-139. 5	12	38. 2	-172. 0	9	0. 000	512	P0/D1/B12. TCP spurious interrupt.
030	42	342	0343	1320	0355 0427	0427 1300	0343 0355 1300 1320	-140. 7	12	44. 2	-172. 4	1	0. 000	512	P0/D1/B12. Lost word frame sync several times.
030	51	342	1239	2045		1301 2045	1239 1300	-139. 9	12	40. 2	-173. 0	3	0. 000	512	P0/D1/B12. TCP not able to set and stabilize astro data.
030	12	342	2000	0445	2045 2102	2102 0445	2000 2045	-139. 6	12	37. 5	-172. 0	7	0. 000	512	P0/D1/B12.
031	41	343	0141	1330	0446 1313		0141 0446 1313 1330	-141. 9	12	38. 7	-172. 0				P0/D1/B12. Record only.
031	62	343	1245	2045	1245 1313 1955 2015	1313 1955	2015 2045	-142. 3	12	37. 0	-173. 1	1	0. 000	512	P0/D1/B12. TCP spurious interrupt.
031	12	343	2000	0445	2000 2015	2015 0445		-139. 9	12	37. 4	-172. (	8	0. 000	512	P0/D1/B12.
032	41	344	0424	1330	0445 1234		0424 0445 1234 1330	-142. 7	12	36. 8	-173. 0				P0/D1/B12. Record only.
032	62	344	1215	2100	1215 1234 1950 2017	1234 1950	2017 2100	-142. 7	12	36. 6	-174. 0	4	0. 000	512	P0/D1/B12. TCP spurious interrupt.
032	12	344	2000	0530	2000 2018	2018 0530		-140. 4	12	37. 8	-173. 0	8	0. 000	512	P0/D1/B12.

Table 20 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
033	41	345	0427	1330	0530 1236		0427 0530 1236 1330	-142.6	12	36.8	-173.0				P0/D1/B12. Record only.
033	62	345	1215	2100	1215 1236 2006 2027	1236 2006	2027 2100	-142.9	12	35.9	-173.1	2	0.000	512	P0/D1/B12. DIS IMP program stopped.
033	12	345	2020	0530	2020 2027	2027 0530		-140.3	12	39.6	-173.0	14	0.000	512	P0/D1/B12. TXR failed seven times due to ARC detector.
034	41	346	0426	1330	0526 1235		0426 0526 1235 1330	-144.4	12	38.6	-173.0				P0/D1/B12. Record only.
034	62	346	1215	2100	1215 1235 1950 2021	1235 1950	2021 2100	-143.5	12	36.3	-174.0	2	0.000	512	P0/D1/B12. TCP spurious interrupt.
034	12	346	2000	0530	2000 2018	2018 0530		-141.2	12	36.2	-172.0	9	0.000	512	P0/D1/B12.
035	41	347	0427	1330	0531 1234		0427 0531 1234 1330	-143.6	12	38.5	-173.0				P0/D1/B12. Record only.
035	62	347	1215	2100	1215 1234 1950 2027	1234 1950	2027 2100	-143.2	12	35.9	-174.0	2	0.000	512	P0/D1/B12.

Table 20 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
035	12	347	2000	0530	2000 2018	2018 0530		-141.3	12	38.9	-172.0	21	0.000	512	P0/D1/B12.
036	41	348	0428	1330	0531 1240		0428 0531 1240 1330	-143.5	12	38.8	-172.0				P0/D1/B12. Record only.
036	62	348	1215	2100	1215 1240 1950 2021	1240 1950	2021 2100	-143.6	12	40.0	-173.0	2	0.000	512	P0/D1/B12.
036	12	348	2000	0530	2000 2014	2014 0530		-141.3	12	36.0	-172.0	9	0.000	512	P0/D1/B12.
037	41	349	0428	1330	0531 1238		0428 0531 1238 1330	-143.8	12	34.1	-172.0				P0/D1/B12. Record only.
037	62	349	1215	2100	1215 1238 1951 2028	1238 1951	2028 2100	-143.7	12	36.4	-173.0	2	0.000	512	P0/D1/B12.
037	12	349	2000	0530	2000 2019	2019 0530		-141.4	12	38.5	-172.0	9	0.000	512	P0/D1/B12.
038	41	350	0430	1330	0531 1238		0430 0531 1238 1330	-143.2	12	37.7	-172.0				P0/D1/B12. Record only.
038	62	350	1215	2100	1215 1238 1951 2023	1238 1951	2023 2100	-143.9	12	36.3	-173.0	2	0.000	512	P0/D1/B12.
038	12	350	2000	0525	2000 2017	2017 0525		-142.4	12	35.7	-172.0	9	0.000	512	P0/D1/B12.
039	62	351	1200	2100	1200 1218	1218 2100		-144.0	12	36.1	-173.0	9	0.000	512	P0/D1/B12.

Table 20 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
039	41	351	0358	1300	0525 1218		0358 0525 1218 1300	-143.2	12	38.4	-172.0				P0/D1/B12. Record only.
040	62	352	1200	2100	1200 1216	1216 2100		-144.3	12	39.1	-173.0	9	0.000	512	P0/D1/B12.
040	41	352	0400	1300	0400 1216		1216 1300	-143.4	12	39.5	-172.0				P0/D1/B12. Record only.
041	62	353	1200	2105	1200 1224	1224 2105		-144.6	12	36.3	-174.0	13	0.000	512	P0/D1/B12.
041	41	353	0400	1300	0400 1224		1224 1300	-144.7	12	37.7	-172.0				P0/D1/B12. Record only.
042	41	354	0400	1300	0400 1221		1221 1300	-143.1	12	298.4	-163.0				P0/D1/B12. On Paramp/Record only.
042	62	354	1200	2100	1200 1220	1220 2100		-144.6	12	36.8	-173.0	13	0.000	512	P0/D1/B12.
043	41	355	0401	1215	0401 1215			-143.2	12	300.0	-164.0				P0/D1/B12. On Paramp/Record only.
043	62	355	1200	2100	1200 1227	1227 1630 1630* 1730* 1730 2100		-146.3	12	36.7 329.5*	-173.1 -166.3*	16	0.000	512	TLM data lost for total of 26 minutes due to 2 TCP failures. *Paramp P0/D1/B12
044	41	356	0400	1300	0400		1225	-145.1	12	42.5	-172.0				P0/D1/B12. Record only.
044	62	356	1200	2100	1200	1229		-145.0	12	36.22	-173.1	12	0.011 CODED MODE 0.000 UNCODED	512 512	P0/D1/B12. DCC number on DIS printouts was 8140 instead of 8040 (TFR-122075). Problem: Loose pin in the negative-true assembly in DIS 07 rack.
045	41	357	0400	1300	0400	1219		-145.2	12	38.35	-172.0				P0/D1/B12. Record only. Narrow AGC control would not lock 4/REC/125222.

Table 20 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
045	62	357	1200	2100	1200	1223		146. 4	12	36. 33	-173. 1	12	0. 008 0. 008	256 CODED 512 CODED	P0/D1/B12. TCP spurious interrupt (OPEN) (TFR-121693).
046	41	358	0357	1215	0357		1135	146. 0	12	37. 69	-173. 0				P0/D1/B12. Record only.
046	62	358	1115	1915	1115	1141		146. 4	12	36. 34	-174. 09	12	0. 005	512 CODED	P0/D1/B12. TFR-121693 still open. No PE or PD at 1257, but good and moving SCID. Cause: Partial hangup of TCP "B" Computer restarted. TCP spurious interrupt at 1551 - cause unknown - cure, restart.
047	41	359	0242	1215	0242		1138	-145. 6	12	37. 48	-172. 0				P0/D1/B12. Record only.
047	62	359	1115	1915	1150	1142		-144. 3	12	35. 96	-172. 4	12	0. 000	512	P1/D1/B12. Science 1 TCP page print destroyed due to paper jam. Ten frames lost (TFR-130306).
048	41	360	0239	1215	0239			-146. 4	12	37. 29	-172. 0				P0/D1/B12. Record only
048	62	360	1200	1915	1200	1228		-145. 6	12	34. 68	-172. 4	12	0. 000 0. 005	256 512 CODED	P0/D1/B12.
049	41	361	0241	1215	0241		1148	-146. 4	12	38. 07	-172. 0				P0/D1/B12. Record only.
049	62	361	1115	1915	1115	1157		-145. 5	12	35. 93	-172. 0	12	0. 003	512 UNCODED	P0/D1/B12. TCP spurious interrupt.
050	41	362	0011	1251	0011 1005		1158 1251	-147 0	12	226. 1	-164. 0				P0/D1/B12. Record only. On paramp from 0335 to 0339 and back on paramp at 1005.
050	62	362	1047	2045	1047 1202 1951 2018	1202 1951	2018 2045	-146. 7	12	36. 8	-172. 0	3	0. 000	512	P0/D1/B12.
050	12	362	2000	0300	2000 2018	2018 0300		-144. 6	12	35. 2	-172. 0	14	0. 000	512	P0/D1/B12.

Table 20 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
051	41	363	0229	1215	0301 1136		0229 0301 1136 1215	-146.2	12	36.2	-173.0				P0/D1/B12. Record only.
051	62	363	1115	1915	1115 1136 1806 1834	1136 1806	1834 1915	-146.5	12	34.2	-172.4	3	0.000	512	P0/D1/B12. TCP spurious interrupt. TCP data lost for 22 minutes and 54 seconds.
051	12	363	1815	0330	1815 1835	1835 0330		-145.0	12	37.3	-172.0	8	0.000	512	P0/D1/B12.
052	41	364	0241	1215	0331 1142		0241 0331 1142 1215	-146.3	12	38.1	-173.0				P0/D1/B12. Record only
052	62	364	1115	1915	1115 1142 1806 1832	1142 1806	1833 1915	-145.7	12	37.0	-172.4	1	0.000	512	P0/D1/B12.
052	12	364	1815	0330	1815 1833	1833 0330		-144.8	12	36.7	-172.0	10	0.000	512	P0/D1/B12.
053	41	365	0238	1140	0331 1104		0238 0331 1104 1140	-146.4	12	34.6	-173.0				P0/D1/B12. Record only.
053	62	365	1040	1940	1040 1104 1734 1759	1104 1734	1759 1940	-146.3	12	37.4	-172.0	4	0.000	512	P0/D1/B12.
053	12	365	1742	0406	1742 1759	1759 0303 0333 0406	0303 0333	-144.6	12	35.7	-172.0	9	0.000	512	P0/D1/B12.

Table 20 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time			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)				
054	41	366	0235	1140	0406 1107	0301 0332	0235 0301 0332 0406 1107 1140	-146.7	12	32.7	-173.0				P0/D1/B12. Record only.
054	62	366	1040	1940	1040 1107 1821 1849	1107 1821	1849 1940	-145.9	12	36.4	-172.0	3	0.000	512	P0/D1/B12.
054	12	366	1830	0045	1830 1849	1849 0045		-145.0	12	37.4	-173.0	10	0.000	512	P0/D1/B12.

Table 21. Operations data by pass number (January 1969)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
055	41	01	2345	1224	0046 1145		2345 0046 1145 1224	-147	12	33.50	-173				P0/D1/B12. Record only.
055	62	01	1125	1940	1125 1146 1821 1853	1146 1821	1853 1940	-146.3	12	35.05	-172	3	0.000 0.000	256 512	P0/D1/B12.
055	12	01	1830	0355	1830 1847	1847 0355		-145.3	12	36.1	-172	10	0.000	512	P0/D1/B12.
056	41	02	0238	1140	0354 0511 0537 1140		0238 0354 0511 0537	-147.2	12	37.9	-172				P0/D1/B12. Record only.
056	42	02	0446	0536	0446 0511	0511 0536		-146.5	12	34.8	-172.5	1	0.000	256	P0/D1/B12. Station on Pioneer VIII was requested to go to Pioneer IX and send CMD 2/064.
056	62	02	1040	1940	1040 1059 1821 1851	1059 1821	1851 1940	-146.5	12	35.1	-172	3	0.000	512	P0/D1/B12. TCP Spurious interrupt at 1146.
056	12	02	1830	0330	1830 1846	1846 2330 0258 0330	2330 0258	-146.2	12	35.8	-172	13	0.000 0.000	512 256	Tracked on paramp from 2230 to 2330 for coded mode degradation test. P0/D1/B12.
057	41	003	0238	1117	0331 1034	0255 0315	0238 0255 0315 0331 1034 1117	-146.8	12	36.1	-172.0				P0/D1/B12. Record only.
057	62	003	1017	2005	1017 1034 1931 1949	1034 1931	1949 2005	-146.2	12	35	-172.4	4	0.000	512	P0/D1/B12. TCP Spurious interrupt (TFR-121693).

Table 21 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
057	12	003	1906	0330	1932 1942	1942 0330	1906 1932	-145.4	12	36.6	-172	10	0.000	512	P0/D1/B12.
058	41	004	0236	1140	0331 1140		0236 0331	-147.5	12	35.08	-172				P0/D1/B12. Record only.
058	61	004	1040	1940	1040 1848		1848 1940	-145.9	12	49.02	-171.2				P0/D1/B12. Record only.
058	12	004	1830	0330	1830 1848	1848 0330		-145.6	12	37.1	-172.0	12	0.000	512	P0/D1/B12.
059	41	005	0236	1140	0331 1109		0236 0331 1109 1140	-147.5	12	35.3	-172				P0/D1/B12. Record only.
059	61	005	1040	1936	1040 1109	1109 1851	1851 1936	-145.5	12	48.4	-171.2	3	0.000	512	P0/D1/B12.
059	12	005	1830	0329		1851 0329	1830 1851	-146.1	12	37.0	-172	10	0.000	512	P0/D1/B12.
060	41	006	0200	1100	0331 1036		0200 0331 1036 1100	-147.2	12	NOT TAKEN	-172				P0/D1/B12. Record only.
060	61	006	1015	1900	1013 1036 1751 1817	1036 1751	1817 1900	-146.4	12	63.5	-170	3	0.003	512	P0/D1/B12.
060	12	006	1800	0230	1800 1817	1817 0131 0201 0230	0131 0201	-146.1	12	37.0	-172	10	0.000	512	P0/D1/B12.
061	41	007	0122	1115	0231 1035	0131 0201	0122 0131 0201 0231 1035 1115	-147.6	12	39.28	-172				P0/D1/B12. Record only.

Table 21 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
061	61	007	1015	1800	1015 1035 1651 1728	1035 1651	1728 1800	-147	12	49.9	-171.2	4	0.000	512	P0/D1/B12.
062	12	007	1700	0317	1700 1728 0157 0221	1728 0157 0251 0317	0221 0251	-145.8	12	37.3	-171	10	0.000	512	P0/D1/B12.
062	41	008	0159	1100	0159 0221 0318 1037	0221 0251	0251 0318 1037 1100	-147.8	12	34.4	-172				P0/D1/B12. Record only.
062	61	008	1015	1900	1015 1037 1821 1843	1037 1821	1843 1900	-146.8	12	48.9	-171.2	5	0.100	512	P0/D1/B12.
062	12	008	1800	0230	1822 1843	1843 0230	1800 1822	-146.7	12	37.7	-173	10	0.000	512	P0/D1/B12.
063	41	009	0200	1100	0231 1037		0200 0231 1037 1100	-147.8	12	NOT MEAS-URED	-172				P0/D1/B12. Record only.
063	61	009	1015	1900	1015 1037 1751 1816	1037 1751	1816 1900	-147	12	64.14	-171.2	3	0.000	512	P0/D1/B12.
063	12	009	1800	2400	1800 1816 2301 2317	1816 2301 2341 2400	2317 2341	-146.2	12	37.1	-173	10	0.000	512	P0/D1/B12. TDH data bad from 1800 to 1830 due to PC-143 failure (TFR-120400/129206).
064	41	010	2255	1131	2301 0001	2317	2255 2341 1037	-147.2	12	34.46	-171.0	NONE	N/A	N/A	P0/D1/B12. VCO printout was intermittently bad due to interference from desk calculator. Record only.

N/A: Not Available

Table 21 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
064	61	010	1015	1900	1015 1751	1037	1816	-146.9	12	48.64	-171.26	4	0.002	512	P0/D1/B12.
064	12	010	1800	0230	1800	1816		-146.8	12	36.0	-172.0	10	0.000	512	P0/D1/B12. Punch 1 tape arm problem (TFR-120400/129214). One bad doppler resolver readout at 014502.
065	41	011	0130	1030	0231		0130 1009	-148.4	12	33.14	-172.0	NONE	N/A	N/A	P0/D1/B12. FR-1400 Tape B prime for pass. Reload only.
065	62	011	0934	1914	0934 1741	1015	1803	-146.5	12	37.11	-172.4	3	0.000	512/256	P0/D1/B12. Periodic interrupts and halts of TCP caused a total loss of 1 hour, 49 minutes and 10 seconds of data - cause unknown (TFR-121693/128134).
065	12	011	1744	0230	1744	1803		-147.3	12	36.5	173	10	0.000	512	P0/D1/B12. TDH punch, 1 garbled data (TFR-120400/129216).
066	41	012	0200	1100	0231		0200 1036	-147.7	12	33.7	-172	0			P0/D1/B12. Record only.
066	62	012	1015	1900	1015 1751	1044	1811	-149	12	36.50	-165.9	3	0.000	256	P0/D1/B12. Parity error rate ($\overline{PER}$) bad - TCP out of lock several times. No TFR. Switched power supply.
066	12	012	1751	0230	1751	1811		-147.4	12	37	-173	10	0.000	512	P0/D1/B12.
067	41	013	0057	1000	0231		0057	-149.6	12	31.5	-172	0			P0/D1/B12. Wrong synthesizer setting due to operator error. Record only.
067	61/67	013	0937	1804	* SEE STRANGE LANGUAGE ON POST TRACK	*	*	-147.7	MSFN	52.34	-170	3	0.001	512	P0/D1/B12. No anomalies.
067	12	013	1700	0130	1700	1724		-146.9	12	35.0	-173	15	0.000	512	P0/D1/B12. Punch 1 bad - missing digits from 1725 to 1728. Switched to Punch 2. (TFR-120400/129218).

N/A: Not Available
*MSFN does not list these items

Table 21 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
068	41	014	0058	1000	0131		0058	-148.4	12	31.18	-172	0	0	0	P0/D1/B12. Record only.
068	61/67	014	0930	1802	*	*	*	-148.5	MSFN	48.2	-169	3	0.441 0.200	256 512	P0/D1/B12. Intermittent LHA oscillation in program mode, manual position mode, collimation tower mode, and stow mode, but does not affect auto or manual velocity modes.
068	12	014	1700	0200	1700	1720		-144.6	12	40.5	-172	11	0.000	512	P1/D1/B12.
069	41	015	0127	1000	0201		0127 0957	-149.0	12	28.73	-172.0	NONE	N/A	N/A	P0/D1/B12. FR-1400 Tape 2B stopped (TFR-125285). Record only.
069	61/67	015	0927	1830	0930 0950	0950 1830		-148.5	12	49.81	-169	5	0.010	512	P0/D1/B12.
069	11/18	015	1813	0004	2142 2357	1940 2142	1815 1940	-150	12		-162	0	0.000		P0/D1/B12.
069	12	016	0000	0130	0000 0019	0019 0130		-148	12	39.5	-173	2		64	P0/D1/B12.
070	41	016	0101	1000	0131 1000		0101 0131	-149	12	45.47	-172	0			P0/D1/B12. Record only.
070	61/67	016	0923	1815	0923 0945	0945		-148.7	12	48.31	-172	13	0.020	512	P0/D1/B12.
070	**18	016	1635	0130	1635 0130			NOT PROVIDED	12	27.50	-163				Predict problems. See post track report. Record only.
071	41	017	0054	1000	0054 0956		0956 1000	-149	12	45.1	-173				Record only.

N/A: Not Available
*MSFN does not list these items
**PRIME APOLLO AT GOLDSTONE

Table 21 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
071	MAD-X	017	0920	1800	0920 0958 1650 1724	0958 1650	1724 1800	-148.9	12	51.07	-168	3	0.035	512	P0/D1/B12.
071	12	017	1658	2300	1658 1724	1724 2300		-147	12	35.3	-172	10	0.000	512	P0/D1/B12.
072	41	017/018	2209	1044	2302 0958		2209 2302 0958 1044	-149	12	42.02	-171	N/A			P0/D1/B12. Record Only.
072	MAD-X	018	0922	1802	0922 0958 1651 1802	0958 1650		-149	12	50.86	-172	3	0.050	512	P0/D1/B12.
072	12	018	1658	0130	1658 1709	1719 0130		-147.4	12	45.0	-171	10	0.000	512	P0/D1/B12. High $\overline{\text{PER}}$ from start of track to 1734.
073	41	019	0058	1000	0132 1000		0058 0132	-149	12	44.7	-171	N/A			P0/D1/B12. Record only.
073	MAD-X	019	0912	1800	0912 0945 1650 1800	0945 1650		-149.4	12	48.19	-168	3	0.130	512	P0/D1/B12.
073	12	019	1658	0130	1658 1718	1718 0130		-147.9	12	34.8	-172	10	0.000	512	P0/D1/B12
074	41	020	0057	1000	0131 0912		0057 0131 0912 1000	-149.8	12	47.8	-171				P0/D1/B12. Record only.
074	62	020	0848	1812	0848 0912 1131 1729	0912 1131	1729 1812	-148.8	12	36.9	-165.6	1	0.030	256	P0/D1/B12. On Paramp at 1529 due to bad maser (TFR-130372). Record only mode from 1130 to 1812.

N/A: Not Available

Table 21 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
074	12	020	1658	0145	1658 1726	1726 0145		-148.2	12	36.3	-172	12	0.000	512	P0/D1/B12.
075	41	021	0057	1000	0146 1000		0057 0146	-150	12	48.2	-171				P0/D1/B12. Record only.
075	62	021	0900	1640	0900 1609		1609 1640	-148.4	12	36.03	-172	0	0.010	256	P0/D1/B12. Record only mode from 1130 to 1640.
075	12	021	1540	0145	1540 1609	1609 0145		-148.8	12	36.0	-172	13	0.000	512	P0/D1/B12. Demod failed at 1710. GOE Demod phase voltage caused high parity error (TFR-12/GOE/132568).
076	41	022	0026	0900	0145 0322		0026 0145	-150.2	12	45.5	-171				P0/D1/B12. Data lost from 0147 to 0149 due to engineering bus power glitch. Lost maser, went to Paramp from 0313 to 0322. End of Track. Record only pass.
076	51	022	0830	1711	0830 0929 1556 1626	0930 1556	1626 1700	-148.4	12	40.6	-172	2	0.035	512	P0/D1/B12.
076	GDS	022	1605	0100	1605 2308	1620 0100		-149	12	N/A	-163	3	0.070	64	P0/D1/B12. Track terminated at 2125 due to high winds. Track resumed at 2308.
077	41	022/023	2356	0900	0102 0823		2356 0102 0823 0900	-150.4	12	47.1	-171				P0/D1/B12. Record only.
077	51	023	0759	1704	0759 0822 1556 1631	0824 1556	1632 1704	-148.6	12	41.2	-172	3	0.000 0.000	64 512	P0/D1/B12.
077	18 GDS	023	1557	0100	1557 1635 2247 2259	1635 2247 2259 0100		-151	12	N/A	-163	9	0.000	64	P0/D1/B12. Antenna pointing drive tape jammed at 1935 and at 2227 causing loss of signal.

Table 21 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
078	41	024	2127	1009	2228 2257 0101 0924		2127 2228 2257 0101 0924 1009	-151	12	44.7	-172				P0/D1/B12. Record only.
078	51	024	0859	1655	0859 0923 1607 1624	0924 1606	1624 1655	-148.4	12	39.8	-171.5	8	0.000	512	P0/D1/B12.
078	12	024	1600	1827	1607 1625	1625 1821	1600 1607 1821 1827	-148.6	12	39.4	-172	2	0.000	64	P0/D1/B12 Ended track early due to maser failure.
078	GDS	024	1810	2350		1821 2350	1810 2334	-152	12	N/A	-164	6	0.000	64	P0/D1/B12. Lost power to X-Y axes at 2334, 2339, and at 2345.
079	41	025	2356	0900	2356 0844		0844 0900	-148.3	12	45	-172				P0/D1/B12. Record only.
079	62	025	0820	1720	0820 0844 0912 1646	0844 0912	1646 1720	-147	12	38.7	-172	2	0.003	512	P1/D1/B12.
079	12	025	1630	0115	1630 1650	1650 0101	0101 0115	-148	12	36.5	-164	9	0.000	64	P0/D1/B12. Tracked on Paramp-maser inoperative.
080	41	026	0026	0121			0026 0121	-147.9	12	45.1	-172				P1/D1/B12.
080	42	026	0024	0910	0909 0910	0101 0831	0024 0101 0831 0909	-151.3	12	38.8	-172.5	2	0.000	512	P0/D1/B12.
080	62	026	0815	1710	0911 1642	0831 0911	0815 0831 1642 1710	-147.7	12	38.6	-172	1	0.005	512	P1/D1/B12.

N/A: Not Available

Table 21 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
080	12	026	1615	0047	1615 1635 0013 0039	1635 0013	0039 0047	-149	12	351.8	-163	9	0.000	64	P0/D1/B12.
081	42	027	0011	0905	0011 0037 0801 0905	0037 0801		152.0	12	38.7	-172	2	0.070	512	P0/D1/B12.
081	62	027	0809	1828	0809 1601	1601 1828		-147.6	12	38.9	-172.4	1	0.008	512	P1/D1/B12.
081	12	027	1703	2253	1734 2248		1703 1734 2248 2253	-150	12	381.2	-162	0	0.140	64	P0/D1/B12. Thirty minutes late for track due to maser removal. Station power failure from 2130 to 2139. No transmitter due to 400-cycle generator failure.
082	42	028	2225	0902	2225 2245 0352 0405 0845 0902	2245 0352 0405 0845		-151.3	12	34.2	-171.8	10	0.250	512	P0/D1/B12.
082	62	028	0805	1647	0842 1606	1606 1647	0805 0842	-146.1	12	37.4	171.4	1	0.007	256	P1/D1/B12.
082	GDS-X	028	1531	2120	1531 1616 2000 2120	1701 2000	1616 1701	-152	12	52.5	-173	10	0.000	256	P1/D1/B12.
083	42	029	2019	0833	2019 2039	2039 0833		-151	12	33.6	-172.7	1	0.000	256	P0/D1/B12.
083	62	029	0800	1630	0834 1551		0800 0834 1551 1630	-145	12	38.7	-170	0	0.015	256	P1/D1/B12.

Table 21 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
083	12	029	1530	0030	1530 1550 2344 0004	1550 2344	0004 0030	-145.5	12	38.6	-172	9	0.030	256	P1/D1/B12.
084	42	030	2328	0831	2343 0003	0003 0831	2328 2343	-152.8	12	34.3	-171.7	2	0.000	64	P0/D1/B12.
084	62	030	0800	1545	0832 0944 1039 1520	0944 1039	0800 0832 1520 1545	-149	12	40.6	-172	3	0.500	64	P1/D1/B12.
084	12	030	1456	0045	1456 1520 2344 0012	1520 2344	0012 0045	-146.8	12	43.6	-171	8	0.000	64	P1/D1/B12.
085	42	030	2342	0832	2342 0010	0010 0823		-154.0	12	35.2	-171	1	0.200	64	P0/D1/B12.
085	62	031	0750	1557	0832 0958 1102 1557	0958 1102	0750 0832	-148.9	12	40.6	-172	2	0.080	64	P1/D1/B12.
085	12	031	1530	0031	1530 1551 2327 2352	1551 2327	2352 0031	-146.9	12	38.8	-173	28	0.000	256	P1/D1/B12.
086	42	031	2327	0830	2327 2352	2352 0830		-153.8	12	35.2	-171	5	0.030	256	P0/D1/B12. At 2338, intermittent NRZ data from GOE to REC during very bad parity error rate and decoder percent periods. At 0400, frequent loss of word frame sync. (TFR/TCP/128039).

Table 22. Operations data by pass number (February 1969)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
086	62	032	0740	1630	0832 0851 0912 1050	0851 1912 1050 1107	0740 0832 1107 1550	-149.9	12	41.8	-172.0	2	0.250	512	P1/D1/B12. TCP glitches caused loss of lock for 2 minutes and 8 seconds.
086	12	032	1530	0030	1530 1550 1648 1706 2322 2355	1550 1648 1706 2322	2355 0030	-147.7	12	39.4	-172.0	8	0.030	512	P1/D1/B12. At 1643, XMTR failed due to external inter-lock fault.
087	42	032	2322	0832	2322 2351	2351 0832		-154.5	12	46.8	-171.7	3	0.000	256	P0/D1/B12. Lightening from local thunder storm caused noise spikes on system noise temperature to increase to 300°K - T/M PER increased.
087	62	033	0740	1630	0832 1549		0740 0832 1549 1630	-149.7	12	38.4	-172.0		0.010	512	P1/D1/B12.
087	12	033	1530	0027	1530 1550 2322 0001	1550 2322	0001 0027	-147.4	12	40.3	-172.0	8	0.010	512	P1/D1/B12.
088	42	033	2322	0829	2322 0001	0001 0829		-154.0	12	33.6	-171.7	3	0.000	256	P0/D1/B12.
088	62	034	0737	1640	0807 1548	1548 1637	0737 0807 1637 1640	-149.8	12	39.4	-172.4	1	0.003	512	P1/D1/B12. Lost 8 minutes of TCP T/M data due to Klystron problems.
088	12	034	1632	0015	2324 2356	1637 2324	1632 1637 2356 0015	-146.3	12	368	-161.0	10	0.000	64	P1/D1/B12. At 1528, maser down due to broken closed cycle refrigeration (CCR) line (TFR-120700/128945). On paramp.

Table 22 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
089	42	034	2323	0820	2323 2351 0808 0820	2351 0808		-153.5	12	37.3	-171.7	4	0.000 0.500	256 512	P0/D1/B12.
089	62	035	0728	1636	0938 1518	0904 0938 1518 1552	0728 0904 1552 1636	-148.9	12	38.7	-172.0	2	0.050	512	P1/D1/B12.
089	12	035	1540	0015	1702 1850 2324 2355	1552 1702 1850 2324	1540 1552 2355 0015	-148.0	12	380	-162.0	8	0.000	64	P1/D1/B12.
090	42	035	2323	0815	2323 2352 0807 0815	2352 0807		-152.5	12	34.9	-172.0	7	0.000	256	P0/D1/B12.
090	62	036	0735	1615	0807 1544		0735 0807 1544 1615	-149.8	12	40.3	-171.0	0			P1/D1/B12. Record only.
090	12	036	1515	1925	1515 1541	1541 1925		-147.3	12	312	-163.0	8			P1/D1/B12. Track terminated at 1925 to perform maser maintenance.
090	GDS-X	036	2136	0019	2136 2247	2247 0019		-156.0	12	38.8	-173.0	12	0.000	512	P1/D1/B12. Special pass requested by ARC to check S/C sun sensors.
091	41	036	2324	0730	0020 0720		2324 0020	-150.8	12	39.7	-172.0				P1/D1/B12. Record only.
091	51	037	0649	1530	0649 0721	0721 1520	1520 1530	-150.3	12	43.6	-171.0	2	0.000	256	P0/D1/B12.
091	12	037	1430	2330		1525 2330	1430 1525	-148.9	12	40.5	-170.0	17	0.000	512	P1/D1/B12.

Table 22 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
092	41	037	2227	0730	2332 0649		2227 2332 0649 0730	-151.3	12	39.6	-172.0				P1/D1/B12. Record only.
092	51	038	0624	1520	0624 0648 0957 1009	0650 0920 1010 1432		-148.9	12	42.5	-171.0	3	0.050	512	P0/D1/B12 from 0624 to 0920. P1/D1/B12 from 0957 to 1520.
092	12	038	1413	0002		1433 0002	1413 1433	-149.5	12	38.2	-170.0	9	0.000	512	P1/D1/B12.
093	41	038	2248	0730	0004 0653		2248 0004 0653 0730	-151.5	12	39.2	-172.0				P1/D1/B12. Record only.
093	51	039	0626	1530	0626 0650	0651 1512	1512 1530	-148.7	12	41.8	-171.5	2	0.000	256	P1/D1/B12.
093	12	039	1440	2330		1512 2330	1440 1512	-148.7	12	39.1	-172.0	10	0.100	512	P1/D1/B12.
094	41	039	2222	0730	2332 0655		2222 2332 0655 0730	-151.8	12	43.6	-172.0				P1/D1/B12. Record only.
094	51	040	0633	1521	0633 0654	0655 1500	1500 1521	-149.4	12	46.7	-171.5	2	0.150	512	P1/D1/B12.
094	12	040	1422	2100		1502 2100	1422 1502	-148.6	12	40.1	-172.0	9	0.040	512	P1/D1/B12.
095	41	040	1956	0840	2102 0805		1956 2102 0805 0840	-151.6	12	40.9	-172.0				P1/D1/B12. Record only.
095	62	041	0745	1515	0745 0805	0805 1442	1442 1515	-149.6	12	40.7	-172.4	1		512	P1/D1/B12. One TCP in emergency mode operation.
095	12	041	1430	2330		1442 2330	1430 1442	-148.9	12	40.1	-171.0	10	0.150	512	P1/D1/B12.

Table 22 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
096	41	042	2241	0745	2332 0622		2241 2332 0622 0729	-151.5	12	289.2	-162.0				P1/D1/B12. Maser failed at 0621, approximately 45 seconds of data were lost - continued pass on paramp. Record only.
096	MAD	042	1203	1403		1230 1330	1203 1230 1330 1403	-153.0	12	30.0	-171.0	2		256	P0/D1/B12. Madrid prime-Apollo station tracked Pioneer IX for first time and demonstrated capability of processing commands and TLM successfully. One TCP in emergency mode operations.
096	62	042	0700	1515	0700 0725	0725 1232 1332 1442	1232 1332 1442 1515	-150.4	12	41.7	-172.4	6		256	P1/D1/B12. One TCP in emergency mode operations.
096	12	042	1430	2325		1442 2325	1430 1442	-150.4	12	38.8	-173.0	12	0.275	512	P1/D1/B12.
097	62	043	0651	1603	0651 0716	0716 1603		-151.6	12	39.06	-172.0	2		512	P1/D1/B12. One TCP in emergency mode operations.
097	GDS	043	1421	2332	2220 2235	1607 2220	1421 1607 2235 2332	-155.2	12	107.0	-168.0	10	0.000	64	P0/D1/B12.
098	42	043	2238	0743	2238 2252 0653 0720	2252 0653	0720 0743	-153.8	12	35.0	-172.0	3	0.000	256	P0/D1/B12.
098	62	044	0700	1515	0700 0721	0721 1515		-151.7	12	41.0	-172.0	2		256	P1/D1/B12. One TCP in emergency mode for coding.
098	GDS	044	1414	2330	1519 1657 2220 2246	1657 2220	1414 1519 2246 2330	-155.4	12	30.0	-168.0	8	0.000	64	P0/D1/B12.

Table 22 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
099	42	044	2223	0730	2223 2244 0637 0704	2244 0637	0704 0730	-154.2	12	34.2	-171.7	3	0.000 0.000	64 256	P0/D1/B12.
099	62	045	0645	1515	0645 0704	0704 1442	1442 1515	-151.0	12	38.8	-172.0	2			P1/D1/B12. Demod power supply failed. Power supply replaced. One TCP in emergency mode of operations.
099	GDS	045	1414	2320		1442 2320	1414 1442	-154.9	12	30.0	-168.0	9	0.040	64	P1/D1/B12.
100	41	045	2243	0745	2323 0722	0722 0745	2243 2323	-149.6	12	42.7	-172.0				P1/D1/B12. Record only.
100	51	046	0700	1430	0700 0722	0724 1404	1405 1430	-150.5	12	43.2	-171.0	2	0.000	256	P1/D1/B12.
100	12	046	1335	2325		1407 2325	1335 1407	-151.1	12	38.7	-172.0	15	0.000	256	P1/D1/B12.
101	41	046	2226	0730	2328 0705		2226 2328 0705 0730	-152.2	12	40.5	-172.0				P1/D1/B12. Record only.
101	51	047	0643	1500	0643 0705	0705 1443	1443 1500	-150.4	12	43.6	-171.0	2	0.000	256	P1/D1/B12.
101	12	047	1430	2320		1442 2320	1430 1442	-151.5	12	40.2	-172.0	9	0.000	256	P1/D1/B12.
102	41	047	2229	0730	2323 0722		2229 2323 0722 0730	-152.4	12	48.7	-172.0				P1/D1/B12. Record only.
102	62	048	0650	1500	0650 0723	0723 1433	1433 1500	-153.0	12	40.7	-172.0	1		256	P1/D1/B12.

Table 22 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
102	12	048	1400	2030		1432 2030	1400 1432	-152.6	12	40.6	-172.0	21	0.000 0.000	256 16	P1/D1/B12.
103	41	048	2028	0804	2034 0730		2028 2034 0730 0804	-151.0	12	284.9	-161.0				P1/D1/B12. Paramp operations. Record only. Pass started 1 hour late due to antenna problems.
103	62	049	0700	1505	0700 0724	0724 1505		-153.0	12	43.2	-172.0	1			P1/D1/B12. One hour and 38 minutes of real time data were interrupted due to microwave failure between DSS 61 and 62.
103	12	049	1448	2259		1503 2259	1448 1503	-151.4	12	39.1	-173.0	9	0.000	256	P1/D1/B12. From 1315 to 1445 antenna failed due to clutch problems (TFR-120600/131526).
104	41	049	2159	0630	2302 0630		2159 2302	-153.6	12	297.2	-166.0				P1/D1/B12. Paramp operations. Record only. Receiver out of lock from 0556 to 0559.
104	62	050	0659	1300	0659 0724 1204 1241	0724 1204	1241 1300	-152.8	12	38.9	-172.4	4			P1/D1/B12. TLM data degraded in real time due to faulty microwave link between DSS 61 and 62.
104	MAD-X	050	1207	1500	1207 1247	1247 1500		-156.4	12	49.2	-171.0	1		64	P0/D1/B12.
105	42	050	2153	0700	2153 2244 0654 0700	2244 0654		-156.3	12	35.0	-171.0	10	0.000	64	P0/D1/B12.
105	62	051	0611	1529	0654 0721	0721 1529	0611 0654	-153.6	12	40.6	-172.0	18		256	P1/D1/B12.
106	42	051	2155	0700	2155 2159 2210 2221	2159 2210 2221 0700		-156.0	12	34.0	-171.7	11	0.000	64	P0/D1/B12.
106	MAD-X	052	0624	1500	0624 0633	0633 1500		-154.6	12	49.5	-172.0	10	0.000	64	P1/D1/B12.

Table 22 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
107	42	052	2152	0700	2152 2217 0613 0657	2217 0613	0657 0700	-156.0	12	33.7	-171.7	13	0.000	64	P0/D1/B12.
107	MAD-X	053	0636	1456	0636 0659	0659 1456		-153.0	12	60.4	-172.0	5		256	P1/D1/B12.
108	42	053	2154	0700	2154 2224 0644 0700	2224 0644		-157.0	12	35.1	-171.7	12	0.000	64	P0/D1/B12.
108	MAD-X	054	0618	1456	0646 0640	0650 1456	0618 0646	-155.1	12	56.0	-172.0	3	0.000	64	P1/D1/B12.
109	42	054	2152	0700	2152 2217 0609 0633	2217 0609	0633 0700	-157.0	12	36.5	-171.7	9	0.000	64	P0/D1/B12.
109	MAD-X	055	0614	1459	0614 0636	0636 1459		-156.2	12	53.7	-172.0	1	0.000	64	P1/D1/B12.
110	42	055	2137	0645	2137 2204	2204 0641		-156.0	12	51.0	-171.0	10	0.000	64	P0/D1/B12.
110	MAD-X	056	0611	1443	0611 0705	0705 1443		-155.7	12	50.7	-172.0	1	0.000	64	P1/D1/B12.
111	42	056	2138	0646	2138 2208 0639 0646	2208 0639		-157.0	12	45.0	-171.0	20	0.000	16	P0/D1/B12.
111	MAD-X	057	0607	1453	0639 0651	0651 1453	0607 0639	-156.5	12	55.1	-172.0	8	0.000	64	P1/D1/B12.
111	12	057	1522	1815	1522 1609 1804 1815	1609 1804		-155.0	12	*	*	9	0.000	64	P1/D1/B12.

*No precalibrations; no postcalibrations.

Table 22 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
112	42	057	1811	0645	1811 1833 0554 0631	1833 0554	0631 0645	-157.0	12	45.5	-170.0	13	0.000	64	P0/D1/B12.
112	MAD-X	058	0607	1454	0607 0628	0628 1454		-157.2	12	55.9	-171.0	11	0.000	64	P1/D1/B12.
112	12	058	1812	2135	1812 1826	1826 2135		-154.0	12	40.1	-173.0	7	0.000	64	P1/D1/B12.
113	42	058	2144	0649	2144 2205 0640 0649	2205 0640		-157.9	12	45.3	-169.5	19	0.000	64	P0/D1/B12.
113	MAD-X	059	0607	1451	0641 0927 1414 1451	0927 1414	0607 0641	-156.2	12	55.7	-172.0	5	0.000	64	P1/D1/B12. Station had excessive down time. Refer to Post Track Report for details.
113	GDS-X	059	1443	2145	1443 1544	1544 2145		-161.0	12		-169.0	10	BAD 0.019	64 16	P0/D1/B12. The command modulation index was not set correctly; therefore, intra-site communication difficulties occurred between DSS 11 and 14 and prime Apollo.
114	42	059	2142	0645	2142 2207 0634 0645	2207 0634		-160.0	12	45.3	-169.5	18	0.000	64	P0/D1/B12.

Table 23. Operations data by pass number (March 1969)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
114	62	60	0600	1500	0636 0700	0700 1434	0600 0636 1434 1500	-157.5	12	34.7	-172	10	0.000	64	P0/D1/B12. At 0723, antenna off point due to APS computer hangup.
114	GDS	60	1341	2135		1439 2135	1341 1439	-159.3	12		-169	6	0.500	8	P0/D1/B12.
115	42	61	2128	0630	2128 2147 0624 0630	2147 0624		-157.4	12	45.8	-168.5	11	0.000	64	P0/D1/B12.
115	62	61	0600	1500	0624 0642	0642 1500	0600 0624	-154.4	12	41.3	-172.4	9	0.000	64	P1/D1/B12.
116	42	61	2122	0630	2122 2149 0619 0630	2149 0619		-157.8	12	34.50	-170.7	13	0.000	64	P0/D1/B12.
116	62	62	0600	1225	0619 0642	0642 1225	0600 0619	-154.5	12	40.1	-172.4	2	0.000	64	P1/D1/B12.
117	42	62	1853	0400	1853 1921	1921 0400		-158.8	12	35	-171	22	0.000	16	P0/D1/B12.
117	62	63	0600	1225	0600 0621	0621 1225		-156.0	12	39.2	-172.4	2	0.000	64	P1/D1/B12.
118	42	63	1854	0400	1854 1918	1918 0400		-159.5	12	34	-171.7	10	0.000	64	P0/D1/B12.
118	62	64	0600	1226	0600 0621	0621 1226		-156.0	12	39.63	-172.4	2	0.000	64	P1/D1/B12.
119	42	64	1853	0400	1853 1924	1924 0400		-157.3	12	35.3	-171.7	11	0.000	64	P1/D1/B12.
119	62	65	0600	1230	0600 0624	0624 1230		-154.3	12	39.0	-172.4	2	0.000	64	P1/D1/B12.

Table 23 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
120	42	65	1853	0400	1853 1921	1921 0400		-157.1	12	35.3	-171.7	10	0.000	64	P1/D1/B12.
120	62	66	0600	1230	0600 0628	0628 1230		-154.7	12	37.9	172.4	3	0.035	64	P1/D1/B12.
121	42	66	2244	0400	2244 2305	2305 0400		-157	12	47	-170.6	10	0.000	64	P1/D1/B12.
121	62	67	0600	1230	0600 0622	0622 1230		-155.6	12	40	-172.4	2	0.035	64	P1/D1/B12.
122	42	67	1856	0400	1856 1921	1921 0400		-157.5	12	48	-170	10	0.000	64	P1/D1/B12.
122	62	68	0600	1230	0600 0622	0622 1230		-155.5	12	37.35	-172.4	2	0.035	64	P1/D1/B12.
123	42	68	1853	0400	1853 1920	1920 0400		-157.8	12	47	-170.6	11	0.000	64	P1/D1/B12.
123	12	69	1230	2030	1230 1255	1255 2005	2005 2030	-156.4	12	42.6	-173	10	0.000	64	P1/D1/B12.
124	42	69	1917	0615	0554 0613	2005 0540	1917 2005 0540 0554 0613 0615	-158.5	12	47	-172.6	1	0.000	64	P1/D1/B12.
124	62	70	0525	1354	0553 0615	0540 0553 0615 1354	0525 0540	-157.5	12	40.9	-170.4	3	0.035	64	P1/D1/B12. Transfer from DSS 42 due to incorrect APS drive tape in use.
125	41	70	1827	0330	1827 0330			-160	12	41.3	-172	0	N/A		P0/D1/B12.
125	MAD-X	71	0532	1000	0532 0540	0540 1000		-160.3	12	35.9	172	2	0.100	16	P0/D1/B12.

Table 23 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
125	12	71	1230	2100	1230	1250	2030	-156.9	12	40	-172	10	0.000	64	P1/D1/B12. Special pass. Uncoded mode — Multi-Mission Telemetry (MMT) test.
126	42	71	1953	0600	0529	2035	1953 0555	-159.0	12	48.0	-171	1	0.000	64	P1/D1/B12. Maser 2 is prime. Maser 1 undergoing maintenance.
126	61	72	0531	0825	0531	0558		-161.0	12	46.0	-172.42	4	0.117	16	P0/D1/B12.
126	12	72	1230	1900	1230	1230		157.0	12	41.2	173	21	0.000	64	P1/D1/B12.
127	42	72	1740	0610	0526 0553	1835 0526	1740 1835 0553 0610	-158.9	12	47.5	-172.8	3	0.000	64	P1/D1/B12.
127	MAD-X	73	0528	1000	0528 0540	0540 1000		-162.8	12	43.6	-173	2	0.000	16	P0/D1/B12.
127	12	73	1230	2100	1230 1253	1253 2046	2046 2100	-157.4	12	40.8	-173	12	0.000	64	P1/D1/B12.
128	42	73	1958	0600	0538 0600	2035 0538	1958 2035	-159	12	38.2	-172.9	2	0.000	64	P1/D1/B12.
128	MAD-X	74	0546	1000	0546 0555	0555 1000		-162.8	12	N/A	-173	2	0.097	16	P0/D1/B12.
128	12	74	1232	2100	1232 1240	1240 2036	2036 2100	-157.4	12	39.2	-173	8	0.000	64	P1/D1/B12.
129	42	74	1949	0600	0557 0600	2035 0557	1949 2035	-159.2	12	38.5	-173.4	2	0.000	64	P1/D1/B12.
129	MAD-X	75	0542	1000	0558 0623	0623 1000	0542 0558	-163.2	12	45.4	-174	2	0.078	16	P0/D1/B12.
129	12	75	1230	2100	1230 1240	1240 2036	2036 2100	-157.3	12	41.7	-173	8	0.000	64	P1/D1/B12.

Table 23 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time			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)				
130	42	75	1952	0600		2036 0600	1952 2036	-160.2	12	34.8	-173.4	1	0.000	64	P1/D1/B12.
130	61	76	0531	1200	0605 0628	0628 1200	0531 0605	-161.2	12	48.8	-173	2	0.050	16	P0/D1/B12. No data for first 2 hours and 40 minutes due to absence of operators, caused by car breakdown.
130	12	76	1213	2030	1213 1245	1245 2030		-157.7	12	45	-173	21	0.000	64	P1/D1/B12.
131	42	76	2124	0400	2124 2153	2153 0400		-159.2	12	36.2	-172.4	1	0.000	64	P1/D1/B12.
131	51	77	0313	1301	0437 0513	0406 0433 0514 1301	0313 0406	-157.0	12	40.6	-171.5	2	0.000	64	P1/D1/B12.
132	42	77	2122	0400	2122 2153	2153 0400		-159.7	12	43.1	-172.4	10	0.000	64	P1/D1/B12.
132	61	78	0533	1246	0533 0558	0558 1246		-158.5	12	42.8	-172.4	6	0.050	64	P1/D1/B12. Antenna drove off point briefly due to accidental shorting of power supply.
132	12	78	1235	2030	1252 2030		1235 1252	-159.0	12	40	-173			16	P1/D1/B12.
133	42	78	2121	0400	2121 2152	2152 0400		-159.7	12	37.1	-172.4	3	0.000	64	P1/D1/B12.
133	61	79	0530	1200	0530 0555	0555 1200		-158.4	12	47.27	-173	10	0.030	64	P1/D1/B12.
133	12	79	1203	2030	1203 2030			-158	12	39.3	-173			16	P1/D1/B12.
134	61	80	0532	1200	0532 0551	0551 1200		-158.6	12	48.4	-173	14	0.080	16	P1/D1/B12.
134	12	80	1200	2030	1200 2030			-158.9	12	40	-173	0	N/A	N/A	P1/D1/B12. MMT operation.

Table 23 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
135	42	80	2122	0400	2122 2153	2153 0400		160.0	12	36	-172.4	8	0.000	64	P1/D1/B12.
135	61	81	0530	1200	0530 0553	0553 1200		159.0	12	42.3	-171.3	10	0.050	64	P1/D1/B12.
135	12	81	1208	2030	1208 2030			-158.9	12	N/A	N/A	0	N/A	N/A	P1/D1/B12. Record only.
136	42	81	2122	0400	2122 2155	2155 0400		-160.3	12	36.3	-172.4	3	0.000	64	P1/D1/B12.
136	61	82	0530	1200	0530 0555	0555 1200		-159.3	12	41	-172.3	3	0.184 0.000	64 16	P1/D1/B12.
137	42	82	2122	0400	2122 2154	2154 0400		-159.9	12	35.2	-172.4	5	0.000	64	P1/D1/B12.
138	61	84	0800	1400	0800 0823	0823 1400		-159.0	12	41	-172.4	22	PE 0.0010	16	P1/D1/B12.
138	12	84	1733	2156	1733 2156			-159.3	12	39.4	-172				P1/D1/B12. MMT pass.
139	42	84	2125	0400	2125 2158	2158 0400		-160.7	12	36.5	-172.4	5	PE 0.0578		P1/D1/B12.
139	61	85	0800	1400	0800 0820	0820 1400		-158.9	12	40.6	-172.4	11	PE 0.0023	16	P1/D1/B12.
140	42	85	2147	0430	2147 2222	2222 0430		-161	12	37.3	-172.4	6	0.000	16	P1/D1/B12. TCP faulting (TFR-108134).
140	61	86	0800	1400	0800 0821	0821 1400		-158.4	12	43.3	-171.3	11	PE 0.0030	16	P1/D1/B12.
140	12	86	1730	2040	1730 2040			-159.4	12	38.8	-173				P1/D1/B12.
141	42	86	2120	0357	2120 2155	2155 0357		-160.9	12	35.5	-172.4	9	PE 0.0003	16	P1/D1/B12.

PE = Probability of Error

Table 23 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
141	61	87	0800	1400	0800 0822	0822 1400		-159.6	12	45.2	-171.2	11	PE 0.0031	16	P1/D1/B12.
142	42	87	2149	0430	2149 2212	2212 0430		-161.7	12	35	-172.9	4	PE 0.0006	16	P1/D1/B12. At 0113, signal level changed from -160.7 to -161.3 dbm – reason unknown.
142	61	88	0758	1352	0758 0825	0825 1352		-160.3	12	44.3	-171.2	13	PE 0.0003	16	P1/D1/B12. Rubidium 2 failed (TFR-128398).
142	12	88	1735	2200	1735 1755	1755 2152	2152 2200	-159.0	12	38.9	-172	4	PE 0.0041	16	P1/D1/B12.
143	42	88	2122	0355		2151 0355	2122 2151	-161.0	12	31.3	-172.7	3	0.0061	16	P1/D1/B12.
143	61	89	0758	1358	0758 0824	0824 1358		-160.7	12	44.0	-171.3	17	0.000	16	P1/D1/B12.
144	42	89	1727	0500	1727 1813	1813 0457	0457 0500	-161.0	12	34.5	-172.9	12	PE 0.0018	16	P1/D1/B12. Acquisition 4 hours early at Project request. One-hour countdown.
144	61	90	0442	1355		0456 1355	0442 0456	-160.3	12	44.3	-171.2	14	PE 0.0082	16	P1/D1/B12.
144	14	90	1330	1730		1403 1723	1330 1403 1723 1730	-153.1	12	31.6	-174	6	0.013 0.114	64 256	SMF mode 2/B12.
144	12	90	1700	2200	2150 2200	1723 2150	1700 1723	-160.5	12	39.5	-173	6	0.000 PE 0.0050	16 16	P1/D1/B12. Dropped uplink on transfer to DSS 42 at 2150 due to operator error in excessive tuning rate.
145	42	90	2126	0500	2151 2225	2225 0458	2126 2151 0458 0500	-162	12	49	-172.9	6	PE 0.0060	16	P1/D1/B12.

PE = Probability of error

Table 24. Operations data by pass number (April 1969)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
145	61	91	0440	1400		0457 1400	0440 0457	-161.9	12	45.3	-171.3	12	PE 0.0100	16	P1/D1/B12.
145	12	91	1351	2030		1403 2018	1351 1403 2018 2030	-160.3	12	39.7	-172	4	PE 0.0040	16	P1/D1/B12.
146	42	91	1958	0500		2018 0458	1958 2018 0458 0500	-163.1	12	33.5	-171.8	11	PE 0.0025 PE 0.0738	16 64	P1/D1/B12. Pretrack calibration was not accurate.
146	61	92	0438	1356		0453 1356	0438 0453	-161	12	40.1	-171.3	17	PE 0.0070	16	P1/D1/B12.
146	12	92	1530	2140	1530 1650	1650 2140		-161	12	40.4	-172	6	PE 0.0074	16	P1/D1/B12.
147	42	92	2155	0500	2155 2225	2225 0458	0458 0500	-162.5	12	34.3	-172.5	4	PE 0.0035	16	P1/D1/B12.
147	61	93	0435	1100		0459 1100	0435 0459	-162	12	46.2	-171.3	8	PE 0.0110	16	P1/D1/B12. Error in pretrack calibration caused signal strength reading to be 3 db higher than actual strength.
147	12	93	1200	1930	1200 1225	1225 1930		-159.9	12	43.9	-173	11	PE 0.0000 PE 0.006	16	P1/D1/B12.
148	42	93	2223	0500	2223 2254	2254 0457	0457 0500	-162.5	12	34.1	-172.5	3	PE 0.0036		P1/D1/B12.
148	61	94	0434	1100		0458 1100	0434 0458	-161.1	12	44.18	-171.27	12	PE 0.0120	16	P1/D1/B12. FR-1400 Tape Recorder Reel 2B was bad - Reel 2A sent in data package.
149	61	94	0432	1100	0432 0502	0502 1100		-164	12	42.84	-172.42	16	PE 0.0116	16	P1/D1/B12.
149	12	95	1530	2200	1530 1609	1609 2200		-161.7	12	39.5	-173	5	PE 0.0070	16	P1/D1/B12.

PE = Probability of Error.

Table 24 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
150	42	95	2224	0500	2224 2256	2256 0448	0448 0500	-162	12	34.7	-172.5	1	0.000	16	P1/D1/B12. Signal level dropped 1 db at 0014. Adjusted TWM 1 compressor JT - return regulator valve.
150	61	96	0430	1056		0448 1056	0430 0448	-161.8	12	42.5	-173.16	10	0.000	16	P1/D1/B12. After going to coded mode, TCP intermittently dropped lock from 0540 to 0605, lost 25 minutes of TLM data - reset Demod/sync rate switch.
151	42	96	2227	0450	2227 2255	2255 0448	0448 0450	-162	12	35	-172.3	4	0.040	16	P1/D1/B12.
151	61	97	0429	1055		0452 1055	0429 0452	-161.3	12	43.88	-172.42	23	PE 0.0118	16	P1/D1/B12. On 16-bit position, bit switch failed to make solid contact on Demod.
151	12	97	1403	2210	1403 1430	1430 2210		-162.2	12	39.8	-172	3	PE 0.0125	16	P1/D1/B12.
152	42	97	2222	0500	2222 2253	2253 0458	0458 0500	-162.5	12	35.2	-172.5	2	PE 0.0054	16	P1/D1/B12. RCVR 1 was out-of-lock at 0454 while tuning for station transfer. RCVR 1 back-in-lock at 0456.
152	61	98	0429	1055		0458 1055	0429 0458	-161.2	12	49.8	-172.4	9	PE 0.0136	16	P1/D1/B12.
153	42	98	2221	0500	2221 2255	2255 0500		-163	12	34.5	-173.5	2	PE 0.0060	16	P1/D1/B12. Bad time code at 2235.
153	61	99	0430	1055	0510 0636	0636 1055	0430 0510	-161.5	12	42.0	-172.4	10	PE 0.0120	16	P1/D1/B12.
153	12	99	1620	2156	1620 1649	1649 2156		-162.3	12	36.6	-172	6	PE 0.2111	16	P1/D1/B12.
154	61	100	0430	1055	0430 0457	0457 1055		-161.6	12	42.95	-172.4	10	PE 0.0214	16	P1/D1/B12.
155	42	100	2223	0500	2223 2311	2311 0459	0459 0500	-162.7	12	35.4	-173	4	PE 0.0122	16	P1/D1/B12.
155	61	101	0430	1055	0757 0826	0490 0757 0826 1055	0430 0490	-161.7	12	41.86	-171.2	9	0.080	16	P1/D1/B12. From 0745 to 0754 lost "U" buss and 11 minutes of data due to a governor failure on generator - switched to standby generator.

Table 24 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
155	12	101	1630	2200	1630 1714	1714 2200		-162.3	12	39.5	-172	14	PE 0.0240	16	P1/D1/B12.
156	42	101	2224	0500	2224 2255	2255 0500		-164	12	45.9	-171.5	7	PE 0.0236	16	P1/D1/B12.
156	61	102	0430	1055		0459 1055	0430 0459	-162.2	12	42.24	-171.27	12	PE 0.0307	16	P1/Di/B12. RCVR glitching during station transfer - no data lost.
157	42	102	2225	0454	2225 2259	2259 0454		-164.0	12	46.0	-171.5	7	PE 0.0330	16	P1/D1/B12.
157	12	103	1620	2200	1620 1653 2144 2200	1653 2144		-162.1	12	39.0	-172.0	17	PE 0.0159	16	P1/D1/B12.
158	42	103	2220	0458	2220 2258	2258 0454	0454 0458	-164.3	12	46.0	-172	7	PE 0.0240	16	P1/D1/B12.
158	61	104	0435	1103		0457 1103	0435 0457	-161.1	12	41.57	-172.4	16	PE 0.0253	16	P1/D1/B12. From 0430 to 0440, unable to lock up RCVR NBR 1 due to faulty reading on frequency counter caused by miscabling.
159	42	104	2222	0458	2222 2259	2259 0458		-164.5	12	47.8	-171.5	8	PE 0.0342	16	P1/D1/B12. At 0330, RCVR was out-of-lock due to APS failure. At 0339, RCVR was back-in-lock, ANT in aided track (TFR-108167).
159	61	105	0435	1105		0459 1105	0435 0459	-162.1	12	41.77	-172.42	10	PE 0.0284	16	P1/D1/B12.
159	12	105	1130	2000	1130 1203	1203 2000		-162.8	12	38.6	-173	4	PE 0.0267	16	P1/D1/B12.
160	42	105	2221	0458	2221 2205	2205 0458		-163.4	12	44.5	-172	5	PE 0.0130	16	P1/D1/B12.
160	61	106	0435	1105		0500 1105	0435 0500	-161.9	12	40.17	-172	11	PE 0.0330	16	P1/D1/B12.
160	12	106	1130	1957	1130 1158	1158 1957		-163.1	12	38.3	-173	13	PE 0.0061	16	P1/D1/B12.

PE = Probability of Error.

Table 24 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
161	61	107	0435	1103	0435 0454	0454 1103		-161.5	12	44.03	-172.4	9	PE 0.0374	16	P1/D1/B12.
162	42	107	2220	0435	2220 2349	2349 0435		-163.5	12	35.13	-171.9	3	0.000	16	P1/D1/B12.
162	61	108	0435	1105		0445 1105	0435 0445	-161.9	12	48.35	-171.9	15	PE 0.0194	16	P1/D1/B12. CMD 5-104 sent in error, vice CMD 5-111 due to operator's error.
162	12	108	1250	2000	1250 1320	1320 2000		-164.0	12	37.1	-173	10	PE 0.0217	16	P1/D1/B12.
163	42	108	2321	0459	2321 2349	2349 0448	0448 0459	-164	12	38	-172.9	5	0.000	16	P1/D1/B12.
163	61	109	0430	1105	0818 0848	0453 0818 0848 1105	0434 0453	-163.9	12	50.58	-171.9	2	PE 0.0200	16	P1/D1/B12. Signal level was erratic.
163	12	109	1130	2000	1130 1201	1201 2000		-163.3	12	38.4	-173	3	PE 0.0258	16	P1/D1/B12.
164	42	109	2222	0459	2222 2255	2255 0459		-164.1	12	34	-172.9	8	PE 0.0182	16	P1/D1/B12.
164	12	110	1109	2214	1109 1142	1142 2214		-164.2	12	37	-173	12	PE 0.0299	16	P1/D1/B12.
165	42	110	2224	0455	2243 2309 0448 0455	2309 0448		-163.3	12	35.5	-172.9	4	PE 0.0189	16	P1/D1/B12.
165	61	111	0527	1152	0527 0607	0607 1152		-164.5	12	40.78	-172.4	10	PE 0.0157	16	P1/D1/B12.
166	42	111	2152	0430	2152 2237	2237 0430		-163.5	12	35.3	-172.8	17	PE 0.0158	16	P1/D1/B12. APS drive ran away at 0157 causing brief signal degradation.
166	61	112	0525	1100	0525 0602	0602 1100		-164	12	42.3	-172.4	1	PE 0.0165	8	P1/D1/B12.
166	12	112	1130	1930	1130 1154	1154 1930		-163.7	12	39.5	-172	3	PE 0.0154	8	P1/D1/B12.

PE = Probability of Error.

Table 24 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time			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)				
167	42	113	2148	0430	2148 2229	2229 0430		-163.5	12	34.7	-172.7	10	PE 0.0034	8	P1/D1/B12.
167	61	113	0529	1040	0529 0559	0559 1040		-164.2	12	44.87	-171.2	1	PE 0.0199	8	P1/D1/B12.
167	12	113	1116	1958	1116 1155	1155 1958		-164.3	12	38.7	-173	19	PE 0.0134	8	P1/D1/B12.
168	61	114	0521	1200	0521 0556	0556 1200		-164	12	41.48	-172.42	12	PE 0.0252	8	P1/D1/B12.
169	42	114	2158	0430	2158	0430		-165.4	12	45.8	-173.4	12	PE 0.0473	8	P1/D1/B12.
169	61	115	0523	1200	0523 0613	0613 1200		-163.8	12	41.45	-172.42	1	PE 0.0223	8	P1/D1/B12.
169	12	115	1130	2000	1130 1200	1200 2000		-165	12	38.8	-172	2	PE 0.0375	8	P1/D1/B12.
170	42	115	2159	0430	2159 2233	2233 0430		-165.2	12	47.7	-172.6	9	PE 0.0470	8	P1/D1/B12.
170	61	116	0530	1200	0530 0602	0602 1200		-163.7	12	43.4	-172.4	1	PE 0.0189	8	P1/D1/B12.
170	12	116	1130	2000	1130 1201	1201 2000		-165.8	12	37.8	-172	5	PE 0.0218	8	P1/D1/B12.
171	42	116	2155	0430	2155 2227	2227 0430		-165.8	12	46	-173	10	PE 0.0170	8	P1/D1/B12.
171	12	117	1101	2212	1101 1147	1147 2212		-166	12	39.6	-172	3	PE 0.0378	8	P1/D1/B12.
172	42	117	2149	0430	2231 2257	2257 0430	2149 2231	-166.4	12	46.1	-172.4	10	PE 0.0600	8	P1/D1/B12. Standard restart required on TCP decoding computer after program. hang up - reason unknown.
172	61	118	0500	1130	0500 0530	0530 1130		-164.2	12	47.48	-172.42	1	PE 0.0206	8	P1/D1/B12.

PE = Probability of Error.

Table 24 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
172	12	118	1430	1945	1430 1537	1537 1945		-166	12	40	-173	2	PE 0.0283	8	P1/D1/B12.
173	42	118	2126	0400	2126 2209	2209 0400		-164.9	12	46.6	-171.9	12			P1/D1/B12. TCP Beta program hang up. Open circuit between TCP and GOE suspected (TFR-108187).
173	61	119	0500	1130	0500 0528	0528 1130		-164.2	12	43.14	-172.4	12	PE 0.0189	8	P1/D1/B12. From 0804 to 0825, Analog Tape 1B was defective. This tape was replaced. No TDH from start of pass - lost 5 hours of data (TFR-141567).
173	12	119	1615	1945	1615 1655	1655 1945		-165	3/12	38.3	-173	4	PE 0.0678	16	P1/D1/B12 to 1730. P1/D1/B3 to 1945. High PE, Low PD.
174	12	120	1616	2145	1616 1647	1647 2145		-166.5	3/12	39.9	-173	3	PE 0.0760 0.0187	16	P1/D1/B12 from 1616 to 1740. P1/D1/B3 from 1740 to 1815. P1/D1/B12 from 1815 to 1943. P1/D1/B3 from 1943 to 2145. At 2130, UWV klystron power supply failed causing loss of pump power and RCVR lock - back to operations at 2145 (TFR-120700 and 140542).
175	42	120	2141	0400	2203 2235	2235 0400	2141 2203	-163.5	12	35.2	-172	10	PE 0.0085 0.0500	8 16	P1/D1/B12. Lost RCVR lock and had numerous RCVR glitches during Channel 7 data point acquisition.

PE = Probability of Error.

Table 25. Operations data by pass number (May 1969)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
175	61	121	0500	1130	0500 0535	0535 1130		-164	12	43.14	-172.42	3	PE 0.0270	8	P1/D1/B12.
176	42	121	2058	0400	2058 2200	2200 0400		-164.7	12	46.5	-171.92	10	PE 0.0625	8	P1/D1/B12.
176	61	122	0500	1130	0500 0535	0535 1130		-163.7	12	43.04	-171.27	1	PE 0.0200	8	P1/D1/B12.
176	12	122	1100	1945	1147 1228	1228 1945	1100 1147	-164.9	12	39.6	-173	10	PE 0.0500	8	P1/D1/B12.
177	42	122	2119	0400	2119 2200	2200 0400		-165	12	45.5	-171.92	9	PE 0.0220	8	P1/D1/B12. From 2159 to 2338, no data from the operational program. Replaced GOE computer buffer (TFR-42/GOE/108194). RCVR glitching during two-way tracking and data point acquisition.
177	61	123	0500	1130	0500 0534	0534 1130		-164.2	12	47.30	-172.42	1	PE 0.0250	8	P1/D1/B12.
177	12	123	1120	1945		1205 1945	1120 1205	-165.4	12	45.5	-173	3	PE 0.0500 PE 0.0250	16 8	P1/D1/B12.
178	42	123	2059	0400	2059 2200	2200 0400		-165.5	12	47	-171.92	8	PE 0.0200	8	P1/D1/B12.
178	61	124	0500	1100	0500 0528	0528 1100		-165	12	42.06	-171.3	3	PE 0.2580	8	P1/D1/B12.
179	51	125	0456	0930	0456 0542	0543 0930		-162.0	12	42.5	-170	10	PE 0.0647	16	P1/D1/B12.
179	12	125	1430	2055	1430 1458	1458 2055		-164.9	12	41.6	-173	5	PE 0.0600	16	P1/D1/B12.
180	51	126	0300	1020	0300 0328	0328 1020		-164.8	12	41	-172	9	PE 0.1605	16	P1/D1/B12.
180	12	126	1230	2055	1230 1425	1425 2055		-165.2	3/6/12	44.3	-170	17	PE 0.0590	16	P1/D1/B12 from 1230 to 1344. P1/D1/B6 from 1344 to 1800. P1/D1/B3 from 1800 to 2055.

PE = Probability of Error.

Table 25 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
181	51	127	0308	1030	0308 0338	0345 1030		-164.2	3	43	-173	11	PE 0.0097	8	P1/D1/B3.
182	51	128	0135	1246	0135 0213 1237 1246	0221 1237		-164.8	3	41.6	-173	9	PE 0.0298	8	P1/D1/B3.
182	17	128	1122	1932	1240 1530	1530 1932	1122 1240	-167.2	12	43.6	-170	1	PE 0.6529	16	P1/D1/B12.
183	47	128	1730	0420	0119 0131	1727 0119 0131 0403	1730 1727 0403 0420	-165.5	12	41.5	-172.2				P1/D1/B12.
183	62	129	0320	1250	1046 1150	0402 1046 1150 1250	0320 0402	-164.8	12	37.9	-172.4	3	PE 0.0248	8	P1/D1/B12. XMTR failed at 1034 - on at 1035.
183	14	129	1117	2200	1117 1134 1303 1341	1341 2200	1134 1303	-157	12	23.4	-176	15	0.003	64	SMF Mode 1/B12.
184	41	129	1902	0535	0221 0302 0326 0535		1902 2221 0302 0326	-168.5	12	43.18	-173				P0/D1/B12. Multi-Mission Telemetry (MMT) from 1902 to 0535.
184	51	130	0139	1247	0139 0315 1027 1123		1143 1247	-170 -164.3	3	39.8	-173.5	0	N/A	N/A	P1/D1/B3. Track interrupted between 0315 and 1027 because of maser warm up.
184	12	130	1037	2224	1037 1125 1949 2021	1125 1949	2021 2224	-166.3	3/12	40.7	-173	8	PE 0.0280	8	P1/D1/B12 from 1030 to 1802. P1/D1/B3 from 1802 to 2224.
185	42	130	1731	0413	1940 2003	2003 0413	1731 1940	-165.5	12	35	-173	1	PE 0.0190	8	P1/D1/B12.

Table 25 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Configuration Temp Pre/Post (°K)	Configuration Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
185	61	131	0314	1225	1100 1146	0426 1100	0314 0426 1146 1225	-165.6	12	41.6	-171.2	2	PE 0.0408	8	P1/D1/B12.
185	14	131	1100	2155	1100 1139	1139 2155		-156.9	12	23.1	-175	19	PE 0.008	64	SMF Mode 1/B12.
186	41	131	1812	0450	2136 2231	2231 0332	1812 2136 0332 0450	-168.6	12	43.3	-172				P0/D1/B12.
186	51	132	0129	1245		0330 1245	0129 0319	-166	3 & 12	42.6	-176	9	PE 0.0606	8	P1/D1/B3 from 0129 to 0955. P1/D1/B12 from 0955 to 1245. Maser warmed up at 1100. RCVR glitching throughout track.
187	42	132	1738	0230	1738 1804	1804 0222	0222 0230	-164.5	12	38.8	-170.5	3	PE 0.0526	16	P1/D1/B12. Unable to acquire telemetry until 2021 because project failed to note S/C in duty cycle store. Maser helium leak caused termination of track early.
187	51	133	0130	1140		0222 1140	0130 0200	-164	3	41.6	-174	7	0.0600	16	P1/D1/B3.
187	12	133	1032	2222		1153 2222	1032 1153	-165.4	12	42	-172	2	0.0270	16	P1/D1/B12.
188	HSK-X	133	1735	0412		2228 0412	1735 2228	-166	12	47.3	-172.2	1	0.0320	8	P1/D1/B12.
188	62	134	0530	1000	0530 0606	0606 1000		-165.4	12	39.4	-172.4	7	0.000	8	P1/D1/B12.
188	12	134	1300	2224	1300 1349	1349 2224		-165.3	3	39.9	-177	4	0.0200	8	P1/D1/B3.
189	41	134	1739	0455	2237 0356		1739 2237 0356 0455	-166.8	12	41.89	-175				P1/D1/B12.

Table 25 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
189	62	135	0308	1445	0308 0358	0358 1445		-165.5	12	37.95	-172.4	2	0.0500	8	P1/D1/B12. Marginal pass.
189	GDS-X	135	1118	2218	1118 1557	1557 2218		-168	12	43.2	-170.4	1	N/A		P1/D1/B12. Transmitter failed at 2139 due to power supply fault.
190	41	135	1738	0515	2158 0515		1738 2158	-168.2	12	45.5	-172	0	N/A		P1/D1/B12.
191	14	137	1446	1931	1446 1545	1545 1931		-157.3	12	23.4	-175	12	0.000	64	SMF Mode 1/B12.
193	62	139	0700	1330	0700 0735	0735 1330		-167.5	3/12	38.71	-172.4	10	PE 0.0270	8	P1/D1/B12 to 0829. P1/D1/B3 to 1330.
193	12	139	1430	2030	1430 1508	1508 2030		-167.6	3	42.6	-178	4	PE 0.0290	8	P1/D1/B3. TCP Alpha failed from 1400 to 1530. (TFR-1100/142650).
194	62	140	0700	1330	0700 0733	0733 1330		-167	3/12	38.26	-174.38	10	PE 0.0320	8	P1/D1/B3 from 0752 to 1330. P1/D1/B12 from 0700 to 0752. CMD 2-027 delayed 3 minutes due to GOE operator.
194	12	140	1430	2028	1430 1508	1508 2028		-167.6	3	43.5	-178	16	PE 0.0300	8	P1/D1/B3.
195	62	141	0700	1329	0700 0735	0735 1329		-167.1	3/12	38.40	-176.37	10	PE 0.0290	8	P1/D1/B3 from 0805 to 1329. P1/D1/B12 from 0700 to 0805.
195	12	141	1430	2027	1430 1516	1516 2027		-167.1	3/12	40.9	-178	4	PE 0.0123	8	P1/D1/B3 from 1540 to 2027. P1/D1/B12 from 1430 to 1540.
196	62	142	0700	1330	0700 0737	0737 1330		-167.5	3/12	38.81	-177	10	PE 0.0253	8	P1/D1/B12 from 0700 to 0805. P1/D1/B3 from 0805 to 1330.
196	12	142	1430	2027	1430 1513	1513 2027		-167.0	3/12	42.2	-178	4	PE 0.0305	8	P1/D1/B12 from 1430 to 1536. P1/D1/B3 from 1536 to 2027.
197	62	143	0700	1330	0700 0743	0743 1330		-166.7	3/12	39.46	-176.3	10	PE 0.0280	8	P1/D1/B12 from 0700 to 0807. P1/D1/B3 from 0807 to 1330.

Table 25 (contd)

Pass No.	DSS No.	Day of Year	Acq. Time	End of Track	Ground Mode Start/Stop Time 1-Way	2-Way	3-Way	Signal Strength Avg (dbm)	Configuration Loop BW (Hz)	Temp Pre/Post (°K)	Thres Pre/Post (dbm)	No. of Cmds	Average PER	Bit Rate	Comments
197	12	143	1420	2030	1420 1507	1507 2030		-165.4	3/6/12	42.5	-178	2	0.0400	8	P1/D1/B12 from 1420 to 1614. P1/D1/B6 from 1614 to 1820. P1/D1/B3 from 1820 to 2030.
199	12	145	1430	2032	1430 1511	1511 2032		-166.2	3/12	43.5	-178	10	0.0526	8	P1/D1/B12 from 1430 to 1536. P1/D1/B3 from 1536 to 2032.
201	14	147	1239	1600	1239 1311 1330 1444 1514 1520	1311 1330 1444 1514 1520 1600		-158.3	12	23.5	-175	1			SMF Mode 1/B12. SMF Mode 2/B12. Station started track in mode at 1239, should have been in Mode II - went to Mode II at 1456.
202	61	148	1100	1431	1100 1215	1215 1431		-168.2	3/12	44.35	-175.9	6	PE 0.0600	8	P1/D1/B12 from 1100 to 1215. P1/D1/B3 from 1215 to 1431.
203	42	149	0035	0400	0035 0212	0212 0400		-165	12	36.3	-172.4	3	PE 0.0860 PE 0.0718	16 8	P1/D1/B12.
203	14	149	1440	2124	1440 1518	1518 2124		-158.3	12	23	-174	24	0.018	64	SMF Mode 1/B12.
203	61	149	1100	1423	1100 1205	1205 1423		-166.4	3/12	39.2	-175.9	3	PE 0.0700	8	P1/D1/B12. P1/D1/B3.
204	42	150	0028	0353	0028 0124	0124 0353		-165.5	12	37.8	-173.5	4	PE 0.0400	8	P1/D1/B12. At 0102, antenna HA problem developed due to faulty power supply. "U" bus circuit breaker tripped at 0353.
204	61	150	1100	1430	1100 1151	1151 1430		-166.4	3 & 12	39	-175.9	7	PE 0.0600	8	P1/D1/B3 from 1100 to 1141. P1/D1/B12 from 1141 to 1211. P1/D1/B3 from 1211 to 1430.
205	42	151	0027	0358	0027 0115	0115 0358		-166.7	12	34	-172.4	4	0.000	8	P1/D1/B12.
205	14	151	1221	1600	1221 1314	1314 1600		-157.6	12	23	-174	7	0.018	64	SMF Mode 1/B12.

Table 26. Operations data by pass number (June 1969)

Pass No.	DSS No.	Day of Year	Acq Time	End of Track	Ground Mode Start/Stop Time 1-Way	Ground Mode Start/Stop Time 2-Way	Ground Mode Start/Stop Time 3-Way	Avg Signal Str dbm	Configuration Code	System Temp °K	Receiver Thresh (dbm)	No. of Cmds	Error Rate	Bit Rate	Comments
206	42	152	0029	0359	0029 0111 0356 0359	0111 0356		-166.5	P1/D1/B12	33.3	-175.5	8	0.000	8	
208	42	153	1926	0300	1926 2016	2016 0300		-165	P1/D1/B12	34	-174.4	2	0.01553	8	
208	61	154	0830	1430	0830 0940	0940 1430		-166.4	P1/D1/B3 P1/D1/B12	48.1	-173.8	7	0.0700	8	TWM 2. Maser 1 down for maintenance - this caused a higher error rate.
209	61	155	0830	1430	0830 0914	0914 1430		-166.7	P1/D1/B3 P1/D1/B12	47.1	-174.5	8	0.700	8	TWM 2.
210	61	156	0830	1430	0830 0932	0932 1430		-167.6	P1/D1/B3 P1/D1/B12	41.1	-174.1	8	0.0580	8	Receivers dropped lock from 1322 to 1331 - reason unknown.
211	42	156	1925	0300	1925 2036	2036 0300		-166	P1/D1/B12	43.5	-172.4	2	PE 0.0336	8	TLM data was not processed until 23 minutes after acquisition due to a bad connection on the Beta TCP operational program interrupt patch panel (TFR-42/TCD/108249). In error, the AIS VCO's was on MM69 mode. This resulted in the FR-1400 failure to record the GOE sync status, GOE data mode, RCVR 1 lock, and the COMD tones. This problem was corrected at 2325 (TFR-108251).
211	61	157	0830	1430	0830 1033	1033 1430		-167.5	P1/D1/B12 P1/D1/B3	42.5	-172.3	7	PE 0.0550	8	
211	14	157	1921	2043	1921 2043			-159.3	SMF 1/B12	N/A	N/A	0	N/A		
212	42	158	1923	0300	1923 2129	2129 0300		-166.3	P1/D1/B12	34	-172.4	2	PE 0.0400	16	
212	61	158	0830	1430	0830 0919	0919 1430		-167.5	P1/D1/B3	41.4	-174.9	19	PE 0.0500	8	
213	42	158	1923	0300	1923 2015	2015 0300		166.5	P1/D1/B12	34	-172	2	PE 0.0400	8	

Table 26 (contd)

Pass No.	DSS No.	Day of Year	Acq Time	End of Track	Ground Mode Start/Stop Time			Avg Signal Str dbm	Configuration			No. of Cmds	Error Rate	Bit Rate	Comments
					1-Way	2-Way	3-Way		Configuration Code	System Temp °K	Receiver Thresh (dbm)				
213	61	159	0830	1430	0830 0912	0912 1430		-167.3	P1/D1/B3	42.3	-174	7	PE 0.0410	8	
213	12	159	1402	2000		1456 2000	1402 1456	-165.7	P1/D1/B12	44.3	-177	1	0.025	8	
215	14	161	1133	1906	1133 1214	1214 1906		-157.8	SMF 1/B12	26	-174	22	PE 0.0039	64	
217	14	163	1310	1900	1310 1344	1344 1900		-158.8	SMF 2/B12	23.2	-175	10	PE 0.0040	64	
218	42	163	2334	0325	2334 0039	0039 0325		-167.2	Pi/D1/B12	37	-176.5	1	PE 0.0608	8	TDH VCO XMTR counter reacted intermittently. It was replaced at the end of track (TDH/108268).
218	61	164	0900	1330	0900 0950	0950 1330		-168	P1/D1/B12 P1/D1/B3	42.5	-174.9	1	0.000	8	
219	42	164	0021	0320	0021 0131	0131 0320		-166.1	P1/D1/B12	36.1	-172.4	4	PE 0.0500	8	
219	14	165	1009	1630	1009 1054	1054 1630		-158.6	SMF 1/B12	49.7	-175	10	0.000	64	
220	61	166	0913	1122	0913 1017	1017 1122		-169.2	P1/D1/B12	42.1	-175.9	0	BAD	8	Acquisition delayed 13 minutes due to faulty frequency shifter in doppler extractor. Track ended 2 hours early to adjust polarizer.
221	61	167	0800	1200	0800 0911	0911 1030	1138 1200	-166.9	P1/D1/B3	42	-174.9	2	0.000	8	
221	42	166	2155	0258	2155 2301	2301 0258		-168.6	P1/D1/B3	48.3	-176.1	10	0.0600	8	RCVR 1 in 3 Hz bandwidth - glitching occurred during entire pass.
221	14	167	1032	1603	1032 1124	1124 1603		-158.5	SMF 1/B12	23.6	-175	21	0.000	64	TCP failed at 1103 due to broken pin in Demod cable - XFR to DSS 12 TCP and GOE at 1225 (TFR-136266).
222	61	168	0800	1300	0800 0915	0915 1300		-167.4	P1/D1/B3	42.7	-172.2	8	0.000	8	
223	42	168	2200	0300	2200 2305	2305 0300		-168	P1/D1/B3	48.2	-176.1	1	PE 0.0600	8	RCVR glitching occurred during entire pass.

Table 26 (contd)

Pass No.	DSS No.	Day of Year	Acq Time	End of Track	Ground Mode Start/Stop Time			Avg Signal Str dbm	Configuration			No. of Cmds	Error Rate	Bit Rate	Comments
					1-Way	2-Way	3-Way		Configuration Code	System Temp °K	Receiver Thresh (dbm)				
224	61	170	0800	1200	0800 0911	0911 1200		-167	P1/D1/B3	42	-175.9	2	PE 0.0360	8	
224	14	170	1222	1830	1222 1502	1502 1830		-160	P1/D1/B12	17	-175	9	0.0470	64	Ultra cone.
225	61	171	0800	1300	0800 0909	0909 1300		-168.9	P1/D1/B3	42.1	-175.4	8	0.000	8	
226	42	171	2259	0310	2259 0310			-168	P1/D1/B3 P1/D1/B12	36.5	172.4		PE 0.0600	8	A special CCU test was conducted during pass. RCVR signal level was -167.11 dbm while in manual gain and was -168.22 dbm in AGC.
226	61	172	0800	1300	0800 0848	0848 1300		-168.4	P1/D1/B3	41.9	-175.4	8	PE 0.0400	8	
227	42	172	2152	0300	2152 2301	2301 0300		-167.6	P1/D1/B12	43.8	-172.4	1	0.000	8	
227	61	173	0800	1200	0800 0845	0845 1117	1117 1200	-168	P1/D1/B3	42.5	-175.4	2	PE 0.0400	8	From 0800 to 1200, TCP computer buffer had intermittent errors in decoded data (TFR-141708).
227	14	173	1023	1600		1116 1600	1023 1116	-158.4	P1/D1/B12	22.3	-175	21	PE 0.0030	64	At 154430, antenna to brake mode due to low-film height on Pad 1. At 1553, antenna back in precision on mode (TFR-136296).
229	42	174	2240	0315	2240 0019	0019 0315		-167	P1/D1/B3 P1/D1/B12	35.8	-170.4	9	0.0649	8	RCVR 1 was in 3 Hz, AGC calibrations problems - XFR to 12 Hz operations to maintain TCP lock.
229	14	175	1158	1559	1158 1238	1238 1559		-158.3	P1/D1/B12	23.2	-174	24	0.0000 0.0057	16 64	
231	42	177	2254	0315	2254 2348	2348 0315		-167	P1/D1/B3	35.8	-175	1	0.0400	8	
231	61	177	0800	1230	0800 0804 0811 0854	0804 0811 0854 1230			P1/D1/B3	44.9	-175	1	0.0400	8	

Table 26 (contd)

Pass No.	DSS No.	Day of Year	Acq Time	End of Track	Ground Mode Start/Stop Time			Avg Signal Str dbm	Configuration			No. of Cmds	Error Rate	Bit Rate	Comments
					1-Way	2-Way	3-Way		Configuration Code	System Temp °K	Receiver Thresh (dbm)				
230	14	176	1021	1500	1021 1055	1055 1500		-157.4	P1/D1/B12	22	-173	15	PE 0.0000	16	
													0.0040	64	
231	14	177	1156	1704	1156 1232	1232 1704		-158.3	P1/D1/B12	22	-174	10	0.0040	64	
232	42	178	2255	0242	2255 0011	0011 0242		-169.5	P1/D1/B3	42	-172	0	0.0746	8	TWM 2 prime.
232	61	178	0800	1230	0800 0848	0848 1230		-167.1	P1/D1/B3	NONE	NONE	3	0.0366	8	
232	14	178	1600	2005	1600 1656	1656 2005		-158.2	P1/D1/B12	24.6	-175	11	PE 0.0000	16	
													PE 0.0059	64	
233	42	178	2252	0315	2252 0010	0010 0315		-166.5	P1/D1/B3	36.5	-177.6	1	PE 0.0419	8	
233	61	179	0800	1230	0800 0904	0904 1230		-167.8	P1/D1/B3	43.1	-175.9	7	PE 0.0440	8	
234	61	180	0800	1205	0800 0855	0855 1117	1117 1205	-167.4	P1/D1/B3	43.0	-175.9	1	PE 0.0419	8	
234	14	180	1025	1630		1117 1630	1025 1117	-158.2	P1/D1/B12	22.6	-174	11	PE 0.0047	64	

X. Performance Analyses

Analyses in this section cover the procedures, results, and anomalies in *Pioneer IX* telemetry, frequency, and prediction, the fitterate program, pseudo-residuals, and acquired metric data. These encompass parity error rate (PER), hertz variations of frequency from predictions, doppler noise and bias, and SNR values.

A. Telemetry Performance

1. General. The real-time telemetry quality is indicated by the PER printout on the engineering telemetry printout. A parity of error of 0.116 is equivalent to one error in 1000 consecutive bits of information and is regarded as the limiting value for uncoded and convolutional coded unit operation. One bit error per 10^3 bits equals 0.116. Bit error rate equals PER $\times$ 0.009117.

The Deep Space Station coded mode of operation probability of error—the decoding bit error rate printout—is illustrated in Figs. 29–34. From the decoding computer, the probability of error appears on the engineering data printout and is sent in real-time to the SFOF. The nominal value is verified with the Project. The variation in system temperatures is among the causes affecting the probability of error data; further analysis verifies the telemetry performance at the stations.

2. Recorded data. Figure 29 graphically displays the November 1968 parity error rate along with the applicable bit rate modes. The figure also illustrates that all stations recorded below nominal values at the telemetry bit rate mode of 512 bits/s. The exception to those passes in which a high PER was obtained and defined is listed in Table 27.

Figure 30 illustrates that almost all stations recorded below nominal values at the telemetry bit rate mode of 512 bits/s in December 1968. The exception to those passes in which a high PER was obtained are also found in Fig. 30.

A slight increase in parity error rate at Deep Space Stations 12 and 62 was probably due to switching between the uncoded mode to the coded mode of operation. In addition, telemetry command processor spurious interrupts were prevalent at both stations and real-time telemetry data was lost.

On pass 28 at DSS 51, a very high PER was indicated because of a frequency and timing subsystem problem. The station reported that no accurate station time was available for the telemetry command processor.

Figure 31 illustrates the February probability of error in the coded mode of operation at the Deep Space Station. The probability of error data illustrated in the figure are the lowest value recorded during the pass and appear below the estimated maximum value of 0.07. The probability of error data appears to be consistent between the stations at 512, 256, and 64 bits/s; however, the variations in system temperatures and other unknown causes apparently affect the data, as illustrated in Fig. 31.

During March 1969, the higher probability of error noted on pass 144 at DSS 61 (Fig. 32) was apparently due to the telemetry command processor being unable to stay in lock. No reason for this anomaly was noted. The data illustrated in Fig. 32 are the lowest values recorded during the pass, seemingly below the estimated maximum value of 0.07. The nominal value of 0.04 was verified with the Project for good telemetry which allows minimum computer reduction time at the ARC.

The probability of error data appears consistent between the stations at 64 bits/s and 16 bits/s. However, the variations in system temperatures and other unknown causes apparently affect the data, as illustrated in Fig. 32. The effect of the polarizer installation on the probability of error data started on passes 119 and 132 at Deep Space Stations 42 and 61, respectively.

Figure 33 illustrates the probability of error in the coded mode of operation at the Deep Space Stations during April 1969. The data illustrated in Fig. 33 represent the lowest values recorded during the pass for the specific bit rate. The data appear to vary between the stations at 16 and 8 bits/s in the coded telemetry mode. The variation in the uncoded and coded telemetry at 16 bits/s at DSS 12 is shown on pass 153. Further analysis of the probability of error data is required to verify the telemetry at the station because of system temperature variation and the traveling-wave maser 1 and 2 temperature.

The probability of error in the coded mode of operation at the Deep Space Stations during May 1969 is shown in Fig. 34. A higher probability of error on pass 185 at DSS 61 was noted. No reason for this anomaly was indicated. The data appear to be consistent between the stations at 16 bits/s and 8 bits/s. However, the variation in system temperatures and other unknown causes apparently affects the probability of error data as illustrated in Fig. 34. Deep Space Station 14 was able to track at 256 bits/s and 64 bits/s in the uncoded mode, but the station had problems when the spacecraft was placed in the coded mode of operations.

Table 27. Passes with high PER (November 1968)

Index number	Pass	Day	Deep Space Station	PER	Comments
1	13	325/326	12	0.437 0.013	Paramp operation and convolutional coded unit testing at 512 bits/s
2	14	326	62	0.123/256 0.003/512	Convolutional coded unit testing and telemetry command processor program reloads
3	19	331	62	0.015/512	Convolutional coded unit testing
4	19	331/332	12	0.005	GOE computer buffer failure

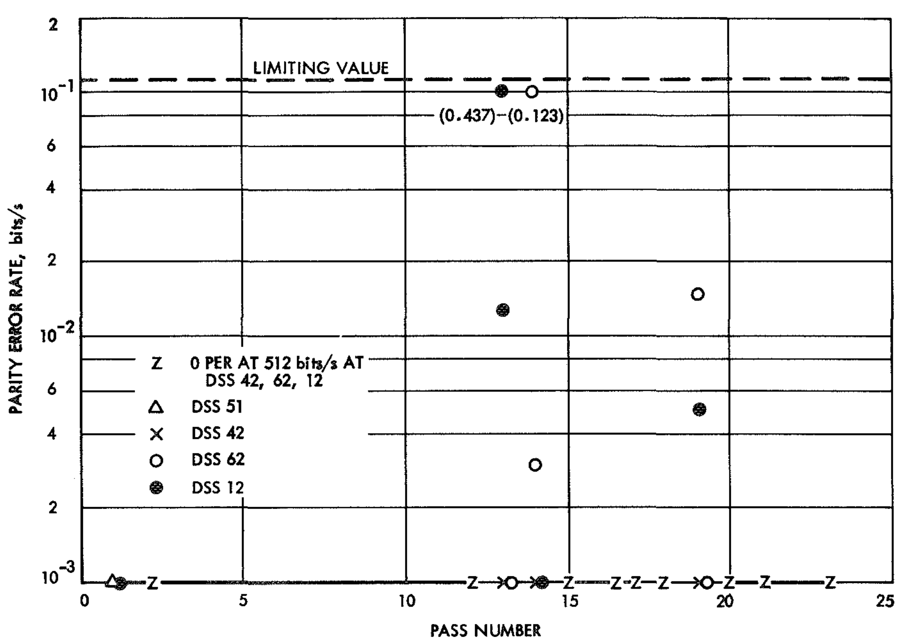


Fig. 29. PER vs pass number (November 1968) (passes 1 through 23)

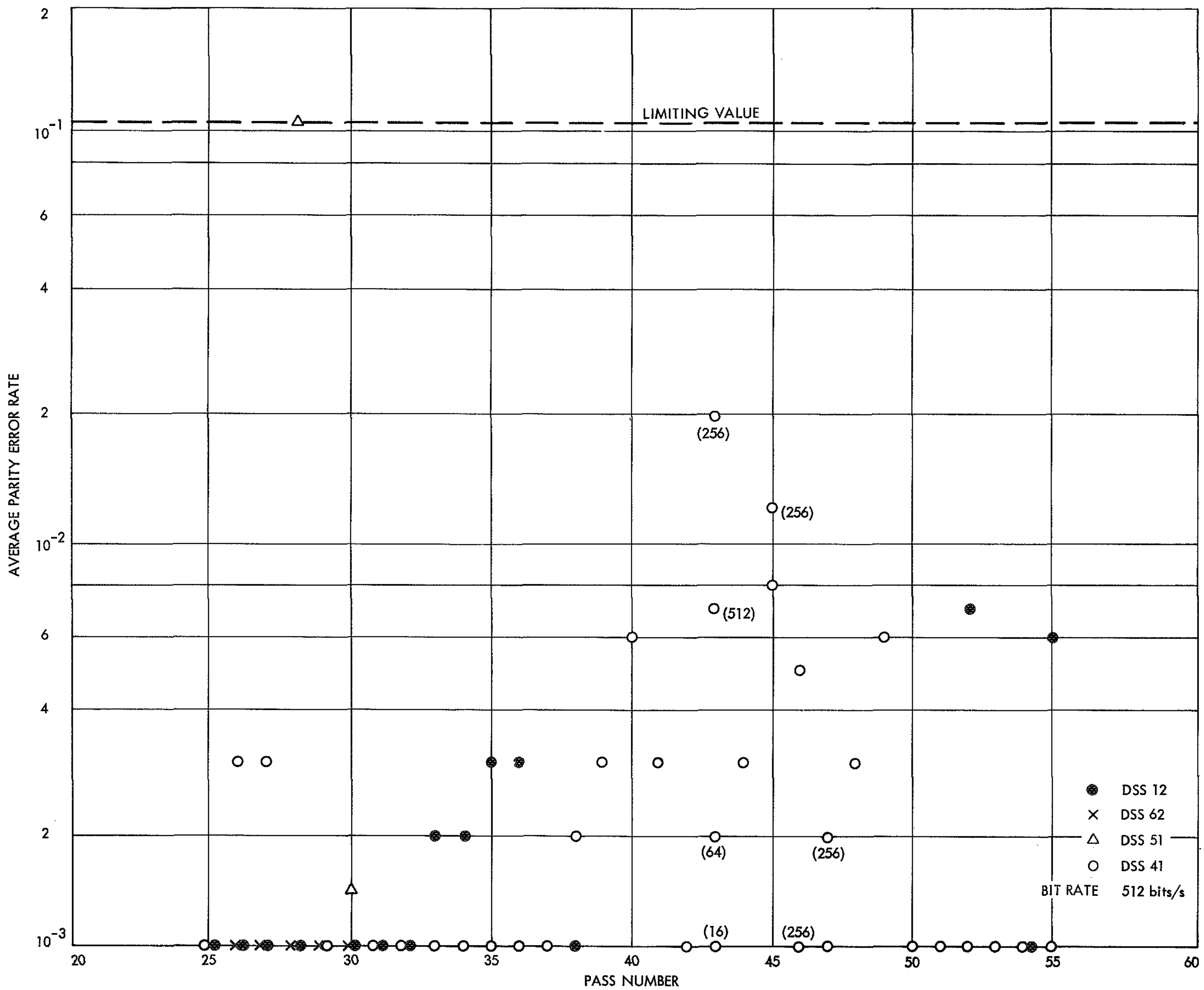


Fig. 30. PER (512 bits/s) vs pass number (December 1968) (passes 24 through 55)

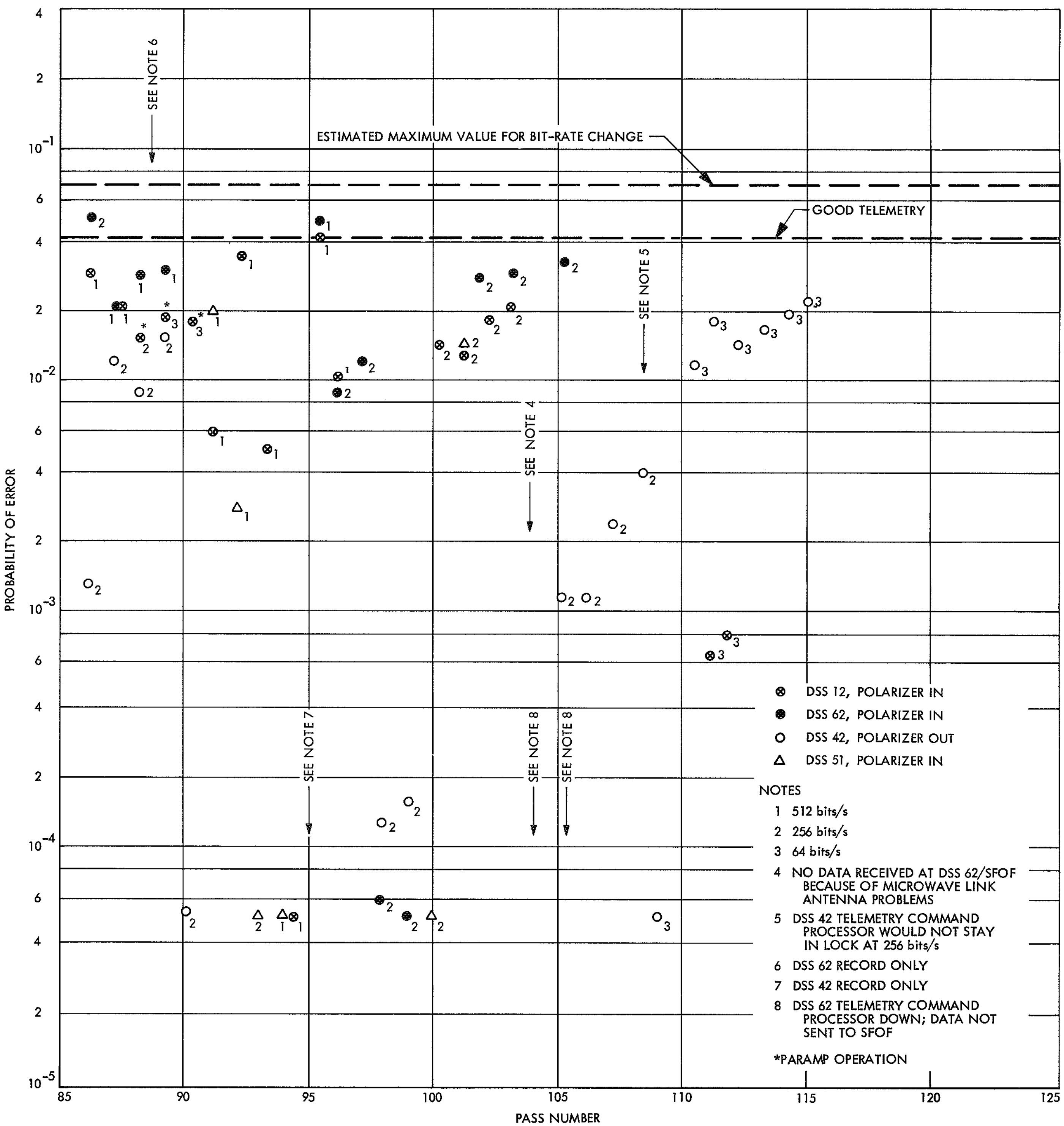


Fig. 31. Decoding of bit-error rate vs pass number (February 1969) (passes 86 through 114)

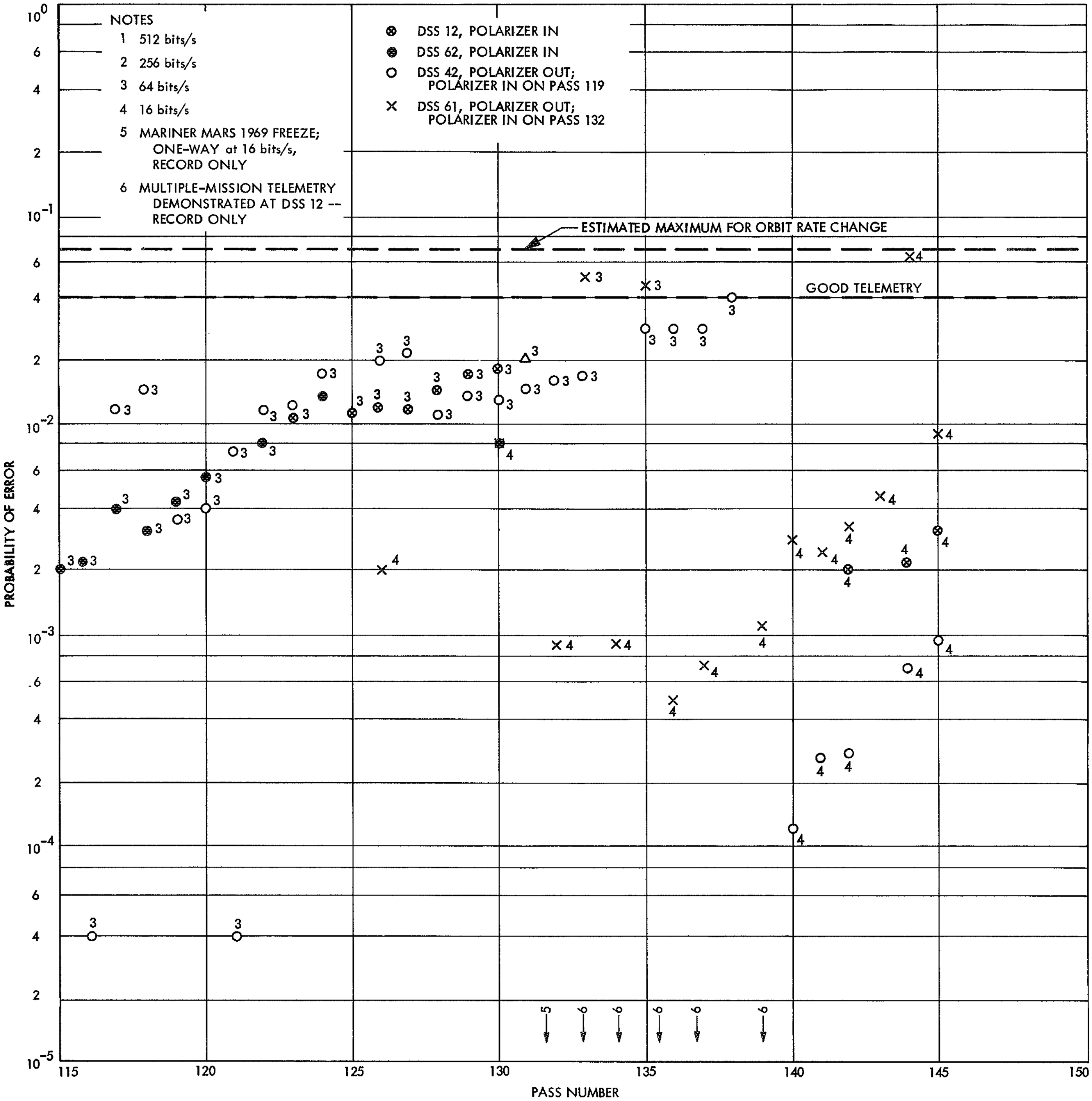


Fig. 32. Decoding of bit-error rate vs pass number (March 1969) (passes 114 through 145)

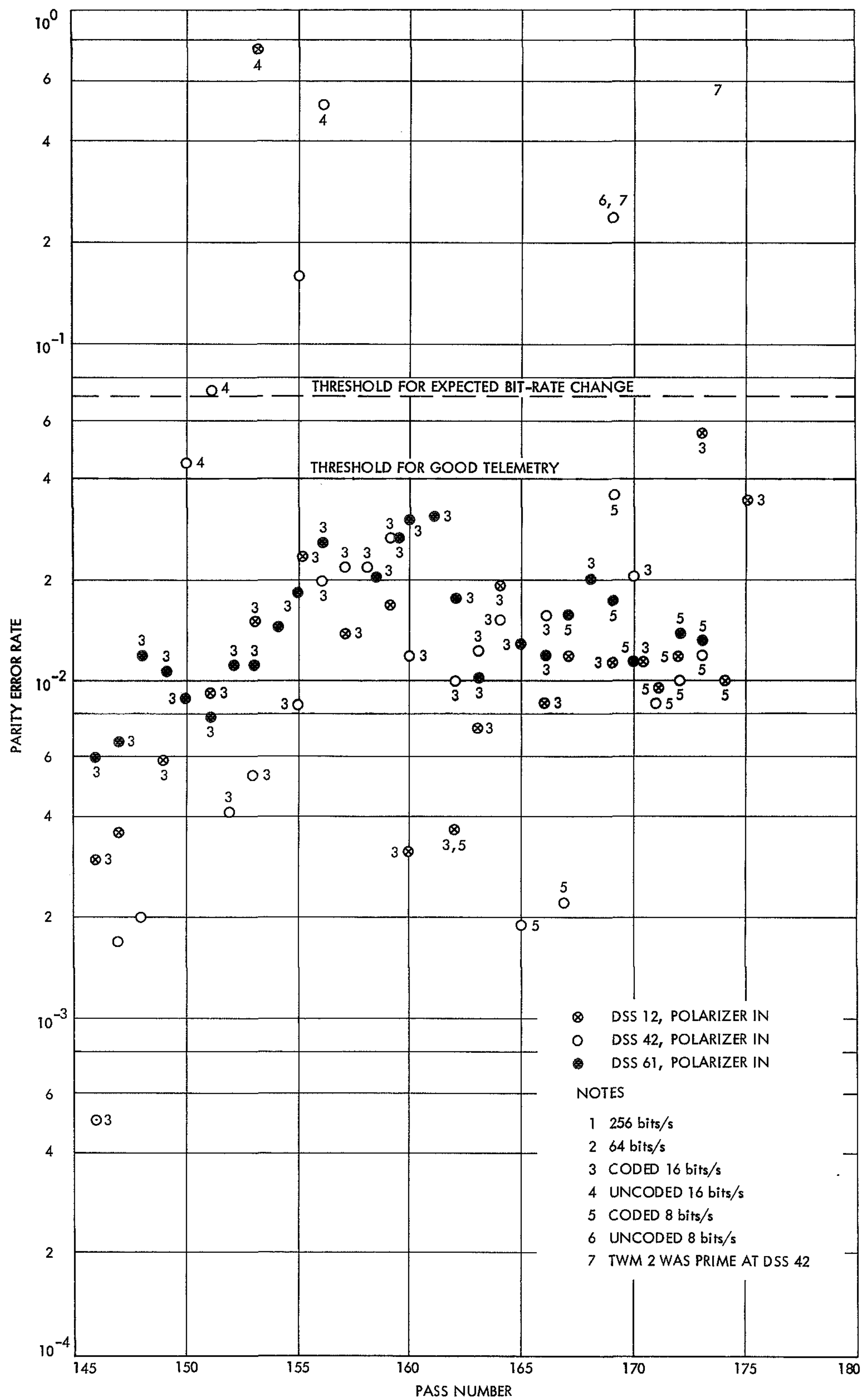


Fig. 33. PER vs pass number (April 1969) (passes 145 through 175)

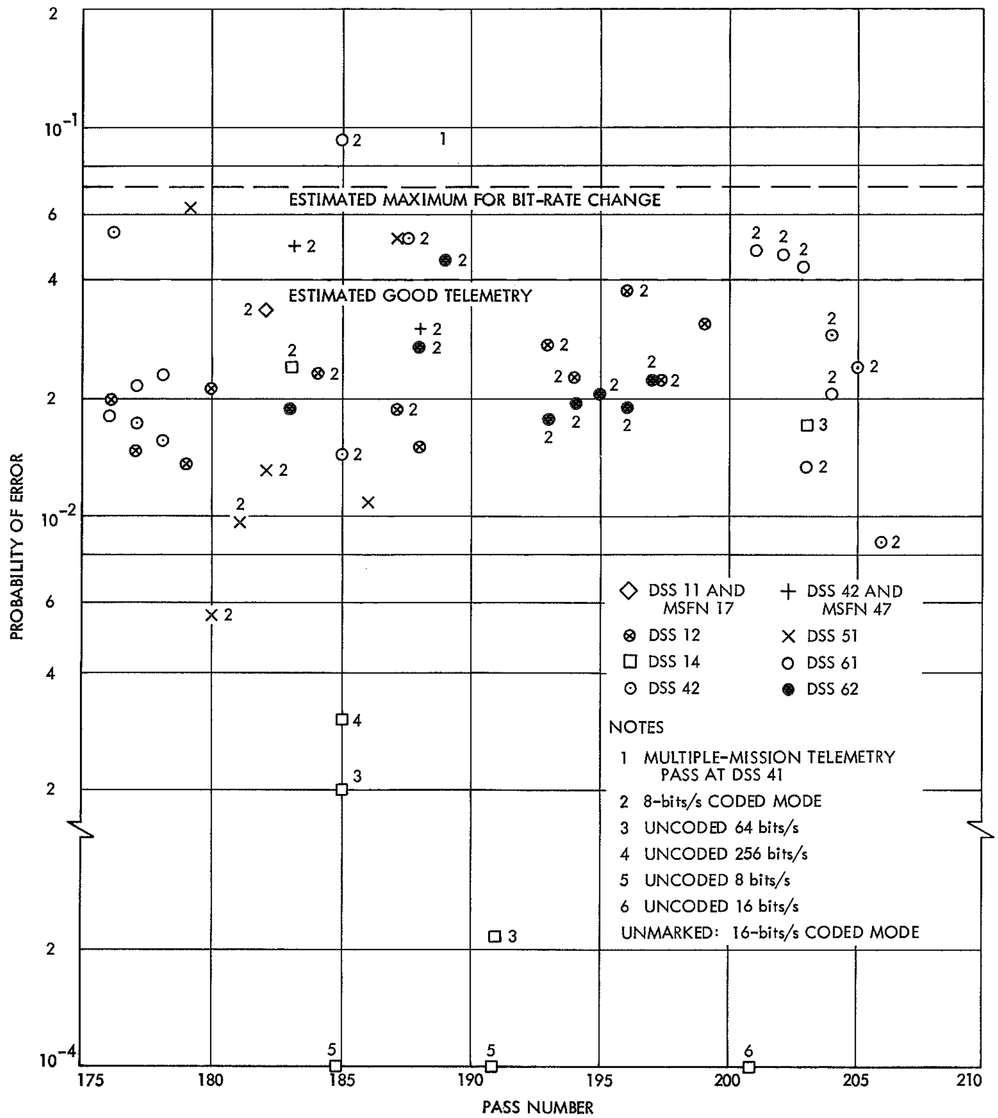


Fig. 34. PER vs pass number (May 1969) (passes 175 through 206)

3. ***Receiver signal strength.*** The down-link signal strength values are plotted in Figs. 35 and 36 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 determine the accuracy of the predictions. The signal strength values presented after the partial Type II orientation at DSS 12 on pass 2 indicated an approximate 5-dBmW improvement. Also, after pass 4, DSS 62 indicated an average signal strength slightly below that predicted. Deep Space Station 12 indicated an improved signal strength starting on pass 15, but returned to the normal trend on pass 18. The possible types of precalibration countdowns used were investigated.

Deep Space Station 12 values are slightly above the predicted curve in most cases; DSSs 41 and 62 are close to 2 dBmW below prediction. (See Fig. 36.) Since there was an approximate 2-dB difference between the maser and the paramp, DSS 41 changed reported paramp signal strengths by 2 dBmW on passes 42 and 43. On pass 47, DSS 62 found a loose connector in the cable wrap-up portion of the antenna, which accounted for a 2-dBmW better signal strength.

The engineering data processed by the telemetry command processor have an assigned up-link value of −153 dBmW for one-way track. The assigned up-link value of −153 dBmW is of no consequence and therefore is not listed for one-way passes.

B. Frequency and Prediction

Plots of the measured auxiliary oscillator and the best-lock frequencies (channels 6 and 7) are illustrated in Figs. 37–59 for the purpose of evaluating predictions supplied by the Project at the ARC. The predicted curve is superimposed over the actual frequency data so that an adjustment can be made when the actual data differ significantly with predictions.

The acceptable tolerance is 1000 Hz. After a study by the *Pioneer* Project, a new prediction curve was made for the auxiliary oscillator for April 1969 because the predictions differed substantially from the actual values in January, February, and March 1969.

A lack of early data resulted when there were few acquisitions performed by the Deep Space Stations. With the spacecraft maintained in the two-way lock, transfers between the Deep Space Stations were accomplished. No data points were available in those cases. Table 28 presents the variations of frequency from the prediction for November through June 1969.

C. Fitterate Program

1. Explanation. The fitterate program is an SDS 930 computer program which processes tracking data handling (TDH) subsystem data in posttrack time for purposes of quality analysis. For an interval of legal (correct, not garbled or distorted) printed doppler data with a constant sample interval, 1-s doppler frequencies are calculated and fitted by a least-square technique (with a polynomial of the degree n, where n may range from 1 to 9). Residual differences between the actual data and the curve of the least-squares polynomial are calculated, then the standard deviation about the curve is calculated. All residuals are tested to see whether they exceed 3.5σ; if they do, the corresponding points are discarded and a new curve fitted to the remaining data. This process is repeated until all residuals for the last curve pass a 3.5σ test. Where data for one pass need to be processed in multiple intervals, a composite σ is calculated according to the weighted rss formula:

$$\sigma_{\text{comp}} = \left(\frac{\sum_{i=1}^{n} a_i \sigma_i^2}{\sum_{i=1}^{n} a_i} \right)^{1/2}$$

where

a_i = number of points in i interval

σ_i = standard deviation for the final curve for the ith interval

n = number of intervals for the pass

2. Fitterate analysis. A list of the fitterate runs made during the period of this report (the fitterate was not employed in May and June 1969) is presented in Table 29. The fitterate runs were made to determine a value in which to adjust the pseudo-residual data.

The table is broken down by sample rate and month. Columns are provided for the station number, the pass number, the day of the current year, the time interval over which the doppler points were received, the actual number of points processed, the number rejected on 3.5σ (σ = standard deviation), the rejection criterion, the number rejected, and the noise computed by the fitterate for the given run. The doppler noise data appeared normal.

The fitterate program report for January 1969 notes that the interim monitor program tapes (data input sources for fitterate analysis) from DSS 12 were not received after pass 32 because of the phase 1 monitor checkout. This condition continued. An excessive number of input rejections on pass 57 at DSS 62, which were a result of data time outages, were also investigated. A check of the TDH tape received in the data package indicated there were no time outages present.

Table 28. Approximate variation of frequency from prediction

Period	Frequency, Hz		
	Auxiliary oscillator	Channel 6 best-lock	Channel 7 best-lock
Nov 1968	75	25	15
Dec 1968	25	35	15
Jan 1969	—[a]	25	25
Feb 1969	—[a]	25	25
Mar 1969	—[a]	25	25
Apr 1969	200–400[b]	No acquisition	25
May 1969	25	No acquisition	5–20[c]
Jun 1969	25	10	10–20[d]

Under study:

[a]Auxiliary frequency trend deviation from predicted value too great; offset by approximately 1000 Hz.

[b]Deviation from new predicted value made after study.

[c]Data lower than predicted frequency by approximately 5 to 20 Hz; more satisfactory curve approximately 10 Hz below indicated predicted curve.

[d]Data frequency within 10 Hz except for a few data points that lie within 20 Hz.

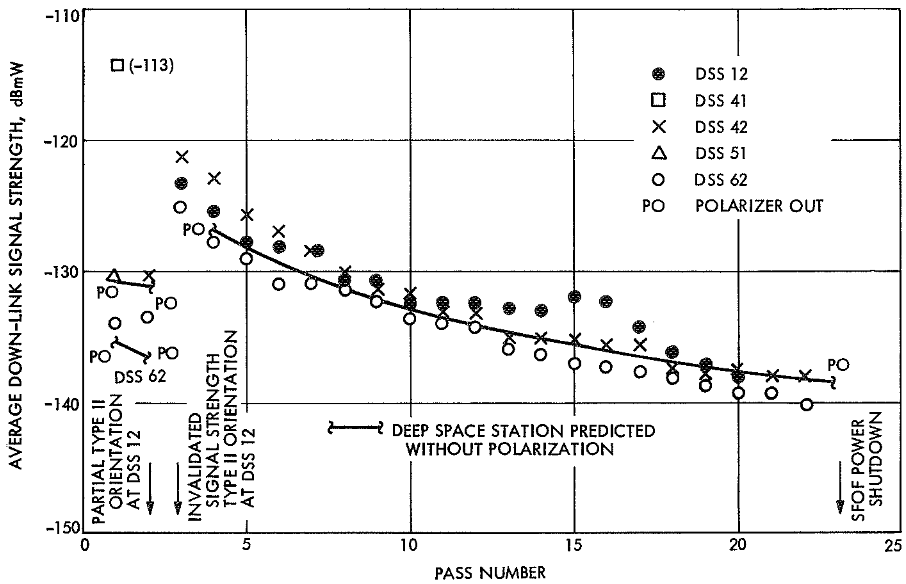


Fig. 35. Receiver down-link signal strength vs pass number (November 1968) (passes 1 through 23)

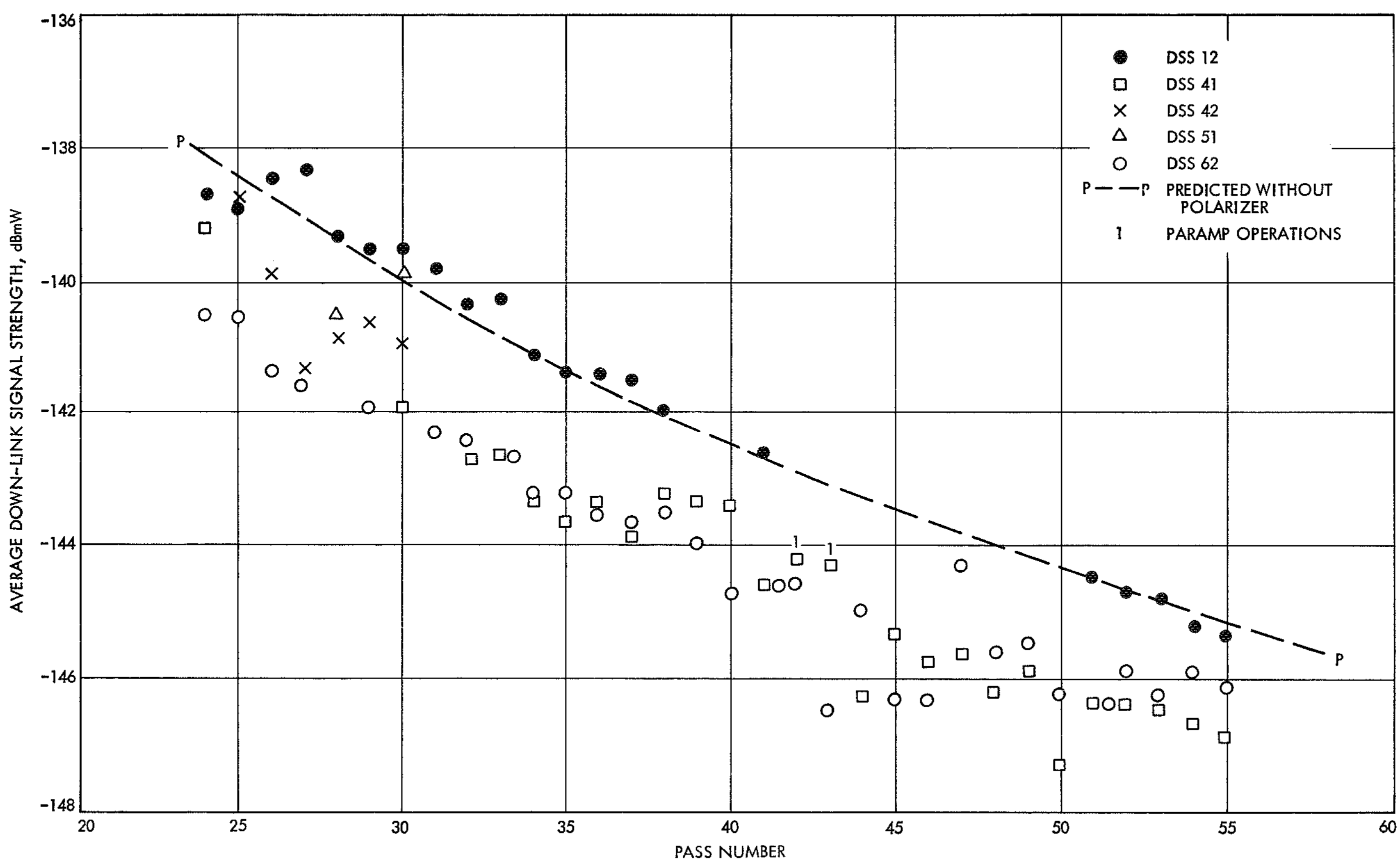


Fig. 36. Receiver down-link signal strength vs pass number (December 1968) (passes 24 through 55)

Table 29. Fitterate summaries by sample rate and month

Deep Space Station	Pass number	Day	Time (GMT)		Actual points	Points rejected		Noise σ, Hz
			From	To		3.5σ	Input	
November, 1-s sample rate								
63	04	316	1849:33	1901:27	714	0	0	0.103
42	18	330	0749:30	0801:31	714	0	5	0.053
42	26	338	0718:51	0729:59	669	0	0	0.061
November, 1-min sample rate								
42	03	315	0620:02	1418:02	475	4	0	0.002
42	04	316	0607:02	1412:02	485	1	0	0.003
62	06	318	2200:02	0248:02	173	1	44	0.003
42	07	319	0601:02	1417:02	471	2	22	0.002
42	13	325	0602:02	1410:02	485	1	0	0.004
42	19	331	0550:02	1205:02	369	1	4	0.003
12	23	335	2217:02	0419:02	291	0	17	0.004
42	29	341	0400:02	1150:02	463	0	6	0.004
December, 1-s sample rate								
62	39	351	1635:02	1647:13	724	2	1	0.005
December, 1-min sample rate								
12	25	337/338	2327:02	0234:02	137	2	35	0.004
42	25	337	0410:02	1159:02	454	0	12	0.004
62	33	345	1237:02	2006:02	418	3	5	0.004
62	39	351	1233:02	1634:02	240	1	0	0.003
62	54	366	1116:02	1819:02	—	2	0	0.004
January, 1-s sample rate								
62	65	11	1417:20	1429:16	717	0	2	0.045
January, 6-s sample rate								
62	80	26	0839:45	0909:39	285	0	3	0.0107
January, 1-min sample rate								
62	57	003	1043:02	1930:02	438	10	60[a]	0.0042
61	64	10	1101:02	1751:02	411	0	0	0.0044
62	65	11	1018:02	1415:02	230	8	0	0.0054
62	74	20	0916:02	1129:02	115	1	7	0.0066
42	80	26	0110:02	0828:02	432	0	0	0.0060
42	84	30	0008:02	0831:02	477	16	12[b]	0.0084
42	85	31	0026:02	0831:02	485	1	0	0.0065
February, 1-s sample rate								
62	102	048	1057:36	1109:45	725	1	4	0.0631
42	110	056	0018:05	0029:40	690	2	5	0.0961

[a]Time errors due to missing data points.
[b]Doppler field recycled to zero before full count at 0635:02.

Table 29 (contd)

Deep Space Station	Pass number	Day	Time (GMT) From	Time (GMT) To	Actual points	Points rejected 3.5σ	Points rejected Input	Noise σ, Hz
February, 1-min sample rate								
42	090	036	0002:02	0806:02	479	2	5	0.0060
62	096	042	0732:02	1227:02	291	3	2	0.0059
42	099	045	0113:02	0636:02	324	0	1	0.0058
62	099	045	0713:02	1432:02	435	5	0	0.0053
62	102	048	0730	1056	207	0	0	0.0062
62	103	049	0733:02	1408:02	375	17[c]	3	0.0044
62	105	051	0729:02	1528:02	466	7[c]	7	0.0054
42	106	051/052	2225	0621	467	6	3	0.0058
42	110	056	0034:02	0638:02	364	1	1	0.0056
42	111	056/057	2230	0645:02	489	2	5	0.0095
42	113	058/059	2214	0637	504	0	0	0.0056
March, 1-s sample rate								
42	117	62/3	2357:16	0009:01	703	3	0	0.087
62	124	70	0954:25	1006:01	696	1	0	0.0794
42	124	69	2347:00	2353:31	696	1	0	0.079
61	130	76	0954:25	1006:01	709	0	0	0.119 (Unexplained)
61	138	84	0930:54	0942:50	717	0	0	0.092
42	145	90	2309:55	2322:10	728	0	2	0.095
March, 1-min sample rate								
	117	62/3	1933	2355	263	0	0	0.0053
42	118	63/4	1929	0359	511	0	0	0.0069
	119	64/5	1932	0359	504	4	1	0.0049
	120	65/6	1931	0358	507	1	0	0.0049
61	126	72	0609	0824	131	0	3	0.0045
42	132	77/8	2206	0359	350	0	4	0.0053
	133	78/9	2206	0359	351	1	2	0.0054
	143	88/89	2207	0355	339	0	8	0.0094
	145	90/91	2324	0440	313	0	4	0.0059
April, 1-s sample rate								
42	152	97	2310:01	2315:09	309	0	0	0.121
	166	111/112	2255:11	2304:19	547	2	0	0.117
	173	118	2247:54	2300	718	7	0	0.130
61	151	97	0917:01	0928:39	691	4	3	0.115
	158	104	0910:26	0922:27	721	1	0	0.122
	172	118	0901:06	0912:54	636	10	1	0.154
April, 1-min sample rate								
42	147	92/93	2239	0442	357	1	5	0.007
	150	96/97	2318	0433				

[c]Under investigation by systems data analysis (SDA) group.

Table 29 (contd)

Deep Space Station	Pass number	Day	Time (GMT) From	Time (GMT) To	Actual points	Points rejected 3.5σ	Points rejected Input	Noise σ, Hz
April, 1-min sample rate (contd)								
42	157	103/104	2318	0454	289	4	17[d]	0.0089
	162	108	0013	0425	244	1	7	0.0077
	169	114/115	2254	0430	318	3	14	0.013
	170	115/116	2256	0430	307	2	25[e]	0.014
	172	117/118	2321	0429	299	0	10[d]	0.0187
	173	118/119	2302	0400	283	2	12[d]	0.014
61	147	93	0516	1159	293	9	31[e]	0.0051
	155	101	0849	1053	101	1	18[e]	0.005
	158	104	0519	0907	212	1	13[e]	0.0069
	162	108	0457	1104	320	1	41[e]	0.0107
	169	115	0706	1144	362	4	11[d]	0.011
	170	116	0616	1145	319	3	6[d]	0.011
	172	118	0548	0900	186	1	4	0.023

[d]Bad data condition codes due to receiver out-of-lock conditions.

[e]Missing data points due to Goldstone duplicate standard computer facilities tape packing problems at 800 bits/in.

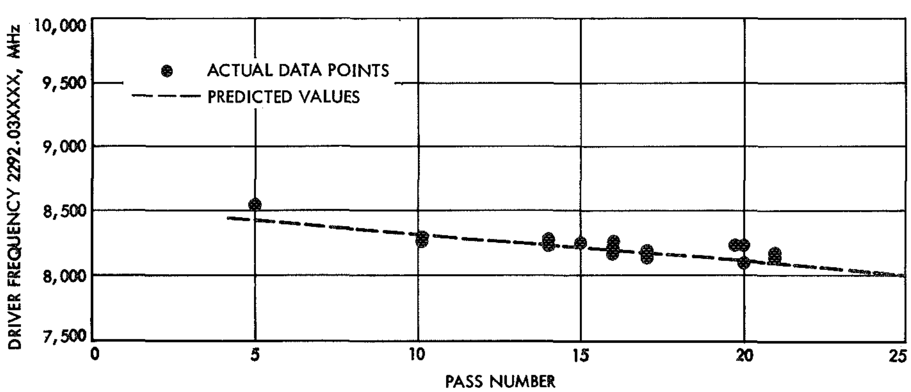


Fig. 37. Spacecraft auxiliary oscillator frequency vs pass number (November 1968) (passes 1 through 23)

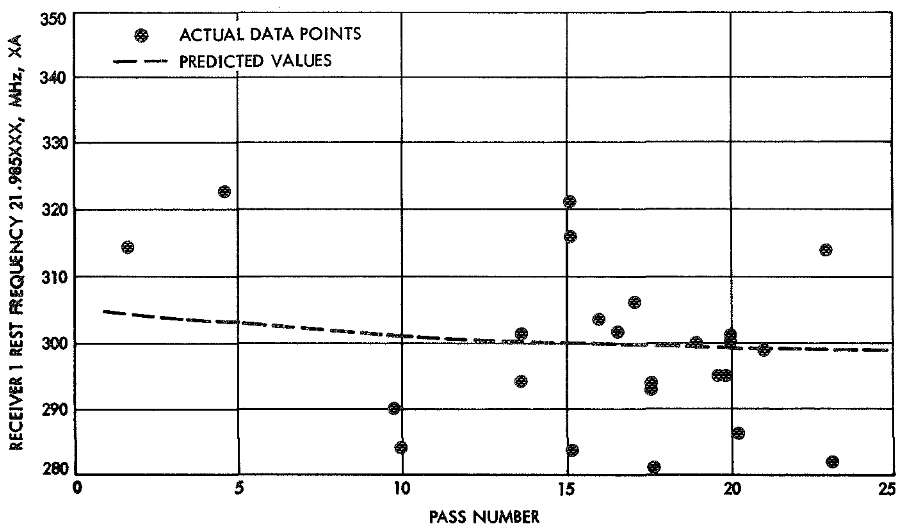


Fig. 38. Channel 6 best-lock frequency vs pass number (November 1968) (passes 1 through 23)

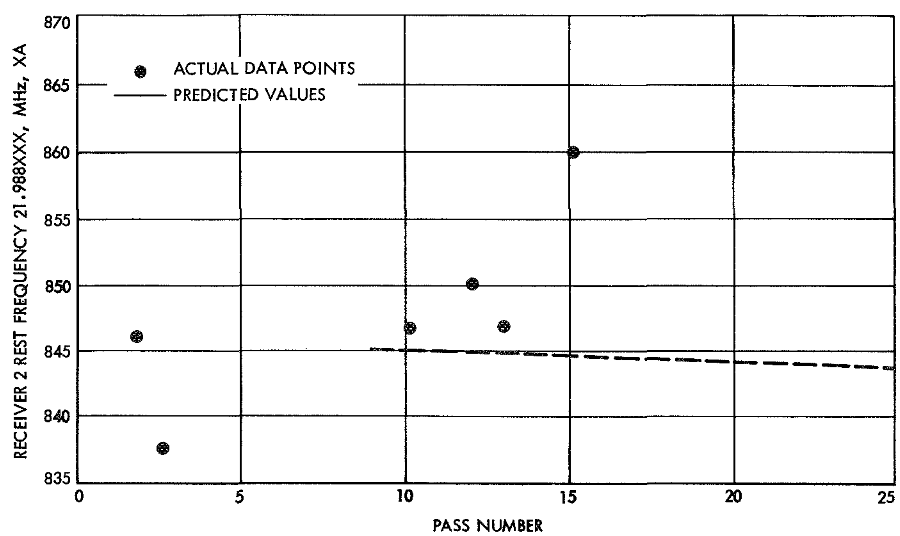


Fig. 39. Channel 7 best-lock frequency vs pass number (November 1968) (passes 1 through 23)

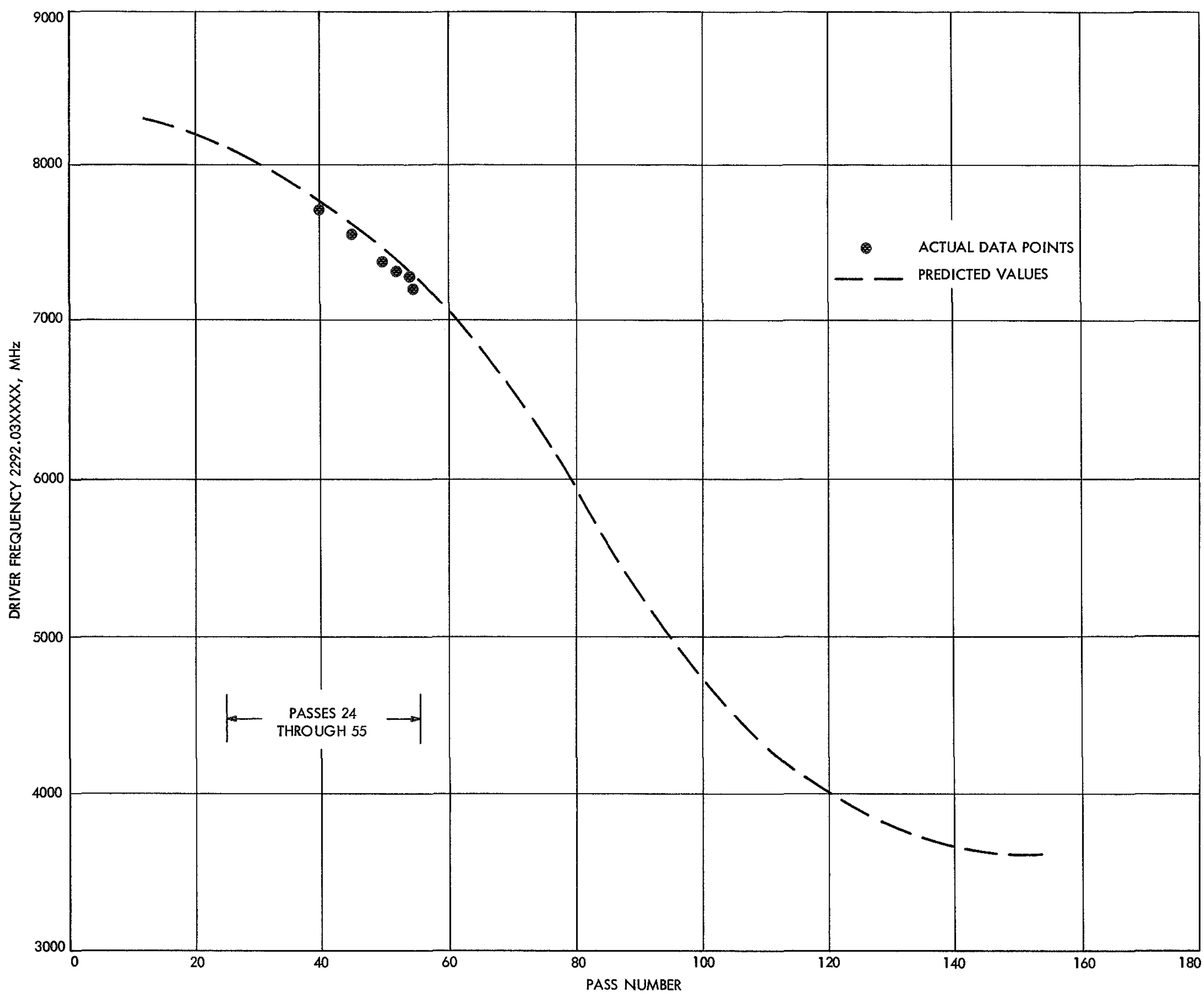


Fig. 40. Spacecraft auxiliary oscillator frequency vs pass number (December 1968) (passes 24 through 55)

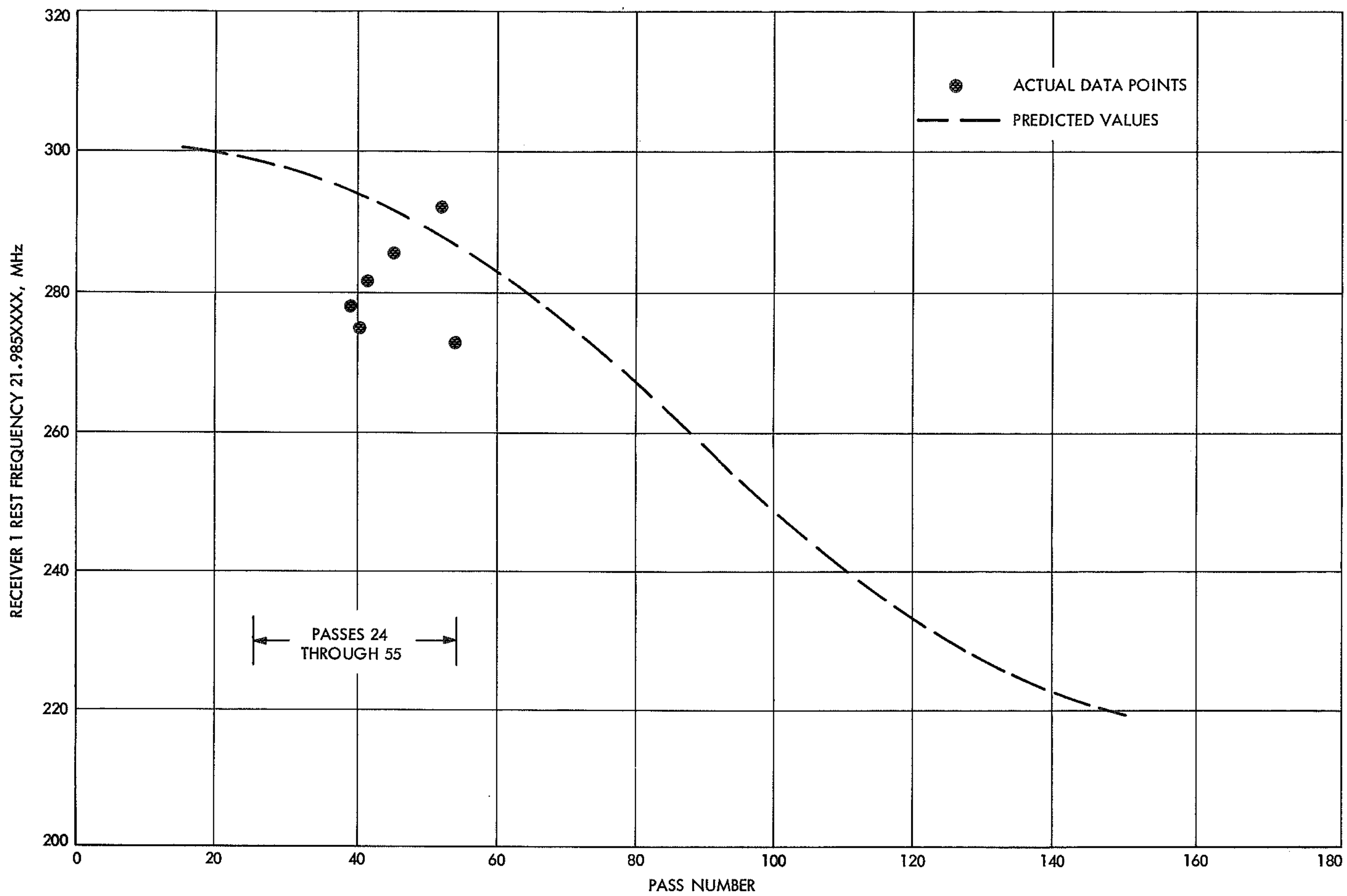


Fig. 41. Channel 6 best-lock frequency vs pass number (December 1968) (passes 24 through 55)

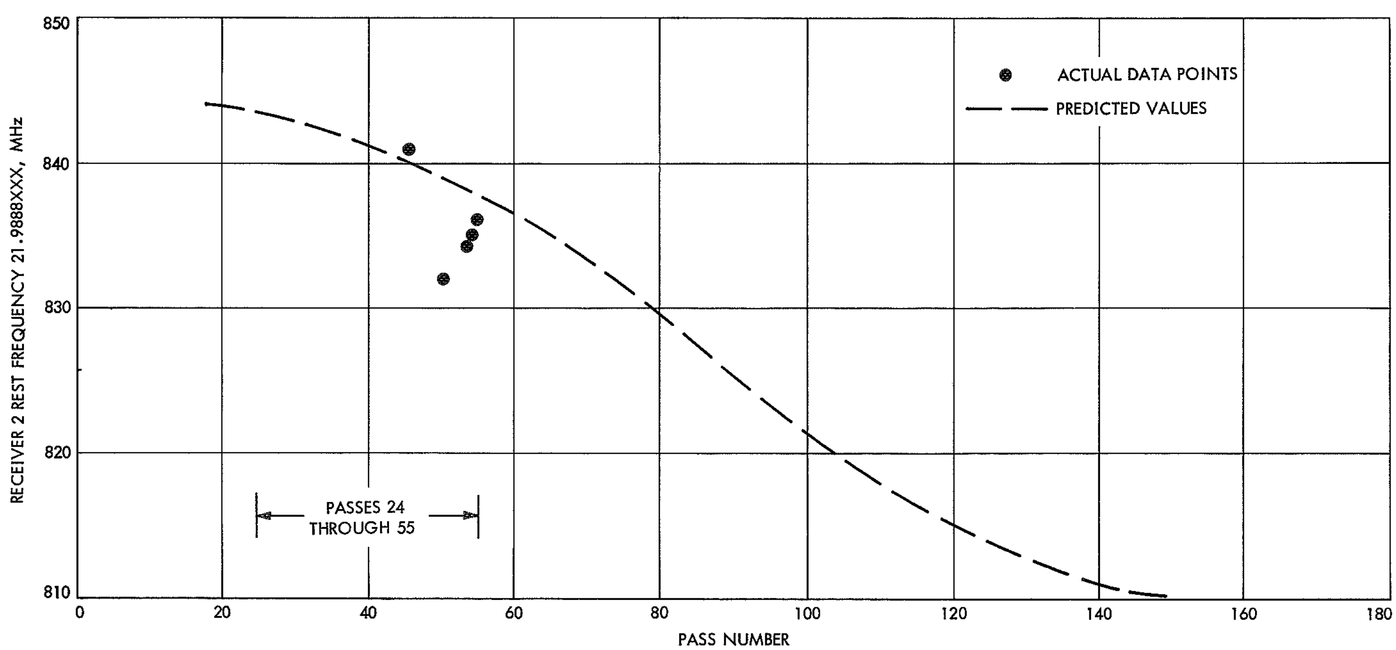


Fig. 42. Channel 7 best-lock frequency vs pass number (December 1968) (passes 24 through 55)

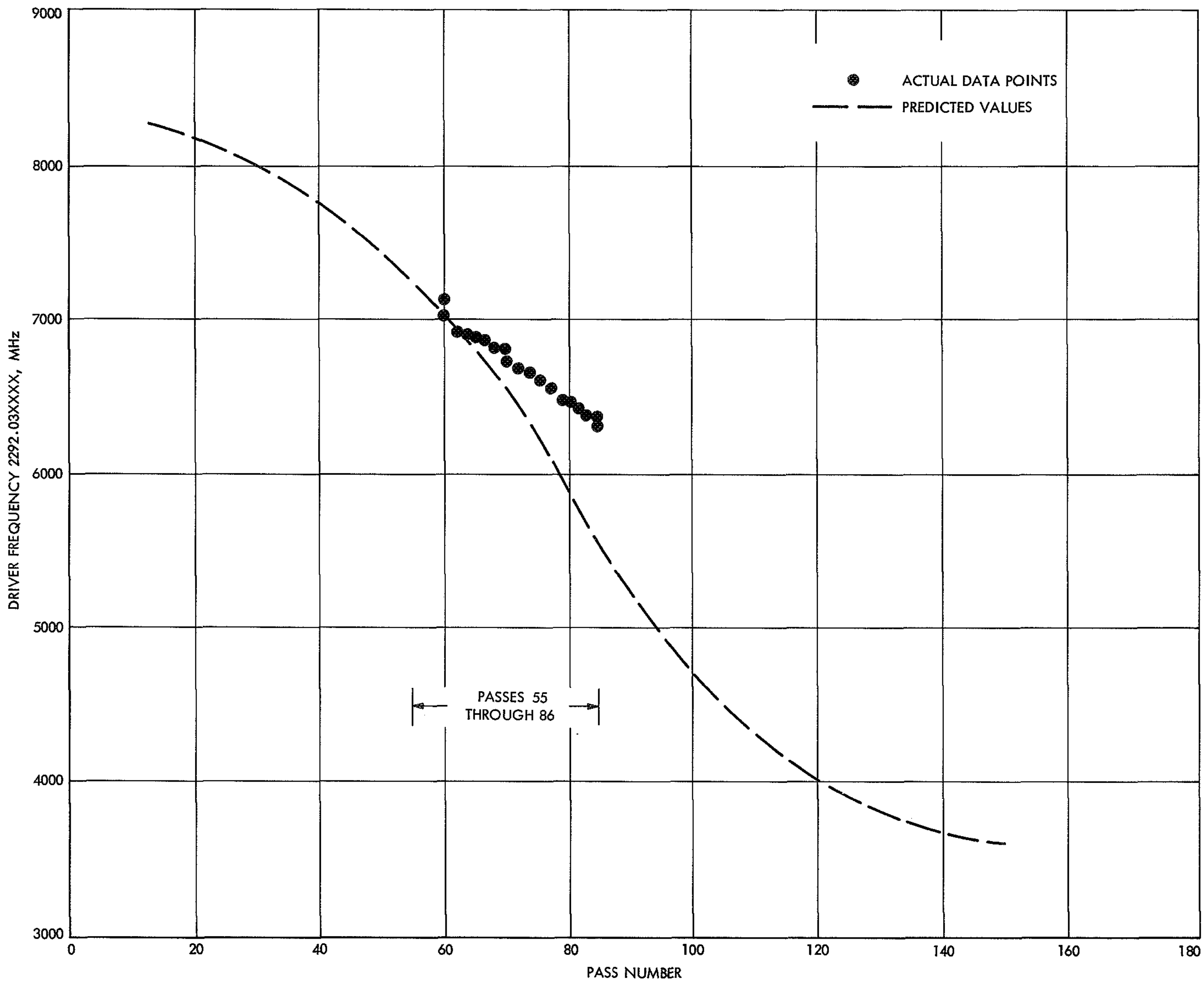


Fig. 43. Spacecraft auxiliary oscillator frequency vs pass number (January 1969) (passes 55 through 86)

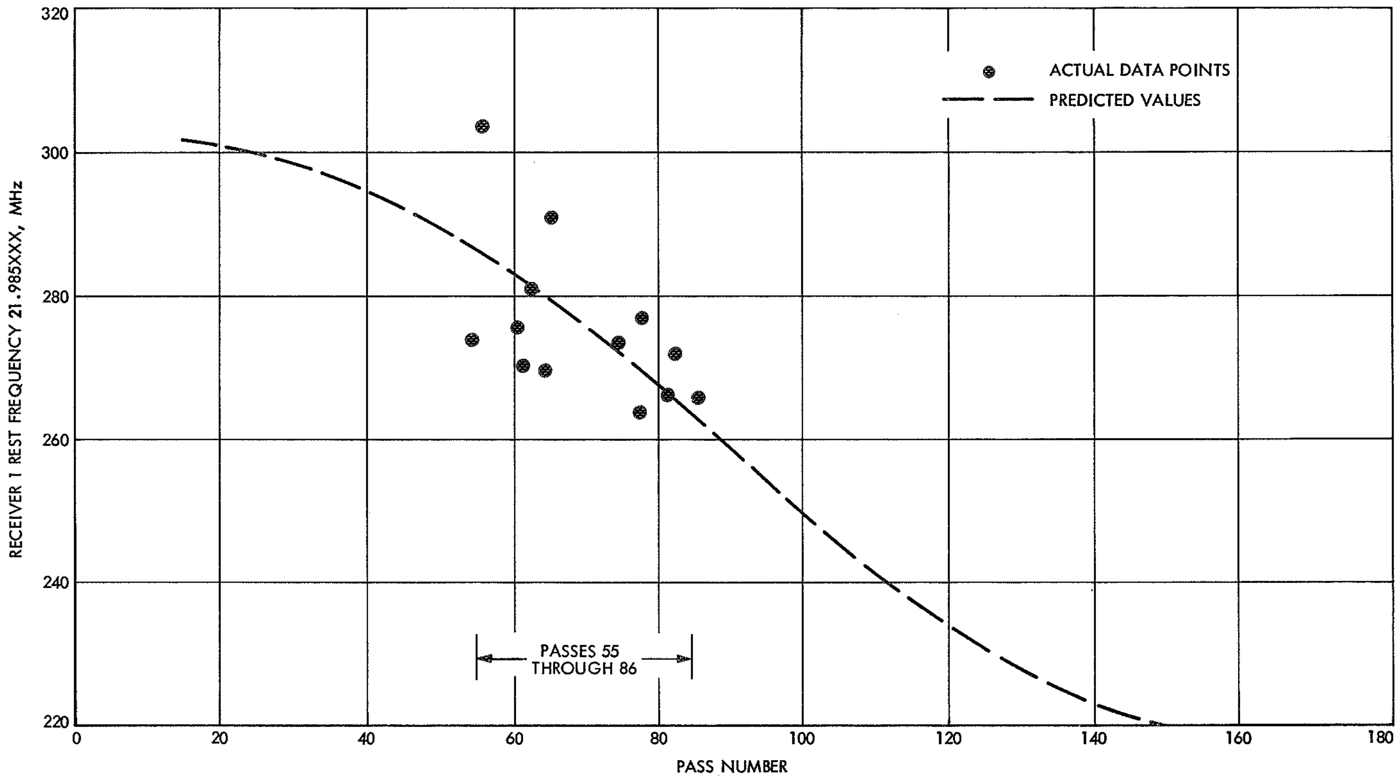


Fig. 44. Channel 6 best-lock frequency vs pass number (January 1969) (passes 55 through 86)

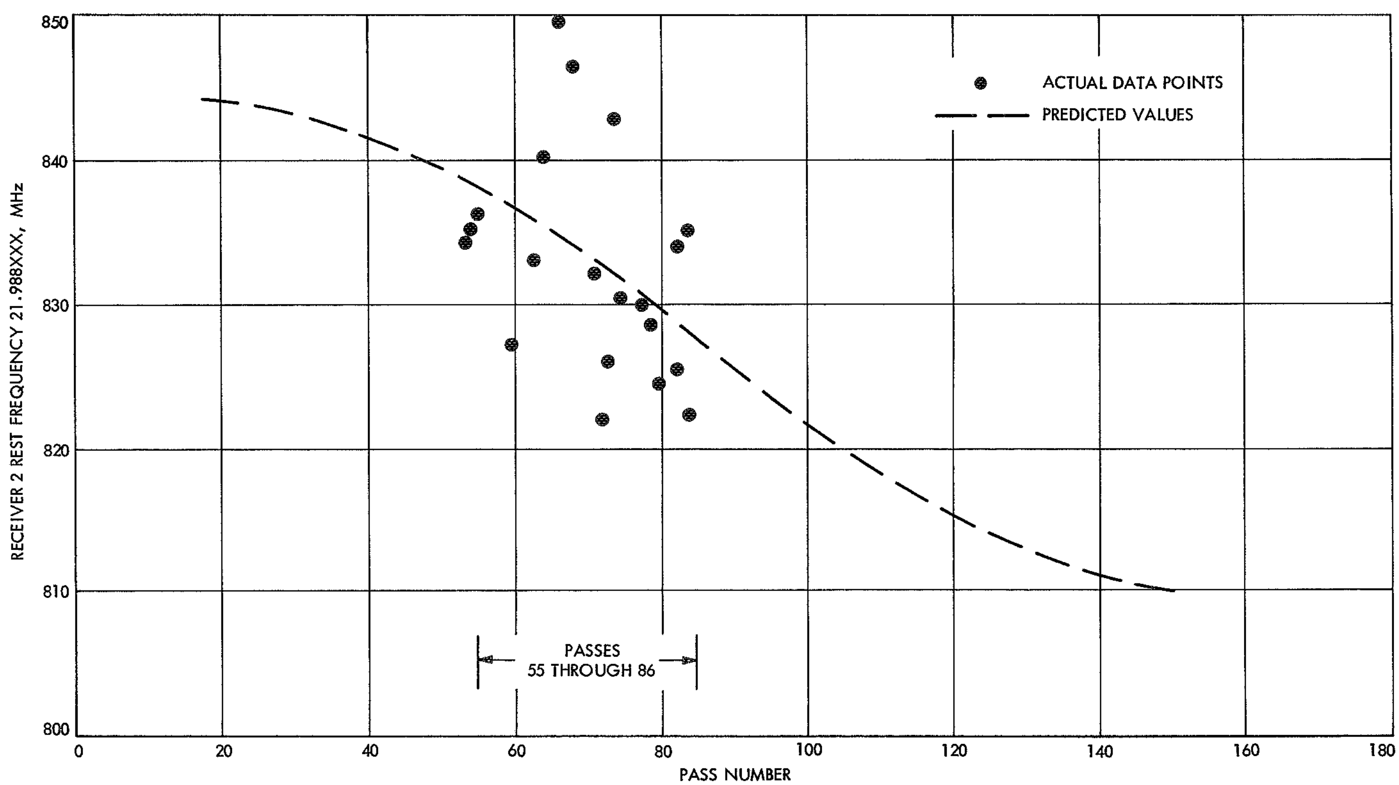


Fig. 45. Channel 7 best-lock frequency vs pass number (January 1969) (passes 55 through 86)

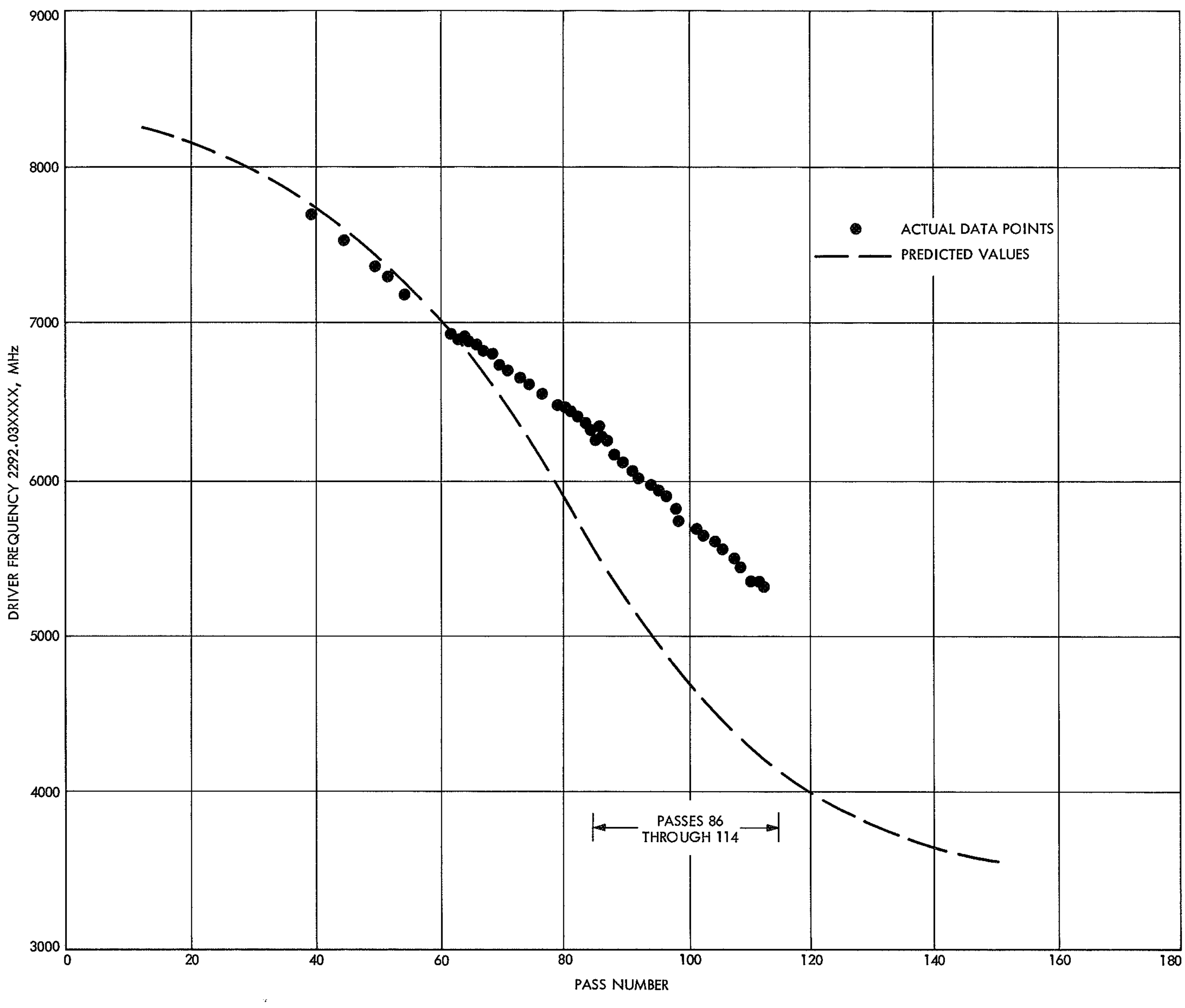


Fig. 46. Spacecraft auxiliary oscillator frequency vs pass number (February 1969) (passes 86 through 114)

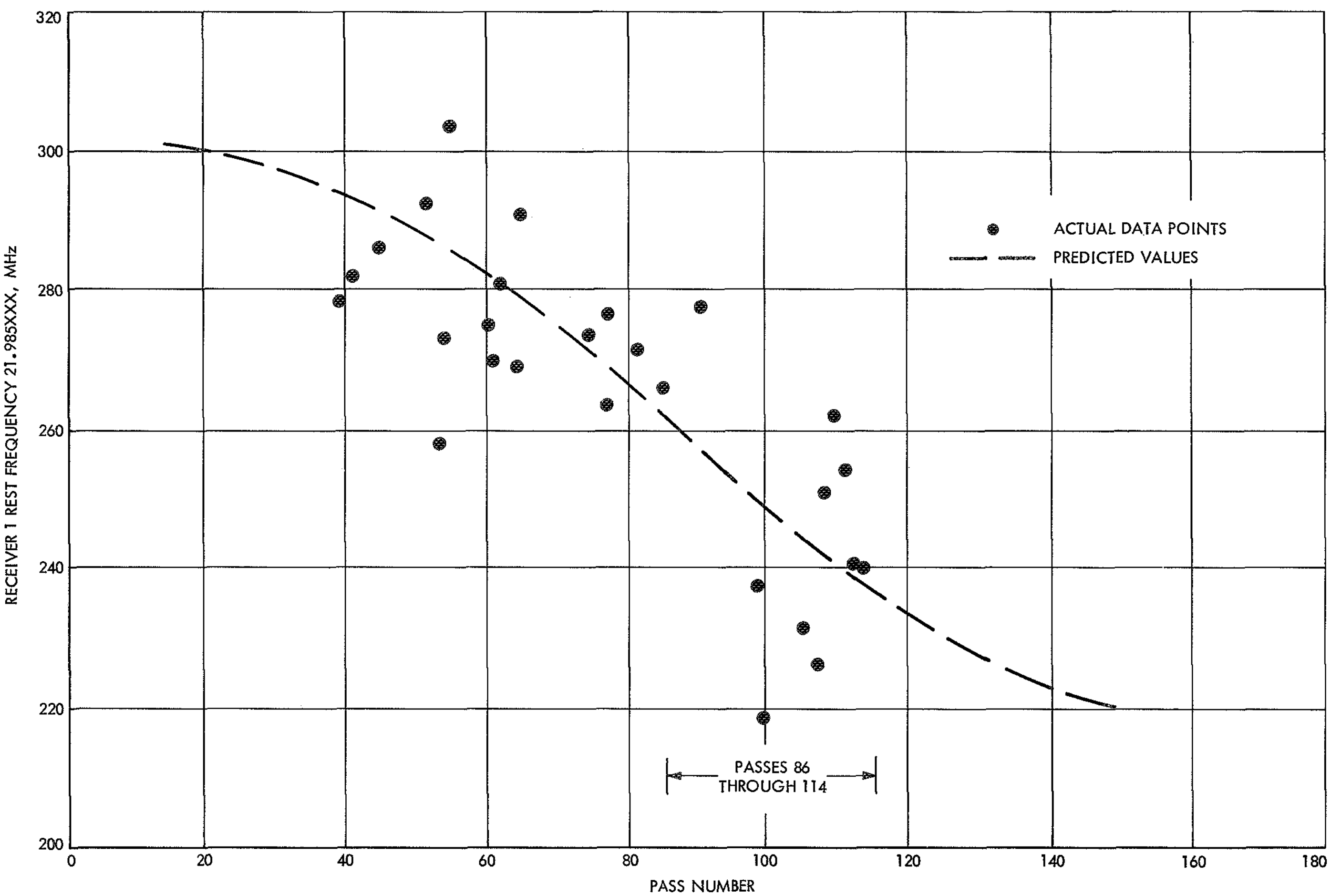


Fig. 47. Channel 6 best-lock frequency vs pass number (February 1969) (passes 86 through 114)

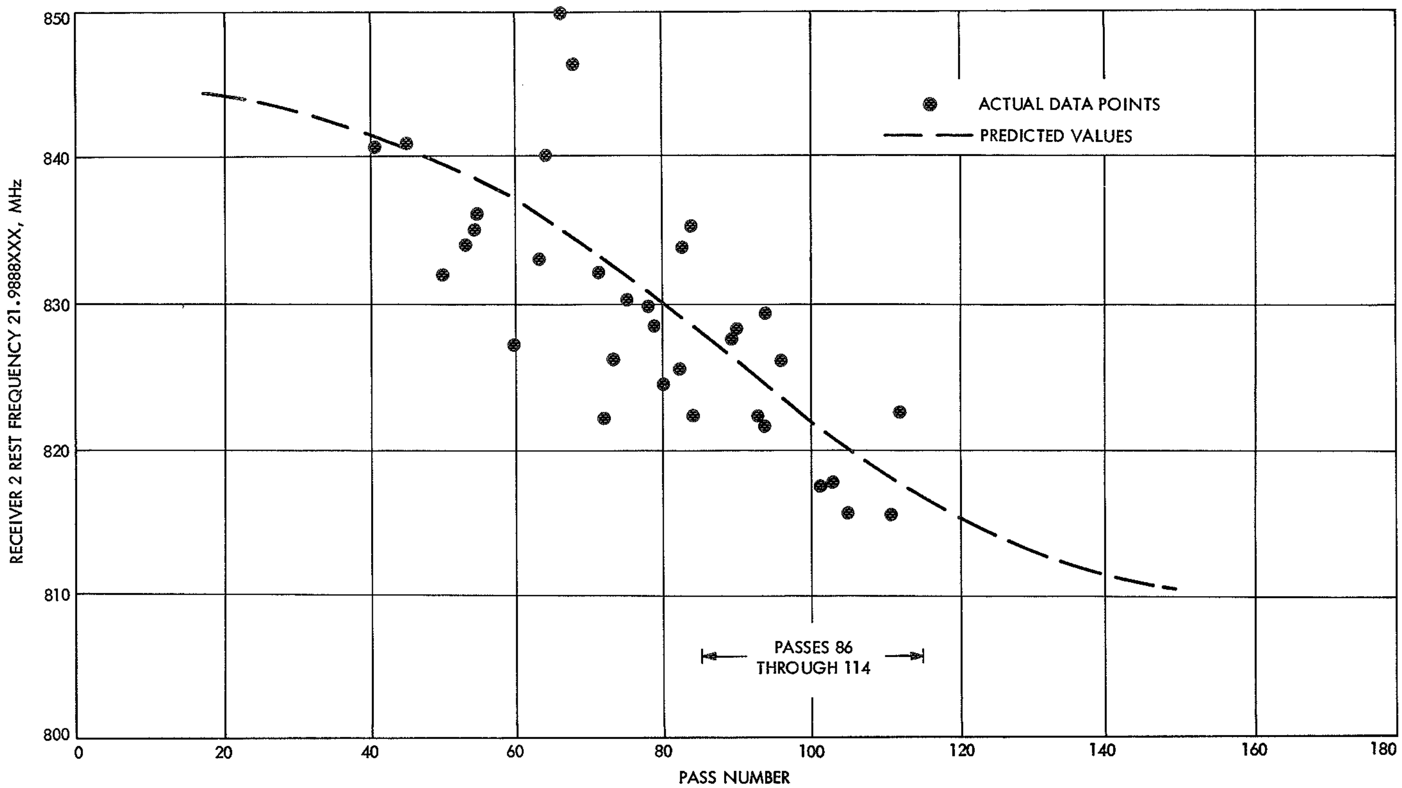


Fig. 48. Channel 7 best-lock frequency vs pass number (February 1969) (passes 86 through 114)

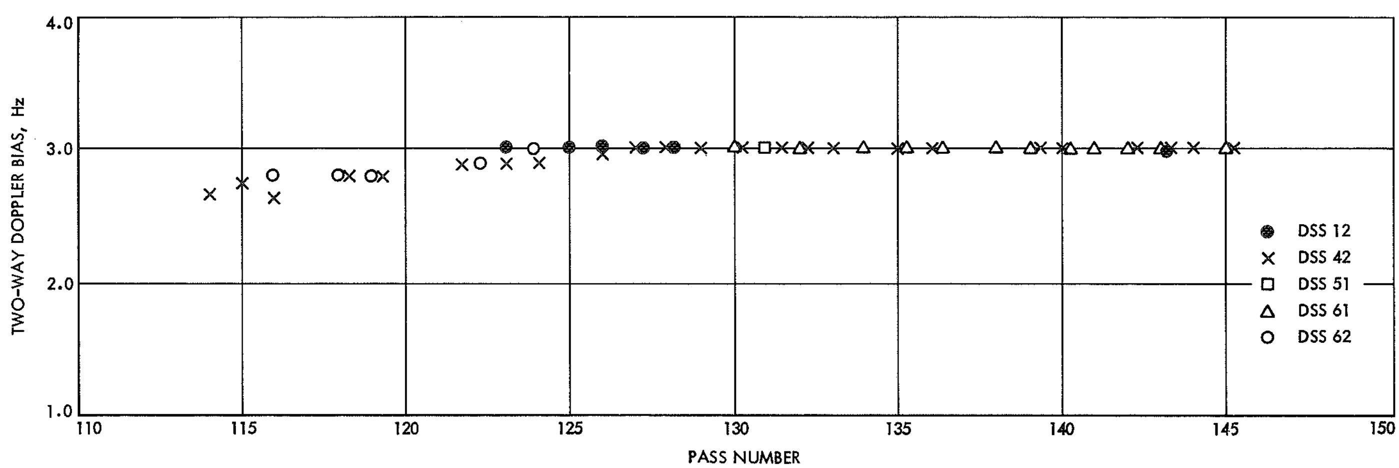


Fig. 49. Doppler bias trend vs pass number (March 1969) (passes 114 through 145)

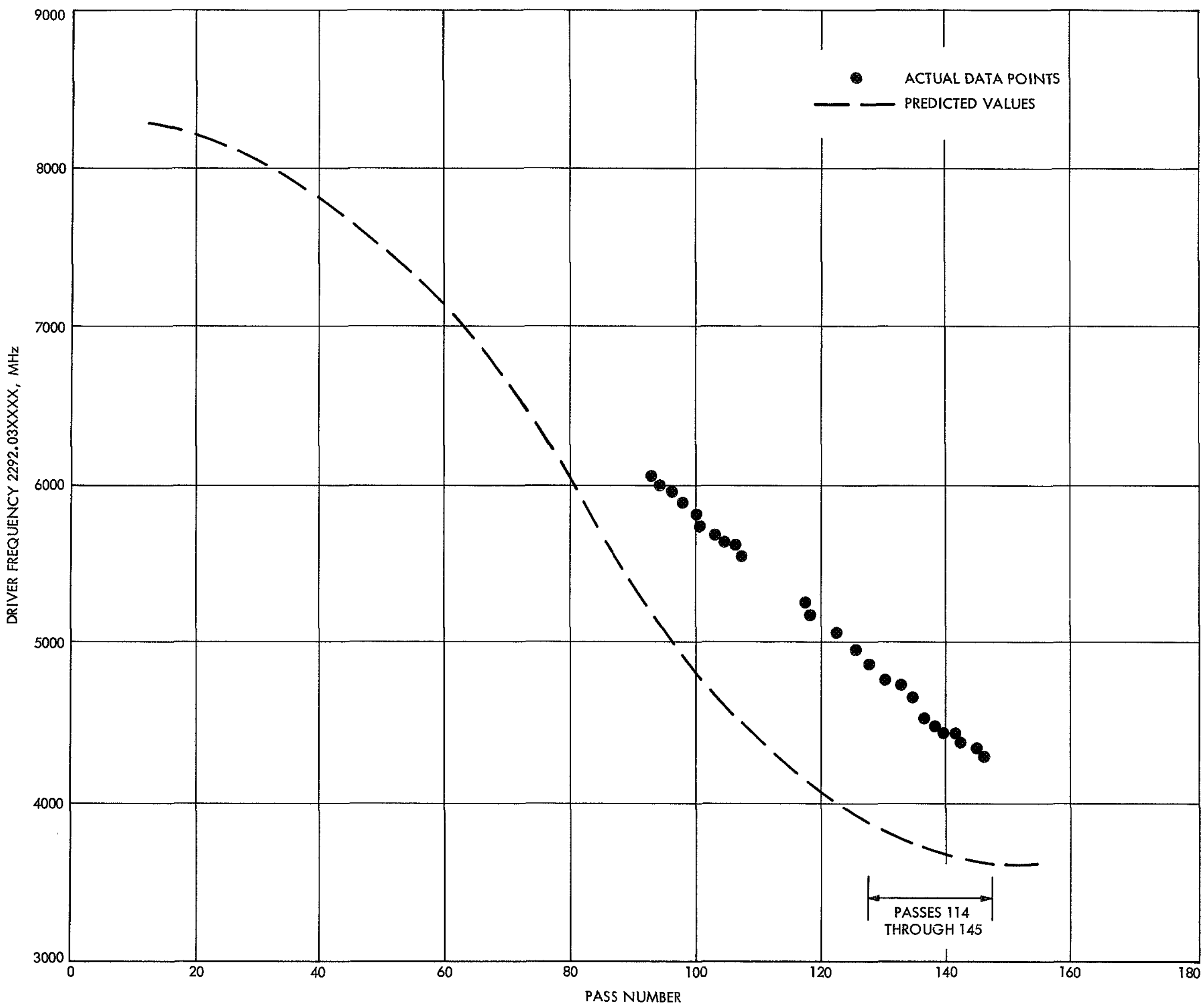


Fig. 50. Spacecraft auxiliary oscillator frequency vs pass number (March 1969) (passes 114 through 145)

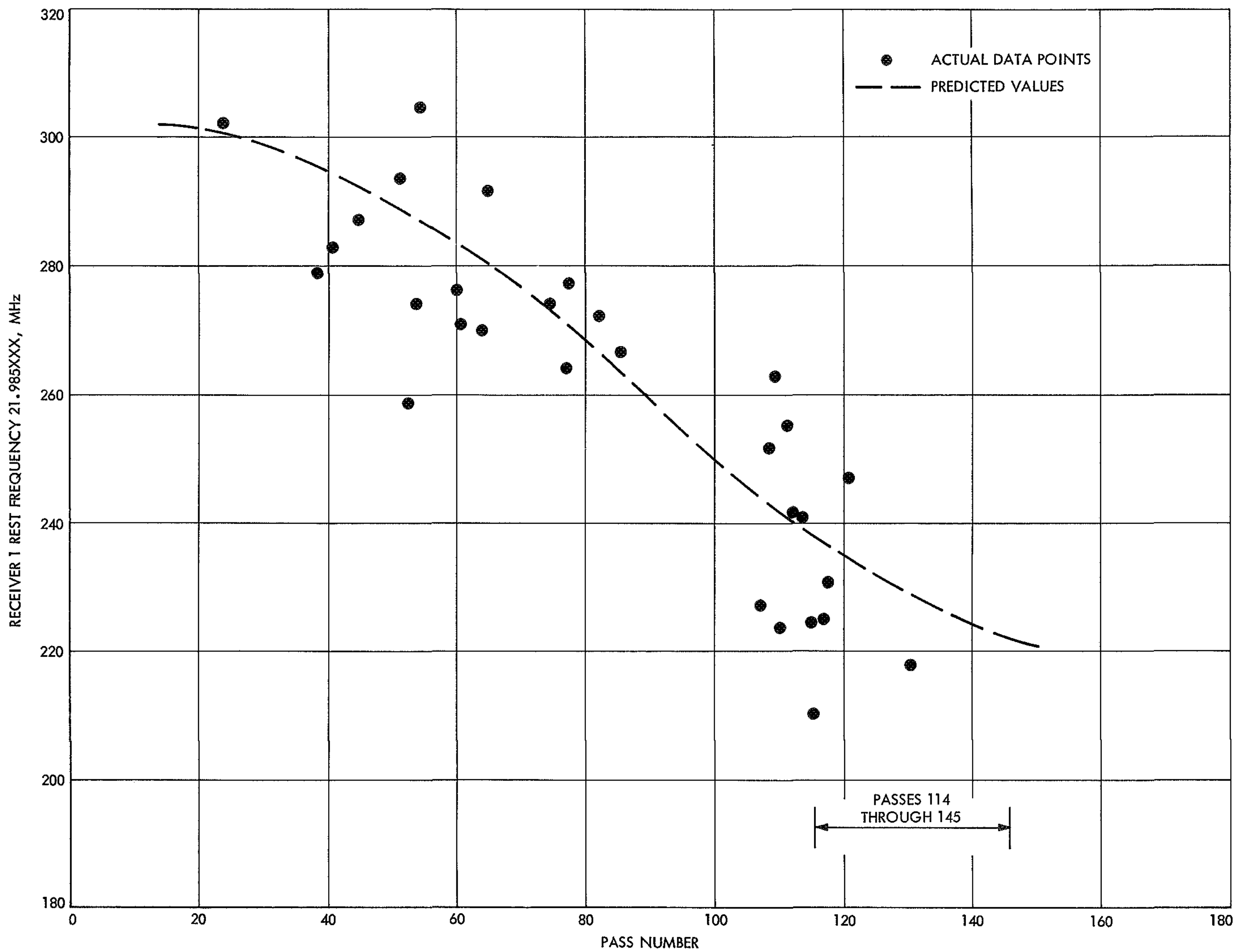


Fig. 51. Channel 6 best-lock frequency vs pass number (March 1969) (passes 114 through 145)

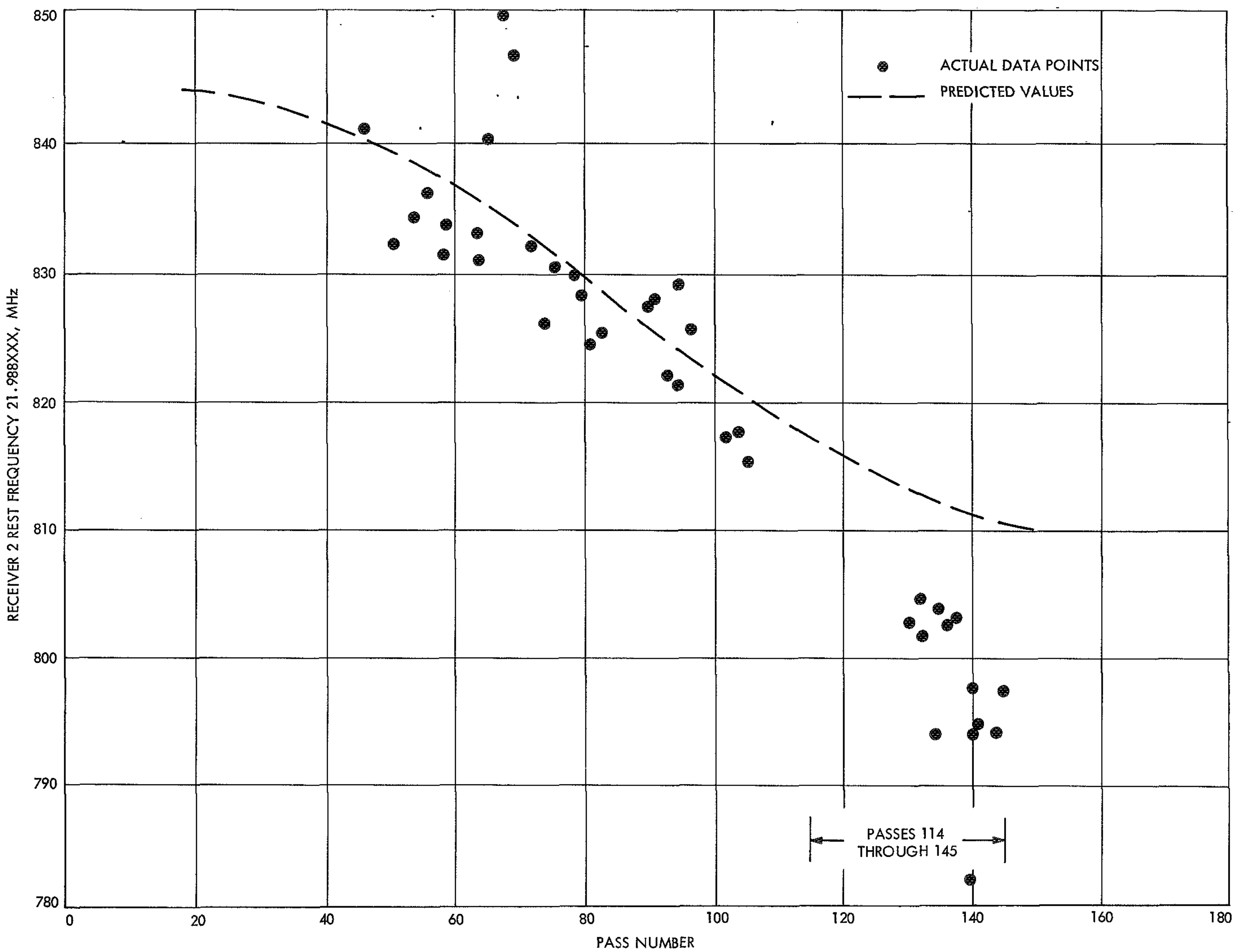


Fig. 52. Channel 7 best-lock frequency vs pass number (March 1969) (passes 114 through 145)

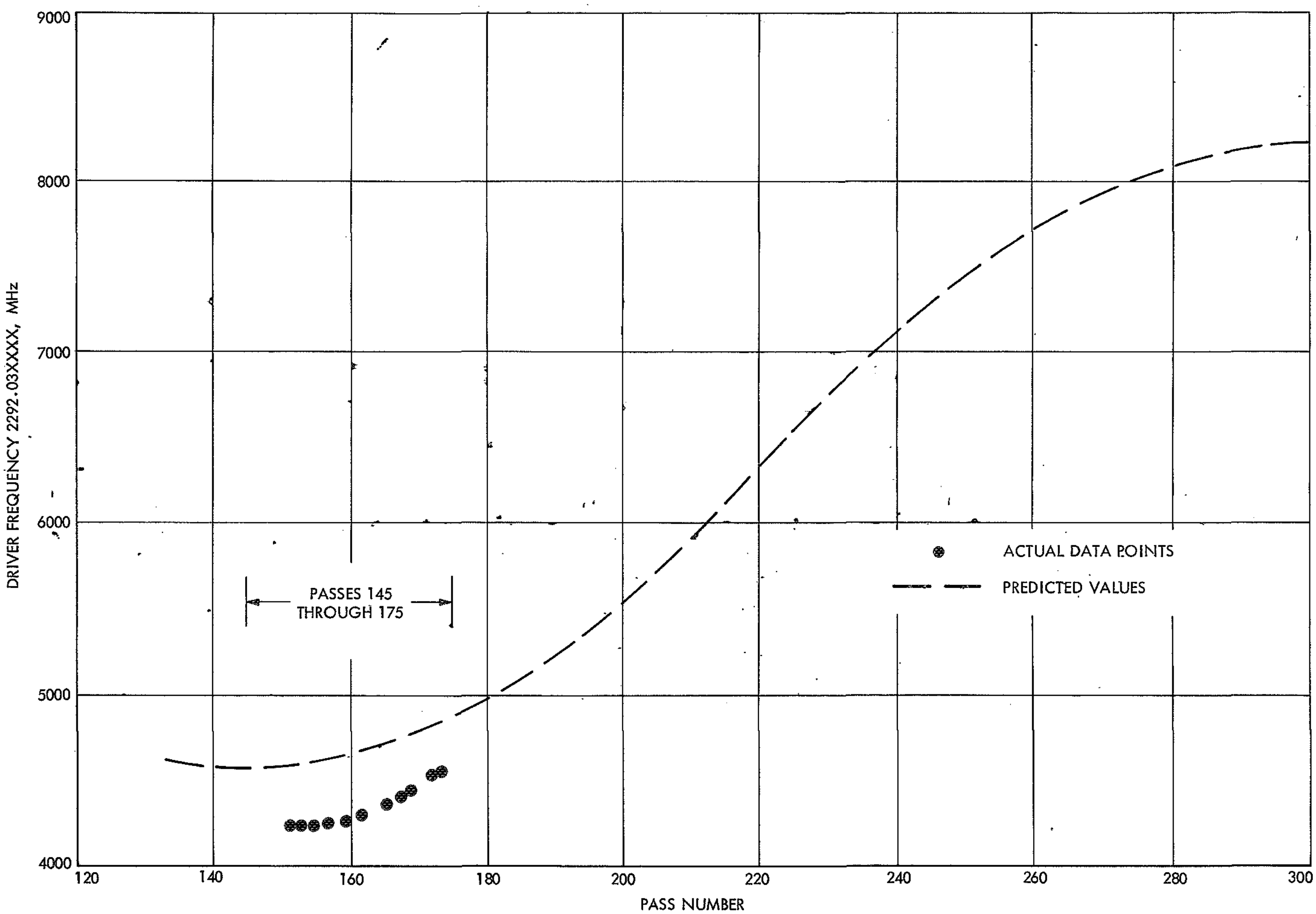


Fig. 53. Spacecraft auxiliary oscillator frequency vs pass number (April 1969) (passes 145 through 175)

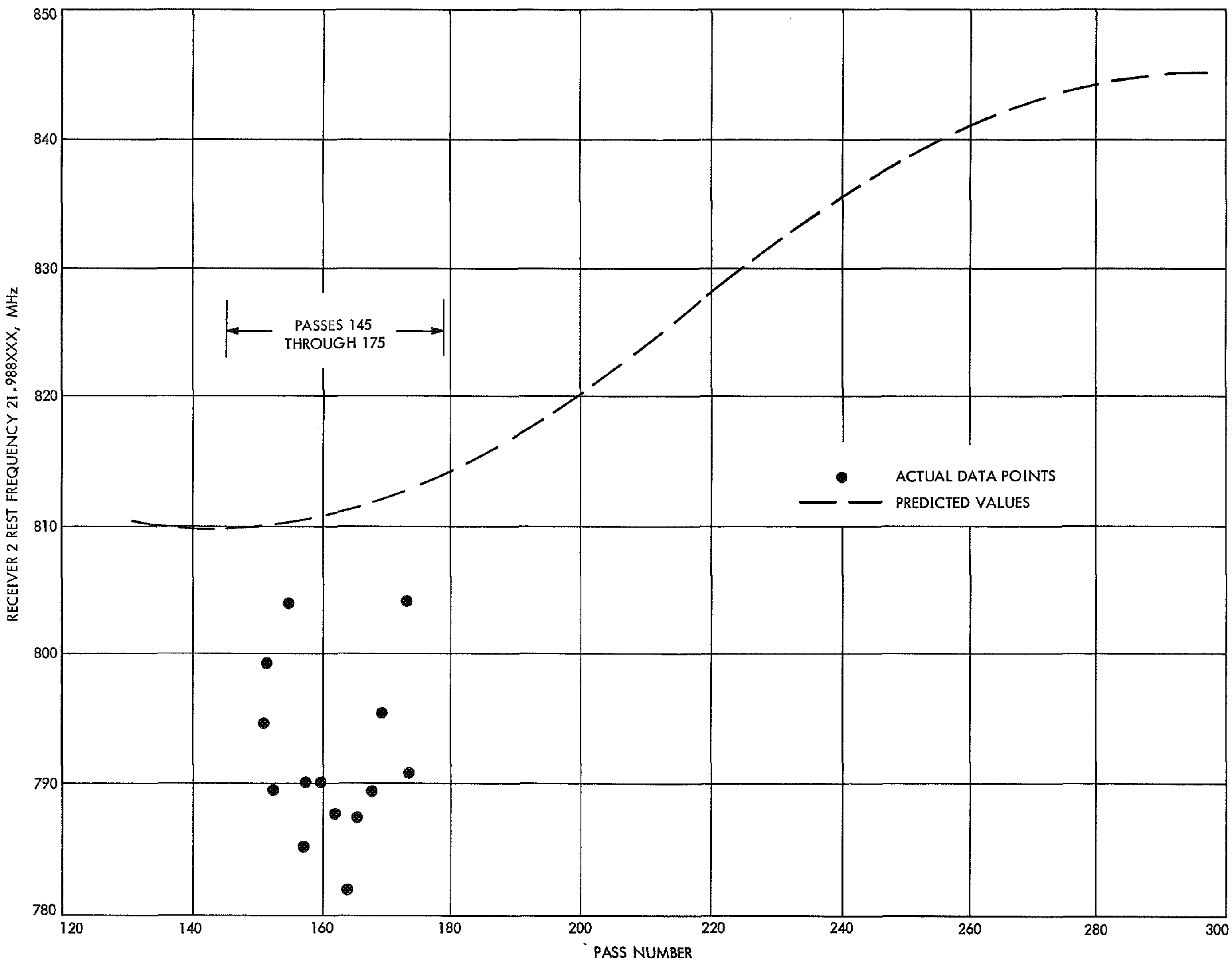


Fig. 54. Channel 7 best-lock frequency vs pass number (April 1969) (passes 145 through 175)

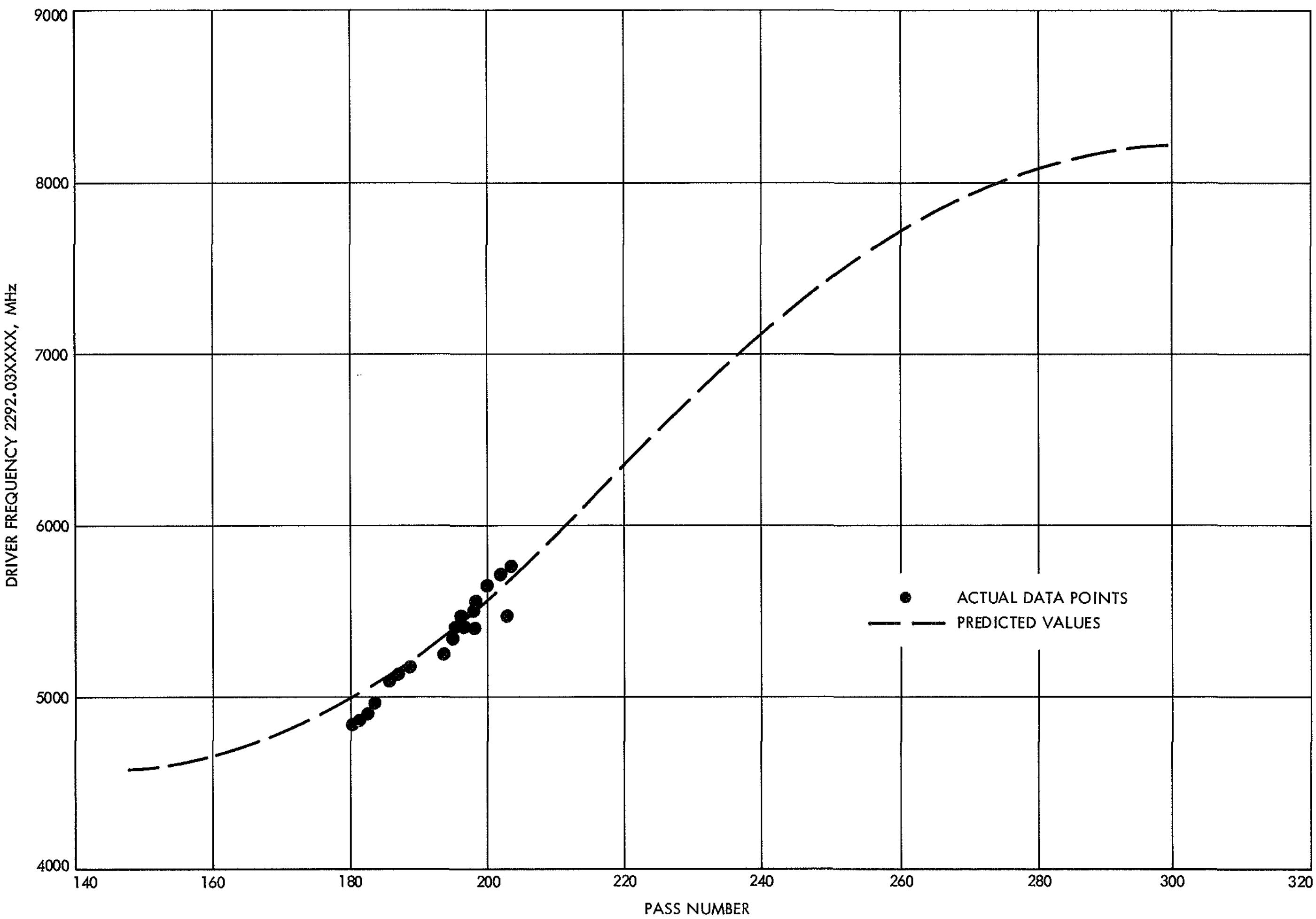


Fig. 55. Spacecraft auxiliary oscillator frequency vs pass number (May 1969) (passes 175 through 206)

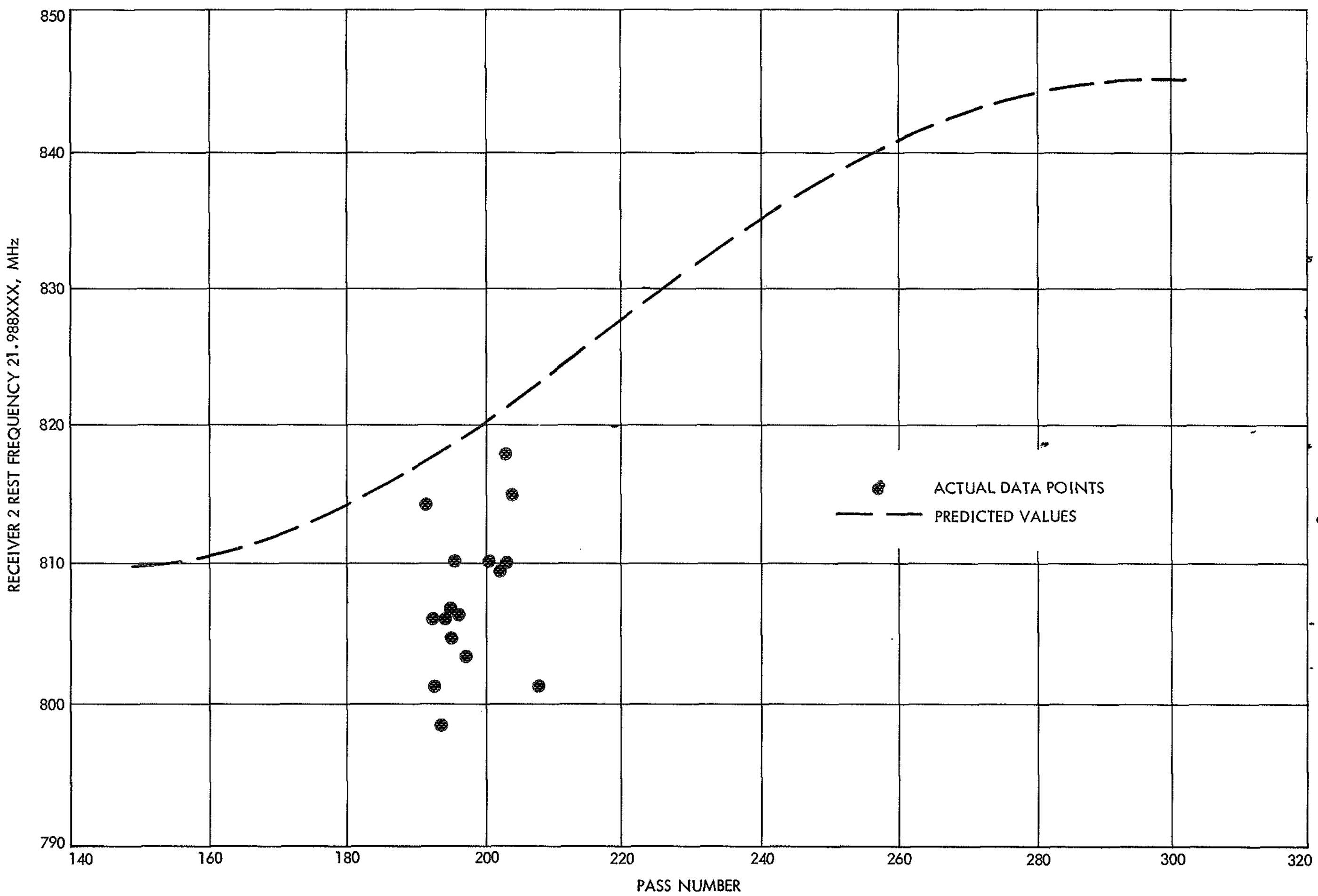


Fig. 56. Channel 7 best-lock frequency vs pass number (May 1969) (passes 175 through 206)

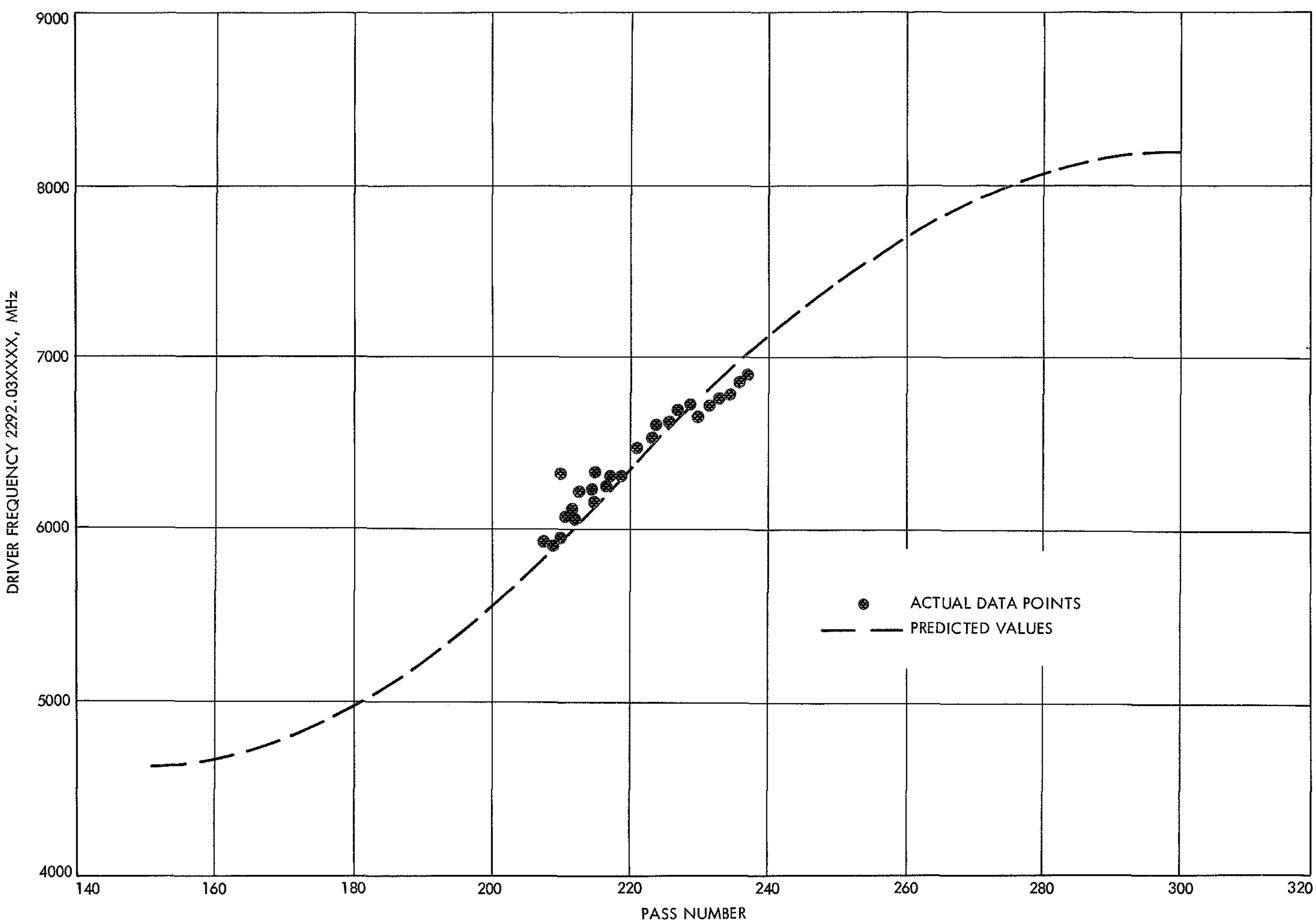


Fig. 57. Spacecraft auxiliary oscillator frequency vs pass number (June 1969) (passes 206 through 236)

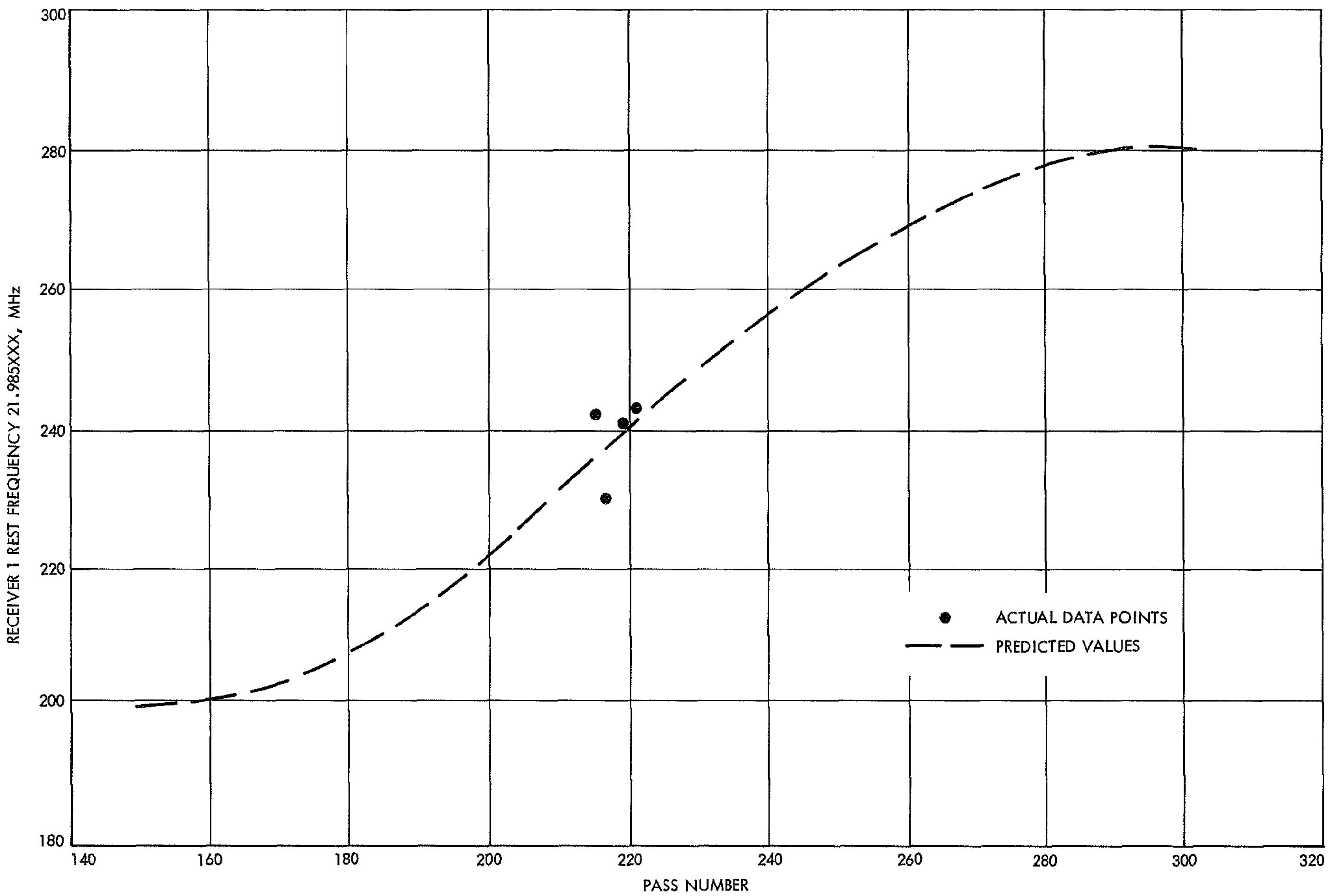


Fig. 58. Channel 6 best-lock frequency vs pass number (June 1969) (passes 206 through 236)

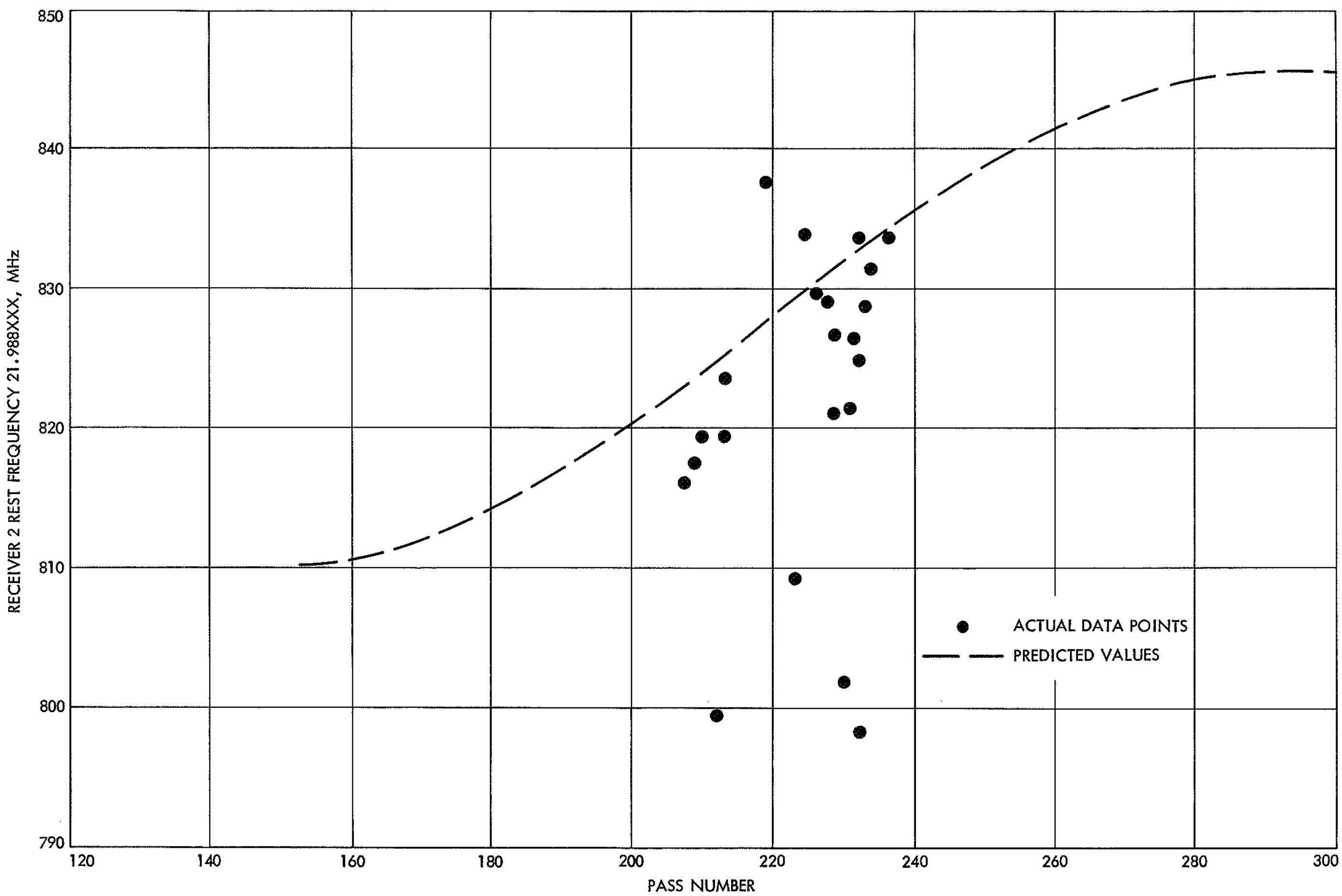


Fig. 59. Channel 7 best-lock frequency vs pass number (June 1969) (passes 206 through 236)

During March 1969, the standard deviation and actual 1-s data noise appeared higher than nominal. An analysis of the data indicated the nominal value should be closer to 0.095 Hz for a 12 dBmW signal strength above threshold.

An increase in noise in the 1-min data during April 1969 was a result of the apparent near-threshold conditions reached by the spacecraft—the conditions causing apparent receiver loss-of-lock. These conditions, however, seemed normal for the near-threshold conditions.

D. Pseudo-Residual Analysis

1. Introduction. Type II orientation, inferior conjunction, *Mariner VI* testing, a telemetry command processor lamp bank failure, and near-threshold conditions for the 85-ft-diam antenna stations played some part in the doppler noise value during the period covered by this document. There was also a doppler trend special analysis.

Figures 60-98 illustrate the data bias values computed by pseudo-residual analysis month by month.

2. Two-way doppler data. The approximate two-way doppler data bias values for the first month (November 1968) was near 0.0 Hz. However, during passes 2, 3, and 4, the approximate bias was 6.6 Hz because of the amount of partial Type II orientation performed, which changed the spacecraft position and velocity vector. The new state vector used for passes 5–23 was an improvement over the older doppler bias, the doppler bias returning to near 0.0 Hz (Figs. 60 and 61).

Missing data points generally resulted from the SFOF system and the monitor operational problems. However, the Goddard communications processor (CP) was down on pass 17. The approximate doppler bias values for December 1968 were from near 0.0 to 0.50 Hz. The low bias indicated that the state vector supplied was useful for operational Deep Space Station prediction during this interval. The missing data points resulted primarily from the SFOF IBM 7044 and CP problems. In addition, several D8 merge tape problems caused loss of pseudo-residual data.

Figure 62 shows an estimate of the 1-min two-way doppler noise computed for November 1968. As indicated in the graph, estimates were generally lower than predicted. The additional term added to the expected noise on doppler data was due to pseudo-residual computation, which could be defined as:

$$\sigma c = (\sigma^2_{\mathrm{Resid}} - \sigma^2_{\mathrm{FIT}})^{1/2}\ \mathrm{Hz}$$

where

σc = corrected prediction due to Resid

σ_{Resid} = residual estimated noise, Hz

σ_{FIT} = fitterate computer noise output, Hz

In Fig. 62, the prediction model for pseudo-residual computation starts on pass 3.

Figure 63 shows an estimate of the 1-min doppler noise computed for December 1968. All stations performed on or below the estimated noise level. However, several minor reported problems were noted (Table 30) that allowed the Deep Space Station to correct the TDH and the related subsystems in order to continue quality doppler tracking.

The estimated noise level gradually increased until the return-trip light time reached 1 min. At approximately 1-min return-trip light time, the estimated level reached 0.010 Hz to a maximum for 5-min centered predictions and a high signal strength above threshold.

See Figs. 64 and 65 for an estimate of the 1-s doppler noise computed for November and December 1968. The 1-s data were taken at the meridian crossing for approximately 12 min in a two-way coherent mode. The 1-s data were taken weekly, accounting for the few data points. In November, most of the noise estimates indicated below the predicted nominal value, indicating the excellent quality of the doppler data.

In December 1968 (see Fig. 65), the 10-s data on pass 35 at DSS 12 was within the acceptable fitterate prediction (0.015 Hz).

Table 30. Two-way doppler noise anomalies (December)

Pass	Day	Deep Space Station	Comments
32	344	62	Blunder point indicated at 1716:43
34	346/347	12	Blunder point indicated at 2100:02 and 2121:02—magnitude 5 and 742, respectively
53	365	62	Blunder point indicated at 1707:02. Magnitude of approximately 2.7 Hz
53	365/366	12	Resolver malfunction at 2300:00 0259:02

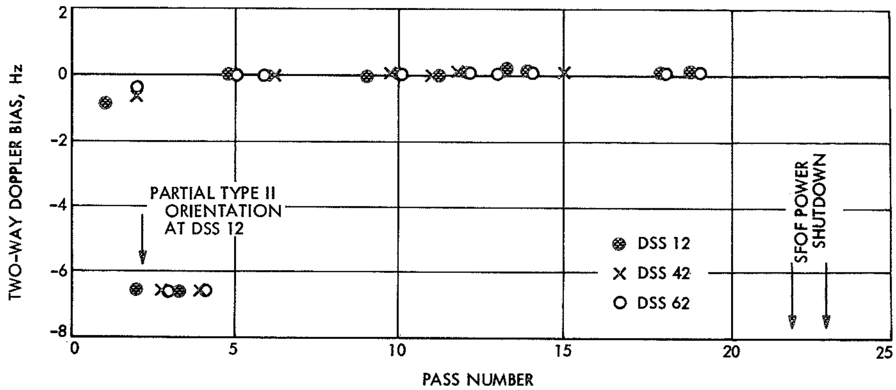


Fig. 60. Doppler bias vs pass number (November 1968) (passes 1 through 23)

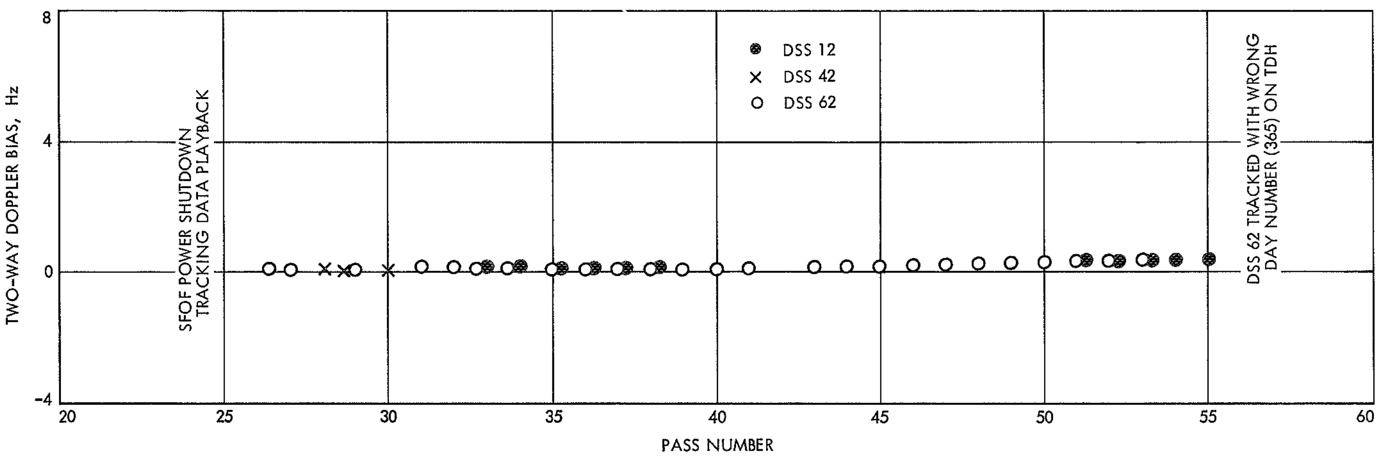


Fig. 61. Doppler bias vs pass number (December 1968) (passes 24 through 55)

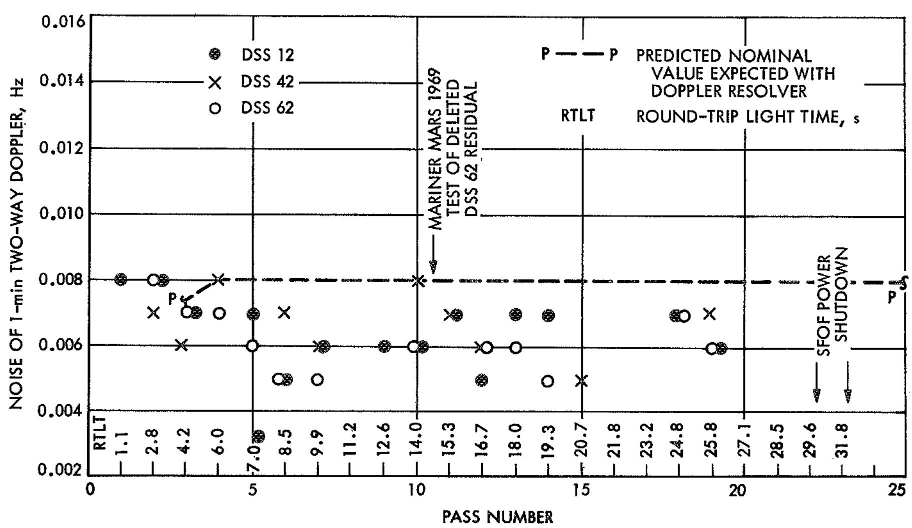


Fig. 62. Two-way doppler noise, 1-min sample rate vs pass number (November 1968) (passes 1 through 23)

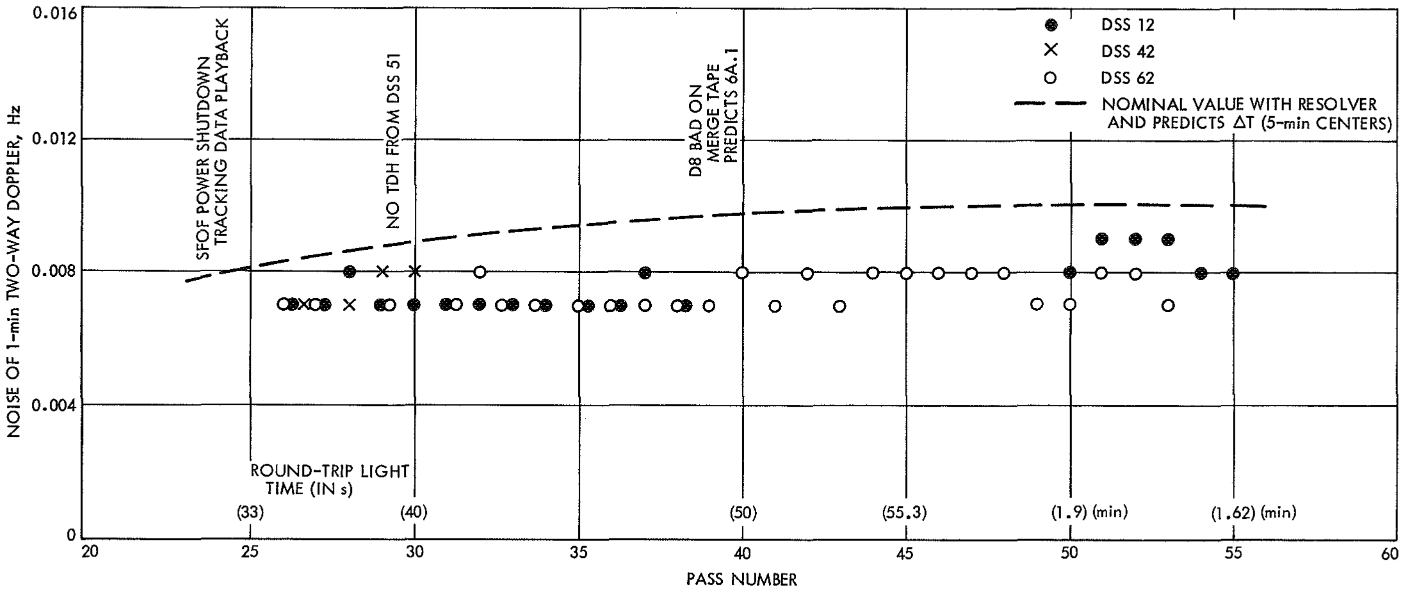


Fig. 63. Two-way doppler noise, 1-min sample rate vs pass number (December 1968) (passes 24 through 55)

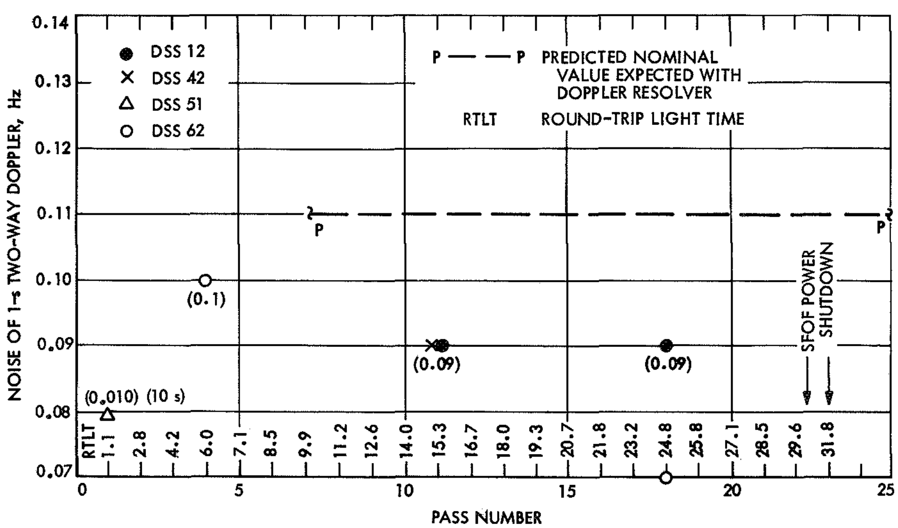


Fig. 64. Residual 1-s two-way doppler noise vs pass number (November 1968) (passes 1 through 23)

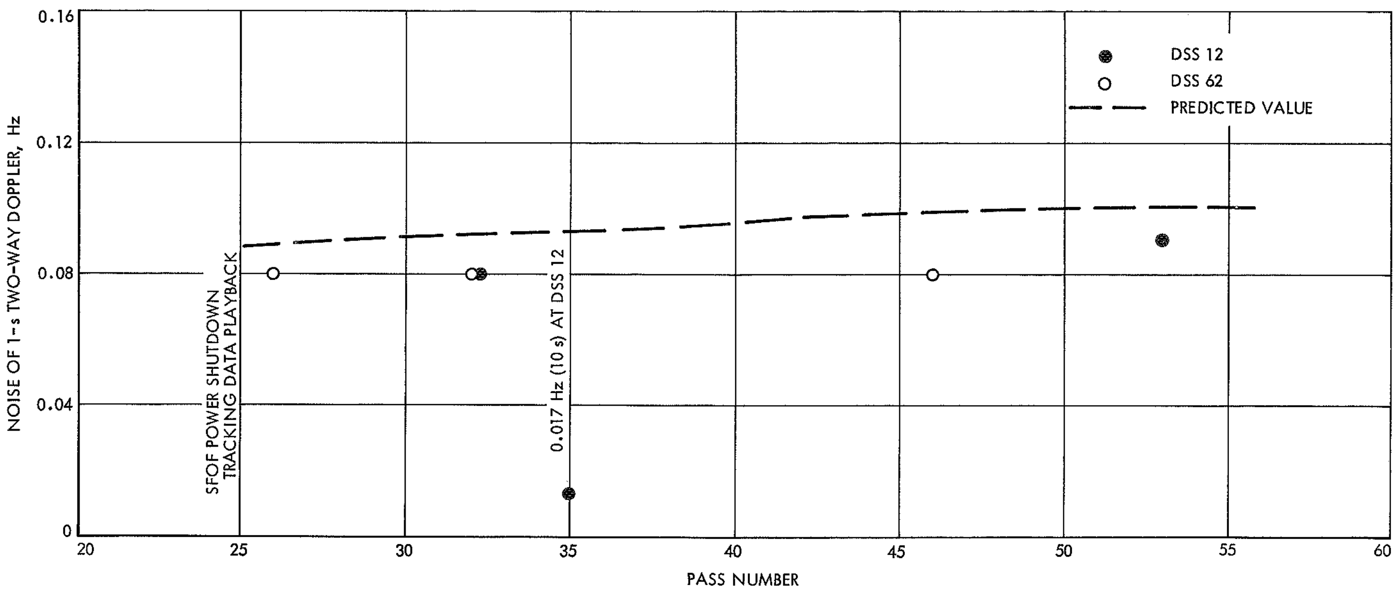


Fig. 65. Residual 1-s two-way doppler noise vs pass number (December 1968) (passes 24 through 55)

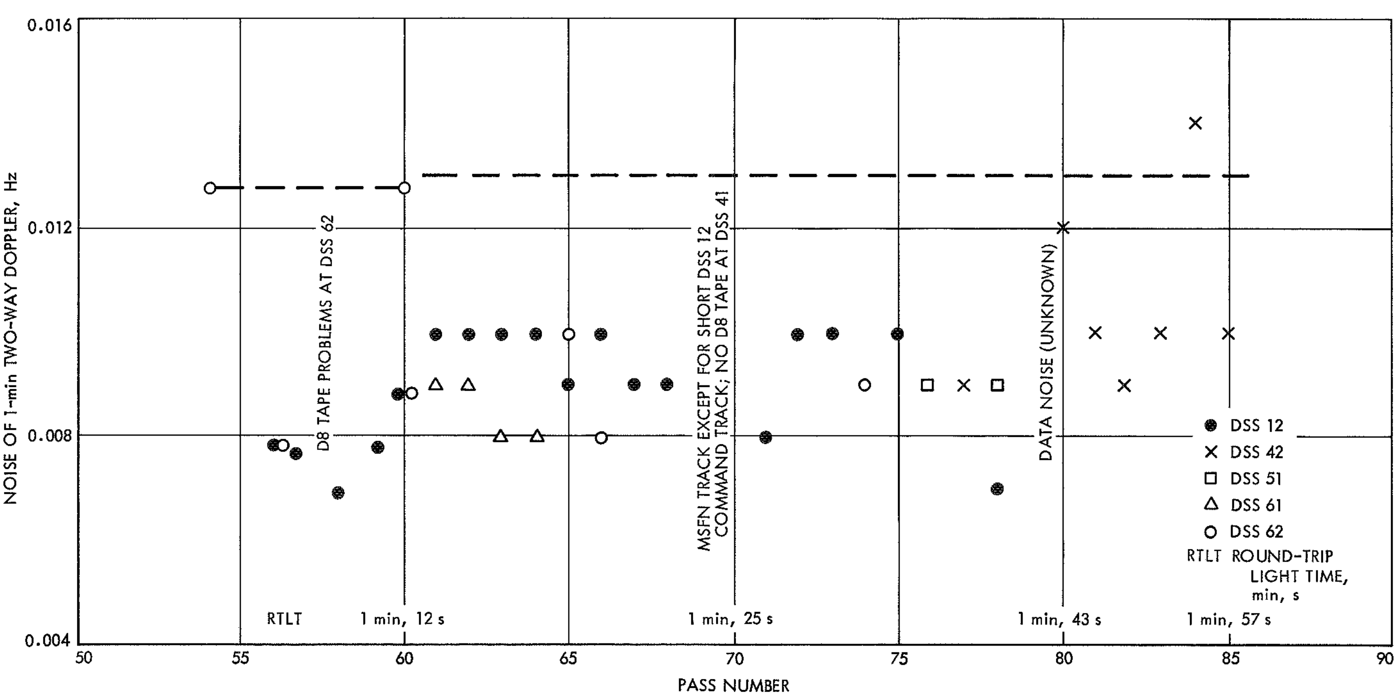


Fig. 66. Residual 1-min two-way doppler noise vs pass number (January 1969) (passes 55 through 86)

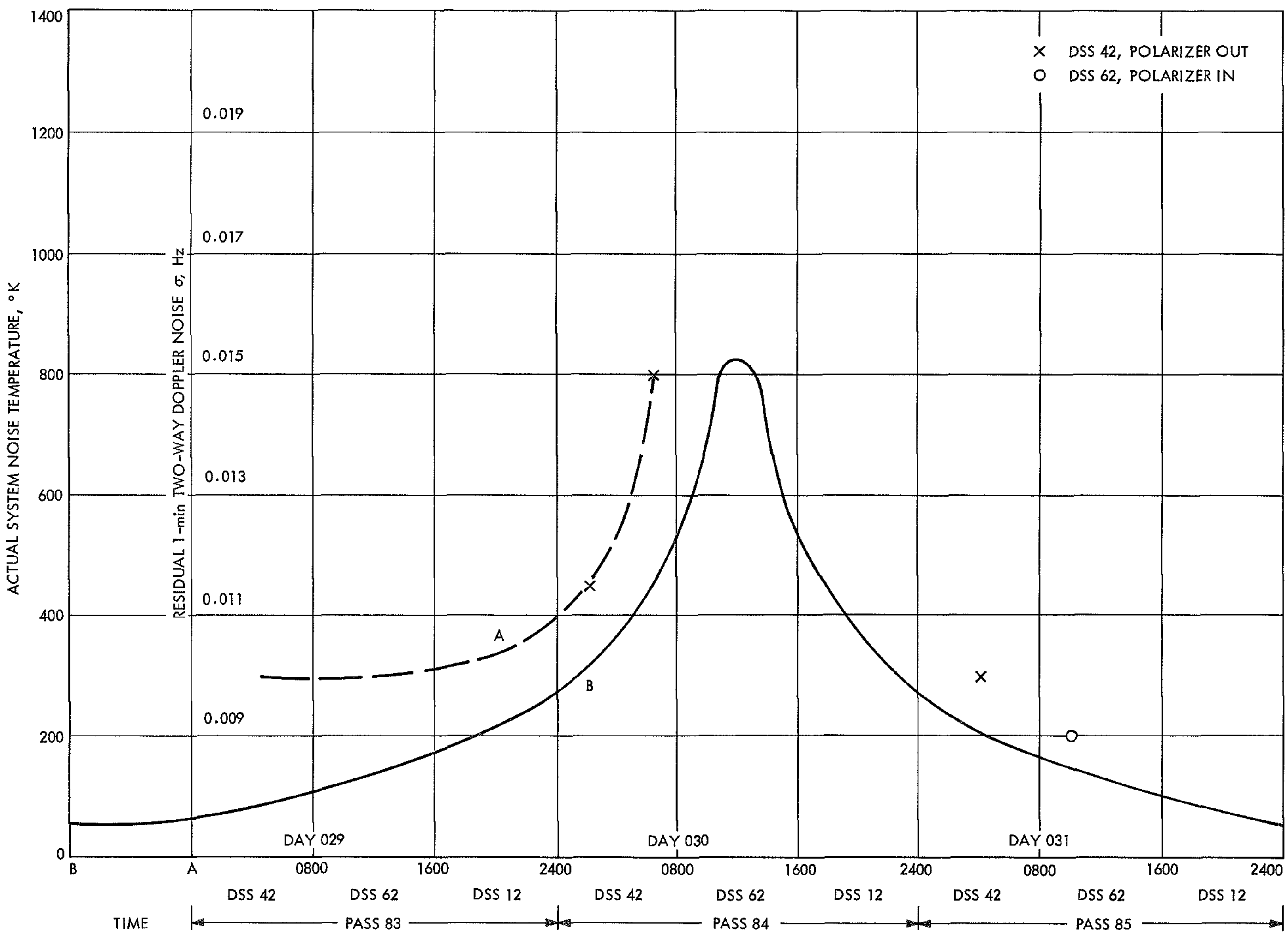


Fig. 67. Effects of two-way doppler caused by system noise temperature (1-min) (January 1969) (passes 55 through 86)

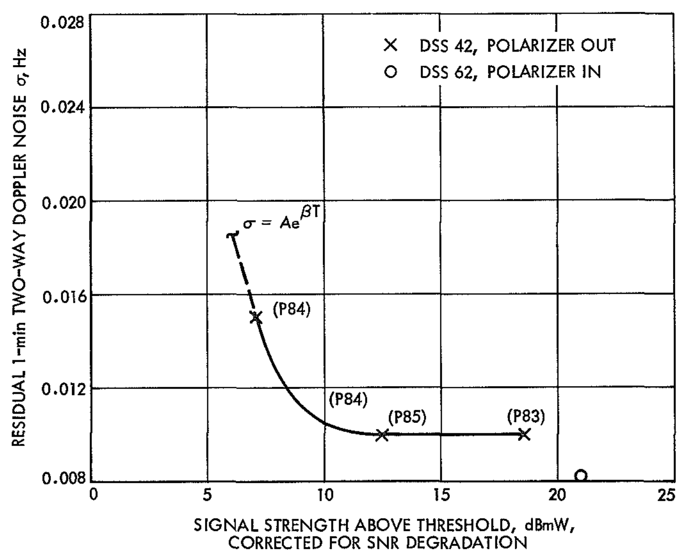


Fig. 68. Effects of inferior conjunction on 1-min two-way coherent doppler noise (January 1969) (passes 55 through 86)

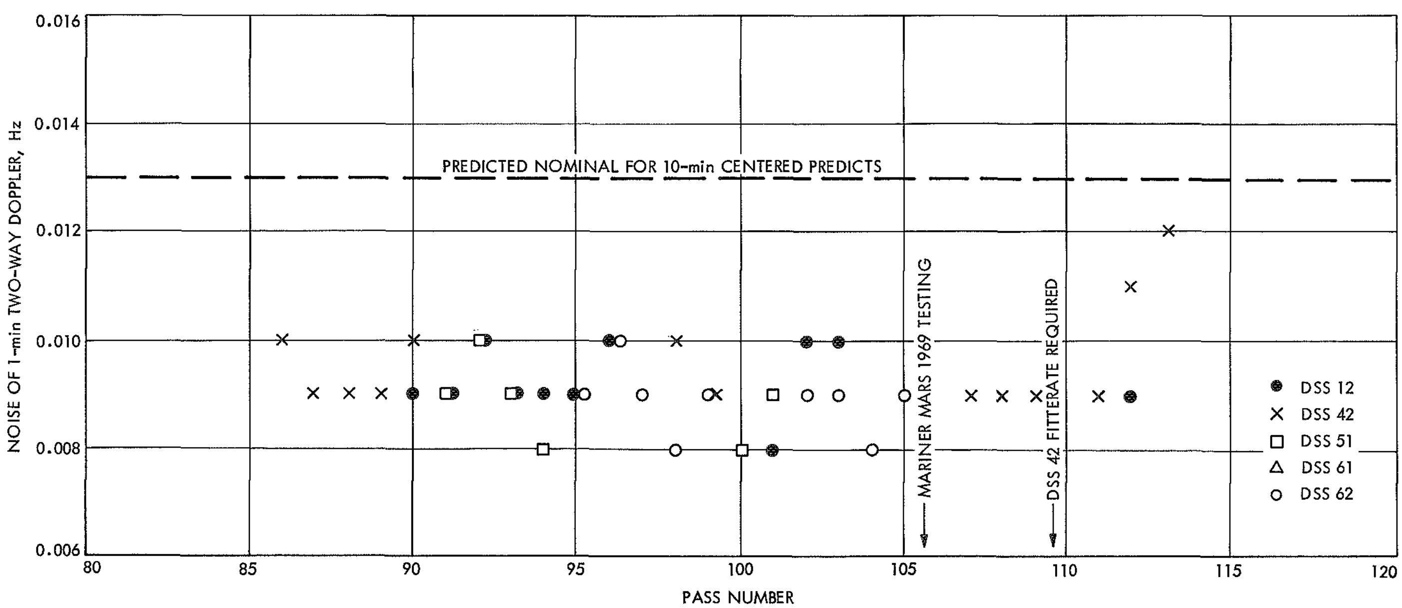


Fig. 69. Residual 1-min two-way doppler noise vs pass number (February 1969) (passes 86 through 114)

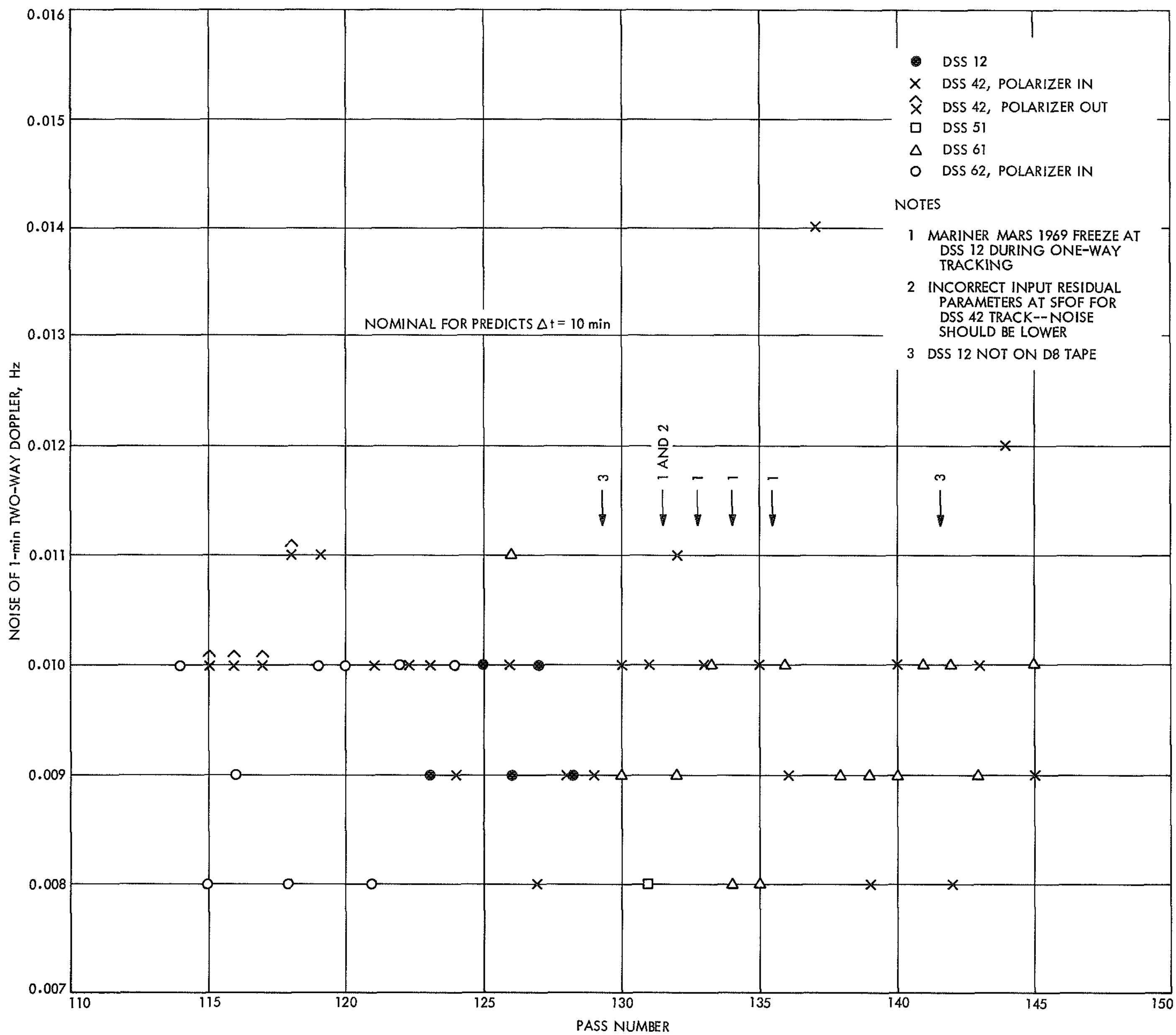


Fig. 70. Residual 1-min two-way doppler noise vs pass number (March 1969) (passes 114 through 145)

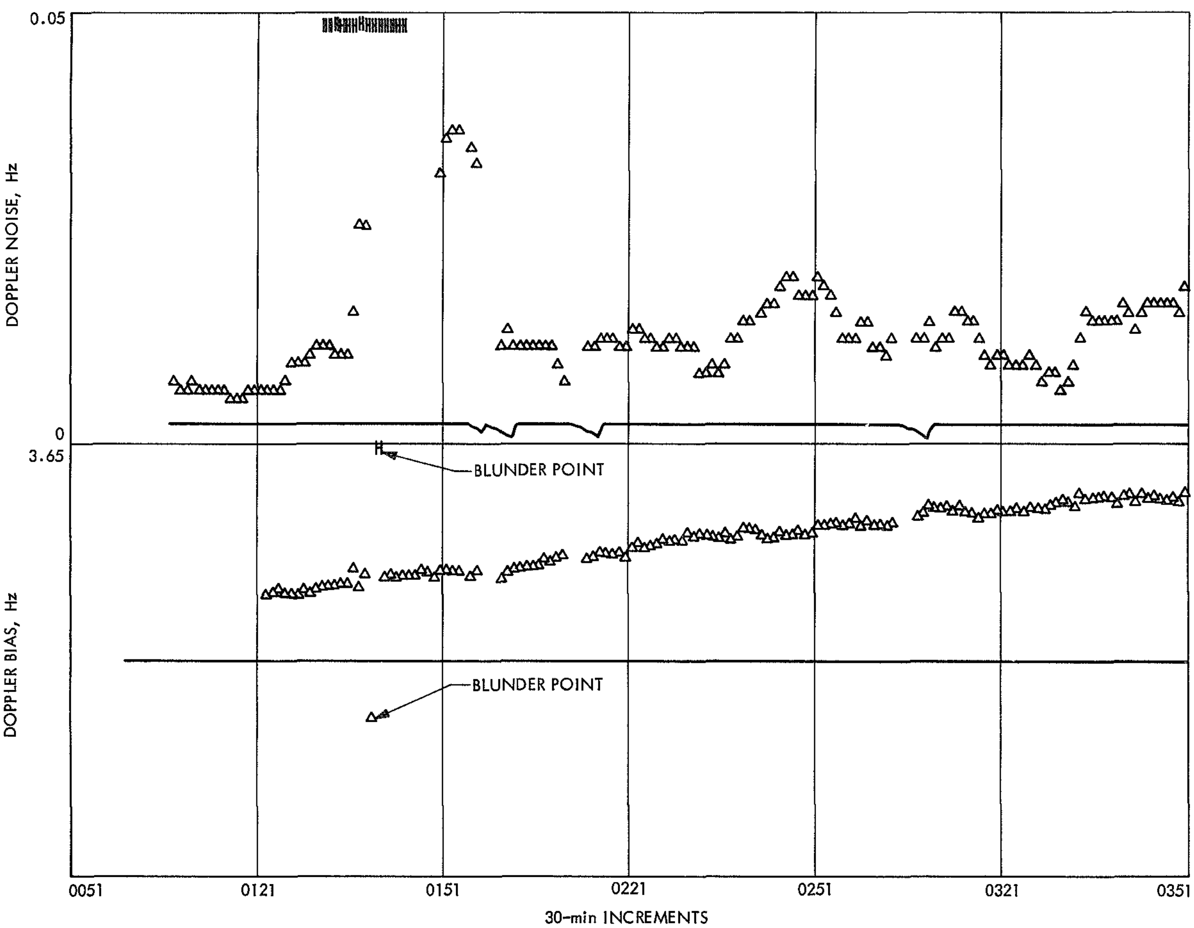


Fig. 71. Typical effects of blunder points on residual data (DSS 42, pass 137, day 083, March 1969)

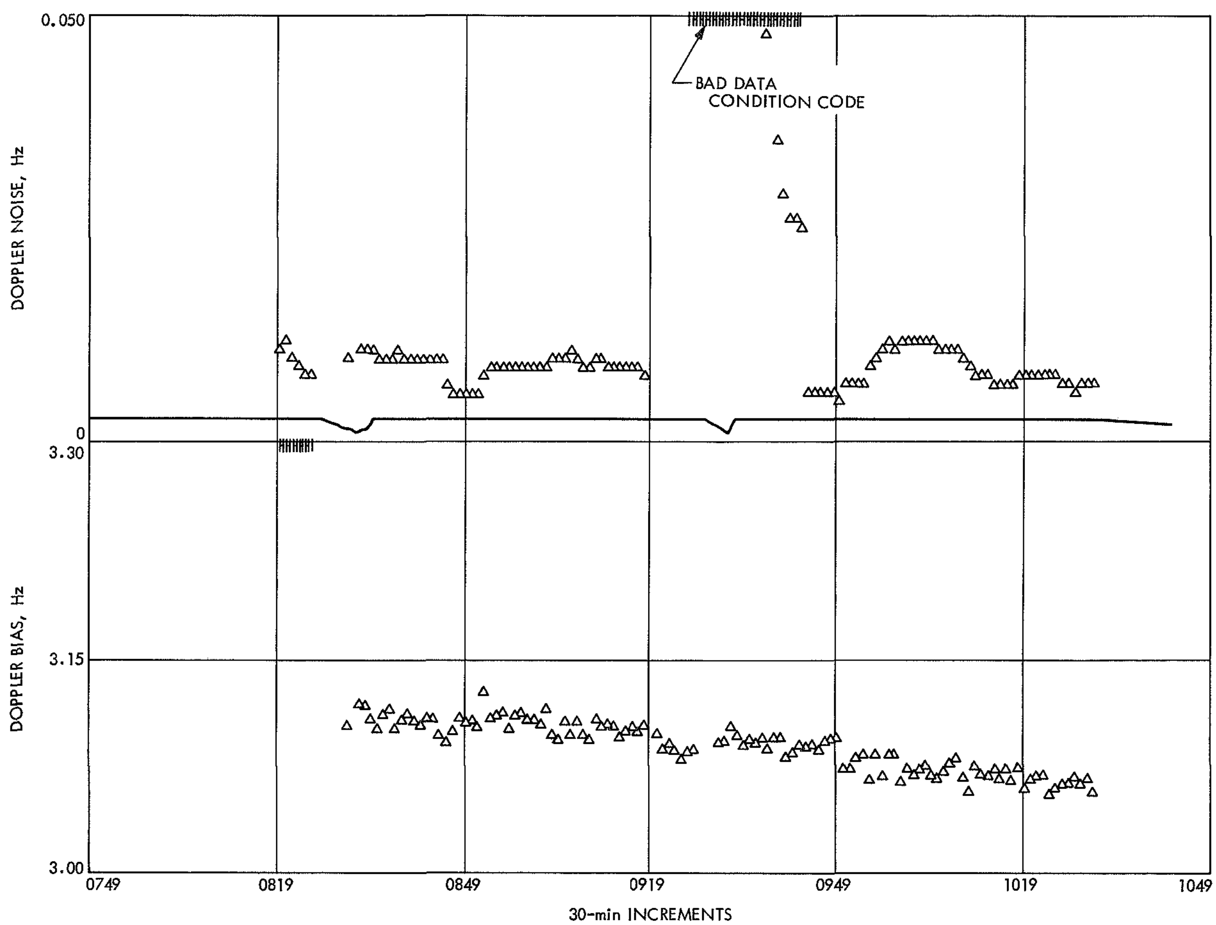


Fig. 72. Typical effects of blunder points on residual data (DSS 61, pass 133, day 079, March 1969)

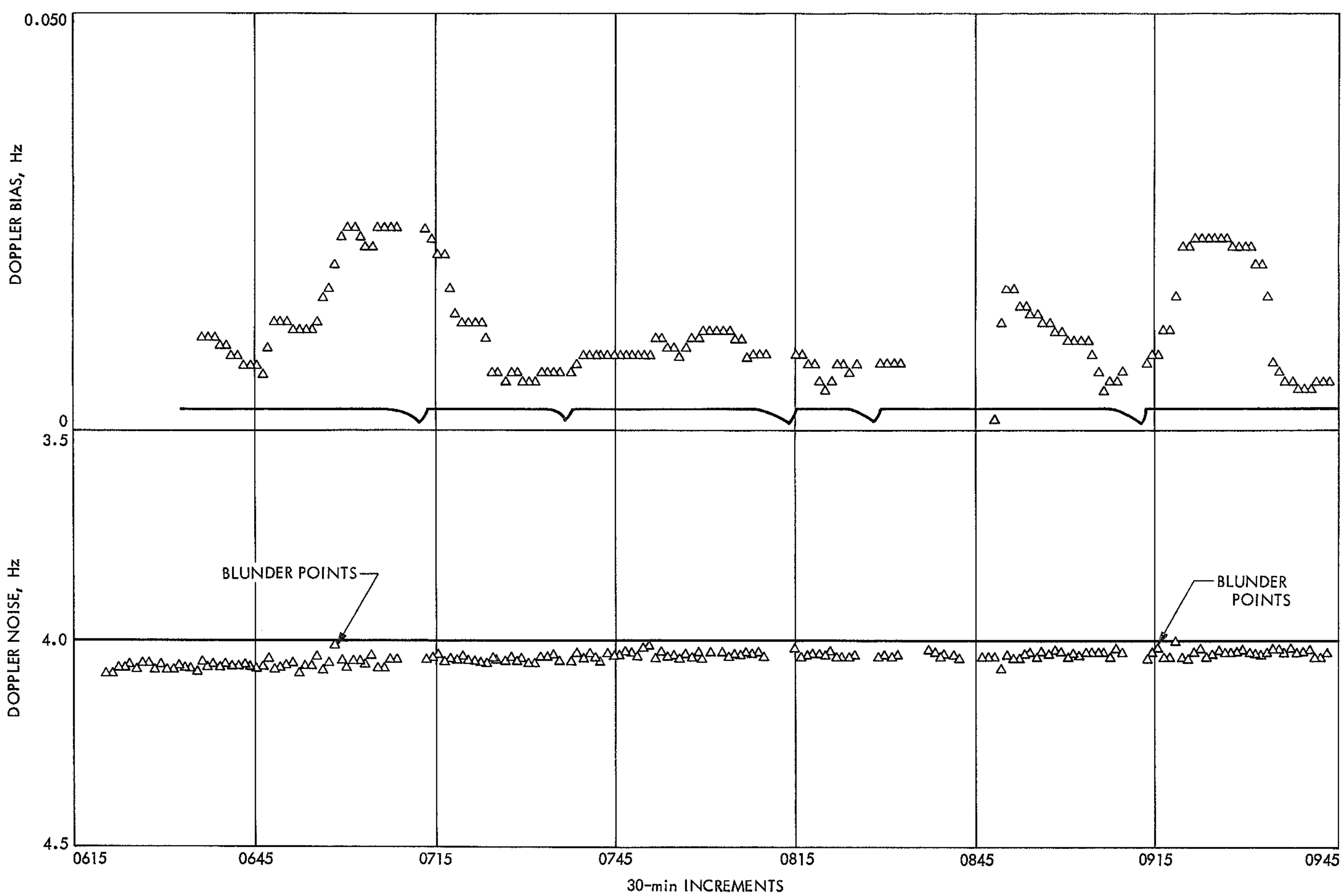


Fig. 73. Typical effects of blunder points on residual data (DSS 62, pass 124, day 070, March 1969)

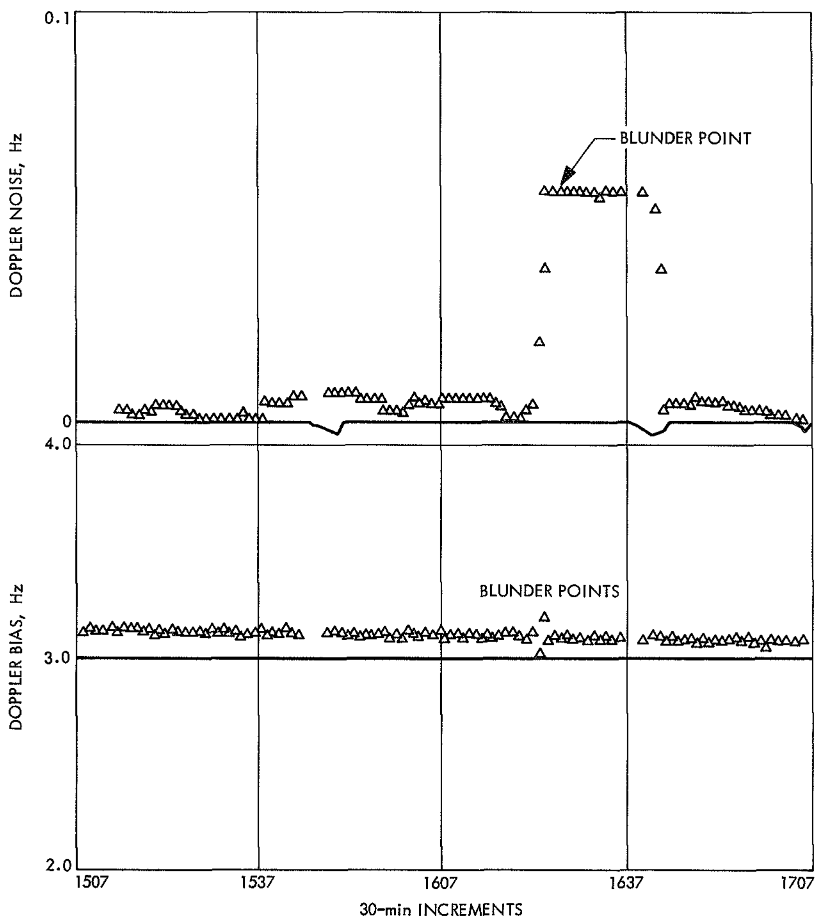


Fig. 74. Typical effects of bad resolver point on residual data (DSS 12, pass 127, day 073, March 1969)

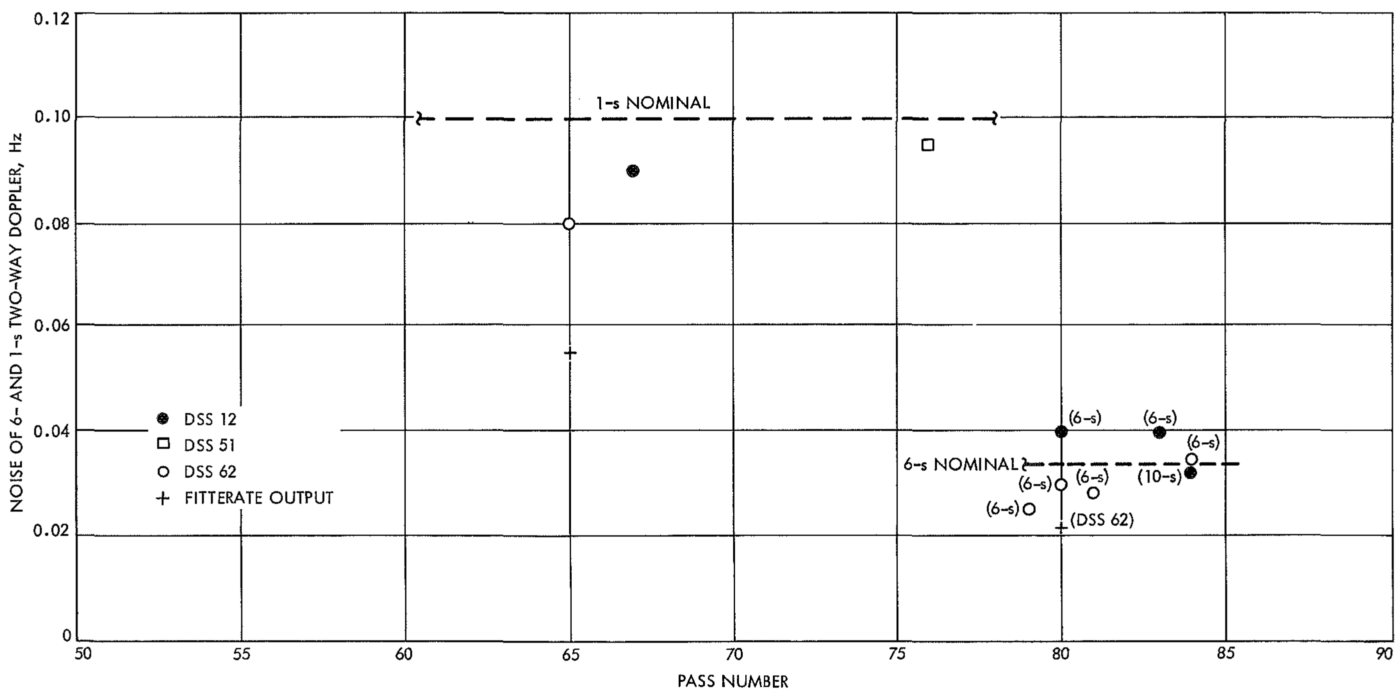


Fig. 75. Residual 1-, 6-, and 10-s two-way doppler noise vs pass number (January 1969) (passes 55 through 86)

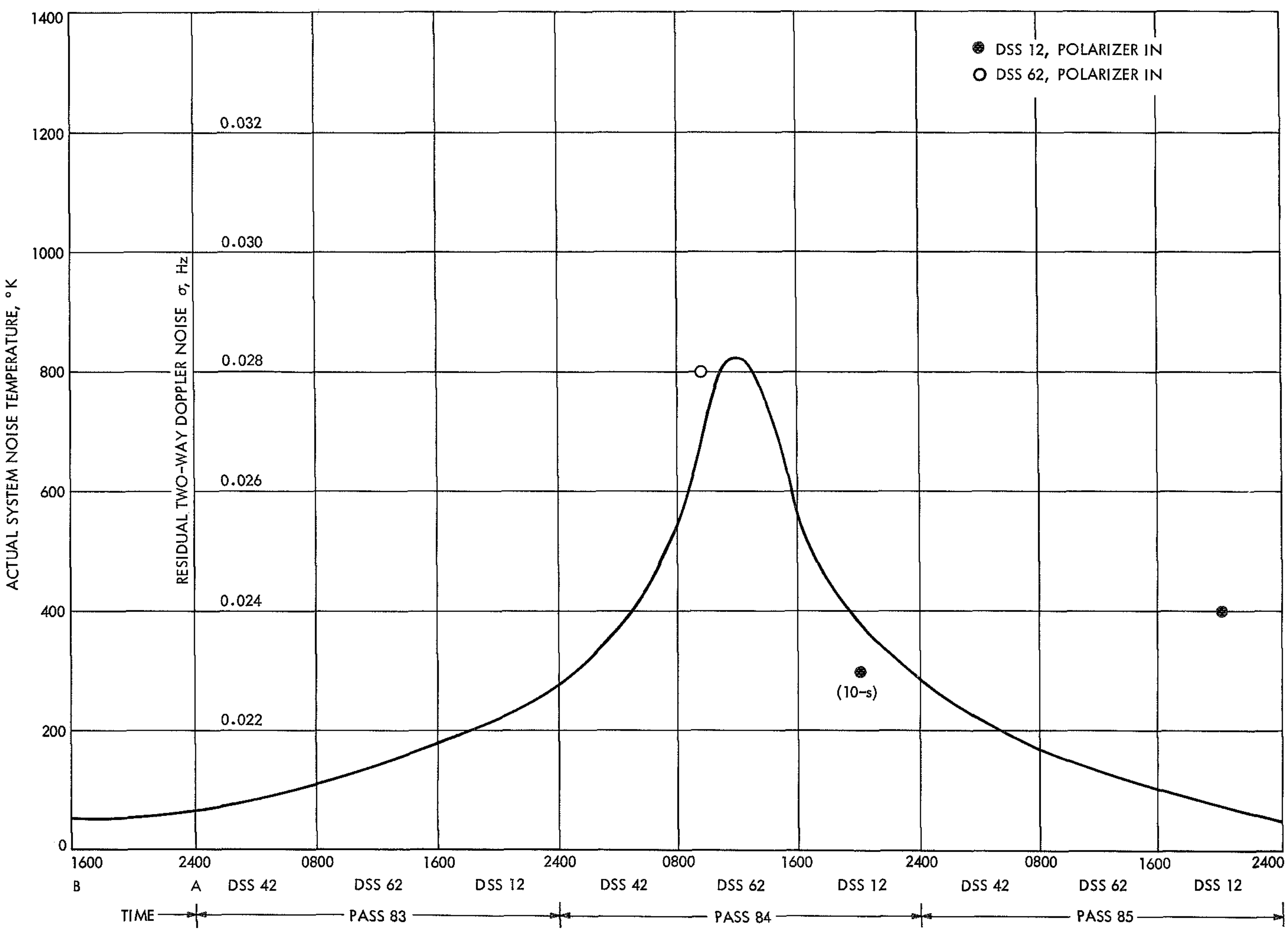


Fig. 76. Effects of two-way doppler caused by system noise temperatures (6- and 10-s) (January 1969) (passes 55 through 86)

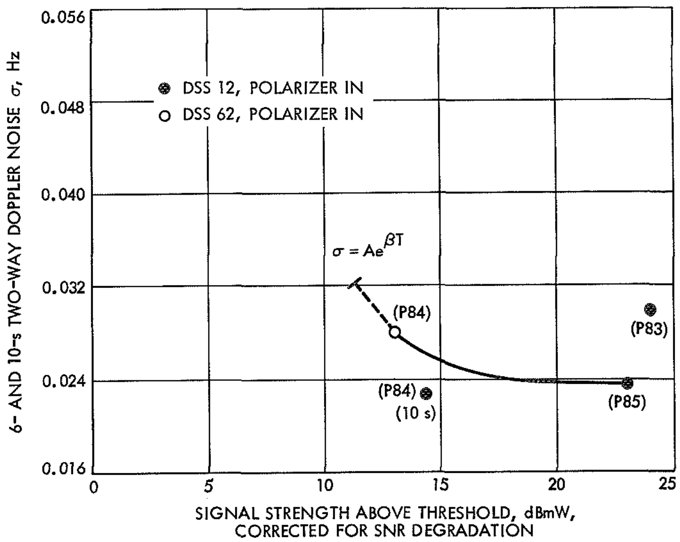


Fig. 77. Effects of inferior conjunction on 1- and 6-s two-way coherent doppler noise (January 1969) (passes 55 through 86)

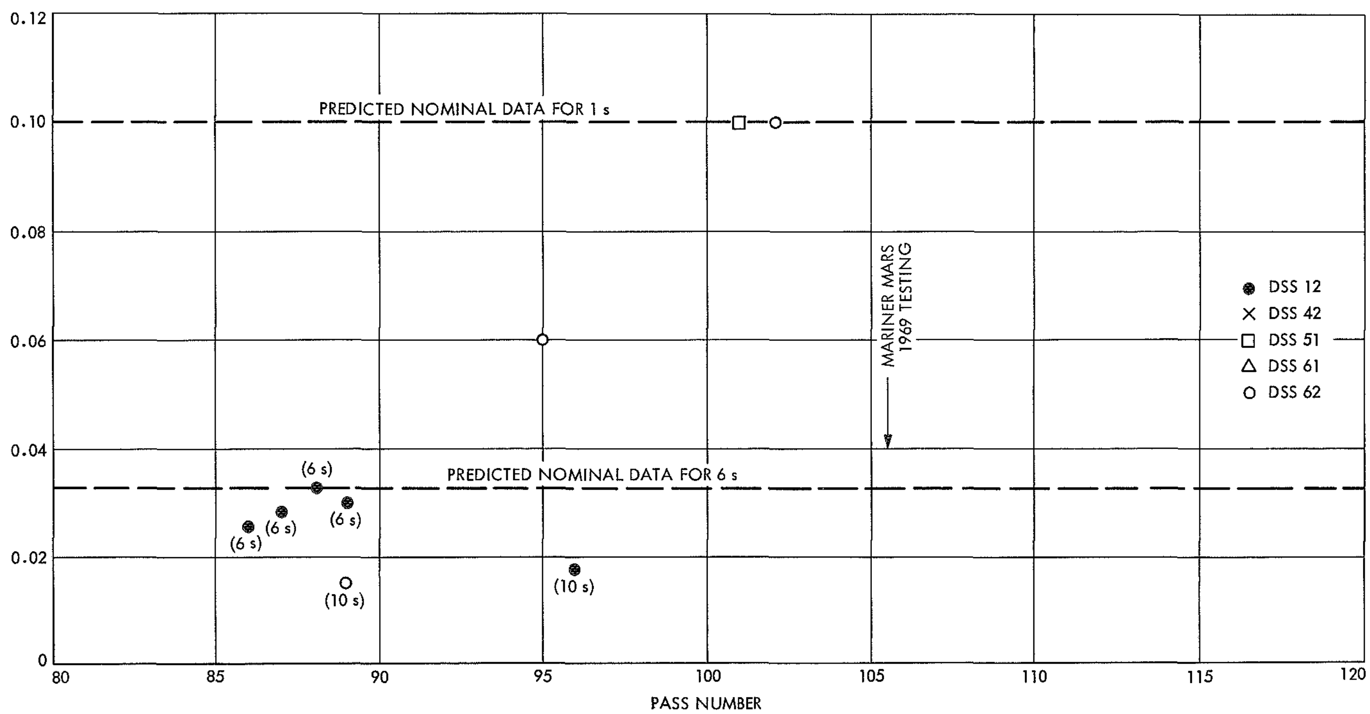


Fig. 78. Residual 1-s two-way doppler noise vs pass number (February 1969) (passes 86 through 114)

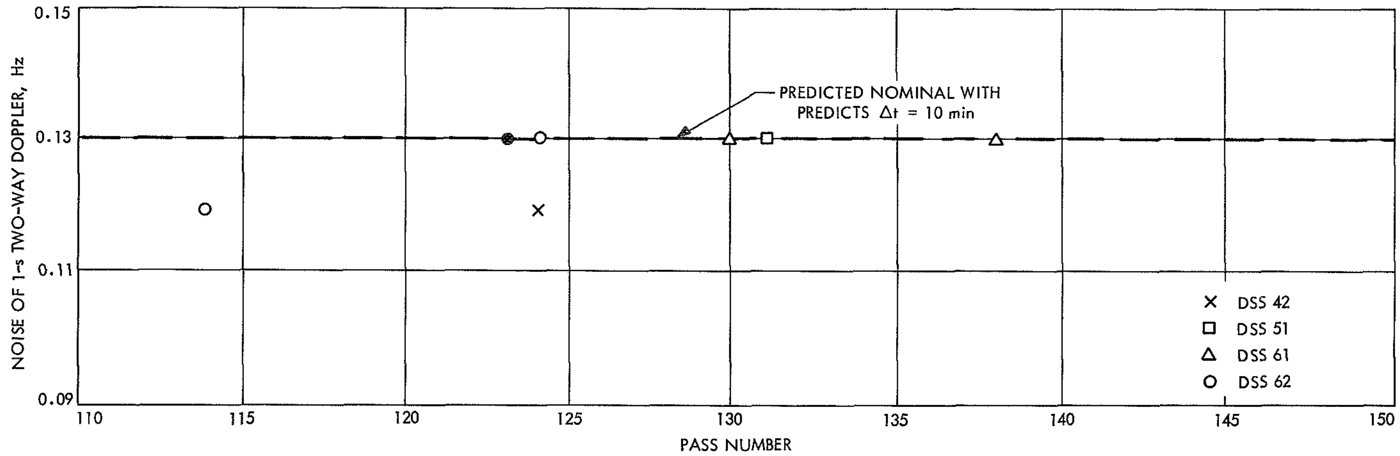


Fig. 79. Residual 1-s two-way doppler noise vs pass number (March 1969) (passes 114 through 145)

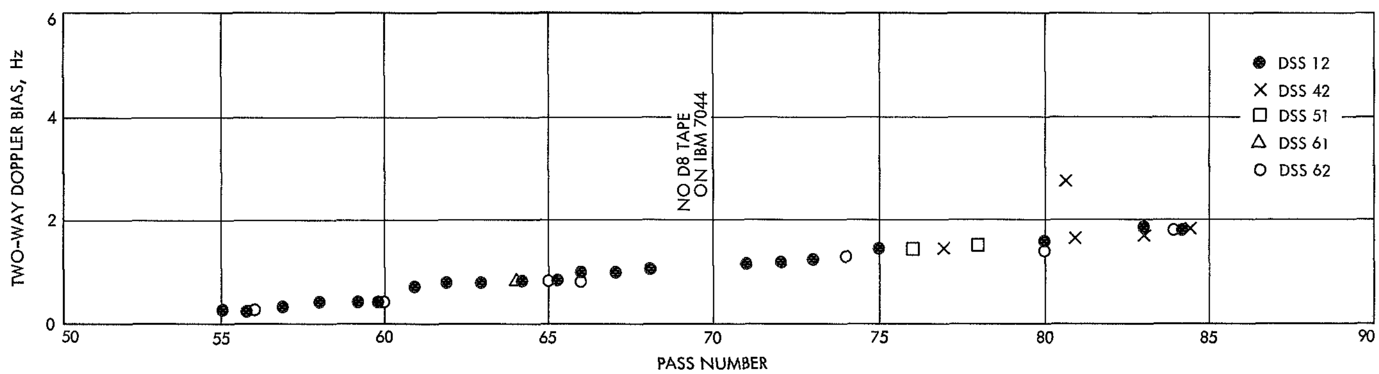


Fig. 80. Doppler bias vs pass number (January 1969) (passes 55 through 86)

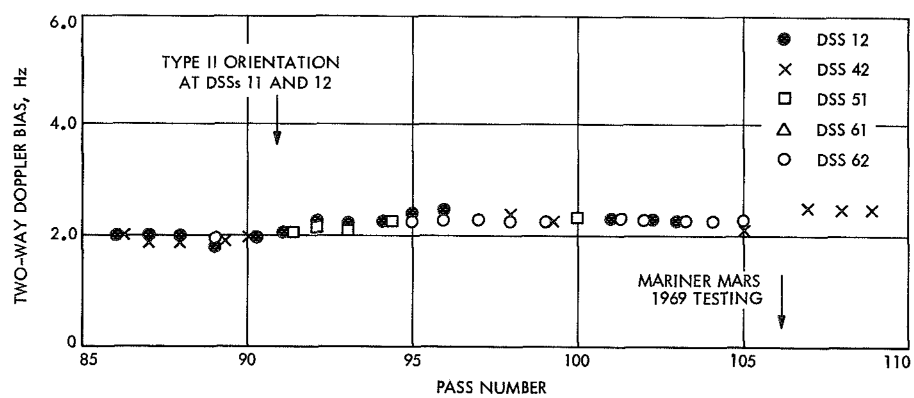


Fig. 81. Doppler bias vs pass number (February 1969) (passes 86 through 114)

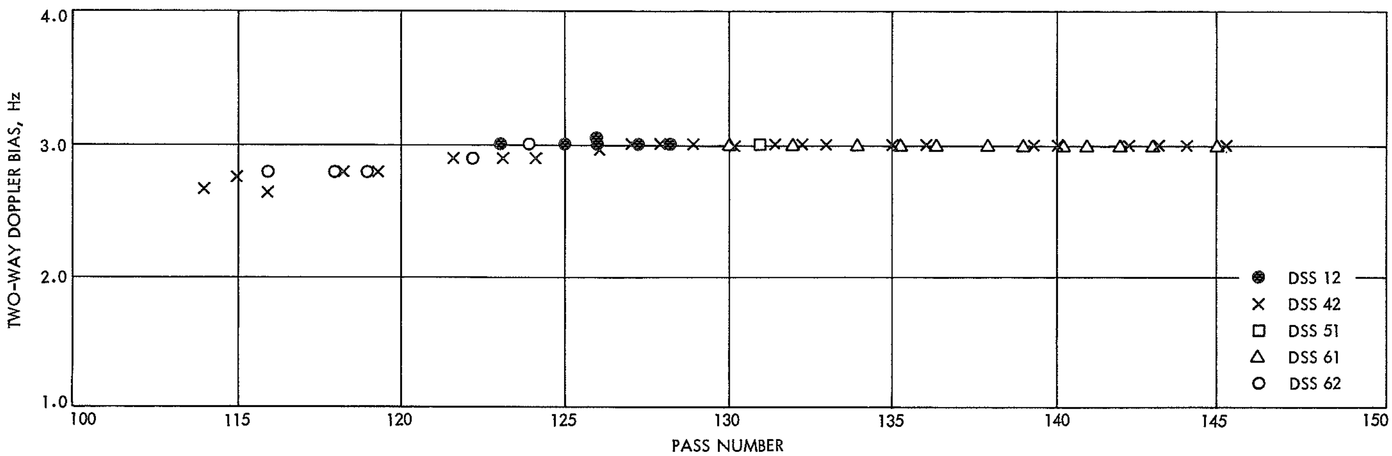


Fig. 82. Doppler bias vs pass number (March 1969) (passes 114 through 145)

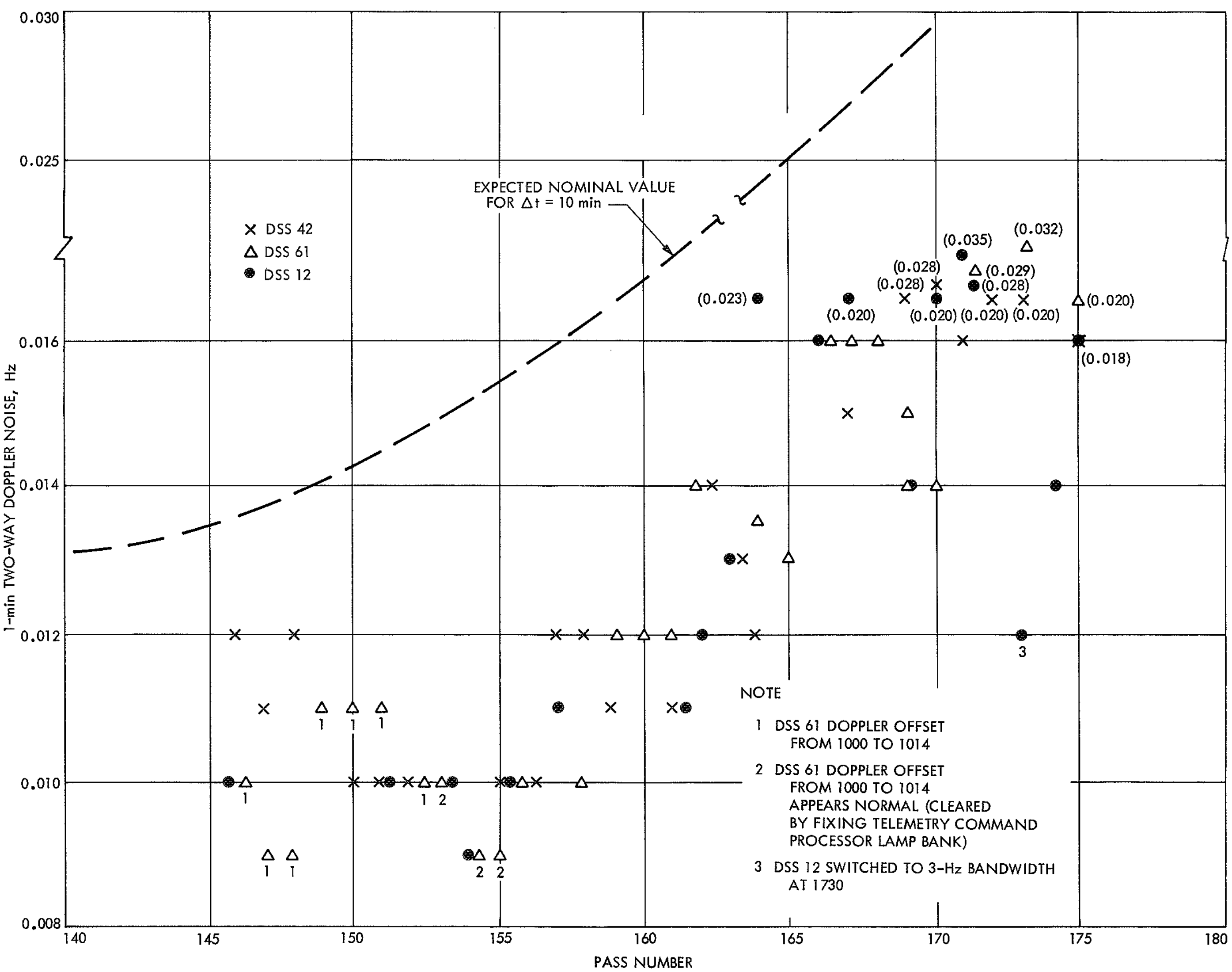


Fig. 83. Residual 1-min two-way doppler noise vs pass number (April 1969) (passes 145 through 175)

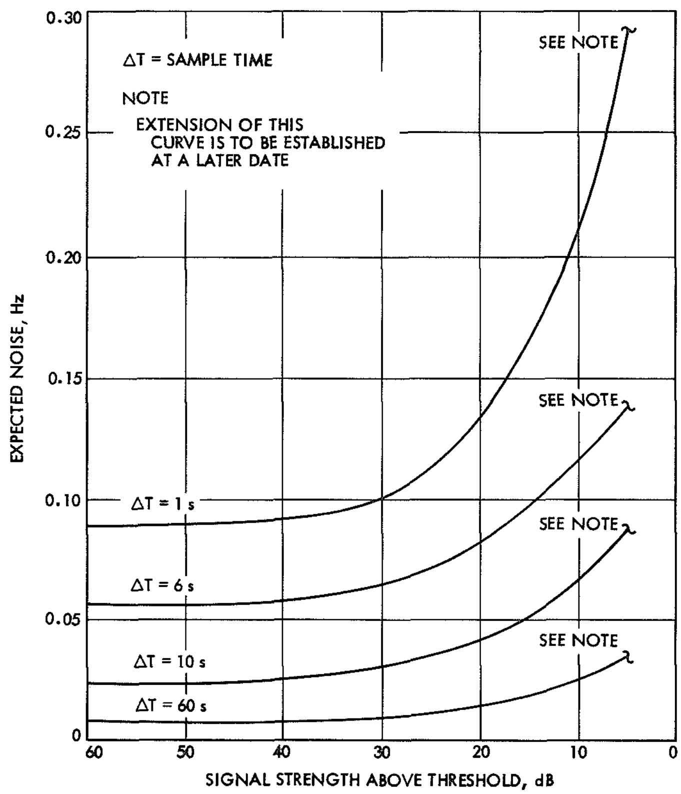


Fig. 84. Residual expected doppler noise vs signal strength above threshold (April 1969) (passes 145 through 175)

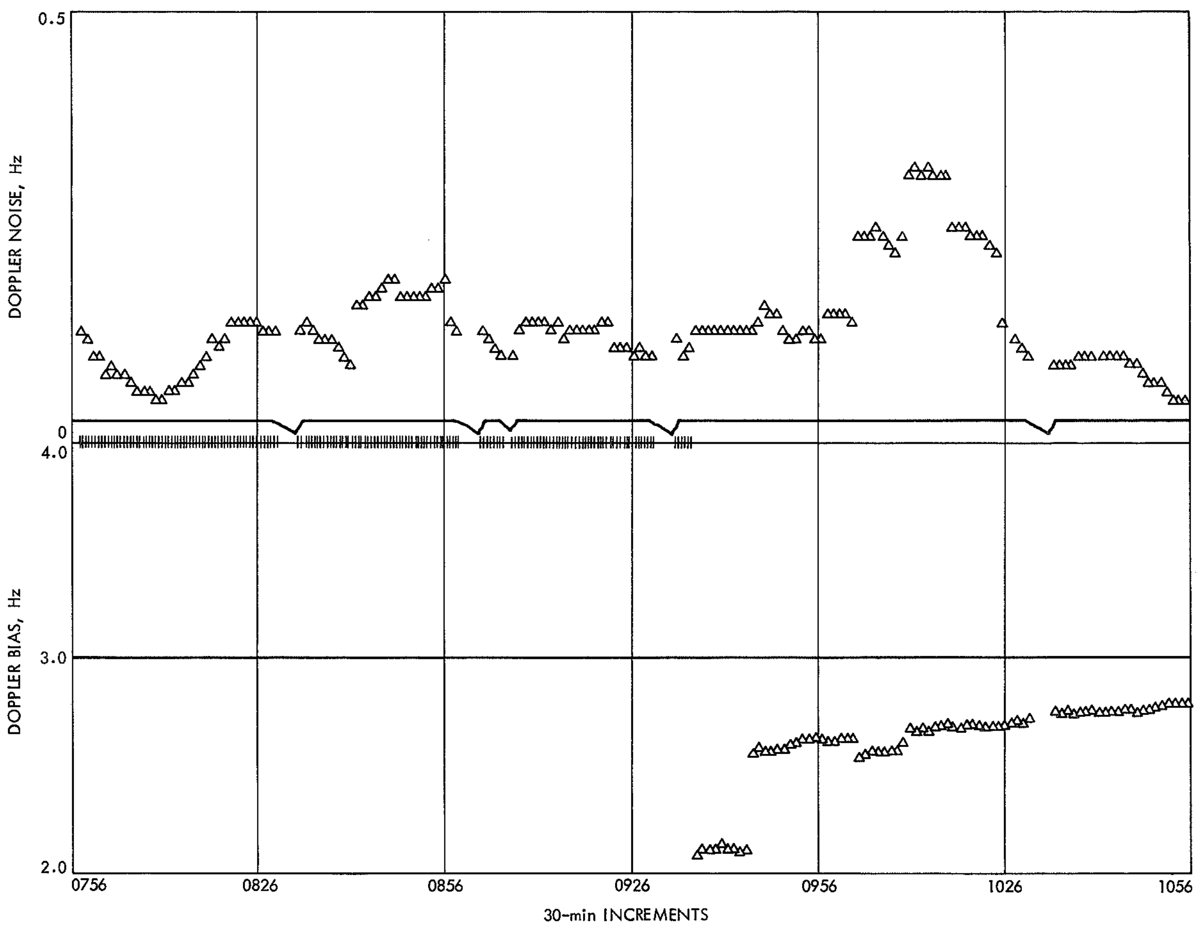


Fig. 85. Effects of doppler offset caused by telemetry command processor (DSS 61, pass 146, day 092, April 1969)

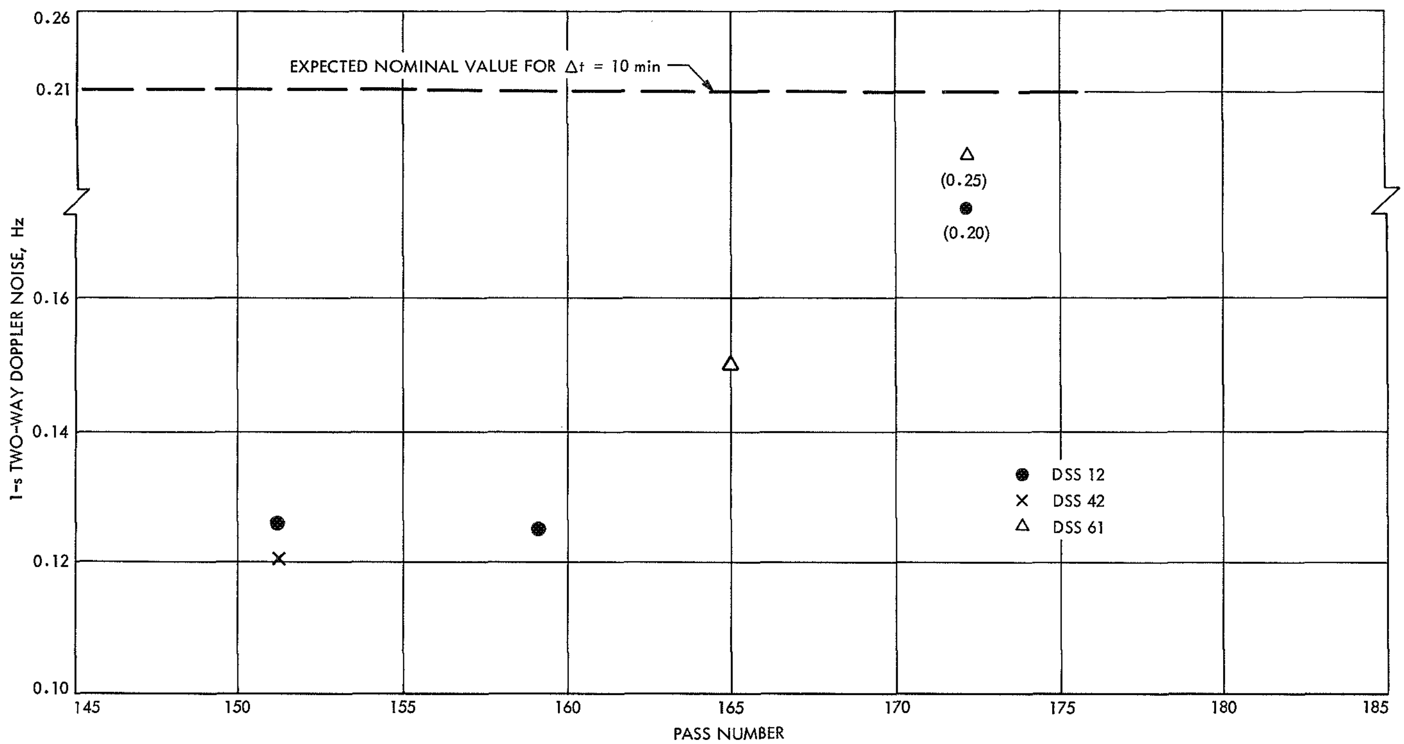


Fig. 86. Residual 1-s two-way doppler noise vs pass number (April 1969) (passes 145 through 175)

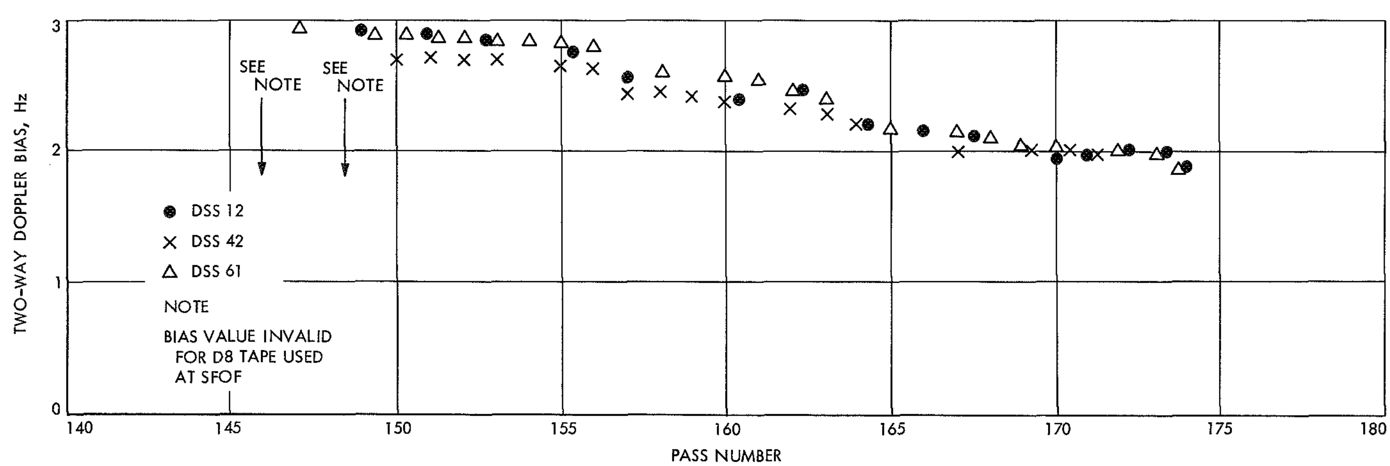


Fig. 87. Doppler bias vs pass number (April 1969) (passes 145 through 175)

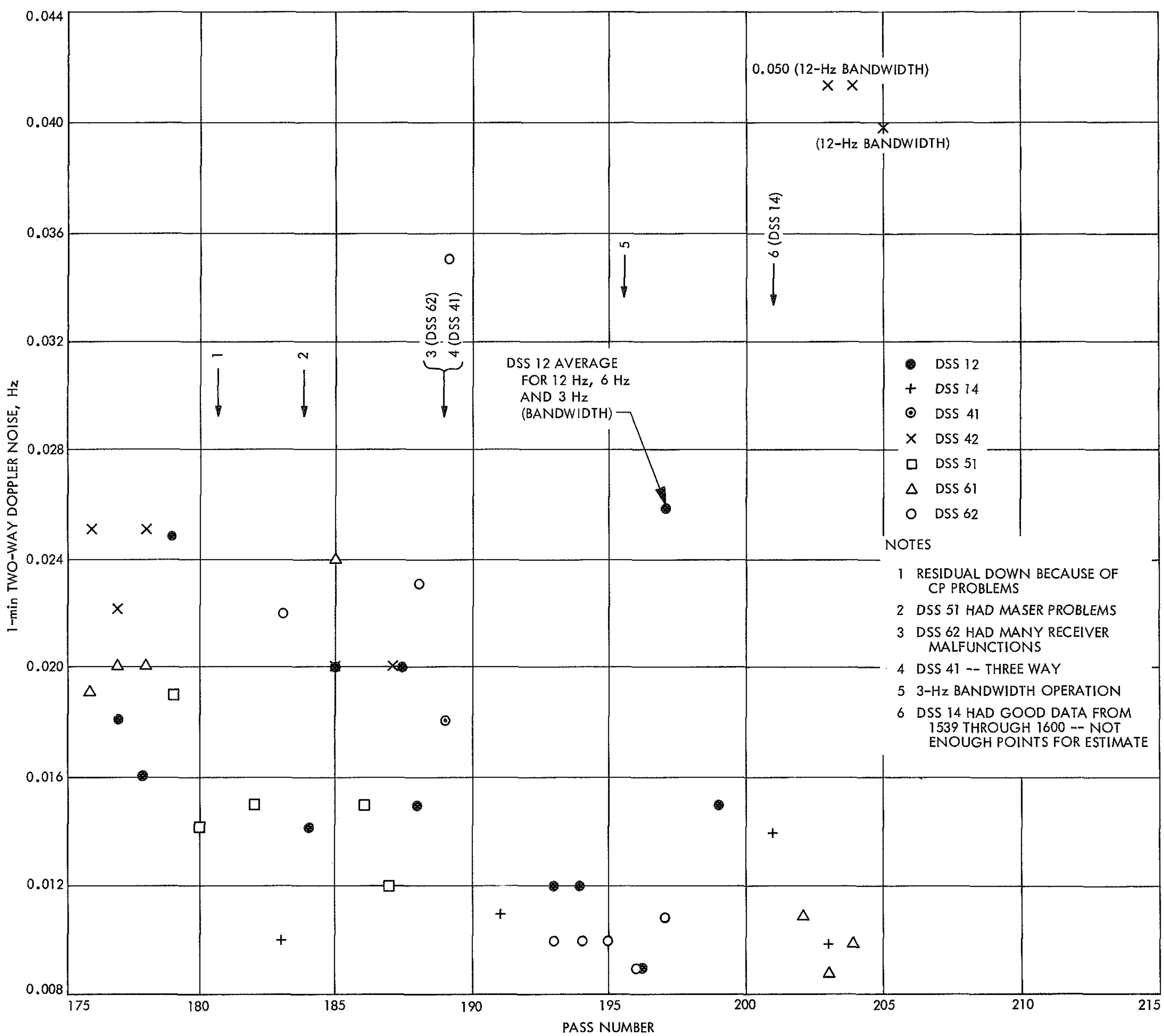


Fig. 88. Residual 1-min two-way doppler vs pass number (April 1969) (passes 175 through 206)

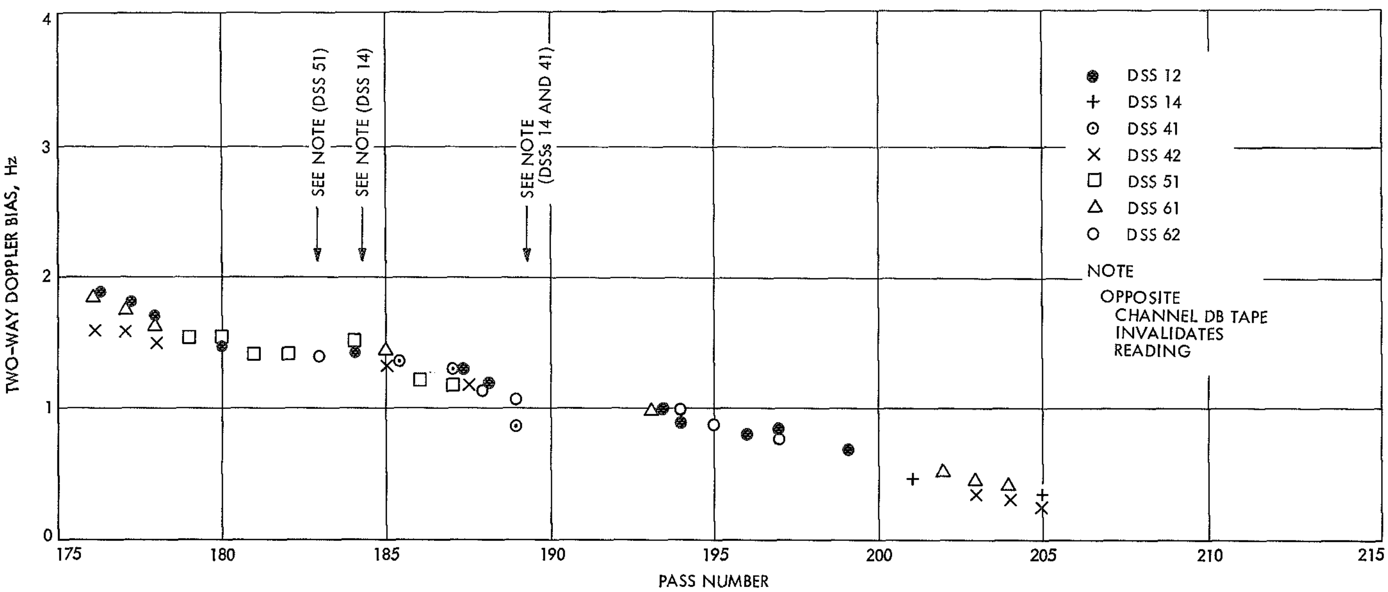


Fig. 89. Doppler bias vs pass number (May 1969) (passes 175 through 206)

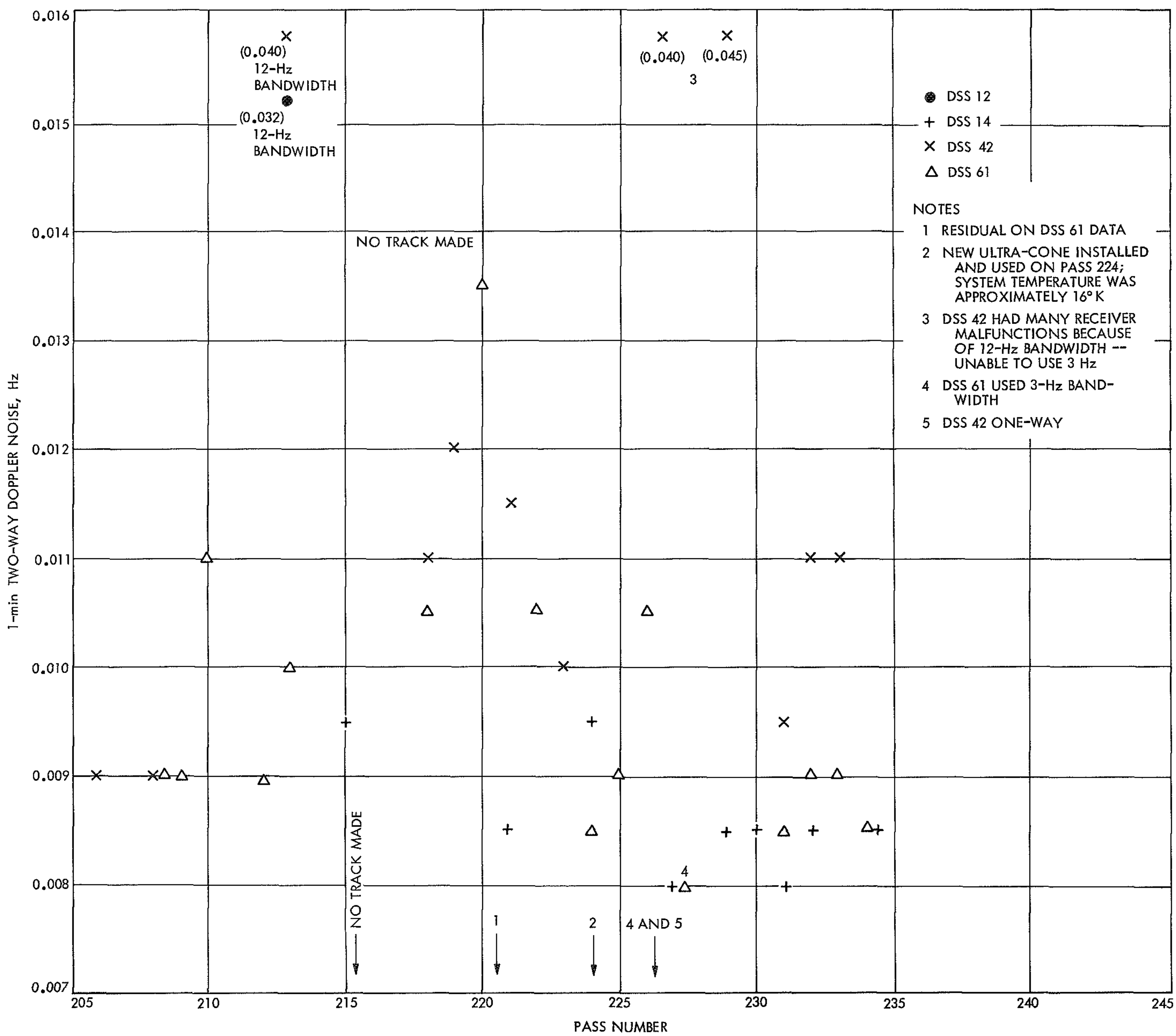


Fig. 90. Residual 1-min two-way doppler noise vs pass number (June 1969) (passes 206 through 236)

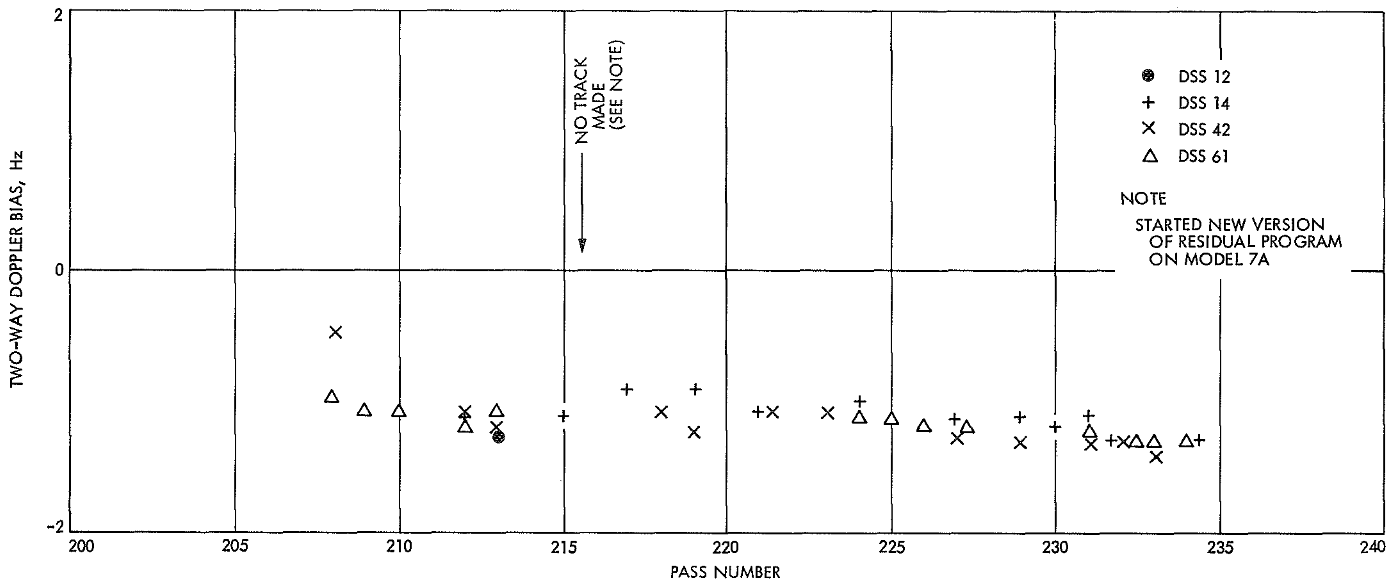


Fig. 91. Doppler bias vs pass number (June 1969) (passes 206 through 236)

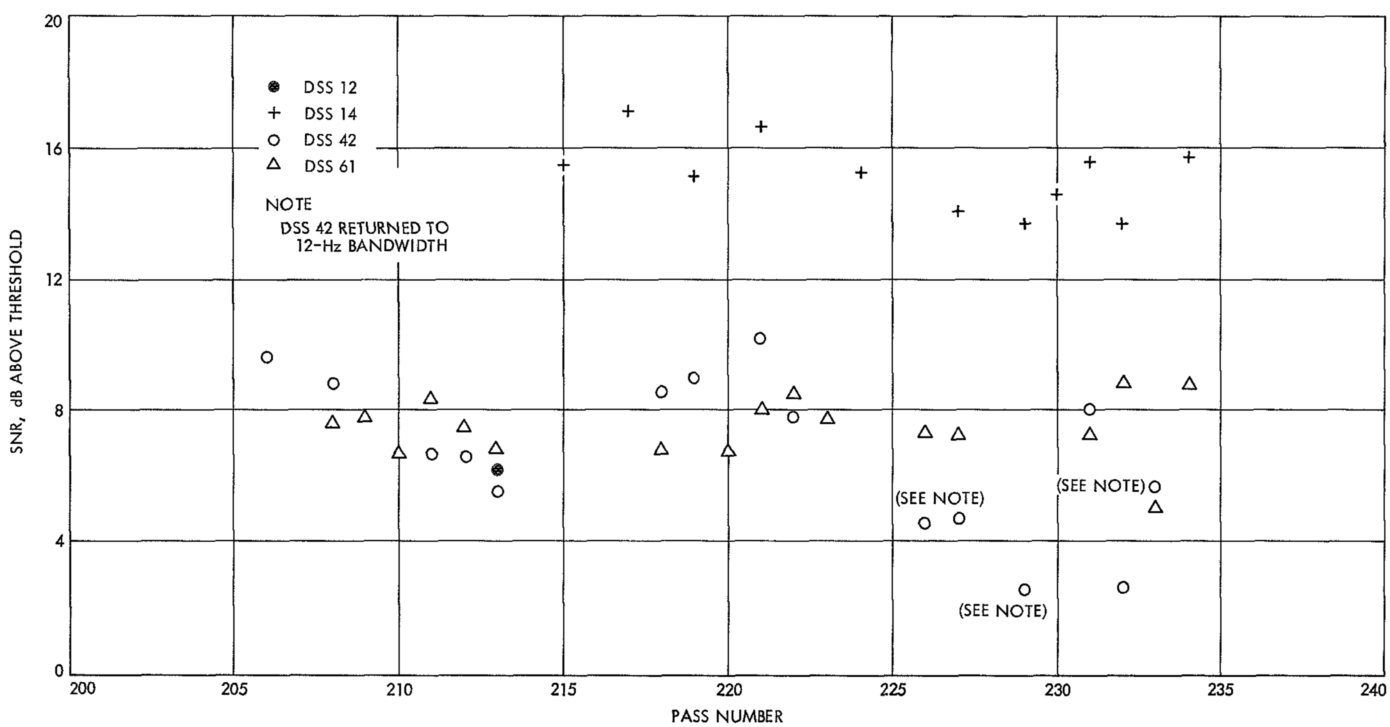


Fig. 92. Signal-to-noise ratio vs pass number (June 1969) (passes 206 through 236)

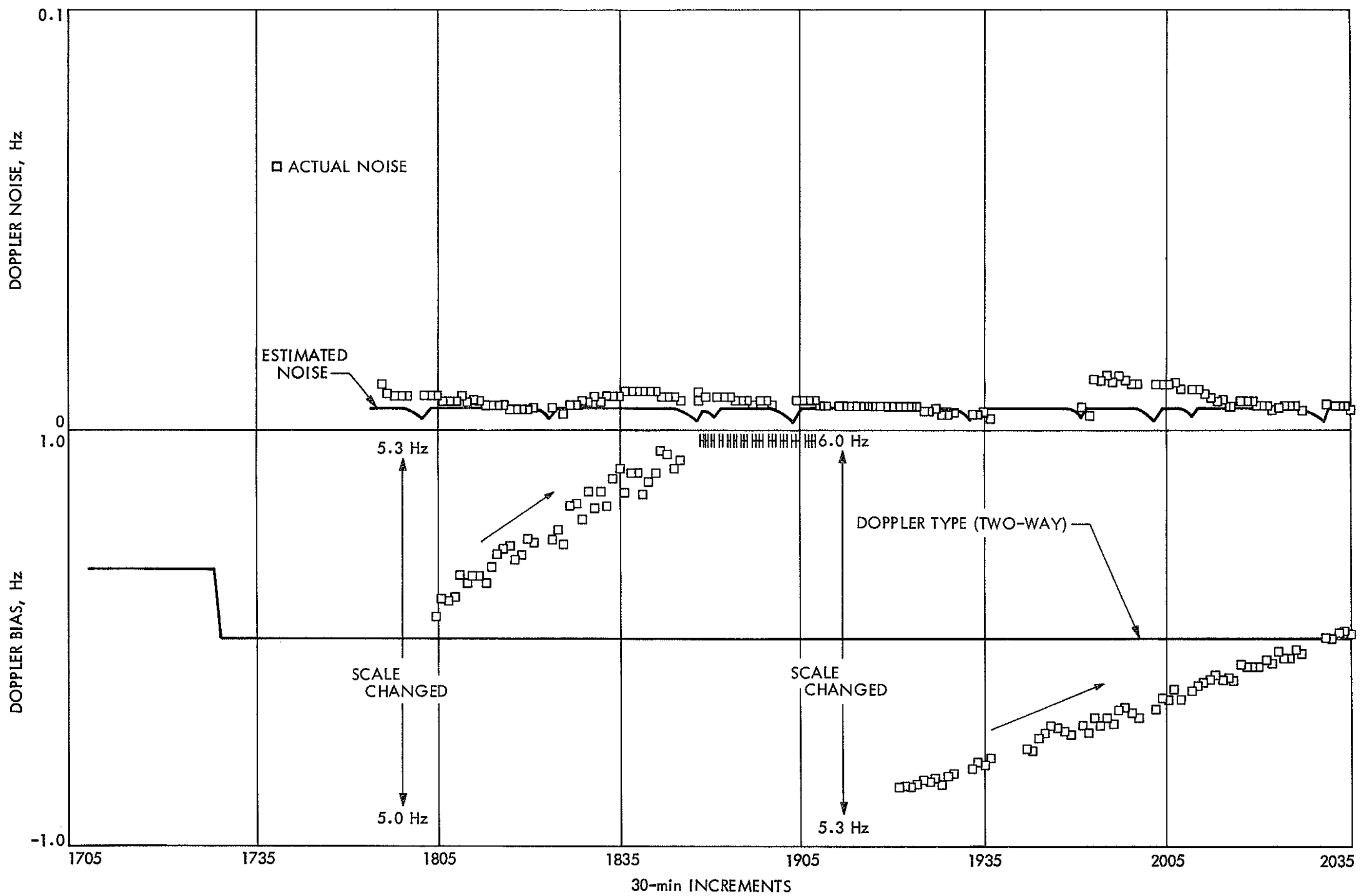


Fig. 93. DSS 12 effects of early doppler trend (pass 61)

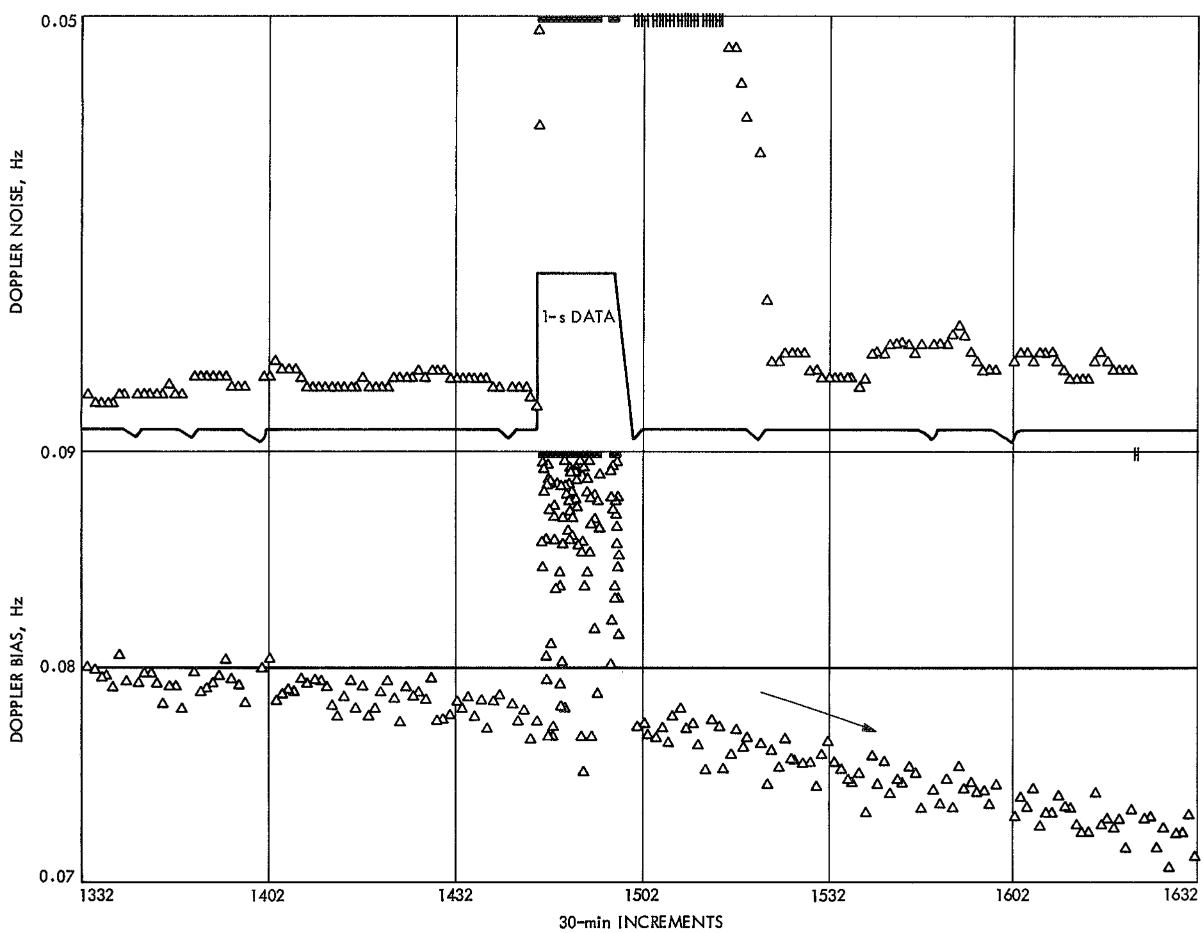


Fig. 94. DSS 61 effects of late doppler trend (pass 60)

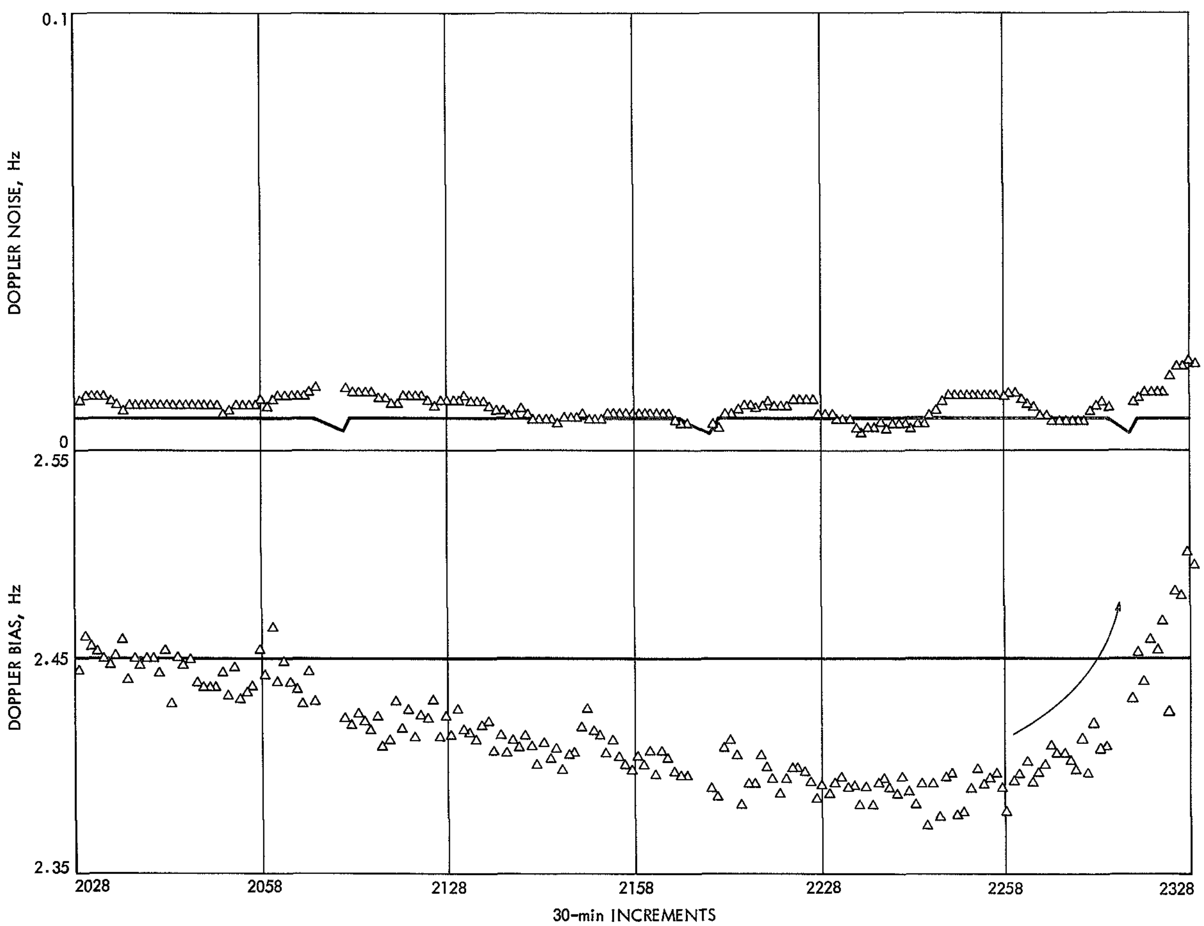


Fig. 95. Apparent effects of index of refraction (DSS 12, pass 100, day 046)

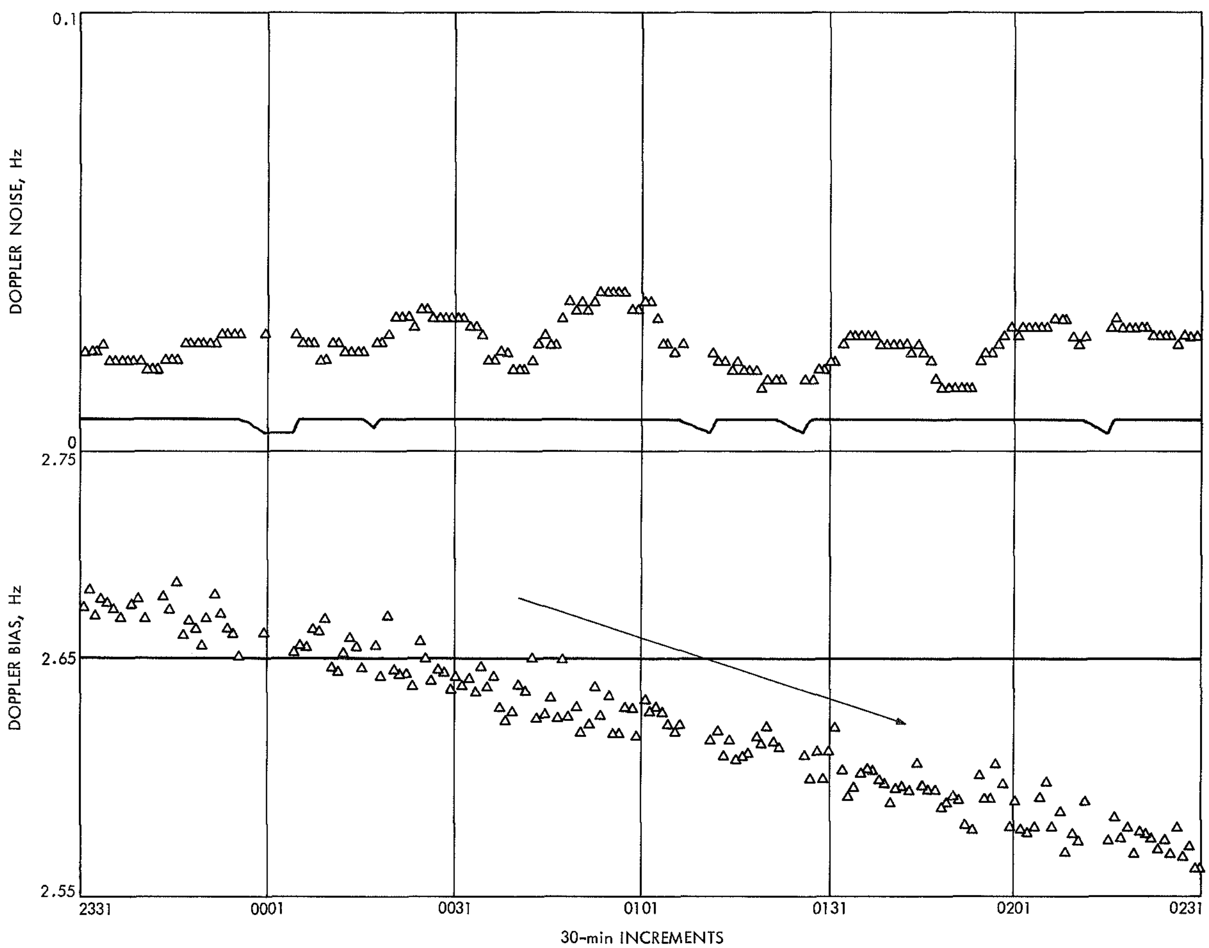


Fig. 96. Effects of early–late doppler trend (DSS 42, pass 109, day 054)

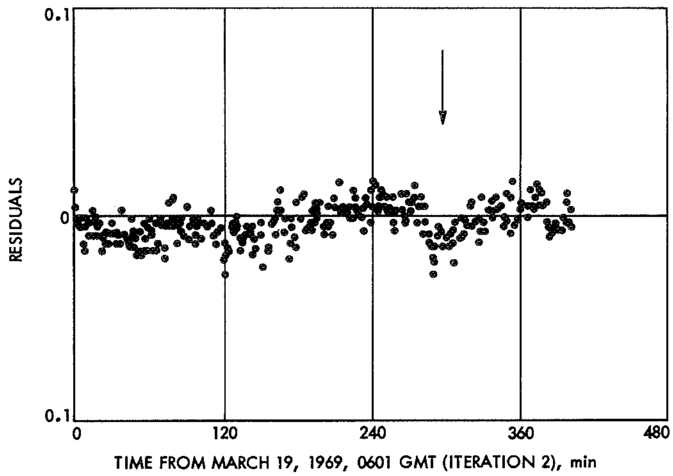


Fig. 97. Single precision orbit determination program true residuals (pass 132)

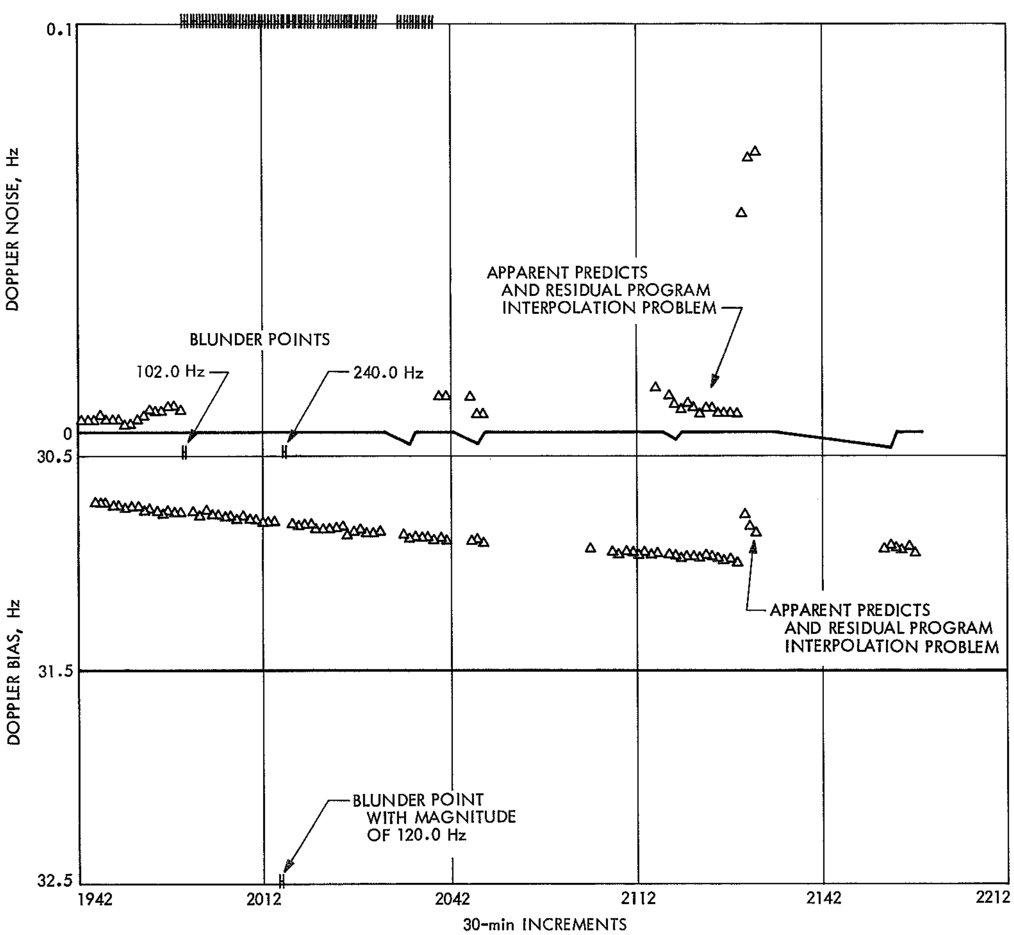


Fig. 98. Effects of special doppler trends (DSS 14, pass 183, day 129)

Figure 66 illustrates the estimated doppler noise as derived from the residuals during January 1969. On pass 84 at DSS 42, the doppler noise value was estimated at 0.014 Hz. This value was above the predicted nominal value of 0.013 Hz, apparently a result of the inferior conjunction.

Figure 67 illustrates the effects of the inferior conjunction on the DSS 42 two-way coherent doppler. The dash part of the curve indicates a characteristic trend which occurred because of a higher system temperature. It may be possible to represent this dash curve by a form of an exponential equation such as

$$\sigma = Ae^{\beta T}$$

where:

σ = standard deviation

A = some constant

β = some constant

T = system temperature (°K)

e = exponential

This requires verification by a more detailed analysis. Since the inferior conjunction caused a much higher system temperature, a degradation in the SNR resulted. In Fig. 68, the SNR degradation range was from 3 to 12 dB at the maximum (0.65) sun–earth–spacecraft inferior conjunction angle.

The February 1969 estimated and nominal doppler noise values are illustrated in Fig. 69. The doppler noise values are below the nominal value of 0.013 Hz, which is based on a predicted interval of 10-min step size appearing on the D8 tape. The observed doppler data were differenced against the D8 tape (observed minus predicted). The higher doppler noise value on pass 113 at DSS 42 was investigated by fitterate; no apparent problem was noted with the data quality.

A residual data point was lost due to *Mariner VI* testing and checkout at the SFOF. This data point is indicated in Fig. 69.

The March estimated and nominal doppler noise values are illustrated in Fig. 70. The doppler noise values were below the nominal value of 0.013 Hz except for pass 137 at DSS 42.

The higher doppler noise value of pass 137 at DSS 42 was investigated and the blunder points were noted at 0138:02 with a magnitude of 10 Hz, and at 0141:02 with a magnitude of 120 Hz. The blunder points are illustrated in Fig. 71 and are noted by the HHHH on the noise and bias scale indicators. The doppler data indicate that the apparent cause of the blunder point was caused by the receiver adding counts, and not the doppler counter in the TDH subsystem. Other real-time residual illustrations are shown in Figs. 72, 73, and 74.

In Fig. 75, the 1-s data for January 1969 illustrate that the stations apparently tracked below the nominal noise level of 0.100 Hz. This information was verified by a fitterate run on the data from pass 65 at DSS 62 (see Fig. 75).

The 6- and 10-s data indicate that the data from DSS 12 was above nominal. This nominal noise level apparently was due to the maser problem and the inferior conjunction experienced during this period.

The effect of the higher noise level at the Deep Space Station is illustrated in Fig. 76, but not enough data points were available to verify the noise-level trend. However, the equation $\sigma = Ae^{\beta T}$ may be used for further analysis of the noise trend, as indicated in Fig. 77.

In Fig. 78, the 1-s data for February 1969 illustrate that the stations apparently tracked on or below the nominal noise level of 0.100 Hz. The 6- and 10-s data were apparently tracked on or below the nominal noise level of 0.040 Hz.

In Fig. 79, the 1-s data for March 1969 illustrate that the stations apparently tracked on or below the nominal noise level of 0.130 Hz. The quality of the data estimated appears to be good during March. This quality was verified by checking the fitterate output. An analysis of the fitterate output may be found in the fitterate portion of this document.

3. Doppler bias trend. The doppler bias for January 1969 is illustrated in Fig. 80. The doppler bias ranged from approximately ±0.6 to ±1.9 Hz. The low bias indicates that the state vector supplied was useful for the operational Deep Space Station predictions.

The doppler bias trend for February 1969 is illustrated in Fig. 81. The doppler bias ranged from approximately

±2.0 to ±2.77 Hz. The low bias trend indicates the state vector supplied was useful for the operational Deep Space Station predictions during this interval. Type I and Type II orientations were performed on pass 90 at Deep Space Stations 11 and 17. Because of the lack of tracking data, no analysis was made of the results of these orientations.

As shown in Fig. 82, during March 1969, the doppler bias ranged from approximately ±2.6 to ±3.1 Hz. The low bias trend indicates that the state vector supplied was useful for the operational Deep Space Station predictions.

The estimated and nominal doppler noise values for April 1969 are illustrated in Fig. 83. The predicted nominal doppler noise value indicates an exponential growth from 0.013 to 0.030 Hz (Figs. 83 and 84). This exponential trend is a result of the rapidly changing threshold condition reached by *Pioneer IX*.

Figure 85 is a residual plot for pass 146 at DSS 61. This figure illustrates the March 1969 doppler offset, which was apparently due to the telemetry command processor lamp bank failure. The doppler offset was observed and also noted in real-time by network analysis team (NAT) personnel. The doppler offset was due to the overload of the 1 pulse/s derived from the PC 141 clock in the frequency and timing subsystems. This failure was corrected by DSS 61 and did not reappear after pass 152.

The higher noise value started on pass 162 at Deep Space Stations 42 and 61 because of the rapidly approaching threshold conditions. A theoretical nominal curve was provided to estimate the bounds of good data (see Fig. 84). The higher doppler noise estimates experienced appear to be an exponential curve which theoretically follows the threshold conditions when using a 2 B_{LO} of the 12-Hz bandwidth.

On pass 173, DSS 12 experimentally changed from the 2 B_{LO} of 12-Hz bandwidth to the 2 B_{LO} of 3-Hz bandwidth. An apparent imrovement in doppler noise was evident on passes 173 and 174 because of the 3-Hz bandwidth.

In Fig. 86, the 1-s data illustrate that the stations apparently tracked on or below the nominal noise level of 0.13 Hz until pass 160. The small growth in the nominal noise value from 0.21 to 0.25 Hz was a result of the threshold conditions.

The April 1969 doppler bias trend is illustrated in Fig. 87; the doppler bias ranged from approximately ±2.9 to ±1.80 Hz. The low bias trend indicates that the state vector supplied was useful for the operational Deep Space Station predictions.

The two-way doppler data are illustrated in Fig. 88 for May 1969. A higher noise trend between passes 176 and 190 is shown. After pass 190, the noise decreased significantly; i.e., from an average of 0.020 Hz to 0.010 Hz.

Decrease in noise apparently resulted from the use of a 3-Hz bandwidth. On pass 197 at DSS 12, the signal strength above threshold was less than 10 dB. On this pass, a special test was conducted at a different receiver 2 B_{LO} bandwidth. The results of the average noise are estimated in Table 31. There is an apparent decrease in noise at 3-Hz bandwidth.

Table 31. *Pioneer IX* receiver bandwidth test results (May)

Bandwidth, Hz	Average doppler noise $\bar{\sigma}$, Hz	Down-link, dBmW	Up-link, dBmW
12	0.045		
6	0.022	−165.6	−130
3	0.011		

The doppler bias trend for May is illustrated in Fig. 89; the doppler bias ranged from approximately 1.9 Hz to ±0.9 Hz. The low bias trend indicated that the state vector supplied by the orbit determination group was useful for the operational Deep Space Station predictions.

The June 1969 two-way doppler data are illustrated in Fig. 90. Generally, the noise was below the estimated nominal value; however, the higher noise on passes 213, 227, and 229 at Deep Space Stations 12 and 42 was apparently due to the use of the 12-Hz bandwidth above the threshold. The doppler bias trend for June 1969 is illustrated in Fig. 91; the doppler bias ranged from approximately −1.0 to −1.34 Hz.

Figure 92 illustrates the actual decibels above threshold during June. The lower SNR at DSS 42 was apparently a result of the use of the 12-Hz bandwidth during passes 226, 227, 229, and 232. An 8-dB margin with the 3-Hz bandwidth occurred on pass 231 at DSS 42. Since a margin of 3 to 5 dB was indicated for a 12-Hz bandwidth, a 3-dB improvement is valid when using a 3-Hz bandwidth configuration. The data deviation appears to be within the tolerance of ±3 dB.

4. Doppler trend special analysis. An early doppler trend was noted in January at DSS 12 (Fig. 93). Also, a similar trend was noted at DSS 61, but near the end of the pass (Fig. 94). The problem was investigated by the orbit determination and the SDA groups. The investigation included the station locations, and the refraction model was used in reducing data. The areas of investigation were radius and longitude uncertainties in station location, and estimated index of refraction (DSS 12, $N = 240$). The index of refraction for pass 61 at DSS 12 could not be calculated because of a lack of temperature and barometer readings.

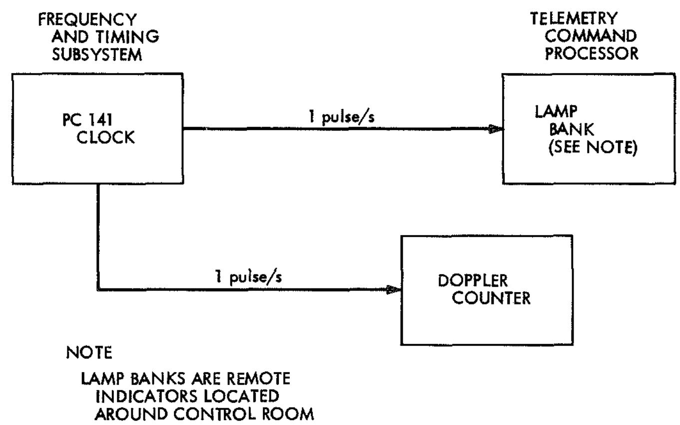
Then, during the February 1969 report period, a new problem developed, as illustrated in Fig. 95. increase in the doppler bias cusp trend near the end of the track was believed to be a result of the index refraction correction stored in the prediction program. The index of refraction is equivalent to $NN = 360$ for *Pioneer IX* predicts. It appeared that $NN = 240$ could better approximate the index of refraction correction for the higher-altitude stations, such as Deep Space Stations 12, 61, and 62. Plans were continued to check $NN = 240$ for future prediction purposes.

In addition to the station-location uncertainties, Fig. 96 indicates that the early–late doppler trend was possibly due to use of the D8 tape; that is, a channel 6 D8 tape was used when tracking two-way coherent data on channel 7 or *vice versa.*

Figure 97 illustrates a single precision orbit determination program plot of true residuals. These residuals are the difference between the actual tracking data and the calculated data from the orbit determination process. The plot labels for Fig. 98 are CC3 for two-way data (Hz) vs time starting at 0600:01.

On pass 132 at DSS 61, the doppler shifted at approximately 1020 GMT (Fig. 97). This problem was noted by the station and verified by the pseudo-residual illustrations. This failure was a result of a faulty lamp bank readout at the telemetry command processor. The block diagram of the configuration here explains how this failure can be detected by the doppler counter. Because of a faulty lamp bank in the telemetry command processor, an apparent overload on the 1 pulse/s at the doppler counter shifted the doppler frequency as indicated in Fig. 97. The SDA investigated.

Figure 98 is a residuals plot for pass 183 at DSS 14 illustrating several blunder points at 102(H), 240(H), and 120(L) cycles. The blunder points are shown by the letters *H* and *L* in the doppler bias. The blunder point effect is a long string of *HHHHHHH* in the doppler noise due to the size of the noise estimator table (15 points were used in computing the noise). The double-sided *H* and *L* blunder points were apparently the result of a problem in the doppler counter or timing subsystem. The doppler offset at approximately 2137 GMT was apparently a result of the prediction and pseudo-residual interface problem of interpolation.



E. Metric Data

An analysis of the *Pioneer IX* anomalies for June 1969 only is presented in this section. A summary by pass number of the *Pioneer IX* metric performance is given in Table 32. All column headings are self-explanatory except P_{noise} (dBm) and the text/plot number. The noise power P_{noise} at receiver threshold is used to compute the SNR (decibles above receiver tracking threshold). The receiver can maintain a very narrow noise bandwidth (with values ranging from 3 to 152 Hz) centered around the received carrier, or IF, frequency.

The VCO phase lock loop tracks the incoming signal as shifted by the presence of the doppler. The doppler extractor continuously provides the two-way doppler frequency, a 1-MHz bias, as present on the received carrier frequency. The doppler shift is accumulated by a frequency counter. The noise in the counted doppler is thus correlated to the amount of phase jitter appearing on the detected carrier frequency.

Table 32. Metric data (June 1969)

Pioneer IX				Receiver					Tracking Data					System Failure/Anomaly	
Date	Day	Pass	DSS	$\overline{SS}$ (dbm)	SNT (°K)	Bandwidth (Hz)	DB Above Tracking Threshold	P_{Noise} DBM	Estimated Noise, σ Hz	Actual Noise, σ Hz	HA Residual	DEC Residual	Number of Blunder Points	Text/Plot Number (Para Ref)	Comments
6/1/69	152	206	42	-166.0	38.0	3 12	9.5 6.27	-175.5 -172.3	0.013	0.011	-0.003	-0.003	7	3a	RCVR glitches throughout pass.
6/2/69	153	208	42	-165.5	37.0	3	8.98	-174.4	0.013	0.011	-0.007	-0.005	1		RCVR glitches throughout pass.
6/3/69	154	208	61	-166.4	51.0	3 12	7.41 5.87	-173.8 -172.3	0.015	0.014	-0.004	-0.002	0		Many RCVR glitches throughout pass.
6/4/69	155	209	61	-166.7	55.8	3 12	7.86 5.57	-174.5 -172.2	0.015	0.015	-0.006	-0.002	2		Many RCVR glitches throughout pass.
6/5/69	156	210	61	-167.5	48.0	3 12	6.66 4.77	-174.1 -172.2	0.016	0.017	-0.002	-0.003	2		Many RCVR glitches throughout pass.
6/6/69	157	211	14	-159.0	24.0	12	N/A	N/A	N/A	N/A	N/A	N/A		3b	One-way only. DSS 14 performed a special test for polarizer angle data.
6/6/69	157	211	61	-167.5	51	3	8.3	-175.8	0.014	0.011	-0.003	-0.005	3		RCVR glitches due to the marginal signal level.
6/6/69	156/157	211	42	-166.0	45	12	6.4	-172.4	0.016	0.060	-0.002	-0.002		3c	Doppler data was noisy during entire pass. A suspect card was written.
6/7/69	157/158	212	42	-166.5	45	12	6.3	-172.8	0.016	0.045	-0.002	-0.005			The noisy doppler data was apparent due to the tracking threshold margins.
6/7/69	158	212	61	-167.5	47	3	7.4	-174.9	0.015	0.011	-0.004	-0.002			Data was normal.
6/8/69	158/159	213	42	-166.5	40	12	5.5	-172.0	0.016	0.040	-0.005	-0.003			Data was suspected.
6/8/69	159	213	61	-167.3	45	3	6.9	-174.2	0.015	0.013	-0.004	-0.001			Data was normal.
6/8/69	159	213	12	-165.8	46	12	6.2	-172.0	0.015	0.032	-0.002	-0.025			Data suspected due to high noise.
6/10/69	161	215	14	-158.5	27	12	15.5	-174.0	0.011	0.012	0.005	0.010			Data was normal.
6/12/69	163	217	14	-158.8	24	12	17.2	-175.0	0.011	0.012					Data was normal. Angle data missing due to master equatorial up-date.
6/13/69	163/164	218	42	-168.0	45	3	8.5	-176.5	0.014	0.015	-0.005	-0.005			Data was normal.
6/13/69	164	218	61	-168.0	44	3	6.9	-174.9	0.016	0.014	-0.003	-0.001			Data noise was computed using Resid system Model 7A version.
6/14/69	164/165	219	42	-166.5	75*	12	9.0	-175.5	0.014	0.017	+0.070	+0.060			*
6/14/69	165	219	14	-158.6	24	12	15.1	-173.7	0.011	0.006	-0.003	-0.001			Data was normal.

Table 32 (contd)

Pioneer IX				Receiver					Tracking Data					System Failure/Anomaly	
Date	Day	Pass	DSS	$\overline{SS}$ (dbm)	SNT (°K)	Bandwidth (Hz)	DB Above Tracking Threshold	P_{Noise} DBM	Estimated Noise, σHz	Actual Noise, σHz	HA Residual	DEC Residual	Number of Blunder Points	Text/Plot Number (Para Ref)	Comments
6/15/69	166	220	61	-169.3	44	3	6.7	-176.0	0.014	0.020	-0.001	-0.035		3d	A bad frequency shifter prevent normal acquisition.
6/16/69	166/167	221	42	-166.0	51	3	10.1	-176.1	0.013	0.016	0.035	0.038			Data was normal.
6/16/69	167	221	14	-158.4	24	12	16.6	-175.0	0.011	0.010	+0.005	+0.001			Data was normal.
6/16/69	167	221	61	-166.9	44	3	8.0	-174.0	0.014						No Resid due to merge tape problems.
6/17/69	168	222	61	-167.5	45	3	8.4	-175.9	0.014	0.014	-0.003	-0.003			Data was normal.
6/18/69	168	223	42	-168.0	55	3	7.9	-175.9	0.014	0.013	+0.049	+0.051			Data was normal.
6/19/69	170	224	61	-167.0	45	3/12	7.9	-174.9	0.014	0.010	-0.002	-0.004			Data was normal.
6/19/69	170	224	14	-159.8	25	12	15.2	-175.0	0.011	0.012	-0.035	0.012		3e	Angle reading off in DEC due to a Datex problem.
6/20/69	171	225	61	-168.7	45	3	7.4	-176.1	0.014	0.011	-0.001	-0.003			Data was normal.
6/21/69	171/172	226	42	-167.5	50	12	4.5	-172.0	0.018	0.045	+0.045	+0.045			One-way during entire pass.
6/21/69	172	226	61	-168.5	46	3	7.2	-175.7	0.014	0.014	-0.006	-0.004			Data was normal.
6/22/69	172/173	227	42	-167.8	53	12	4.6	-172.4	0.014	0.040	+0.045	+0.050			Data was normal.
6/22/69	173	227	14	-158.5	25	12	14.0	-172.5	0.012	0.009	-0.020	-0.010			Data was normal.
6/22/69	173	227	61	-168.1	45	3	7.1	-175.2	0.014	0.009	-0.005	-0.003			Data was normal.
6/24/69	174/175	229	42	-168.0	45	12/3	2.5	-170.5	0.019	0.045	-0.004	-0.003		3f	Site had RCVR 3 Hz BW problem.
6/24/69	175	229	14	-158.3	24	12	13.7	-172.0	0.012	0.009	-0.020	-0.010		3g	TDH printed erroneous EXC VCO frequency.
6/25/69	176	230	14	-157.5	23	12	14.5	-172.0	0.011	0.010	-0.012	-0.015			Data was normal.
6/26/69	176/177	231	42	-167.0	48	3	8.0	-175.0	0.014	0.012	-0.003	+0.005			Data was normal, but RCVR glitches occurred during pass.
6/26/69	177	231	14	-158.2	24	12	15.8	-174.0	0.011	0.009	-0.010	-0.020			Data was normal.
6/26/69	177	231	61	-167.6	45	12/3	7.11	-174.7	0.015	0.010	-0.004	+0.005			Data was normal.
6/27/69	177/178	232	42	-169.5	47	12	2.5	-172.0	0.019	0.015	-0.005	-0.005			Station went down to replace Klystron in maser.

Table 32 (contd)

Pioneer IX				Receiver					Tracking Data					System Failure/Anomaly	
Date	Day	Pass	DSS	$\overline{SS}$ (dbm)	SNT (°K)	Bandwidth (Hz)	DB Above Tracking Threshold	P_{Noise} DBM	Estimated Noise, σHz	Actual Noise, σHz	HA Residual	DEC Residual	Number of Blunder Points	Text/Plot Number (Para Ref)	Comments
6/27/69	178	232	61	-167.2	46	3	8.9	-176.1	0.014	0.011	-0.002	-0.001			Data was normal.
6/27/69	178	232	14	-158.2	25	12	13:8	-172.0	0.012	0.010	-0.090	-0.009			Data was normal.
6/28/69	178/179	233	42	-166.7	51	12	5.7	-172.4	0.016	0.015	-0.004	-0.002			Data was normal.
6/28/69	179	233	61	-167.4	45	3	5.0	-172.4	0.016	0.011	-0.001	-0.002			Data was normal.
6/28/69	180	234	14	-158.1	25	12	15.9	-173.0	0.011	0.010	-0.025	-0.009			Data was normal.
6/29/69	180	234	61	-167.2	48	3	8.7	-175.9	0.014	0.010	-0.002	-0.002			Data was normal.

*The site reported that the pre and post calibrations of system noise temperature measurements were normal. The higher SNT noise was apparently due to the TWM 1 exhibiting excessive gain variations caused by water entering associated antenna mounted box junction.

The noise power at receiver threshold is computed as

$$P_{\text{noise}} = 10 \log \left[\frac{KT_s(BW)}{10^{-3}}\right] \text{dBm}$$

and the SNR (decibel margin above receiver threshold) as

$$\text{SNR} = (P_c) - (P_{\text{noise}})$$

where

P_{noise} = noise power at receiver threshold, dBmW

K = Boltzmann constant (1.38×10^{-23} W-s/deg)

T_s = effective system noise temperature, °K

P_c = received signal level, dBm

BW = received noise bandwidth, Hz

Any difference between P_{noise} calculated and the receiver threshold measured at the station is due to the tolerances of the measuring equipment, which have been given as ±3 dB.

An example of the actual noise power and the SNR per values recorded for pass 221 at DSS 42 is as follows:

$$P_{\text{noise}} = 10 \log \left[\frac{KT_s(BW)}{10^{-3}}\right]$$

$$P_{\text{noise}} = 10 \log \left(\frac{1.38 \times 10^{-23}\,\text{W-s} \times 48.3°\text{K} \times 3}{x \deg x \text{ s}}\right)$$

$$P_{\text{noise}} = 10\,(-23 + 0.14 + 1.68 + 0.478 + 3)$$

$$P_{\text{noise}} = -176.4\,\text{dBmW (site log is 176.1 dBmW)}$$

Then

$$\text{SNR} = (P_c) - (P_{\text{noise}})$$

$$\text{SNR} = -166.0 - (-176.7)$$

$$\text{SNR} = 10.7\text{ dB (natural log 10.1 dB)}$$

Because of the small differences as noted, Table 32 contains the actual receiver threshold value reported by the Deep Space Stations for P_{noise} along with the actual T_s.

The text/plot number gives the text paragraph number covering the system failure/anomaly explanation and the number of any figure associated with the explanation.

Explanations for the symbols contained in the text/plot number column are as follows:

(3a) Receiver malfunctions occurred throughout the pass. The station acquired the spacecraft by using a 12-Hz bandwidth, but tracked using the 3-Hz bandwidth.

(3b) A special test was carried out to obtain optimum polarization angle data. During this unscheduled track, the station was unable to use telemetry command processor alpha and beta computers together. The telemetry command processor beta computer operated normally in the emergency mode. The measured readings from the special test are listed in Table 33.

(3c) The doppler data were noisy during this pass; consequently, a suspect card was written. In addition, there was difficulty with the VCO counter of the station.

(3d) The station had trouble in acquiring the spacecraft because of a bad frequency shifter in the doppler extractor (TFR-141700). The frequency shifter 57/221 module was replaced and the track continued.

(3e) The declination angle on the TDH printout read 5.6 deg because of a Datex problem at the site. The Datex angle binary-coded decimal output was in error. This error was an input to the TDH at the site; consequently, the angle error was sent to the SFOF.

Table 33. Measured readings

Time	Azimuth, deg	Elevation, deg	Polarization angle, deg
1952	255.5	34.7	15
2030	262.11	27.15	20

Appendix

Pioneer E—Prelaunch to Destruct

I. Introduction

The plans, requirements, data, and performance analysis for the Tracking and Data System (TDS) support of *Pioneer E* are covered in this part of the report. The period covered is from the beginning of the prelaunch phase, July 18, 1969, through the 438 s of flight, August 27, 1969. At that time, a destruct signal was transmitted. *Pioneer E*, the fifth spacecraft in the second *Pioneer* generation, was the only failure (launch vehicle failed).

Primary concern of this document is the activities of the Deep Space Network (DSN), managed by the Jet Propulsion Laboratory at Pasadena, Calif., in support of the *Pioneer E* flight. The *Pioneer* Project required the DSN to establish down-link signal acquisition and telemetry demodulation not later than $L+1$ h. The DSN had the support responsibility throughout the life of the *Pioneer E* spacecraft.

General information on systems, facilities, and activities and Project history is given in the main part of this volume.

A. *Pioneer E* Mission

The *Pioneer E* spacecraft was essentially identical to *Pioneer IX* that was launched in November 1968. However, the trajectory of *Pioneer E* was designed to keep the spacecraft near the earth for approximately 900 days instead of traveling directly into an inward or outward orbit around the sun. This orbit would have enabled the spacecraft to investigate interplanetary phenomena in the vicinity of the earth and to transmit data at 512 bits/s for almost 3 yr. To accomplish this, the spacecraft necessarily would have needed to be within 1.32×10^7 km of the earth and within 4×10^5 km of the ecliptic plane. The heliocentric orbit constraints of the mission were as follows:

(1) No earth or moon impact.

(2) Orbit inclination less than 0.2 deg with respect to the ecliptic.

(3) Heliocentric radius $> 0.76 < 1.07$ AU.

B. Prelaunch Testing, Flight Requirements, and Support

The *Pioneer E* test schedule underwent several changes because the launch date was changed from June until late August, and the DSN was heavily loaded by *Mariner* Mars 1969 and *Apollo* activities. The tests completed prior to June were in preparation for a June 18, 1969, launch readiness date. Since these tests had been completed satisfactorily, some were not rerun in August.

Actual prelaunch preparation began upon arrival of the *Pioneer E* spacecraft at AFETR on July 18, 1969. The spacecraft was set up and system tests were begun within 20 working days. After the spacecraft was integrated with the third stage, they were placed on the launch pad at Complex 17-A on August 13, 1969.

The TDS operations organization for *Pioneer E* was nearly the same as for *Pioneer IX*. Two exceptions were as follows: the MSFN station at Honeysuckle Creek, Australia, was to be the prime backup station for initial acquisition; and the DSN was to participate with the MSFN in an engineering demonstration of S-band support to MSFN downrange stations. This was designed to provide real-time transmission of spacecraft telemetry data through a high-speed data line to the SFOF, where arrangements had been made to display the data for the *Pioneer* Project. This required an additional interface through the track chief and the DSS 42 station director with the MSFN station at Honeysuckle Creek. The DSN Operations Control Center (OCC) had an additional interface with the network controller at GSFC.

1. DSN readiness test. The DSN readiness test on August 11, 1969, was programmed to exercise the data flow paths to be used in the launch and future tests. The participants in the test were the communications and operations personnel of Building AO. The simulated tracking data prepared earlier by the RTCF at AFETR were transmitted from the Building AO communications center, with the DSN spacecraft telemetry data being *back fed* from the SFOF to Building AO. Only problems of a minor nature were encountered. These were corrected by the first operational readiness test.

2. Operational readiness tests. The first operational readiness test in preparation for launch was performed on August 14, 1969. Elements of the AFETR, the MSFN, and the DSN, as well as *Pioneer* Project personnel from Building AE Mission Director's Center (MDC), participated. An August 20, 1969, launch, with a liftoff of

2210:18 on a flight azimuth of 108.0 deg, was simulated. Despite several problems experienced by the near-earth TDS, the test was considered satisfactory. The more significant problems are summarized below.

a. Minus count problems. The JPL voice circuits to Buildings AE and AM and to the SFOF were at a low level. The initial level adjustment was made with Building AE; however, when Building AM was added to the network, the circuits were again at a low level. After two adjustments, the level was good. The teletype distributor at Building AO was distorted and patched out. The problem was subsequently attributed to power supply filtering.

b. Plus count problems. The Grand Turk computer, which processed low-speed tracking data, malfunctioned and Building AO did not receive any of the tracking data from that station; static point was generated instead. The high-speed data from the Grand Turk station were available and were used in the calculation of the parking orbit elements. The Bermuda tracking data were unusable because the ground elapsed time was used instead of GMT. The *Apollo* Instrumentation Ship (AIS) *Vanguard* did not receive the *Pioneer* simulation tape in time for the test.

The Building AO transmit teletype circuit malfunctioned, leaving only two circuits. Although the trouble was not found, the line cleared. Necessary correctional measures were coordinated with each element as required. The corrections were completed by the final operational readiness test on August 21, 1969.

3. Final operational readiness test. This test was accomplished satisfactorily. The minor problems encountered in the plus count follow:

(1) The RTCF 3600A computer was not operationally ready at $T+16$ min; it was back on line at $T+40$ min. The 3600B computer carried the load, with minor delays.

(2) Concurrent launch support by the AFETR required the use of the 3600A computer, with additional delays.

(3) An attempt by the RTCF to transmit predicts for DSS 42 at $T+60$ min to Building AO failed because of a computer problem; retransmission 20 min later was good. The RTCF problems did not cause delays that hampered timely support. The problems were satisfactorily resolved before launch.

Following the final operational readiness test, Deep Space Stations 42 and 12, and Honeysuckle Creek, Australia, underwent a *Pioneer* configuration control test. The spacecraft system compatibility test was performed in conjunction with DSS 71, Building AM, and JPL/SFOF to establish RF compatibility of the spacecraft with a typical Deep Space Station.

4. Telemetry tests. The DSN and MSFN collaborated to develop the capability of transmitting both 64- and 512-bits/s telemetry data from Carnarvon, Australia, and the MSFN downrange stations (Merritt Island, Grand Bahama, Antigua, Ascension, and the *Apollo* Instrumentation Ship *Vanguard*). This capability was planned on a demonstration basis from launch through the end of the Carnarvon view-period. In preparation for this support, the following integration, compatibility, and readiness tests were run:

(1) Three engineering data flow tests consisted of: integration of the telemetry detection equipment, the on-site computer software at the network test and training facility, and the 7044 MMT *Pioneer/Mariner* software and display devices at JPL.

(2) One compatibility test verified the compatibility of the hardware–software system interfaces between Carnarvon and JPL/SFOF.

(3) One DSN system readiness test verified the operational readiness of the high-speed data system to send telemetry to the SFOF and the subsequent processing and distribution to displays.

5. Telemetry test results. All tests were satisfactorily performed, with only three significant problems arising. These were as follows:

(1) The station demodulator locked on the data bar; a procedural correction was established whereby the station inverted the data at the bit synchronizer.

(2) The data transmission unit at GSFC, which interfaced with the network support team monitor program, was unable to hold lock on the data stream. This was corrected by the insertion of a special sync word (24 bits) in the automatic data switching system filler block.

(3) The SFOF internal coordination of the high-speed data operations was unsatisfactory, but this problem was also corrected.

All three of the corrections proved satisfactory during operational readiness test 1 on August 14, 1969.

6. Significant prelaunch activities. Activities that were significant during prelaunch were as follows:

(1) April 14: final experiment calibration.

(2) May 12: FPAC acceptance at SFOF.

(3) May 15: SPAC/SSAC acceptance at SFOF.

(4) May 16: SFOF integration 2.

(5) July 18: receive EGSE.

(6) July 18: receive spacecraft at AFETR.

(7) July 23, 24: DSIF–spacecraft compatibility test.

(8) August 11: DSN system readiness test.

(9) August 13: mate spacecraft third stage to *Delta.*

(10) August 14: operational readiness test 1.

(11) August 19: DSIF–spacecraft compatibility test (on stand).

(12) August 21: operational readiness test 2.

(13) August 25: countdown initiation.

(14) August 26: third-stage servicing.

(15) August 26: second-stage propellant servicing.

(16) August 26: first-stage fueling.

(17) August 27: tower removal.

(18) August 27: LOX fill.

II. Launch Phase Major Events

Pioneer launch phase major events and methods of evaluation are covered in the main part of this volume.

III. *Pioneer E* Tracking and Data System Requirements

A. Near-Earth TDS Requirements

The overall near-earth TDS requirements are shown in Table A-1. The earth track is illustrated in Fig. A-1.

B. AFETR Requirements

1. Tracking coverage requirements. The Class I requirements for C-band, VHF, and S-band tracking coverage during the *Pioneer E* mission near-earth flight phase are presented in Table A-2 and illustrated in Fig. A-2.

Table A-1. Near-earth TDS requirements

Station	Telemetry			Tracking	
	Second stage	Third stage	Spacecraft	C-band	S-band
Merritt Island	USB	— CIF	USB CIF	19.18	—
Cape Kennedy	AE STS	AE STS	DSS 71 STS	—	—
Patrick AFB	—	—	—	0.18	—
Grand Bahama Island	USB	—	USB	—	—
Bermuda	X	—	—	X	—
Grand Turk	—	—	—	7.18	—
Antigua (USB)	X	—	X	—	—
Antigua (AFETR)	X	X	X	—	—
Ascension (AFETR)	X	X	X	12.18	—
Ascension (USB)	X	—	X	—	—
Vanguard	X	X	X	X	—
Pretoria	X	X	X	13.16	—
Tananarive	X	X	—	X	—
Carnarvon	X	—	X	—	—
Honeysuckle Creek	—	—	X	—	X
DSS 42	—	—	X	—	X
DSS 51	—	—	X	—	X

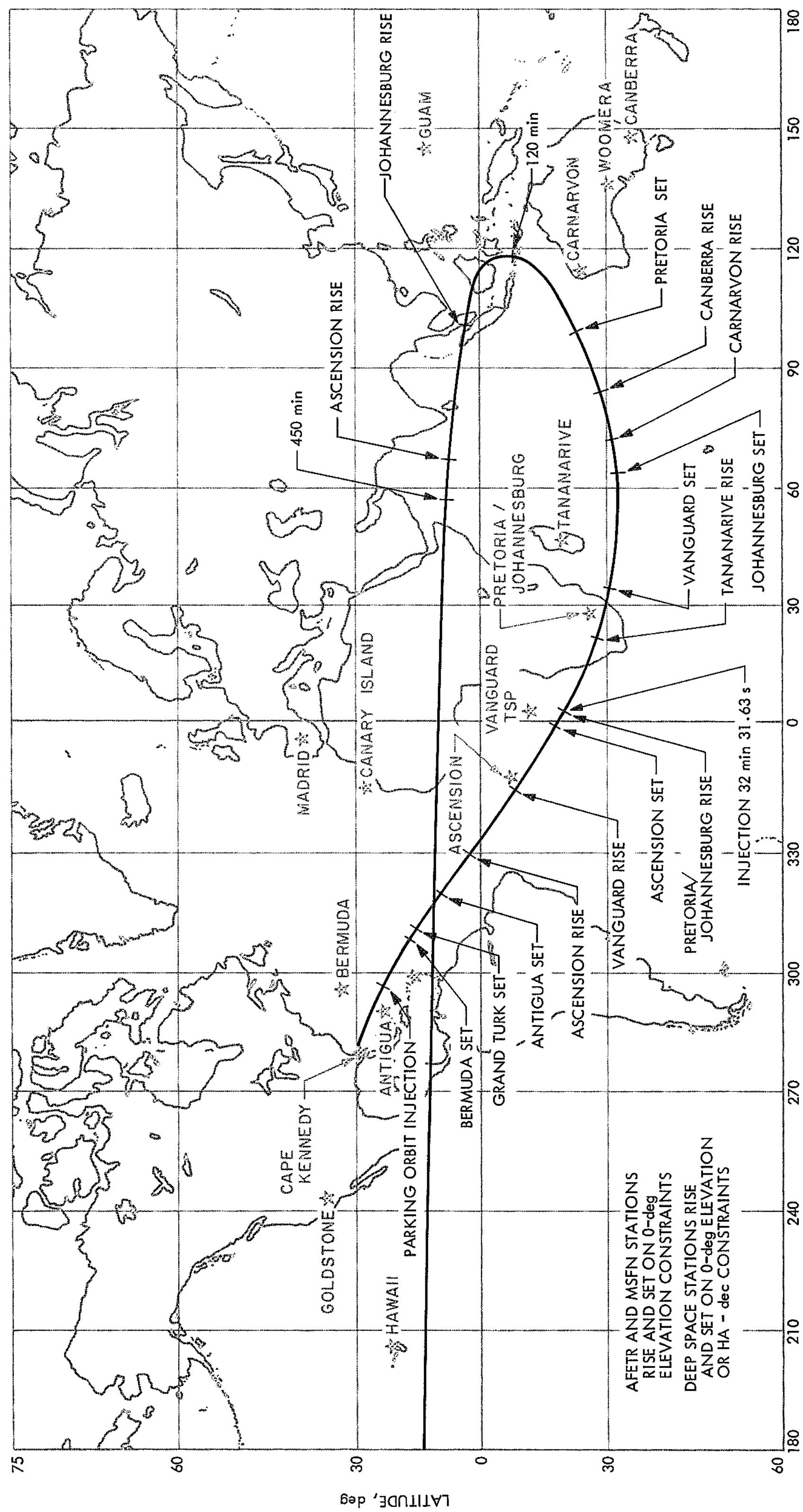


Fig. A-1. Planned *Pioneer E* earth track and station view periods

Table A-2. Class I tracking requirements

Data	Coverage interval
C-band radar	SECO[a] to SECO+60 s
	Third-stage burnout to third-stage/spacecraft separation[b]
VHF telemetry	Second stage (234.0 MHz):
	$L-2$ min to SECO
	Third-stage spinup through third-stage separation
S-band telemetry	Third stage (2250.5 MHz):
	Spinup—30 s through spacecraft separation
	Spacecraft (2292.04 MHz):
	Shroud separation to second-stage cutoff +120 s
	Third-stage spinup to third-stage/spacecraft separation

[a]SECO = sustainer engine cutoff.

[b]This is a Class II requirement, but is shown here because of its relative importance.

2. ***AFETR Real Time Computing Facility.*** The requirements for the AFETR Real Time Computing Facility were as follows:

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

(2) Theoretical solar orbit elements, injection conditions, and inter-range vector based on parking orbit and nominal third-stage performance.

(3) The DSN predicts for Carnarvon, Deep Space Stations 51 and 42 based on the parking orbit and nominal third-stage performance. (The DSS 42 predicts were to be transmitted to the MSFN Honeysuckle Creek station.)

(4) Actual solar orbit elements, injection conditions, and inter-range vector based on post-solar-orbit injection C-band radar tracking data.

(5) The DSN predicts for Deep Space Stations 51 and 42 based on actual solar orbit.

(6) Actual solar orbit elements, injection conditions, and inter-range vector based on DSN metric data.

(7) Heliocentric orbital parameters based on actual solar orbit.

(8) Standard orbital parameters message based on each orbital element solution; in addition, a solution for a 15-day epoch based on the actual solar orbital elements.

3. ***C-band tracking.*** The AFETR configured its radar support of the launch vehicle as indicated in Table A-1. Each radar was assigned to track a specific vehicle beacon and to switch to the other beacon only if its assigned beacon was not trackable. The assignments were as follows:

Station	Vehicle stage
Patrick AFB (0.18)	Second
Merritt Island (19.18)	Third
Grand Turk (7.18)	Second
Ascension (12.18)	Third
Pretoria (13.16)	Third

The Ascension and *Pretoria* radars were committed on a limited basis because of the unavailability of complete trajectory information.

4. ***Computed data.*** The metric and acquisition data flow requirements are indicated in Figs. A-3 and A-4, respectively. The RTCF was configured to provide the computed data requirements as already outlined. A standard orbital parameter message with an epoch of 15 days was to be used instead of a heliocentric orbital parameter message for the *Pioneer E* mission. The standard orbital parameter message was used because one of the objectives of the *Pioneer E* spacecraft trajectory was to go into a heliocentric orbit near the earth for 900 days or more. Even though this was a hyperbolic orbit as seen from the earth, in many respects it resembled an elliptical orbit around the earth.

The standard orbital parameter message, rather than the heliocentric, was used because it was determined that the standard could give a better indication as to the normalcy of the *Pioneer E* spacecraft trajectory and how long the spacecraft would stay within the vicinity of the earth (1.32×10^7 km). The standard orbital epoch was chosen at $L+15$ days because, by this time, the gravitational perturbations on the spacecraft would be minimal and the orbital elements would be easier to evaluate.

The RTCF was to provide the MSFN with acquisition data as follows: (1) inter-range vectors to Carnarvon, Honeysuckle Creek, and *Vanguard*; (2) frequency predicts to Carnarvon and Honeysuckle Creek; and (3) launch trajectory data to Bermuda for acquisition.

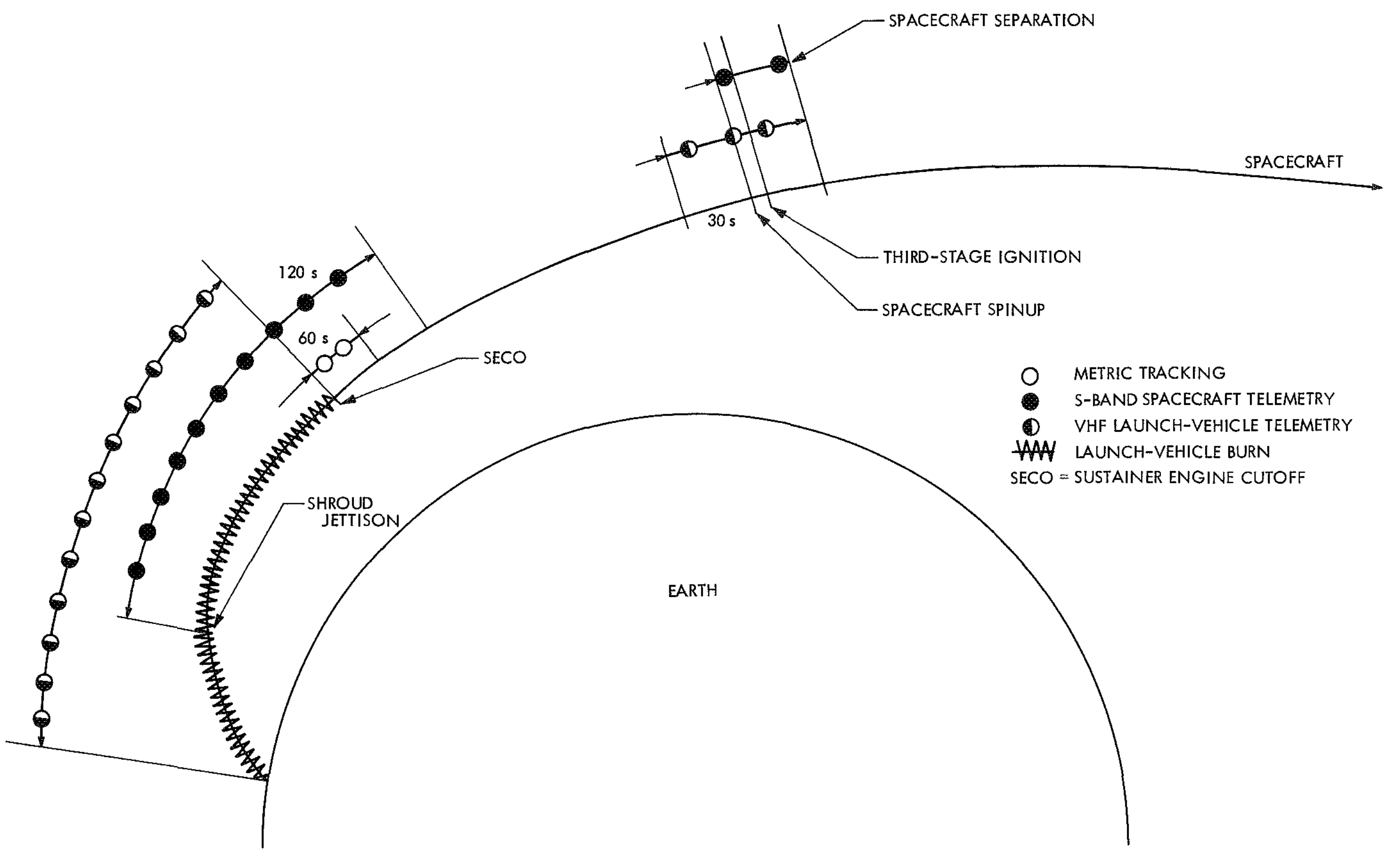


Fig. A-2. Near-earth TDS Class I requirements

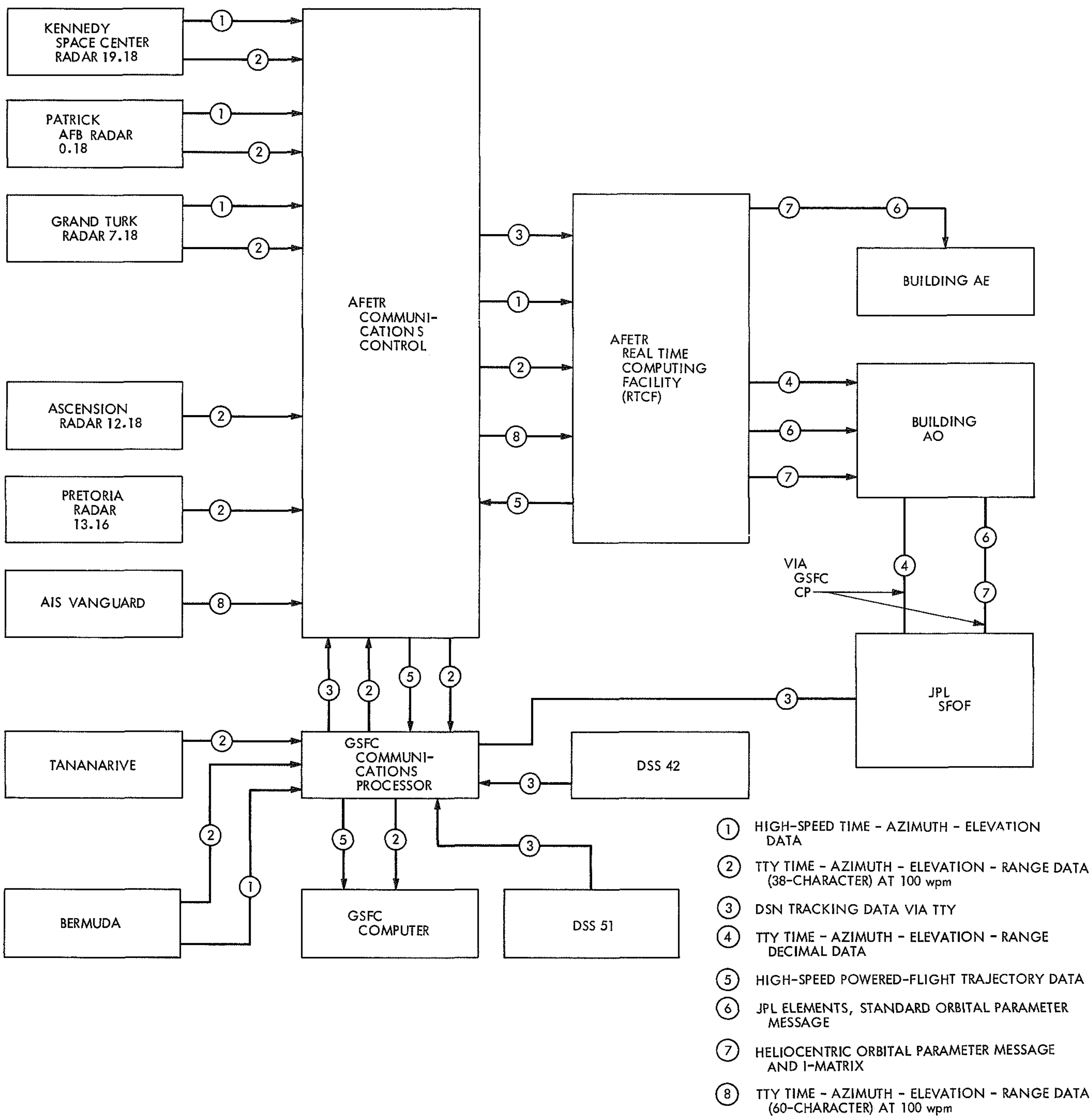


Fig. A-3. Metric tracking data flow

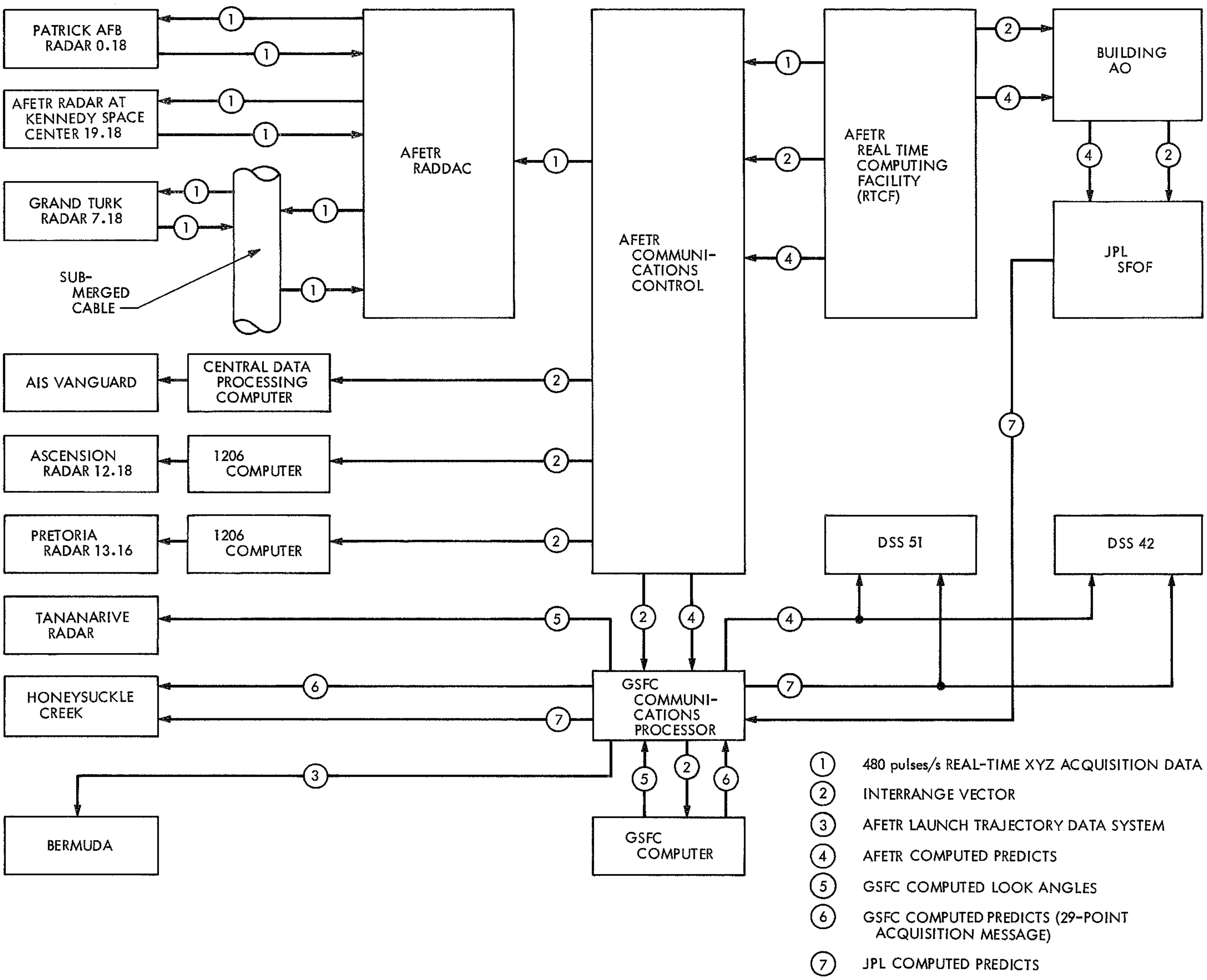


Fig. A-4. Acquisition data flow

The data, either from Grand Turk or Bermuda, were to be used for computing the parking orbit elements. The *Pretoria* data were to be used for computing the solar orbit. The data from Tananarive and the AIS *Vanguard* would also be used if required.

5. Launch vehicle telemetry. The launch vehicle telemetry support was to be provided by Antigua, Ascension, and *Pretoria.* There was to be a gap in the coverage between Antigua set and Ascension rise. The AIS *Vanguard* was scheduled to cover the gap between the Ascension set and the *Pretoria* rise. The real-time retransmission to Cape Kennedy (Building AE) of the second- and third-stage telemetry was to be accomplished by Antigua. Ascension and *Pretoria* were to retransmit selected channels from the second- and third-stage telemetry links in real-time to Building AE. On Merritt Island, Tel-4 was to monitor and control the overall AFETR telemetry operation.

6. Spacecraft telemetry. No definite commitments were provided by the AFETR because of a lack of valid antenna patterns. This was not a change from previous *Pioneer* launches when a facility commitment was deemed acceptable. The support was to be provided by Antigua, Ascension, and *Pretoria.*

C. GSFC Requirements

1. C-band tracking. The MSFN was configured to provide C-band radar beacon tracking, recording, and transmission of the *Delta* second and third stages as follows:

(1) Launch phase: Bermuda fixed radar—special purpose (FPQ)-6/fixed radar, search (FPS)-16—was to beacon track the *Delta* second stage from acquisition to loss of signal and transmit real-time high- and low-speed radar data to GSFC data operations branch and RTCF.

(2) Tananarive was to beacon track the *Delta* third stage from acquisition to loss of signal and transmit real-time, low-speed (38-character) metric data to GSFC data operations branch and RTCF.

(3) Carnarvon was to beacon track the *Delta* second stage from acquisition to loss of signal and was to transmit low-speed (38-character) metric data to GSFC data operations branch.

(4) The AIS *Vanguard* was to beacon track the *Delta* third stage from acquisition to loss of signal and was to transmit low-speed (60-character) metric data to GSFC data operations branch and RTCF.

2. Computed data. The MSFN was required to provide the following:

(1) Prelaunch nominal acquisition data, as well as real-time acquisition data (to include KSC/ULO at AFETR and AFWTR), to participating MSFN stations.

(2) Second-stage orbital parameters (within 2 days after launch) to *Delta* project office.

(3) *Pioneer E* and TETR-C predicted view periods for all MSFN stations and DSS 51 from $L+2$ to $L+30$ days to the *Pioneer* Project.

3. Launch vehicle telemetry. The MSFN sites as indicated in Table A-1 were to receive and record data on the *Delta* second-stage telemetry link. Tananarive and the AIS *Vanguard* were to receive and record data on the *Delta* third-stage telemetry link and, in addition, retransmit selected parameters of the second- and third-stage telemetry links to Building AE at Cape Kennedy.

4. Spacecraft telemetry. The USB sites and the AIS *Vanguard* were to track the S-band transponder. Telemetry data on the 2048-Hz subcarrier were to be demodulated and formatted for retransmission to GSFC for selection and further retransmission to the SFOF. Honeysuckle Creek was to be backup to DSS 42 during the initial acquisition.

D. KSC/ULO Configuration

1. Launch vehicle telemetry. Building AE was to receive link 228.2-MHz (first-stage) data with its own antennas until well after MECO. A Satellite Tracking Station and Complex 17 were to provide backup magnetic tape recording. The 234.0-MHz (second-stage) data were initially to be received in the same way as data on 228.2 MHz (first-stage). However, after SECO, the Building AE real-time stripouts were to be switched to the Antigua subcable data. These data were all to be remoted to the Complex 17 station.

Beginning at liftoff, Building AE was to report the mark events. After approximately $T+40$ s, Building AE was to discontinue the voice reporting of mark events. Later mark events were to come from the AFETR.

The 2250.5-MHz (third-stage) data were to be received by a Satellite Tracking Station and remoted to Building AE. These were also to be received by Building AE. The best source was to be used for the real-time stripouts. The Central Instrumentation Facility (CIF) at

Cape Kennedy was to make a magnetic tape of these data for future analysis.

2. Spacecraft telemetry. A Satellite Tracking Station was to be the prime spacecraft RF receiving station, supporting ground tests as requested in the areas of telemetry reception and remoting it to Building AM as well as reading out frequency and monitoring. During the launch phase, a Satellite Tracking Station was to receive, record, and retransmit spacecraft telemetry to Building AM until loss of signal. The CIF was to receive and record. Building AE was to receive and record as a limited backup. A Satellite Tracking Station would also doppler track the spacecraft link through sustainer engine cutoff, supplying frequency shift versus time data to the master digital command system.

E. DSN Requirements and Support

1. Actual support. Because of the early termination of the mission, DSS 71 was the only DSN station that provided actual support of the *Pioneer E* spacecraft. The station performed in an outstanding manner, supporting all phases of the prelaunch and launch activities without a single fault. No equipment problems were reported during the pass. All DSN requirements and planned support for the near-earth phase are reported here.

2. Requirements and plans.

a. DSS 71. The station was to obtain four or more spacecraft S-band frequency measurements between $L-4$ days and $L-1$ day, and at least one frequency measurement before $L-30$ min. The station was to monitor the health of the spacecraft S-band telemetry data from launch to S-band loss of signal. The data were to be processed through the telemetry command processor. Output to the telemetry command processor was to be displayed on the DSS 71 teleprinter and transmitted in real-time via teletype to Building AM and the SFOF.

Prelaunch checkout, calibration, and the necessary frequency reports were to be provided by DSS 71. The S-band link would have been received at $T-8$ min and the station would have continued tracking as long as possible after launch to assess the performance of the link as an aid to the acquisition of the other Deep Space Stations. The received and demodulated telemetry data were to be sampled and formatted by the GOE/telemetry command processor at DSS 71. The teletype output was to be transmitted to the SFOF. The *Pioneer* space flight operations team was to assess the performance of the spacecraft telemetry during the first phase of the powered flight.

b. Deep Space Stations 51 and 42. The stations were to acquire S-band spacecraft down-link (one-way) and telemetry demodulation not later than $L+1$ h; the operation period of down-link was to be nominally 5 min. The purpose of this requirement was to acquire the spacecraft signal during the transfer to heliocentric orbit and to assess the health of the spacecraft. The stations were to make the necessary spacecraft data mode changes and the experiment turn-ons by establishing two-way lock—if and when requested by mission control. This mode followed the 5-min one-way requirement. Mission control was to send commands from the SFOF via the up-link to the spacecraft and was to assess the health and orbit of the spacecraft. The duration of this requirement was to extend to approximately 4 h after initial acquisition. This requirement was needed to assure the preparation of the spacecraft for scientific data collection. The *Pioneer* spacecraft performance analysis and command team was to assess the spacecraft performance by analyzing the S-band telemetry data.

Depending on the spacecraft view period, DSS 51 was to attempt to make initial acquisition of the down-link S-band telemetry signal (one-way). After acquisition, the sampled telemetry data was to be transmitted via teletype to the SFOF for mission control. The required two-way S-band operation for a duration of at least 4 h after initial acquisition was to be provided by DSS 51. This plan depended on the view period of the spacecraft from DSS 51 after solar orbit injection. The sampled near-real-time science and engineering telemetry was to be provided to the *Pioneer* Project mission control team at the SFOF.

The DSN planned to furnish DSS 42 as the prime acquisition station for the support of *Pioneer E*; thus, any question on the availability of DSS 51 was not to be a launch constraint.

Plans also called for the MSFN *Apollo* prime station at Honeysuckle Creek to serve as a first acquisition emergency backup station. This station was to be connected via a microwave link with the GOE located at DSS 42. The continuous DSS 51 or DSS 42 tracking and data acquisition, including two-way lock, was to complete the near-earth phase of the support.

The data received directly from the spacecraft by Deep Space Stations 51 and 42 was to be processed in real-time by the telemetry command processor. The output of the telemetry command processor was to be displayed on-site, as required, and was to be transmitted to the

SFOF *Pioneer* mission control, ARC/MOS, TRW, and AFETR/Building AO.

The Deep Space Network planned to use near-real-time trajectory information on the resultant parking orbit and on the third-stage/spacecraft injection and solar orbit supplied by the AFETR and the MSFN. These data would be used to update the antenna-pointing information of the DSN acquisition stations to make possible immediate reception of the S-band signal of the spacecraft. The S-band frequency predicts for the same DSN acquisition stations were to be updated during the last phase of the prelaunch countdown by making the spacecraft frequency measurements. This action was required to shorten the time necessary for the S-band carrier frequency search at the acquisition stations.

In addition, the *Pioneer* Project was to provide the DSN with an indication of the normality of the spacecraft injection into solar orbit in real-time. At least 2 mo prior to launch, the following were made available to the *Pioneer* Project: the DSN preflight reference trajectories and a description of the spacecraft telecommunication system design parameters. During all of the prelaunch tests, the DSN used the nominal reference trajectories and the nominal spacecraft S-band frequencies. The DSN made the same information available to the AFETR and MSFN via the systems test and launch operations section of JPL located at AFETR.

c. Ground communications. Figure A-5 shows ground communications support for the near-earth phase. Figure A-6 is a diagram of circuit requirements.

3. *Systems data analysis.*

a. Deep Space Station view periods. A summary of Deep Space Station view periods based on the Block II trajectory was prepared for the expected launch date of August 27, 1969, at 2206:42. The summary is listed in Table A-3. A summary of view periods also was prepared for MSFN backup support from Honeysuckle Creek and Carnarvon. These are listed in Table A-4.

b. First one-way acquisition at DSS 51. The high angle rates on pass 0 exceeded the specifications for DSS 51. A point within the nominal trajectory was to be selected at approximately $L+32$ min, which would allow acquisition of the down-link signal. A plan to attempt to track the entire pass was formulated with DSS 51.

c. Initial acquisition at DSS 42. Initial one-way acquisition at DSS 42 was not expected to present problems because the angle and doppler rates were within the DSN specification and no unusual trajectory constraints existed. Initial two-way acquisition was planned after $L+60$ min. The transmitter turn-on was planned at $L+60$ min. The lower 3σ XA value was selected as the exciter voltage-controlled oscillator frequency at which the RF search should commence upward.

d. DSS predictions. Preflight predictions covering the Block II trajectory were generated and sent to Deep Space Stations 51, 42, and 12 (parking orbit predicts only). In-flight predictions were to be generated as follows:

(1) For the initial two-way acquisition predicts at DSS 42, Model 7A.1 of the prediction program was to be used. The Deep Space Station predictions were to be generated on the $T-45$-min frequency report. These predictions (set 01G) were to be used until approximately $L+4$ h.

(2) The next set of predictions was to be made from the first-orbit solutions. The time span was $L+3$ h to $L+10$ h.

(3) The predictions for DSS 12 and Stanford University were to be made from the second-orbit calculations from $L+9$ h to $L+30$ h.

(4) The AFETR was to generate predictions 01N (nominal) and 01A (actual) at RTCF.

Table A-3. Deep Space Station view periods

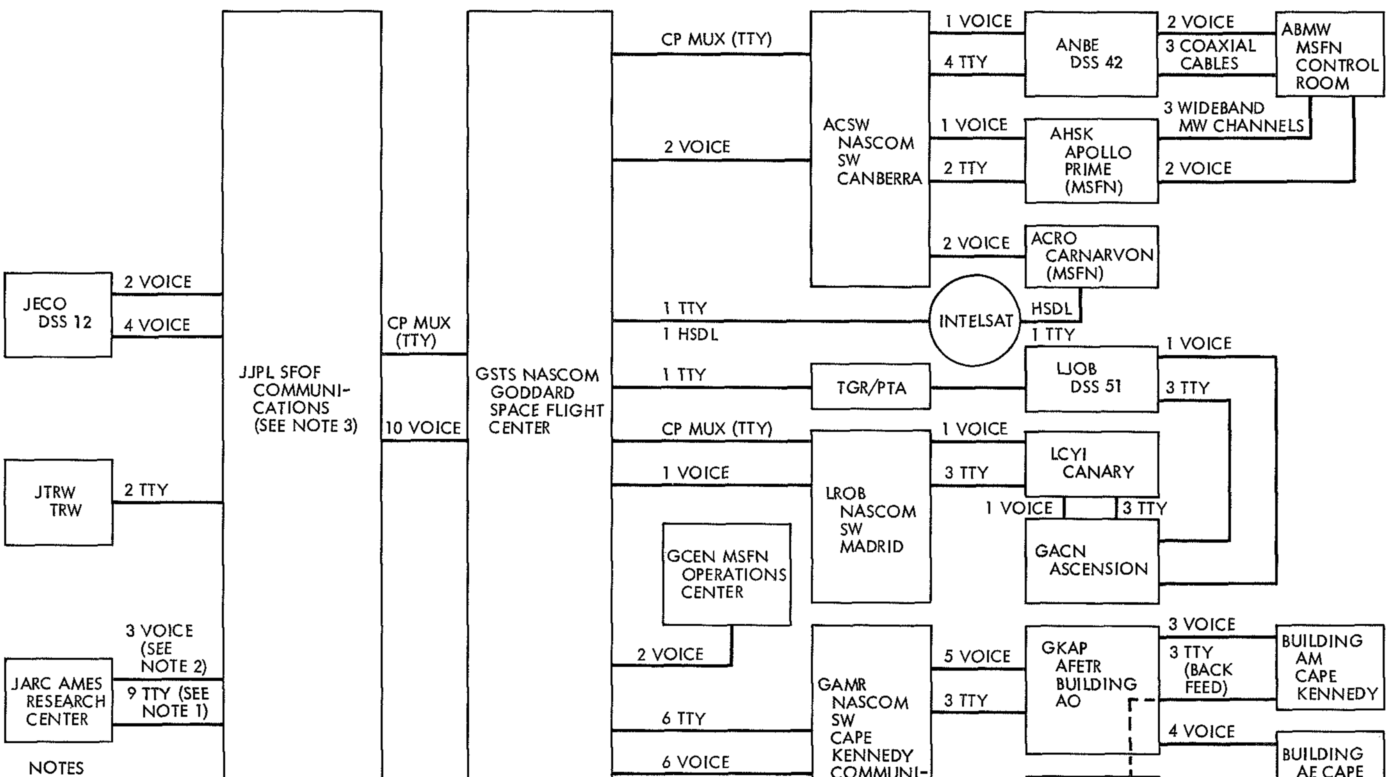
Pass	Station	Day	Rise (TFL[a]) h	min	s	Day	Set (TFL[a]) h	min	s
0	51	239	00	32	32	239	00	47	21
1	42	239	00	53	38	239	04	14	10
1	51	240	03	29	07	240	14	57	46
1	12	240	13	06	49	240	25	42	43
1	Stanford	240	13	12	49	240	26	20	05

[a]TFL = time from launch.

Table A-4. Manned Space Flight Network view periods

Pass	MSFN station	Day	Rise (TFL[a]) h	min	s	Day	Set (TFL[a]) h	min	s
0	Carnarvon	239	00	44	27	239	07	19	26
1	Honeysuckle Creek	239	00	51	27	239	04	38	26

[a]TFL = time from launch.



NOTES

1 NINE TTY SHARED WITH PIONEER VI, VII, VIII, AND IX

2 THREE VOICE SHARED WITH PIONEER VI, VII, VIII, AND IX

3 SFOF INTERNAL COMMUNICATIONS ALLOCATIONS WERE TO BE NEGOTIATED ON THE BASIS THAT ONLY EXISTING FACILITIES AND CAPABILITIES WOULD BE USED

Fig. A-5. Near-earth phase of *Pioneer E* ground communications support

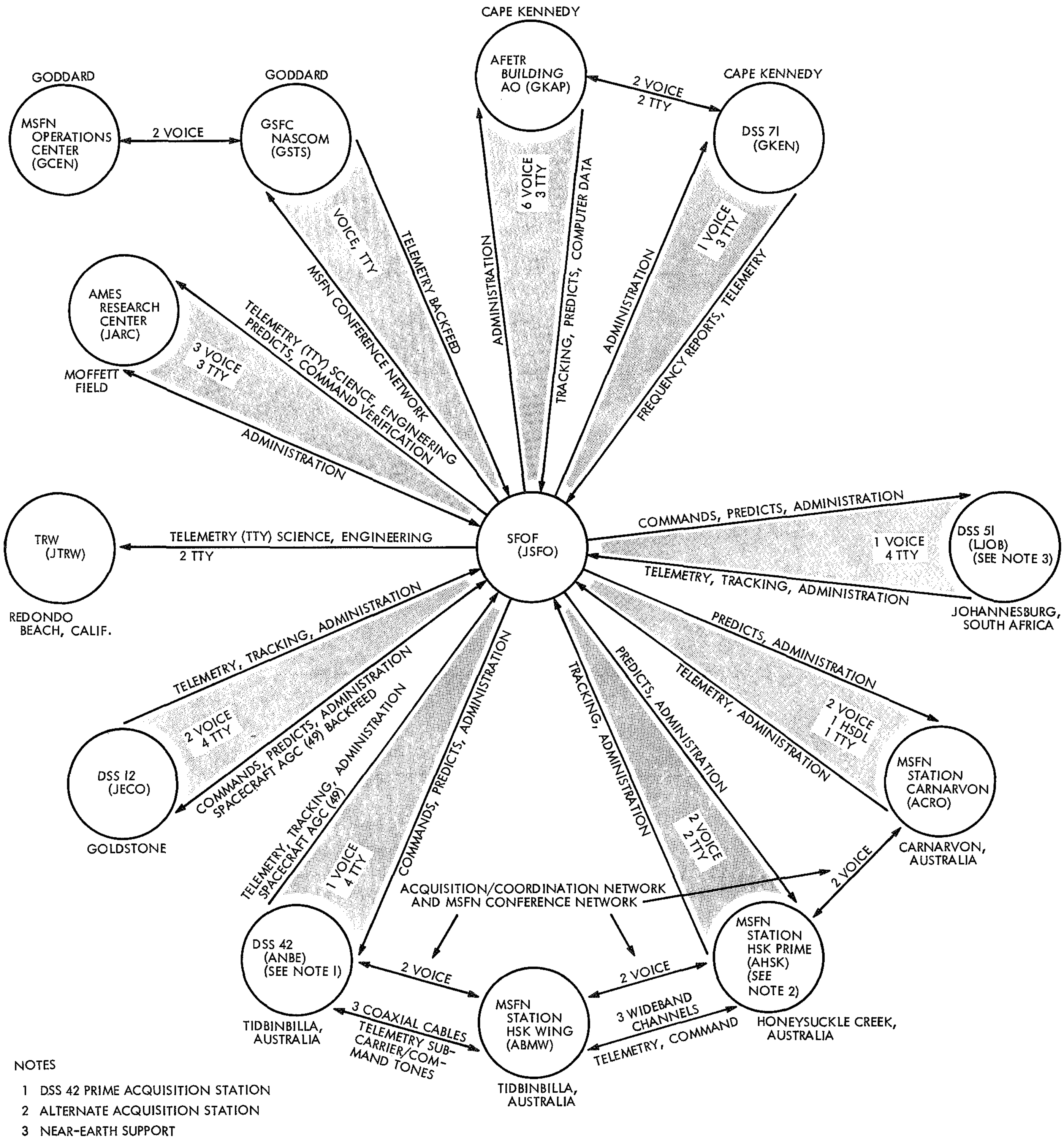


Fig. A-6. NASCOM, MSFN, and DSN GCF circuit requirements diagram for *Pioneer E* (test, launch, and near-earth phases)

IV. Deep Space Requirements

Ending the near-earth phase of the *Pioneer E* mission, the first acquisition of the S-band down-link signal was to be made by DSS 51. This station was to see the spacecraft at $L+32$ min, 43 s for approximately 15 min. Two min prior to the Johannesburg set, Carnarvon was to get the visibility of the spacecraft signal. This station was scheduled to furnish a demodulated *Pioneer* telemetry bit stream via high-speed data lines that was to be transmitted via GSFC to SFOF and processed by the 7044 computer. This real-time MSFN spacecraft telemetry demonstration was to be supported on an engineering basis.

The rise of the first official acquisition station (DSS 42) was to be at approximately $L+50$ min. The *Pioneer* Project planned to evaluate one-way telemetry data for a duration of 5 to 15 min. At $L+1$ h, the Project required establishment of a two-way lock in order to send important commands to the spacecraft. This critical two-way telemetry command and tracking activity was to last approximately 4 h.

After the Project validated the orientation of the spin axis of the spacecraft, the scientific experiments were to be turned on to begin making the measurements of the fields and particles within the magnetosphere of the earth.

At approximately $L+6$ h, 30 min, the DSS 42 view period was to end with DSS 51 taking over the *Pioneer E* support. Then DSS 51 was to begin operations with DSS 42 in a three-way mode after $L+3$ h, 20 min, with DSS 51 in view of *Pioneer E* until $L+14$ h, 40 min. Deep Space Station 12 was to attempt to lock onto the spacecraft signal at $L+13$ h, 18 min. The DSN was to make DSS 12 available for the Type II orientation maneuver during the second Goldstone pass. Because of the earth-lingering trajectory of *Pioneer E,* there was a possibility this maneuver would be made one week after launch. The DSN was committed to furnish full-time 24-h/day support coverage during the first 30 days after launch.

Depending on the available facilities and manpower, the DSN planned to continue the support of the *Pioneer E* mission from $L+31$ days by furnishing at least two passes per day. If the DSN was constrained by limited resources to provide this support from the DSN stations, immediate attempts were to be made to obtain the support from the MSFN stations.

V. Flight Synopsis

A. Launch

The *Pioneer E* spacecraft and the TETR-C satellite were launched at 2159:00.003 at the opening of the window on August 27, 1969, from Complex 17-A, Cape Kennedy, Fla. A *Delta* DSV-3L was the launch vehicle.

A local thunderstorm occurred at $T-1$ h, 11 min, and the gantry was replaced around the launch vehicle until the storm abated; however, the countdown progressed as planned. A delay was caused in one of the receiver 1 frequency measurements, but the L+6-h frequency measurement would have been used if necessary to avoid a delay. At $T-9$ min, all tracking data analysis elements were reported *green* and fully able to support the launch.

B. Power Supply

During the launch countdown, the spacecraft was supplied with external power to conserve the spacecraft battery in case of orientation difficulties after injection. The spacecraft was put on internal power (battery) exclusively at $L-5$ min. Also, because of the necessity to conserve 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 the transmission of telemetry data. The 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 dropped after the TWT was 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.

Because scientific instruments were not 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.

C. Spacecraft Data

On a best-effort basis, the MSFN provided an additional downrange coverage during the boost phase. The

MSFN station configuration modification that established the real-time telemetry coverage at Carnarvon was integrated in several MSFN downrange stations at NASA/KSC just prior to launch. This support coverage was committed for launch on a best-effort basis only at Merritt Island, Grand Bahama, Antigua, Ascension, and the AIS *Vanguard*. These data, received at JPL/SFOF via high-speed data lines in real-time, represent the only spacecraft data collected except for the DSS 71 data received via teletype.

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

D. End of Flight

Analysis of the data received from DSS 71 and the downrange MSFN coverage indicated the spacecraft was operating normally until the destruct signal terminated the flight mission. The spacecraft power parameters indicated the addition of solar-generated power from the illuminated solar array following the shroud jettison. The temperatures began to change. The flight path altered as the vehicle turned southward. This in turn altered the sun look angle to the solar array. The power parameters began unexpected trends and the destruct was commanded at $L+483$ s. Loss of hydraulic pressure in the first stage had caused a faulty roll reference, resulting in an improper flight path for the second stage.

The destroyed launch vehicle, *Pioneer E* spacecraft, and TETR-C satellite impacted in the Atlantic Ocean at 11°30′14″ N lat and 55°42′6″ W lon.

E. Trajectory Sensitivity

The *Pioneer E* trajectory was extremely sensitive to the time of launch during the 16-min available launch window. Figures A-7 and A-8 illustrate the nominal trajectories launched 5 min apart in the launch window. Both trajectories satisfy the 13.2×10^6 km requirement.

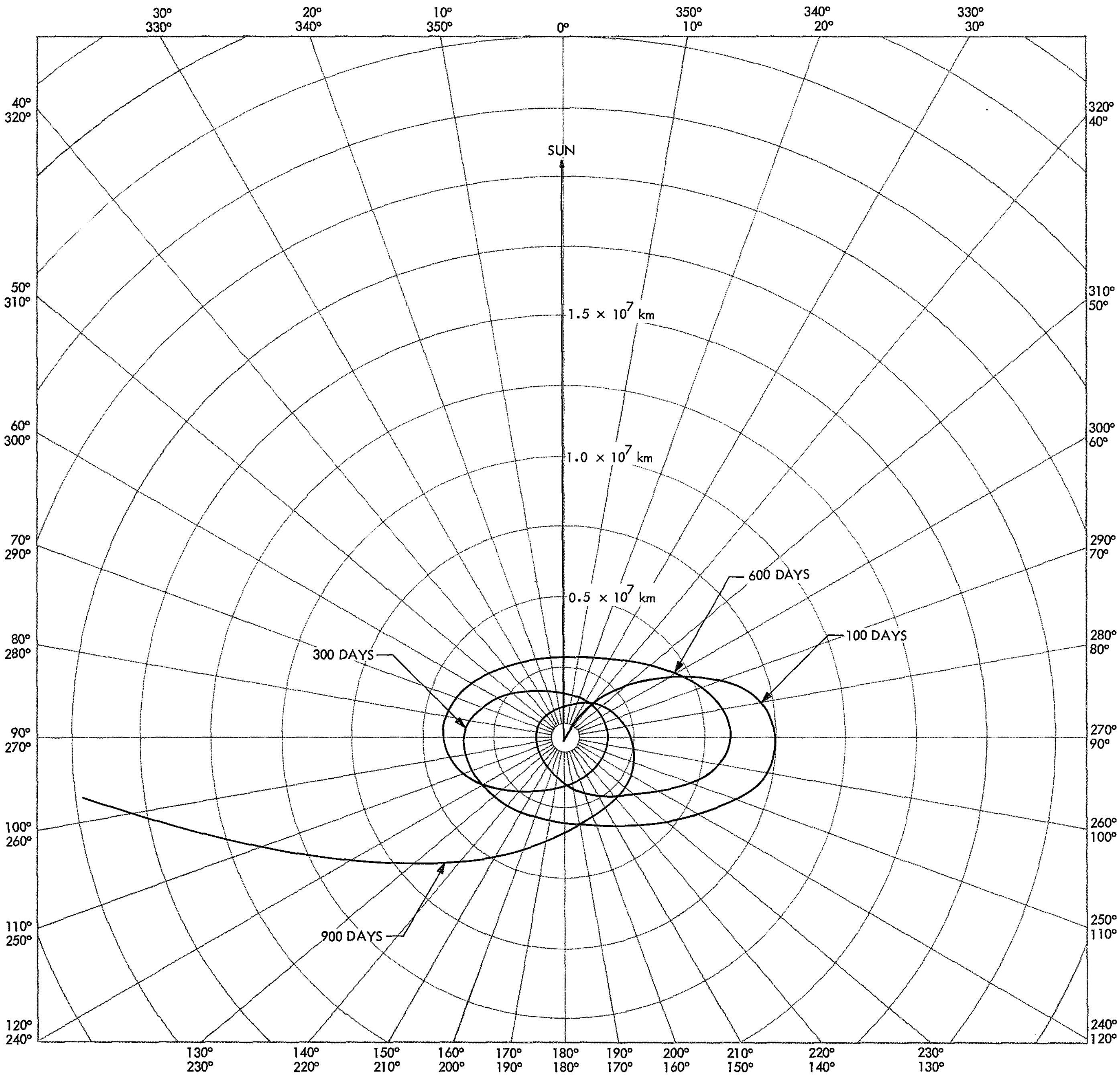


Fig. A-7. Earth–sun line plot of Pioneer E nominal trajectory, $L + 22$ h, 9 min

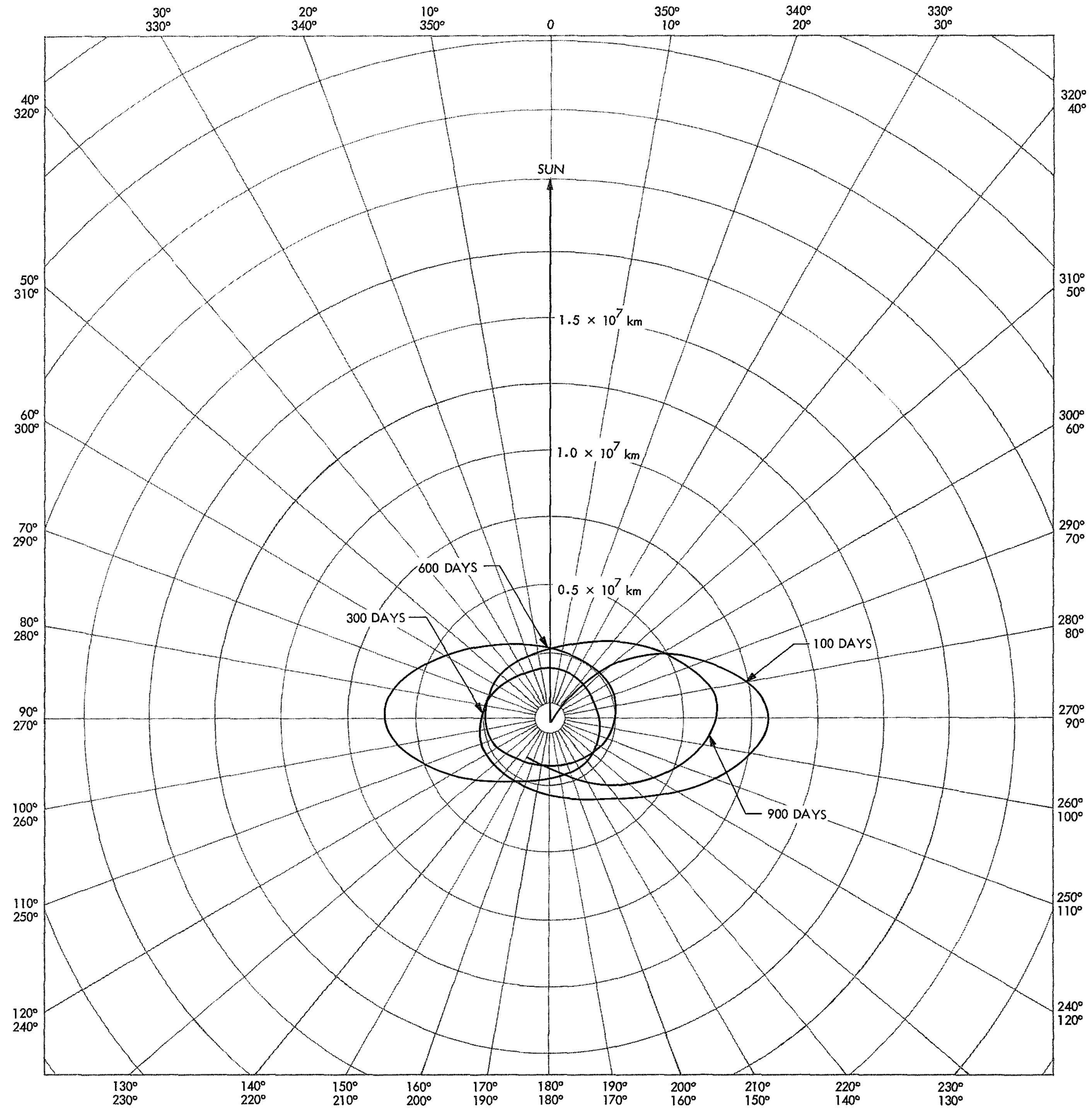


Fig. A-8. Earth–sun line plot of *Pioneer E* nominal trajectory, *L* + 22 h, 14 min

Glossary

AFB	Air Force Base
AFETR	Air Force Eastern Test Range
AFWTR	Air Force Western Test Range
AGC	automatic gain control
AIS	*Apollo* Instrumentation Ship
ARC	Ames Research Center
AU	astronomical unit
az	azimuth
CCF	Central Computing Facility
CIF	Central Instrumentation Facility (Cape Kennedy)
CP	communications processor
DCC	data condition code
dec	declination
DSIF	Deep Space Instrumentation Facility
DSN	Deep Space Network
DSS	Deep Space Station
DTU	data transmission unit
EGSE	electrical ground support equipment
el	elevation
EOM	end of message
ERS	Environmental Research Satellite
ESSA	Environmental Sciences Service Administration
ETO	Estimated Time of Operation
FM	frequency-modulated
FPAC	flight-path analysis and command
GBI	Grand Bahama Island
GCF	Ground Communications Facility
GOE	ground operational equipment
GSFC	Goddard Space Flight Center
H	horizon (plus time)
HA	hour angle
HSDL	high-speed data line
IBM	International Business Machines
JPL	Jet Propulsion Laboratory
KSC	Kennedy Space Center
L	launch (plus time)
LVS	Launch Vehicle System
MDC	Mission Director's Center
MECO	main engine cutoff
MOS	Mission Operations System
MSA	mission support area
MSFN	Manned Space Flight Network
MUX	multiplexer
NASCOM	NASA Communications Network
NAT	network analysis team
NRZ-C	nonreturn-to-zero computer
OCC	Operations Control Center
OTDA	Office of Tracking and Data Acquisition
PER	parity error rate
RCV	receiver–exciter subsystem
RCVR	receiver
RF	radio frequency
RIS	Range Instrumentation Ship
RTCF	Real Time Computing Facility
SAA	S-band acquisition aid (antenna system)
SDA	systems data analysis
SDCC	Simulation Data Conversion Center
SECO	second engine cutoff
SFOD	Space Flight Operations Director
SFOF	Space Flight Operations Facility
SNR	signal-to-noise ratio
SOPM	standard orbital parameter message
SPAC	spacecraft performance analysis and command
SRO	Superintendent of Range Operations

Glossary (contd)

SS	Spacecraft System
SSAC	space science analysis and command
STS	Satellite Tracking Station
T	time
TAER	time–azimuth–elevation–range
TCP	telemetry command processor
TDA	tracking and data acquisition
TDH	tracking data handling
TDS	Tracking and Data System
TETR	*Test and Training Satellite*
TETR-C	*Test and Training Satellite*
TETR-2	*Test and Training Satellite*
TWT	traveling-wave tube
TWX	teletypewriter exchange
ULO	unmanned launch operations
USB	unified S-band
VCO	voltage-controlled oscillator
VHF	very high frequency

Bibliography

Anderson, J. D., *Determination of the Masses of the Moon and Venus and the Astronomical Unit From Radio Tracking Data of the Mariner II Spacecraft,* Technical Report 32-816. Jet Propulsion Laboratory, Pasadena, Calif., July 1, 1967.

Berman, A. L., *ABTRAJ—On-Site Tracking Prediction Program for Planetary Spacecraft,* Technical Memorandum 33-391. Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1968.

Berman, A. L., *Tracking System Data Analysis Report, Ranger VII, Final Report,* Technical Report 32-719. Jet Propulsion Laboratory, Pasadena, Calif., June 1, 1965.

Cain, D. L., and Hamilton, T. W., *Determination of Tracking Station Locations by Doppler and Range Measurements to an Earth Satellite,* Technical Report 32-534. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 1, 1964.

Cary, C. N., and Sjogren, W. L., "Gravitational Inconsistency in the Lunar Theory: Confirmation by Radio Tracking," *Science,* Vol. 160, pp. 875–876, Apr.–June 1968.

Hamilton, T. W., et al., *The Ranger IV Flight Path and Its Determination From Tracking Data,* Technical Report 32-345. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 15, 1962.

Labrum, R. G., Wong, S. K., and Reynolds, G. W., *The Surveyor V, VI, and VII Flight Paths and Their Determination From Tracking Data,* Technical Report 32-1302. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 1, 1968.

Lieske, J. H., and Null, G. W., "Icarus and the Determination of Astronomical Constants," *Astron. J.,* Vol. 74, No. 2, Mar. 1969.

Lorell, J., *Lunar Orbiter Gravity Analysis,* Technical Report 32-1387. Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1969.

Lorell, J., and Sjogren, W. L., *Lunar Orbiter Data Analysis,* Technical Report 32-1220. Jet Propulsion Laboratory, Pasadena, Calif., Nov. 15, 1967.

Bibliography (contd)

Lumb, D. R., "Test and Preliminary Flight Results on the Sequential Decoding of Convolutional Encoded Data from Pioneer IX," paper presented at the IEEE International Conference on Communications, University of Colorado, Boulder, Colo., June 9–11, 1969.

McNeal, C. E., *Ranger V Tracking Systems Data Analysis, Final Report*, Technical Report 32-702. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1965.

Melbourne, W. G., et al., *Constants and Related Information for Astrodynamical Calculations*, Technical Report 32-1306. Jet Propulsion Laboratory, Pasadena, Calif., July 15, 1968.

Miller, L. W., et al., *Atlas–Centaur VI Flight Path and Its Determination From Tracking Data*, Technical Report 32-911. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1966.

Mulholland, J. D., *Proceedings of the Symposium on Observation, Analysis, and Space Research Applications of the Lunar Motion*, Technical Report 32-1386. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 1969.

Mulholland, J. D., and Sjogren, W. L., *Lunar Orbiter Ranging Data: Initial Results*, Technical Report 32-1087. Jet Propulsion Laboratory, Pasadena, Calif. (reprinted from *Science*, Vol. 155, No. 3758, pp. 74–76, Jan. 6, 1967).

Muller, P. M., and Sjogren, W. L., *Consistency of Lunar Orbiter Residuals With Trajectory and Local Gravity Effects*, Technical Report 32-1307. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 1, 1968.

Muller, P. M., and Sjogren, W. L., *MASCONS: Lunar Mass Concentrations*, Technical Report 32-1339. Jet Propulsion Laboratory, Pasadena, Calif., Aug. 16, 1968.

Null, G. W., Gordon, H. J., and Tito, D. A., *The Mariner IV Flight Path and Its Determination From Tracking Data*, Technical Report 32-1108. Jet Propulsion Laboratory, Pasadena, Calif., Aug. 1, 1967.

O'Neil, W. J., et al., *The Surveyor III and Surveyor IV Flight Paths and Their Determination From Tracking Data*, Technical Report 32-1292. Jet Propulsion Laboratory, Pasadena, Calif., Aug. 15, 1968.

Pease, G. E., et al., *The Mariner V Flight Path and Its Determination From Tracking Data*, Technical Report 32-1363. Jet Propulsion Laboratory, Pasadena, Calif., July 1, 1969.

Reiff, G. A., "The Pioneer Space Program," paper presented to the joint national meeting of the American Astronautical Society and the Operations Research Society, Denver, Colo., June 17–20, 1969.

Renzetti, N. A., *Tracking and Data Acquisition for Ranger Missions I–V*, Technical Memorandum 33-174. Jet Propulsion Laboratory, Pasadena, Calif., July 1, 1964.

Renzetti, N. A., *Tracking and Data Acquisition for Ranger Missions VI–IX*, Technical Memorandum 33-275. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 15, 1966.

Renzetti, N. A., *Tracking and Data Acquisition Support for the Mariner Venus 1962 Mission,* Technical Memorandum 33-212. Jet Propulsion Laboratory, Pasadena, Calif., July 1, 1965.

Renzetti, N. A., *Tracking and Data Acquisition Report, Mariner Mars 1964 Mission: Volume I. Near-Earth Trajectory Phase,* Technical Memorandum 33-239. Jet Propulsion Laboratory, Pasadena, Calif., Jan. 1, 1965.

Renzetti, N. A., *Tracking and Data Acquisition Report, Mariner Mars 1964 Mission: Volume II. Cruise to Post-Encounter Phase,* Technical Memorandum 33-239. Jet Propulsion Laboratory, Pasadena, Calif., Oct. 1, 1967.

Renzetti, N. A., *Tracking and Data Acquisition Report, Mariner Mars 1964 Mission: Volume III. Extended Mission,* Technical Memorandum 33-239. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 1, 1968.

Renzetti, N. A., *Tracking and Data System Support for Mariner Venus 1967: Volume I. Planning Phase Through Midcourse,* Technical Memorandum 33-385. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 1, 1969.

Renzetti, N. A., *Tracking and Data System Support for Mariner Venus 1967: Volume II. Midcourse Through End of Mission,* Technical Memorandum 33-385. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 1, 1969.

Renzetti, N. A., *Tracking and Data System Support for the Pioneer Project: Volume I. Pioneer VI. Prelaunch to End of Nominal Mission,* Technical Memorandum 33-426. Jet Propulsion Laboratory, Pasadena, Calif., Feb. 1, 1970.

Renzetti, N. A., *Tracking and Data System Support for the Pioneer Project: Volume II. Pioneer VII. Prelaunch to End of Nominal Mission,* Technical Memorandum 33-426. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1970.

Renzetti, N. A., *Tracking and Data System Support for the Pioneer Project: Volume III. Pioneer VIII. Prelaunch to End of Nominal Mission,* Technical Memorandum 33-426. Jet Propulsion Laboratory, Pasadena, Calif., July 15, 1970.

Renzetti, N. A., *Tracking and Data System Support for Surveyor: Volume I. Missions I and II,* Technical Memorandum 33-301. Jet Propulsion Laboratory, Pasadena, Calif., July 15, 1969.

Renzetti, N. A., *Tracking and Data System Support for Surveyor: Volume II. Missions III and IV,* Technical Memorandum 33-301. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 1, 1969.

Renzetti, N. A., *Tracking and Data System Support for Surveyor: Volume III. Mission V,* Technical Memorandum 33-301. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 1, 1969.

Renzetti, N. A., *Tracking and Data System Support for Surveyor: Volume IV. Mission VI,* Technical Memorandum 33-301. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 1, 1969.

Renzetti, N. A., *Tracking and Data System Support for Surveyor: Volume V. Mission VII,* Technical Memorandum 33-301. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 1, 1969.

Bibliography (contd)

Siegmeth, A. J., and Santiestevan, R., "*Pioneer IX* Mission Support," in *Supporting Research and Advanced Development,* Space Programs Summary 37-59, Vol. II. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 30, 1969.

Sjogren, W. L., *Proceedings of the JPL Seminar on Uncertainties in the Lunar Ephemeris,* Technical Report 32-1247. Jet Propulsion Laboratory, Pasadena, Calif., May 1, 1968.

Sjogren, W. L., *The Ranger III Flight Path and Its Determination From Tracking Data,* Technical Report 32-563. Jet Propulsion Laboratory, Pasadena, Calif., Sept. 15, 1965.

Sjogren, W. L., et al., *Physical Constants as Determined From Radio Tracking of the Ranger Lunar Probes,* Technical Report 32-1057. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 30, 1966.

Sjogren, W. L., et al., *The Ranger V Flight Path and Its Determination From Tracking Data,* Technical Report 32-562. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 6, 1963.

Sjogren, W. L., et al., *The Ranger VI Flight Path and Its Determination From Tracking Data,* Technical Report 32-605. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 15, 1964.

Thornton, J. H., Jr., et al., *The Surveyor I and Surveyor II Flight Paths and Their Determination From Tracking Data,* Technical Report 32-1285. Jet Propulsion Laboratory, Pasadena, Calif., Aug. 1, 1968.

Vegos, C. J., et al., *The Ranger VIII Flight Path and Its Determination From Tracking Data,* Technical Report 32-766. Jet Propulsion Laboratory, Pasadena, Calif. (to be published).

Vegos, C. J., et al., *The Ranger IX Flight Path and Its Determination From Tracking Data,* Technical Report 32-767. Jet Propulsion Laboratory, Pasadena, Calif., Nov. 1, 1968.

Winn, F. B., "Post Landing Tracking Data Analysis," in *Surveyor VII Mission Report: Part II. Science Results,* Technical Report 32-1264. Jet Propulsion Laboratory, Pasadena, Calif., Mar. 15, 1968.

Winn, F. B., "Post Lunar Touchdown Tracking Data Analysis," in *Surveyor Project Final Report: Part II. Science Results,* Technical Report 32-1265. Jet Propulsion Laboratory, Pasadena, Calif., June 15, 1969.

Winn, F. B., "Selenographic Location of *Surveyor VI,*" in *Surveyor VI Mission Report: Part II. Science Results,* Technical Report 32-1262. Jet Propulsion Laboratory, Pasadena, Calif., Jan. 10, 1968.

Wollenhaupt, W. R., et al., *Ranger VII Flight Path and Its Determination From Tracking Data,* Technical Report 32-694. Jet Propulsion Laboratory, Pasadena, Calif., Dec. 15, 1964.

NASA — JPL — Coml., L.A., Calif.