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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Technical Memorandum 33-474

Volume I

Tracking and Data System Support for the Mariner Mars 1969 Mission

Planning Phase Through Midcourse Maneuver

N. A. Renzetti
K. W. Linnes
D. L. Gordon
T. M. Taylor

JET PROPULSION LABORATORY
CALIFORNIA INSTITUTE OF TECHNOLOGY
PASADENA, CALIFORNIA

May 15, 1971

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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 the NASA Communications Network of Goddard Space Flight Center. This volume covers the Tracking and Data System Support for the Mariner Mars 1969 Mission from the planning phase through the midcourse maneuver, Volume II covers the period from the midcourse maneuver through the end of the mission; and Volume III covers the extended mission operations.

ACKNOWLEDGMENTS

The authors acknowledge the considerable assistance of the technical staffs of the several agencies, the Air Force Eastern Test Range of the Department of Defense, the Manned Space Flight Network of the Goddard Space Flight Center, the Deep Space Network of the Jet Propulsion Laboratory, providing tracking and data support. Information relative to the launch vehicle was obtained from reports of the Lewis Research Center; information relative to the mission and the spacecraft was obtained from the Mariner Mission to Mars 1969 Project reports. Information regarding the DSN is based on material generated by the DSN Design Team for the Mariner Mars 1969 Project and the DSN Operations Staff. The authors are indebted to A. C. Belcher and M. E. Binkley of the Office of Tracking and Data Acquisition, National Aeronautics and Space Administration for their support.

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ABSTRACT

The Tracking and Data System support for the Mariner Mars 1969 Project was planned and implemented in close cooperation with the Mission Operations and Spacecraft System of the project. The project requirements for tracking, telemetry, command, simulation, mission control, and compatibility testing were reviewed for matching to DSN capabilities. The DSN capabilities to support the project were set forth in an Operations Plan describing the design of the DSN Systems formulated for the support of this particular project. Each of the systems is described. Unusual new features were the Multi-Mission Telemetry System, which eliminated need for mission-dependent equipment at the tracking stations, and an experimental High-Rate Telemetry System operating at 16,200 bits/s. This unusually high rate, employed for the first time in deep space missions, permitted return of low resolution pictures in real-time, and full resolution pictures played back from the spacecraft tape recorder in less than 3 h. Normal techniques and rates would have required 7 to 8 days of playback.

Flight support was provided in the Near-Earth Phase by the facilities of the Air Force Eastern Test Range and by the Ascension Island Station of the Manned Space Flight Network. The 26-m antenna stations of the Deep Space Network provided the Deep Space Phase support throughout the mission. During the cruise portion of the Deep Space Phase, the DSN 64-m antenna at Goldstone, Calif., provided ranging data to planetary distances; during the planetary encounter, it provided the 16,200 bits/s capability by means of the block-coded, high-rate telemetry system.

Analysis of the support performance shows that virtually all tracking and telemetry data received on earth was acquired, processed, and delivered to the project. All commands delivered to the DSN by the project for transmission to the spacecraft were transmitted successfully.

I. INTRODUCTION

This document, Volume I, covers the Tracking and Data System (TDS) activities in support of the Mariner Mars 1969 Project from the system design phase through the Mariner VII midcourse maneuver. With the inclusion of cruise, encounter, and post-encounter activities in Volume II and the extended operations in Volume III, this report constitutes the complete history of the TDS activities supporting the Mariner Mars 1969 Mission.

A. Mariner Mars 1969 Mission Objectives

The primary mission objective of the Mariner Mars 1969 Project was to conduct flyby missions in order to make exploratory investigations of Mars to set the basis for future experiments, particularly those relevant to the search for extraterrestrial life. The secondary mission objective was to develop technology for succeeding Mars missions.

To implement the primary mission objective, six scientific investigations were selected: (1) visual imaging by television, (2) ultraviolet spectrometry, (3) infrared spectrometry, (4) infrared radiometry, (5) planetary occultation of the S-band radio signals, and (6) celestial mechanics.

Objectives of the visual imaging investigation were (1) to determine the general physiography of the planet at a resolution significantly better than that obtainable from earth, (2) to categorize topographically the basic light and dark areas and determine reasons for the seasonal variations, (3) to explore further the geography of the planetary surface for additional clues to its origin, and (4) to obtain sufficient coverage at a suitable resolution to distinguish, on the basis of crater morphology and other criteria, between an episodic and a continuous history.

The purpose of the ultraviolet spectrometry investigation was to detect the presence of atoms, ions, and molecules in the upper atmosphere of Mars. The atmospheric constituents of prime interest were hydrogen, oxygen, nitrogen, carbon monoxide, nitric oxide, and cyanogen. Although the solar energy is probably not sufficient to excite their spectral lines, argon, krypton, and xenon fly in the spectral range of the instrument and were looked for. Further objectives were to measure the scale height of each of the atmospheric constituents, Rayleigh scattering from the lower atmosphere, ultraviolet reflectivity of the planetary surface, and atmospheric absorption by molecules such as ozones.

The infrared spectrometry investigation sought to acquire data relevant to ascertaining the possible presence of life, current or past, on Mars. The instrument used searched for the presence of an oxidizing or reducing atmosphere, the presence of those poly-atomic molecules that suggest biochemical processes, affect the ambient surface temperature, and limit ultraviolet light flux at the surface, and to measure compositional variations of atmospheric constituents, particularly water vapor, relative to geographical locale.

The purpose of the infrared radiometry investigation was to ascertain the surface temperature. The investigation measured the infrared radiation emitted from the same area of Mars scanned by the television system in order to obtain a temperature mapping correlated with topological or cloud features observed visually. Other objectives were to obtain a surface cooling curve in a scan roughly perpendicular to the terminator, measure temperature of the dark side surface inaccessible from the earth, and to obtain absolute temperature measurements of the south polar cap in order to differentiate between the carbon-dioxide and water caps.

Observations of the occultation of the S-band radio signals by the planet were intended to obtain measurements leading to an improved determination of the pressure and density in the atmosphere of Mars at the surface, and their variation with altitude. Similar measurements were sought on the electron density profile and the radius of Mars.

The purpose of the celestial mechanics investigation was to obtain data to provide improved estimates of the mass of Mars, the mass of the moon, the astronomical units, and the improvement of ephemerides of the earth and Mars.

A secondary mission objective was to develop technology needed for succeeding Mars missions. A number of engineering development objectives were defined. Improvements in the accuracy of orbit determination and flight path control were attempted. Improved temperature control techniques and the acquisition of more precise information on the performance degradation of solar cells was sought. Demonstration of an automatically adjusted brightness gate on the Canopus star sensor was desired to support future planetary missions where automatic acquisition of Canopus as a celestial reference is important.

Future planetary orbiting missions also require demonstration of a 2-deg-of-freedom scan platform to fulfill extensive scan pointing requirements of future scientific experiments.

The Central Computer and Sequencer (CC&S) included the capability to read memory and to be reprogrammed in flight via ground command to demonstrate the degree of flexibility required for planetary orbiter missions.

An experiment in telemetry transmission at 16, 200 bits/s was included to demonstrate the technique of block coding in the transmission of high-data rates over planetary distances.

B. Mariner Mars 1969 Mission Plan

Implementation of the mission objectives was the subject of the Mariner Mars 1969 Mission Plan. This plan included detailed mission requirements from which were derived the requirements on the Mission Operations System (MOS) and TDS. Essential elements of the plan were that two spacecraft of identical configuration, subsequently designated as Mariners VI and VII, would be launched in the period February 23 to April 6, 1969 and encounter the planet Mars at two different, but fixed, arrival dates in the interval July 29 through August 15, 1969. Although the aiming points were different, providing a near-equatorial pass for one spacecraft and a southern polar pass for the other, each spacecraft would conduct a standard encounter sequence. The standard far-encounter sequence consisted of eight photographs taken from E - 22 to E - 12 h and stored in the tape recorder until after near-encounter. Approximately 24 photographs would be taken in the near-encounter during which time only engineering telemetry and certain selected scientific data would be transmitted in real time at 8 1/3 bits/s and 66 2/3 bits/s, respectively. All of the stored data would then be played back after the encounter at 270 bits/s. This standard mission was designed to be dependent only on the 26-m (85 ft) antenna capability of the Deep Space Network (DSN).

Optional standard missions were planned which utilized the 64-m (210 ft) antenna of the DSN at Goldstone, California (Fig. 1), and the experimental high-rate telemetry system under development as a demonstration of the employment of block coding techniques. This capability provided the possibility of returning all of the stored data at a rate of 16, 200 bits/s in less than 3 h. It also provided the capability of providing in real-time, low-resolution television pictures as well as all of the UV and IR data. Consequently, the optional standard missions considered far-encounter picture-taking sequences which started several days before encounter and played back the stored data via high-rate telemetry during each period of visibility from Goldstone.

As a result of mission studies in the last quarter of 1968, the satisfactory progress of development of the high-rate telemetry equipment, and the reliable performance history of the 64-m antenna, the Mission Plan was modified in February of 1969. The heretofore Standard Encounter Sequence was designated the Conservative Sequence to be employed in case the new Standard Sequences could not be followed. Slightly different Standard Sequences were developed for Mariners VI and VII. Mariner VI was to obtain 50 far-encounter pictures to be played back in two groups at approximately E - 28 h and E - 7 h. Mariner VII was to obtain 91 far-encounter pictures to be played back in three groups at E - 52, E - 27, and E - 4 h.

Although these changes did not require changes to the basic TDS support commitments, some modifications were made to the DSN Operations Plan.

C. Launch Vehicle Description

The launch vehicle for the Mariner Mars 1969 Project consisted of an Atlas SLV-3C first stage and a Centaur second stage (Figs. 2, 3, and 4). It is basically the same launch vehicle that was developed for the Surveyor Project.

The Atlas SLV-3C configuration has two main sections, the body or sustainer section and the aft or booster engine section. The vehicle was stabilized and controlled by gimbaling the engine thrust chambers. The propulsion system consisted of two booster engines, each with a thrust of 75,000 kg, a sustainer engine with a thrust of 25,800 kg, and two vernier engines, each with 300-Kg thrust. The engines used liquid oxygen (LOX) and kerosene (RP-1) as propellants. All five engines were in operation at liftoff. The Atlas telemetry subsystem transmitted functional and environmental data on a VHF carrier.

The Centaur stage is driven by two gimbal-mounted liquid hydrogen/liquid oxygen engines which provide a combined thrust of 13, 600 Kg. The same inertial guidance system which controlled the Atlas first stage, controlled the

Centaur second stage. The second stage injected the spacecraft into its interplanetary trajectory in a direct ascent mode. The stage carried a VHF telemetry system and a C-band beacon for radar tracking.

D. Mariners VI and VII Spacecraft Description

The Mariners VI and VII spacecraft configuration is shown in Fig. 5. Each spacecraft with its adapter weighs approximately 326 kg. Three spacecraft of identical configuration were prepared for the two launches. They are capable of automatic operation without the use of ground commands if the sequence stored in the CC&S at launch is that to be followed at encounter and if the trajectory dispersions are small enough to preclude the necessity of trajectory corrections.

The spacecraft design made maximum use of the Mariner IV (1964) spacecraft design and experience. Some of the significant configuration changes between Mariner IV and the Mariners VI and VII spacecraft are as follows:

(1) Dual Traveling Wave Tube (TWT) amplifiers were used, each capable of 20 W output power. The increase from 10 W was one of the changes necessary to perform the high-rate telemetry experiment.

(2) The high-gain antenna was modified to a circular paraboloid of higher gain to optimize the telecommunications performance for the mission.

(3) The flight command subsystem was modified to accommodate an increased number of commands to provide additional flexibility to Mission Operations.

(4) The CC&S memory could be read out by ground commands without changes to the program, and a revised memory could be reloaded by ground command.

(5) The flight telemetry system utilized three frequency-multiplexed telemetry channels, one or two at a time, in five basic data modes. Mariner IV employed a single channel. The engineering channel employed the same data rates as Mariner IV, 8 1/3 or 33 1/2 bits/s. On Mariner IV, science data shared a single channel with the engineering data at these two rates. On Mariners VI and VII, the science channel operated at either 66 2/3 bits/s for real-time transmission during encounter or 270 bits/s in the playback mode. A third channel was provided for high-rate telemetry at 16,200 bits/s. It could be used in the Playback 2 mode to transmit data stored on the analog tape recorder or on the Encounter 2 mode for real-time transmission of low-resolution television pictures and the UV and IR science data.

(6) The data storage subsystem employed two tape recorders. The digital tape recorder, with a capacity of 2.3×10^7 bits, was basically the device used for Mariner IV. An analog tape recorder with an equivalent storage capacity of 1.7×10^8 bits, was used for recording a maximum of about 34 television pictures on four tracks. In the Playback 1 mode, television picture data were transferred through an analog-to-digital converter to the digital tape recorder at 16,200 bits/s. The digital recorder was then played back at 270 bits/s.

The purpose of the digital recorder during encounter was to record all of the UV and IR science data, engineering status of the television subsystem, and every seventh television picture element. The digitally-recorded TV picture constituted a low-resolution picture whose prime purpose was that of calibration of pictures stored on the analog recorder.

(7) The data automation subsystem (DAS) controlled and sequenced the science instruments, collected data from them, conditioned it by encoding, buffering, and formatting, and routed it to the flight telemetry subsystem as was done on previous Mariners. However, analog TV data passed directly to the analog tape recorder without going through the DAS.

(8) The scan control subsystem, on which the scientific instruments are mounted, was designed with 2 deg of freedom. It rotates in cone and clock angle. Cone angle is the angle between the boresight axis of the scan platform and the spacecraft roll axis. Clock angle is measured in the plane perpendicular to the roll axis. When passing the planet, variation in cone angle moves the pointing of the scan platform forward or backward along the line of flight. Variation in clock angle is in a perpendicular direction intended to move the aiming direction closer to or farther from the planetary pole. The Mariners VI and VII scan platform included a second narrow-angle Mars gate sensor. The first initiated the near-encounter recording sequence. The other activated the motor and cooling valves of the infrared spectrometer to initiate the cryogenic cooldown.

The scientific payload of Mariners VI and VII differed substantially from Mariner IV (Fig. 6). It did not include instruments active during cruise; all instruments were of the scanning type to be used during planetary encounter and were mounted on the scan platform (Fig. 7). The salient features of the scientific instruments are as follows:

(a) The television subsystem employed two electro-optical vidicon cameras, a wide-angle camera (field-of-view 11 by 14 deg) and a narrow-angle camera (field-of-view 1.1 by 1.4 deg). The rotary shutter/filter assembly for the narrow-angle camera is equipped with a blue cutoff filter to reduce haze. The wide-angle camera alternated its picture-taking sequence to red, green, and blue filters in order to examine the planetary surface at specific optical wavelengths.

(b) The ultraviolet spectrometer examined the planetary atmosphere and also the surface. It was mounted with its axis at a boresight cone angle of 11 deg less than that of the television subsystem to make certain of examining the upper atmosphere during the time of limb crossing.

(c) The infrared spectrometer examined the spectrum from 1.9 to 14.3 μ in two slightly overlapping channels. The longer wavelength channel, 4.0 to 14.3 μ, achieves its sensitivity by cryogenic cooling of the detector.

(d) The infrared radiometer measured planetary radiation in the wavelength region of 8 through 25 μ with a field-of-view of 0.7 by 0.7 deg.

E. Description of the TDS

The TDS was composed of the facilities and resources of four major support agencies as follows

(1) Air Force Eastern Test Range. The U.S. Air Force, through the Air Force Systems Command and the National Range Division, manages the Air Force Eastern Test Range (AFETR) for the Department of Defense (DOD). As lead range for Mariner Mars 1969, the AFETR arranged the required worldwide support from DOD resources. The AFETR provided prelaunch, launch, and near-earth tracking and data acquisition support for Mariners VI and VII.

(2) Manned Space Flight Network. The Manned Space Flight Network (MSFN), operated for NASA by the Goddard Space Flight Center (GSFC), provided near-earth tracking and data acquisition support for Mariners VI and VII.

(3) NASA Communications System. The NASA Communications System (NASCOM), operated for NASA by the GSFC, provided ground communications circuits required for support of Mariners VI and VII.

(4) Deep Space Network. The DSN, operated for NASA by the Jet Propulsion Laboratory (JPL), provided mission support in the areas of deep space tracking, metric and telemetry data acquisition, commands, and operational control.

The organization developed to manage TDS activities for the Mariner Mars 1969 Project is shown in Fig. 8. Personnel involved in TDS activities had the following responsibilities:

(1) Associate Administrator for Tracking and Data Acquisition. The Associate Administrator for Tracking and Data Acquisition at NASA Headquarters designated JPL as the tracking and data acquisition support center for Mariner Mars 1969.

(2) TDS Manager. JPL appointed a TDS Manager, whose primary responsibility was to match the tracking and data acquisition requirements of the Project with the capabilities of the TDS facilities which provide support. His task was to organize and direct all cognizant agencies in accomplishing the evaluation, planning, and implementation of TDS capabilities to support the mission.

(3) Assistant TDS Manager. The assistant TDS Manager, who also served as the DSN Manager, was directly assigned to the TDS Manager. He was responsible for the planning and implementation of DSN support and, in addition, acted for the TDS Manager in the latter's absence.

(4) TDS Coordinator for the Near-Earth Phase. The TDS Coordinator for the Near-Earth Phase was a representative of the JPL/AFETR Field Station at Cape Kennedy. He was responsible for integrating AFETR, MSFN, and DSN plans, testing, and operations as needed to verify the TDS near-earth phase.

(5) MSFN Coordinator. An MSFN Coordinator from the GSFC was the central point of contact between MSFN elements and other interfacing agencies. He was responsible for MSFN planning support and for assuring that compatible interfaces were established to make the MSFN function an integral part of the TDS in meeting project requirements. He represented the MSFN at TDS meetings and at Project meetings.

(6) AFETR Program Management Officer. The AFETR Program Management Officer was the single point of contact between AFETR elements and other interfacing agencies. He was responsible for AFETR planning support and for assuring that compatible interfaces were established to make the AFETR function an integral part of the TDS in meeting project requirements. He represented the AFETR at TDS meetings and at Project meetings.

(7) DSN Project Engineer. The DSN Project Engineer coordinated all DSN systems and subsystems, working with representatives from numerous technical sections at JPL. He ensured that all systems interfaced in a compatible and timely fashion. He was responsible to both the DSN and the Mariner Mars 1969 Project for matching the requirements of the Project to the capability and commitments of the DSN. He also served as the chairman of the DSN/Mariner Mars 1969 Planning and Operations Team.

(8) DSN Facility Project Engineers. DSN Facility Project Engineers, assigned technically to the DSN Project Engineer, were responsible for interface engineering and operations planning prior to launch. Interface engineering included the system-to-system integration and testing of hardware and software. Operations planning included the design and preparation of the operational support to be supplied to the Project by the DSN. During prelaunch testing and during the flight, the DSN Facility Project Engineers had operational assignments in support of the operational elements of the TDS.

The DSN Planning and Operations Team for the Mariner Mars 1969 Project met once a week under the chairmanship of the DSN Project Engineer for the purpose of controlling and directing the Interface Engineering and Operations Planning. The Facility Project Engineers comprising the team are shown in Fig. 9.

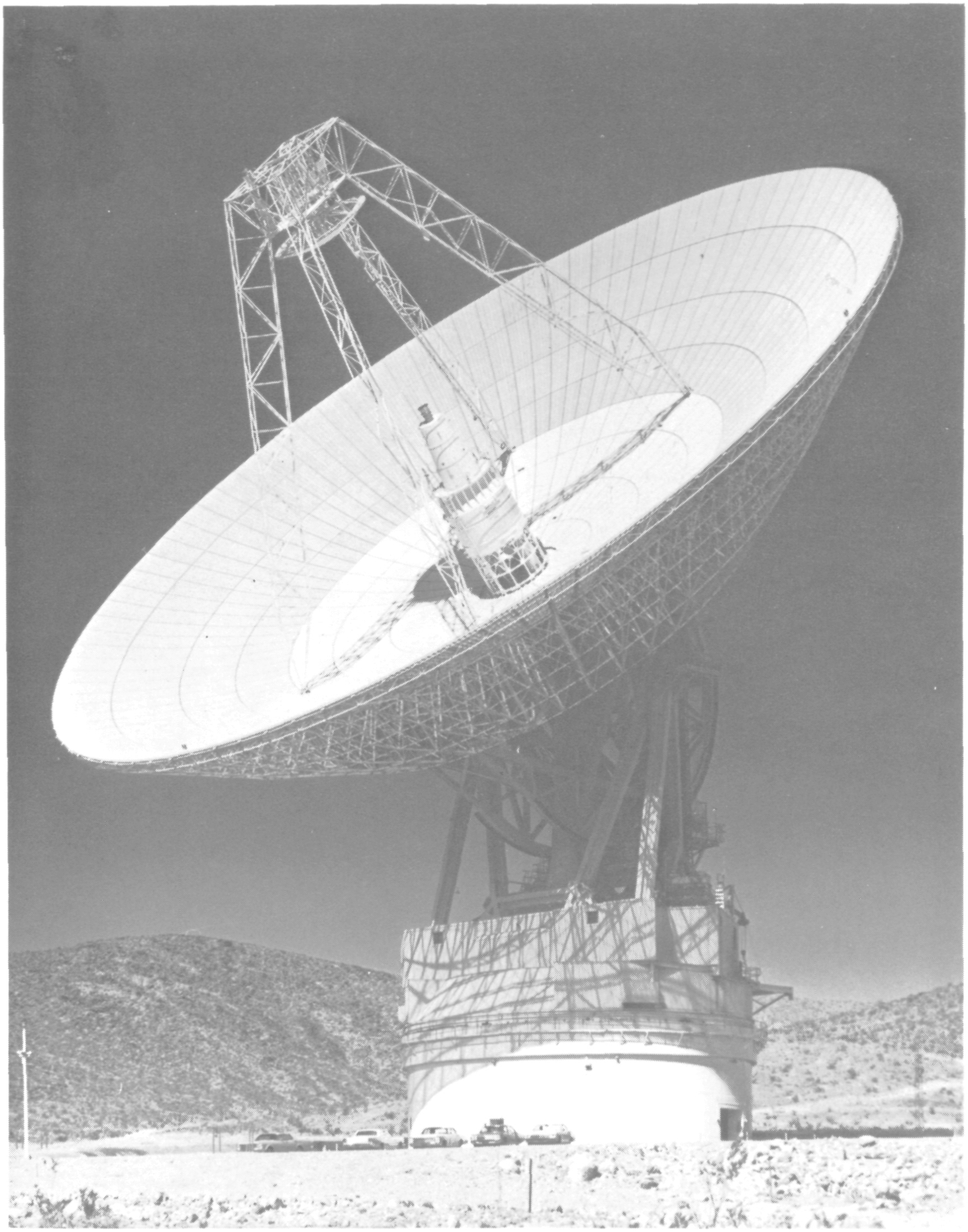

Fig. 1. The 64-m (210 ft) antenna

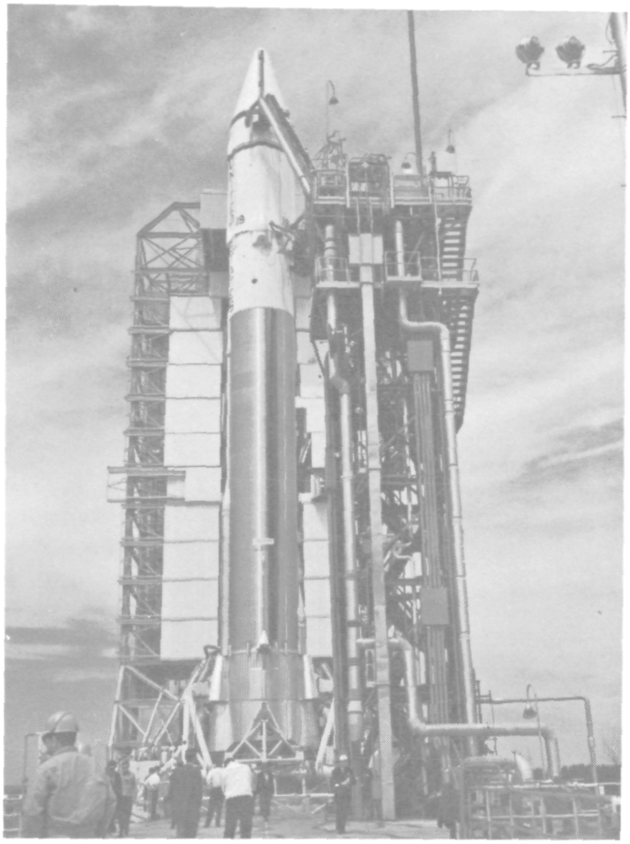

Fig. 2. Atlas/Centaur launch vehicle on pad

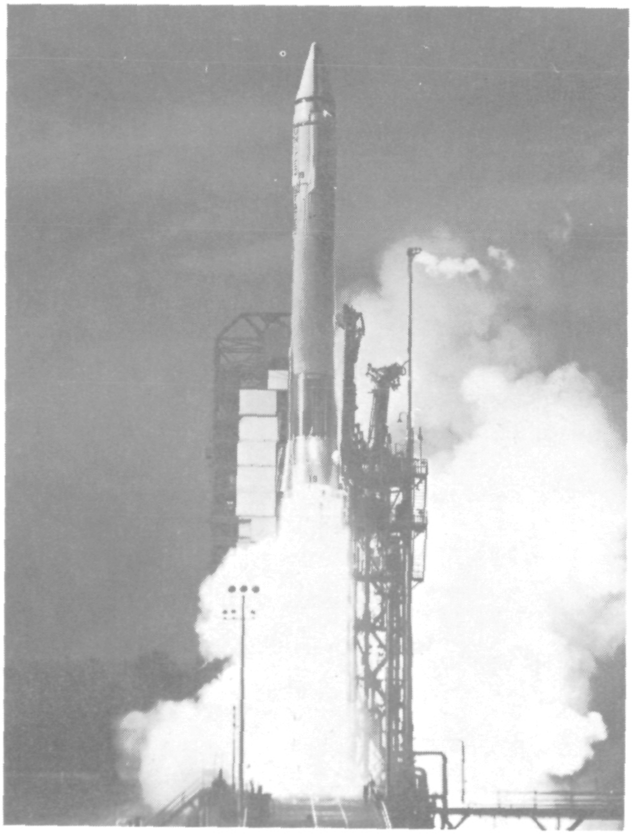

Fig. 3. Atlas/Centaur launch vehicle during blastoff

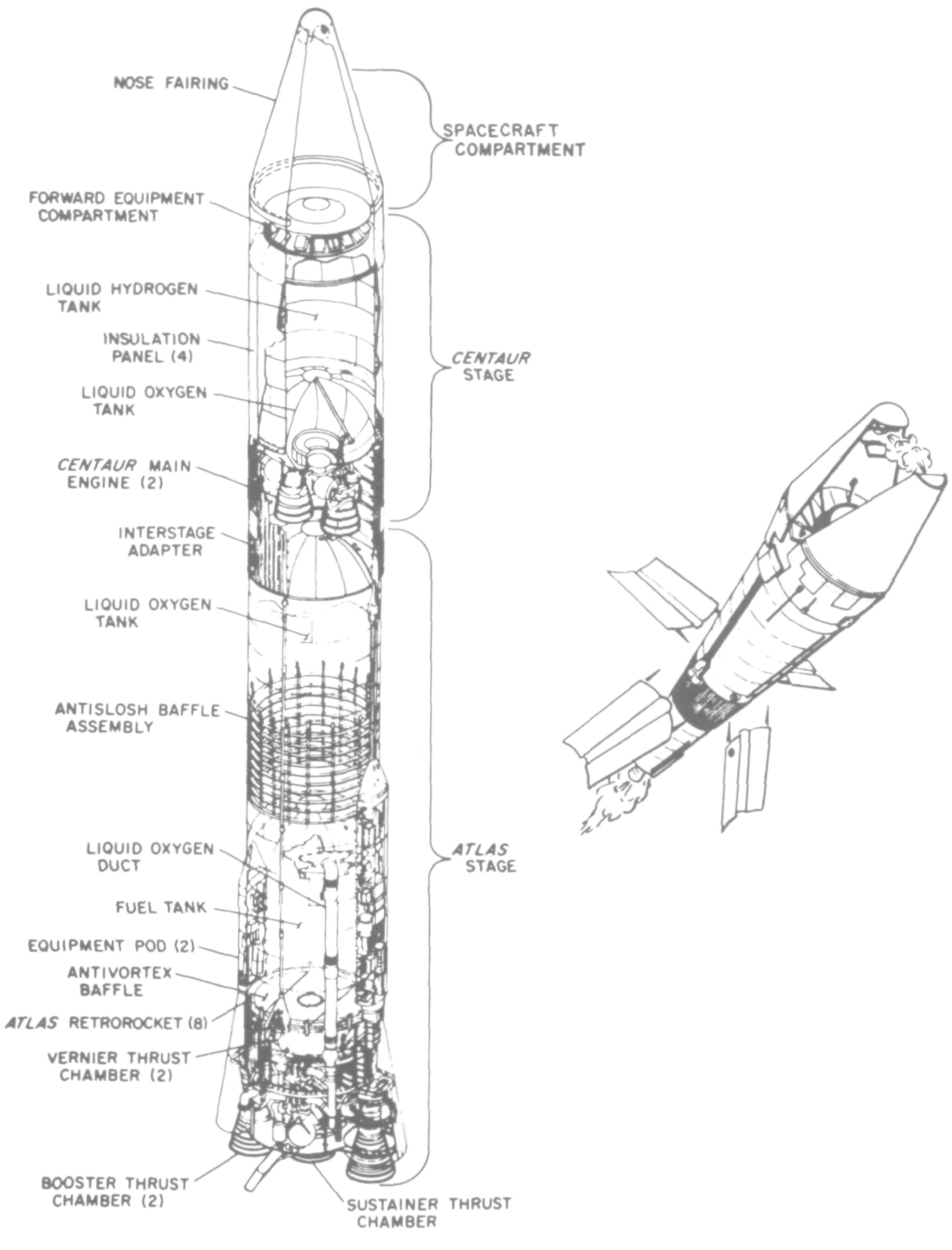

Fig. 4. Atlas/Centaur launch vehicle (schematic)

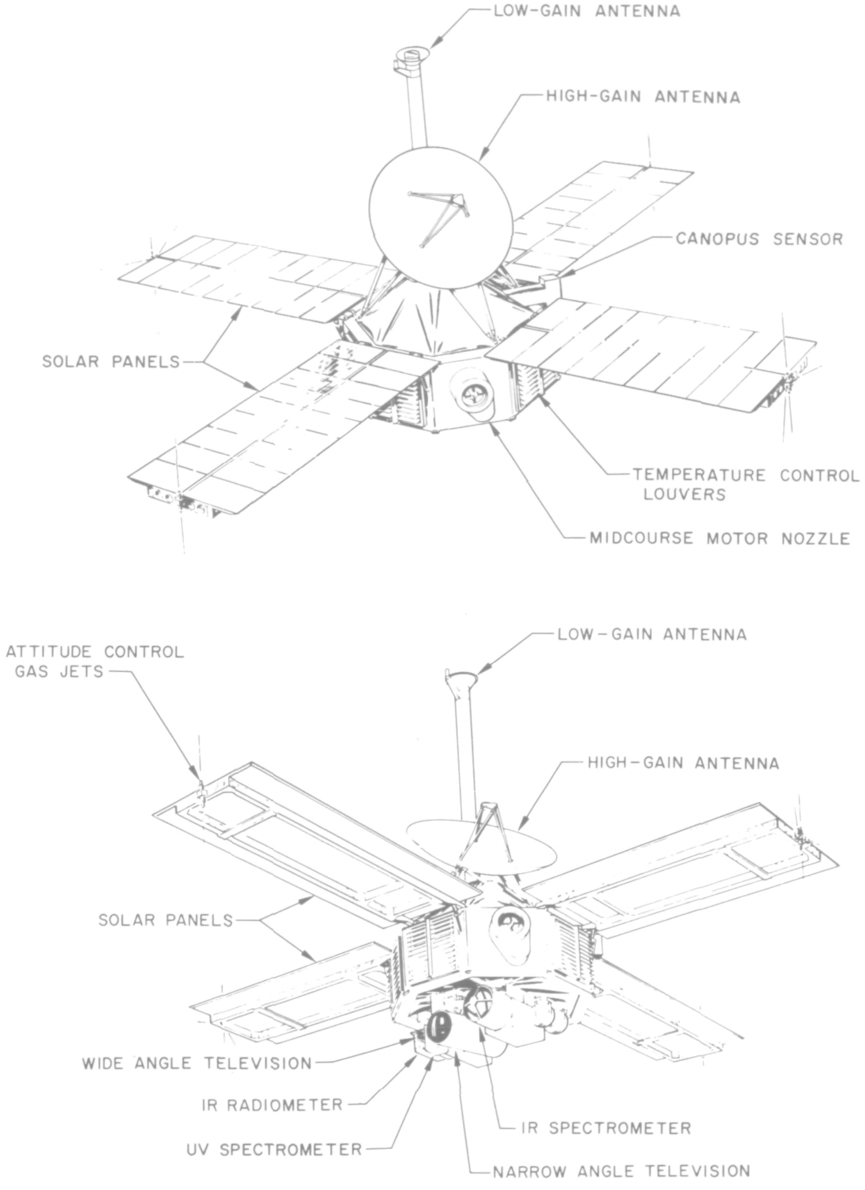

Fig. 5. Mariner Mars 1969 spacecraft configuration

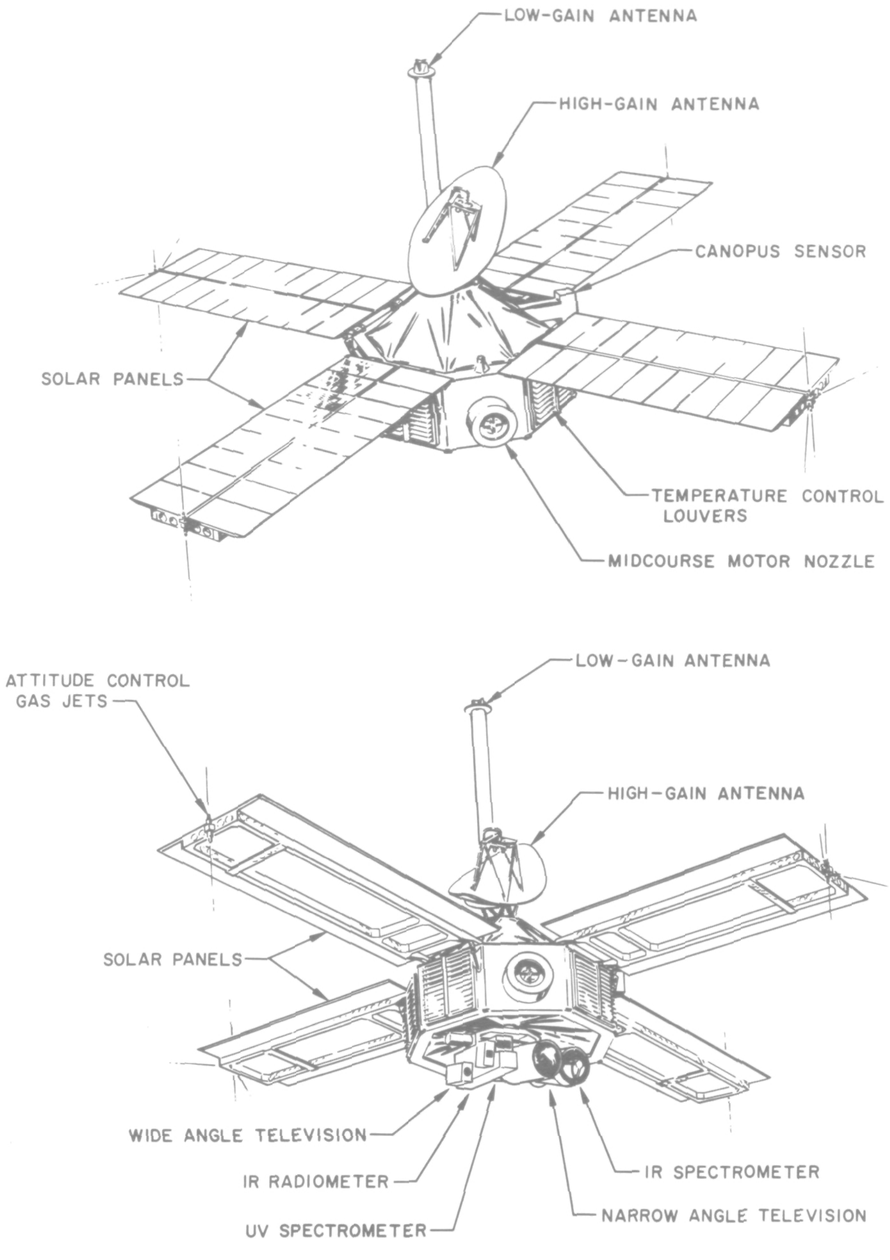

Fig. 6. Mariners VI and VII scientific payload

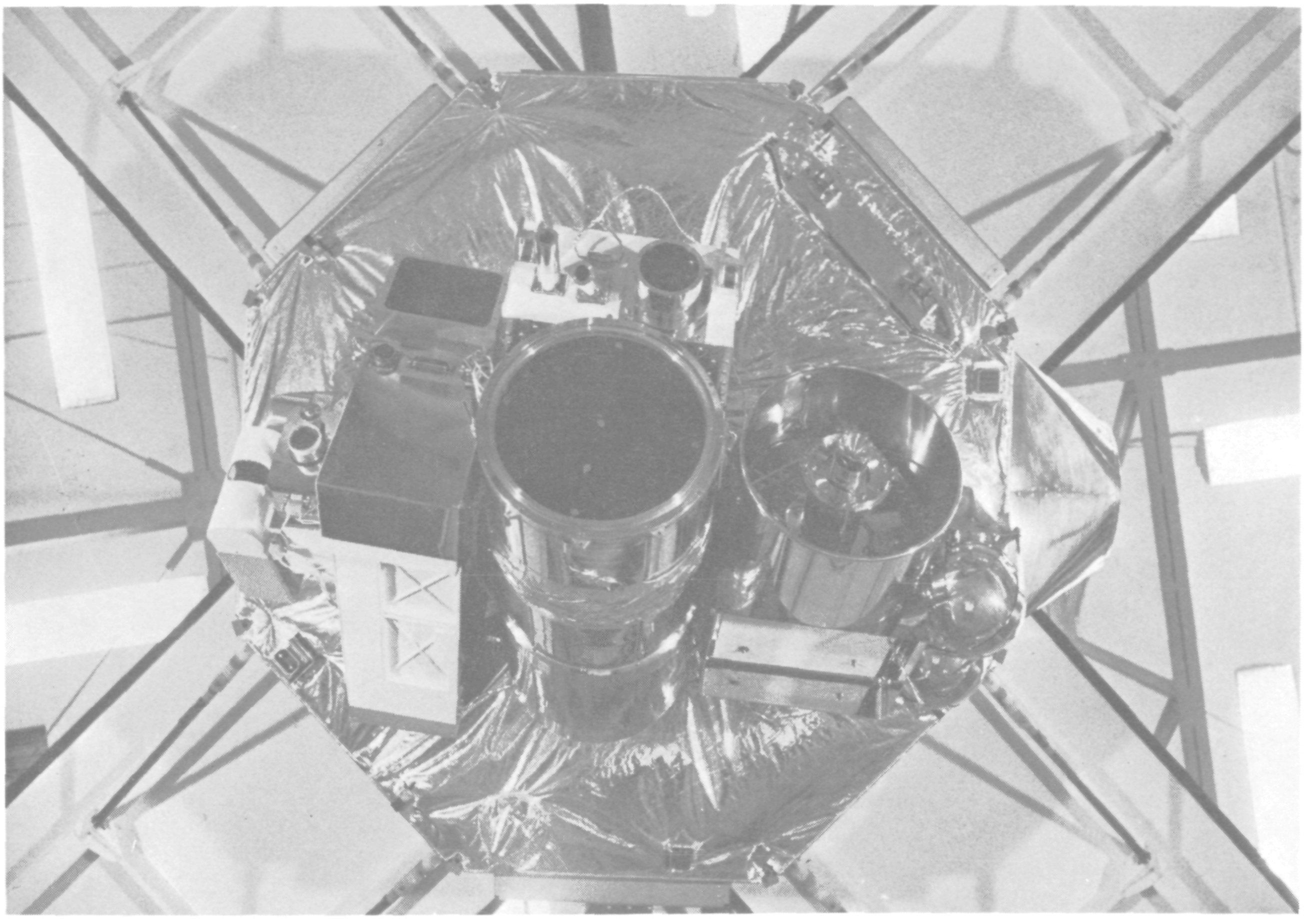

Fig. 7. Scan platform

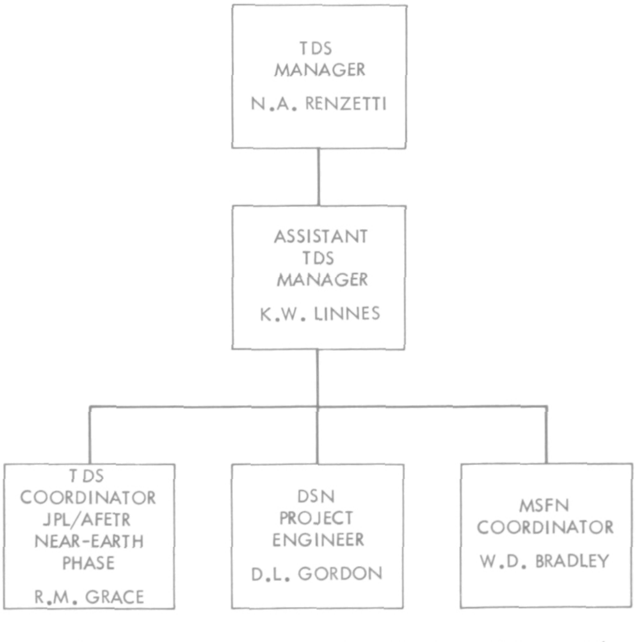

Fig. 8. TDS organization for Mariner Mars 1969

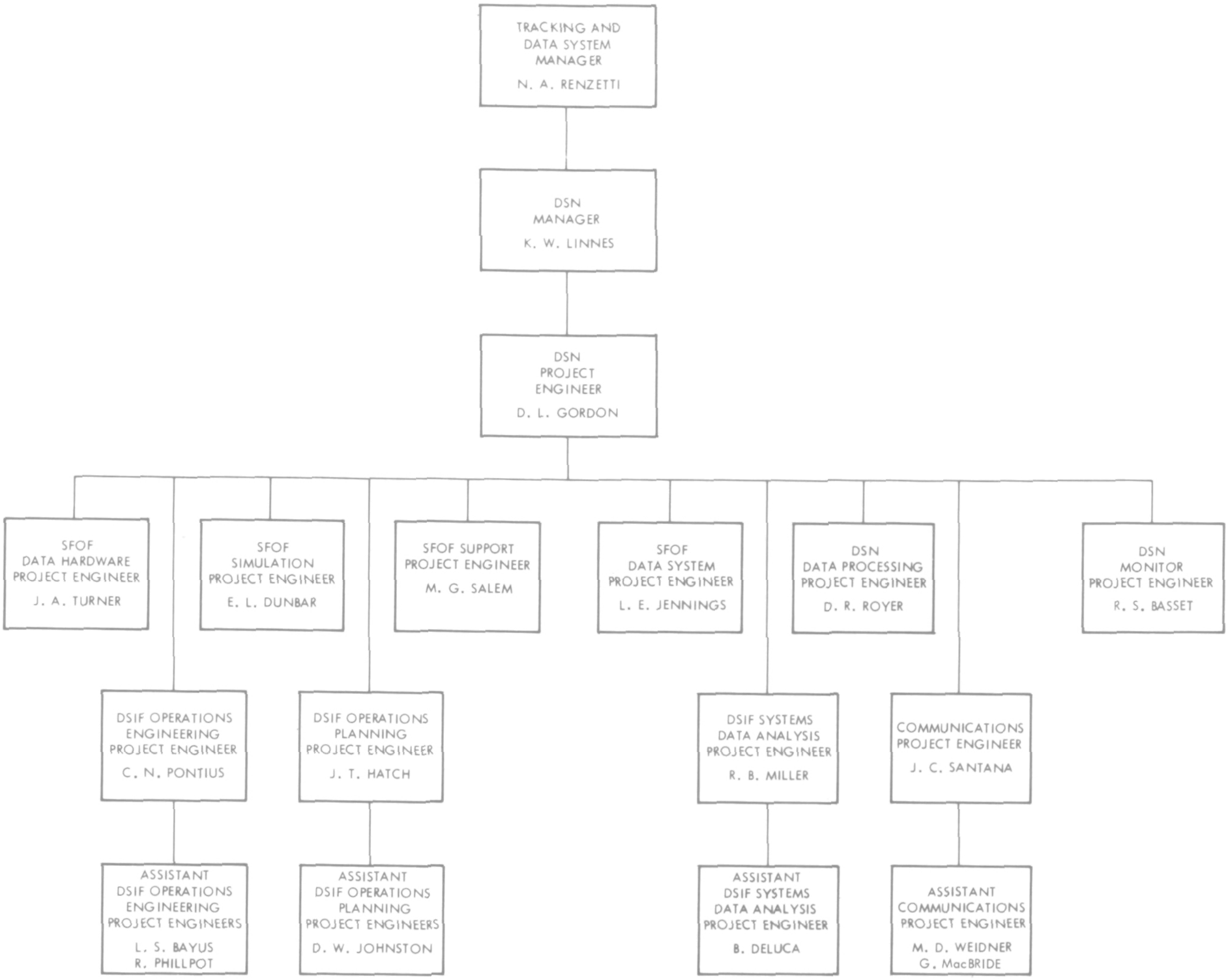

Fig. 9. DSN project engineering organization for Mariner Mars 1969

II. FLIGHT PROJECT TRACKING AND DATA ACQUISITION REQUIREMENTS

A. General

Tracking and data acquisition is defined as the acquisition, transmission, and processing of information which enables the determination of space vehicle position, velocity, direction, system and subsystem performance, and experiment measurements, all with respect to a common time base. The Mariner Mars 1969 Project tracking and data acquisition requirements which the TDS was tasked to support are presented in this section.

The importance of near-earth phase support requirements are indicated by categorizing them either as Class I, II, or III. These requirement classes apply only to the near-earth phase of the mission, and not to the deep space phase.

(1) Class I requirements reflect the minimum essential needs to ensure accomplishment of primary mission objectives. These are mandatory requirements which, if not met, may result in a decision not to launch.

(2) Class II requirements define the needs to accomplish all of the stated mission objectives. Satisfactory Class II coverage increases the probability of mission success and provides additional data for post-flight analysis.

(3) Class III requirements define the ultimate in desired support and should enable the network user to achieve the mission objectives earlier in the program.

Requirements were also identified as occurring in either the near-earth or deep space phase of the mission, and were grouped according to type: (1) metric (tracking), (2) telemetry, (3) data transmission, (4) communications, and (5) data processing. The near-earth phase began with prelaunch activities and continued through launch to continuous DSN view. At this point, the deep space phase began and continued to the end of the mission. Material in this document is organized to follow this division of requirements.

B. Near-Earth Phase Requirements

1. Launch phase coverage. The project required the TDS to plan to support a launch period from February 23 to April 8, 1969, with a launch window each day of 1 hour. Figure 10 shows a general correlation of near-earth tracking and data acquisition requirements with flight profile.

The powered flight trajectory mode was to be direct ascent (i.e., nearly continuous thrusting by the launch vehicle from launch to injection), and was to include one or two yaw maneuvers to achieve required high-orbital inclinations without violating Range Safety restrictions. Launch azimuths for planar trajectories (i.e., trajectories without yaw maneuvers) were between 80 and 108 deg east of north. Trajectories requiring yaw maneuvers had an initial launch azimuth of 108 deg east of north.

Because of the large number of potential trajectories to be flown, a decision was made to choose representative trajectories for the whole launch period for use in planning TDS coverage. These trajectories covered the entire space bounded in Figs. 11 and 12 in an orderly manner. From this group of 85 trajectories, a 17-day group of windows was used to prepare the TDS plans.

TDS coverage problems for the Mariner Mars 1969 Project were less severe than for previous Mariner projects. The use of the direct ascent mode caused injection and Centaur/spacecraft separation events to occur well uprange, in the vicinity of Antigua Island, rather than near the African coast as was the case with three previous Mariner missions. Since the area from Cape Kennedy past Antigua is an area of concentration of AFETR/MSFN resources, coverage of launch through Centaur/spacecraft separation was easier than in the past.

Figure 13 shows the earth tracks for two cases which bound the launch azimuths used: a February 24 launch, a July 31 arrival; and an April 7 launch, August 5 arrival. Injection and separation occur approximately 15 deg east of Antigua. Also, the 1 h launch windows helped to reduce the near-earth TDS coverage problems. Half of the windows opened with a flight path angle of at least 10 deg, which was favorable from a near-earth TDS coverage point of view.

2. Data acquisition. Data acquisition requirements for the near-earth phase included (1) launch vehicle telemetry, (2) launch vehicle metric data, (3) spacecraft telemetry, and (4) spacecraft metric data. The requirements anticipated use of VHF links for launch vehicle telemetry, C-band radar tracking for launch vehicle metric data, S-band reception for spacecraft telemetry and metric data, and VHF links for certain selected spacecraft telemetry channels through the launch vehicle telemetry system.

The data were required:

(1) To establish as quickly as possible the normalcy of the mission.

(2) To determine the minute-by-minute status of the flight.

(3) To aid the DSN, MSFN, and AFETR stations in acquiring the vehicle and/or spacecraft.

(4) To aid project decisions in the event of a non-standard mission.

(5) To allow post-launch analysis.

Table 1 summarizes the coverage requirements for launch vehicle telemetry. A brief description of the Atlas telemetry link (229.9 mHz) is given in Table 2. Tables 3 and 4 give brief descriptions of the Centaur telemetry links. One of these links (225.7 mHz) contained the spacecraft PCM telemetry at 33 1/3 bits/s on Channel 13 (Table 3).

Metric data requirements for the launch vehicle are summarized in Table 5, accuracy requirements on these data are shown in Tables 6 and 7. These requirements apply to the C-band radar tracking of the launch vehicle.

Requirements for acquisition of spacecraft telemetry and S-band metric data in the near-earth phase are shown in Table 8. As indicated, the project requirement for S-band telemetry and metric data extends from separation until 5 days after midcourse maneuver. The TDS assigned to the near-earth phase the responsibility for meeting the requirements from separation until the beginning of the deep space phase. The DSN provided coverage thereafter.

The characteristics of the spacecraft telemetry system are as follows:

(1) Type: PCM/PSK/PM.

(2) Commutated designation: Solid state, fully synchronous, four commutation rates (ratio 1:10:100:200).

(3) Frame format: 100 segments (7 bits/segment), 91 data words (1 segment each), 1 sync group (3 segments long), plus 6 sub-commutation points (1 segment each).

(4) Sync group format: 1 PN frame sync — 15 bits, 1 sub-commutation index word — 6 bits.

(5) Word format: 7 bits: first bit — most significant digit. Seventh bit — least significant digit.

(6) Channel characteristics: see Table 9.

Spacecraft telemetry data acquisition requirement during launch activities is at 33 1/3 bits/s. Prelaunch calibrations were required at all data rates.

3. Communications. Project communication requirements in the near-earth phase were, for data and voice channels within the elements of the TDS and between the TDS facilities and the project launch operations facilities, adequate to conduct test and launch operations. Specific requirements were for three voice circuits from Bldg AO at Cape Kennedy, the site of Mission Control during test and launch, and the Space Flight Operations Facility (SFOF) at JPL. Exact numbers of transmission circuits for teletype data and high-speed data lines were not specified.

4. Data processing. Data processing tasks which the TDS was required to accommodate during the near-earth phase consisted primarily of trajectory computations and spacecraft engineering and science telemetry conversions. Data processing in this sense is defined as those requirements which need the use of central computer facilities. Because data processing is not an independent TDS function, the project stated a portion of their requirements in terms of equipment needs rather than data needs. For the near-earth phase, the project required dual IBM 7044/7094 computers at the SFOF for conversion of spacecraft data to engineering and science units and for processing metric data in providing trajectory computations and predict information.

Requirements for computations resulting from tracking data were as follows:

(1) Transfer orbit elements, inter range vector (IRV), and Mars mapping based on C-band radar metric data after injection.

(2) DSN predicts for DSS 51 and the MSFN ACN site based on the orbital elements above.

(3) Transfer orbit elements, IRV, and Mars mapping based on Centaur guidance telemetry data after injection.

(4) Transfer orbit elements, IRV, Mars mapping, and I-matrix based on recursive C-band radar metric data solution.

(5) Spacecraft orbit elements, IRV, Mars mapping, and I-matrix based on S-band radar metric data after separation.

(6) DSN predicts to DSS 51 and the MSFN ACN site based on the spacecraft orbital elements above.

(7) Centaur postdeflection orbit elements, IRV, Mars mapping, and I-matrix based on C-band radar metric data after the deflection.

(8) Centaur postdeflection orbit elements, IRV, Mars mapping, and I-matrix based on Centaur guidance telemetry data after the deflection.

C. Deep Space Phase Requirements

1. Deep space phase coverage. Project requirements for TDS support during the deep space phase were divided according to mission intervals as shown in Table 10. Coverage of basically two types was required. Continuous coverage was required during launch, trajectory correction, and encounter operations. During cruise, the requirement was for telemetry data often enough to detect any spacecraft problems and take corrective action. Two consecutive spacecraft telemetry commutator cycles were stated, as an adequate amount of information provided these operations were separated by a time slightly less than the spacecraft battery life. Since only engineering data were to be transmitted during cruise, observation periods of at least 28 min at 33 1/3 bits/s or 112 min at 8 1/3 bits/s were required, separated by not less than 5.6 h, 5.6 h is the closest multiple of a commutator cycle to the 6-h battery life restriction.

Metric data during cruise were required no less often than once every 4 days with the restriction that they must be derived from a complete horizon-to-horizon pass with no more than 20% of the data missing. One pass every 2 weeks per spacecraft from the station equipped with the 64-m antenna (DSS 14) was desired to meet a secondary objective; i.e., improvement of trajectory determination by the inclusion of ranging data obtained from research and development ranging equipment. Overall telecommunications performance did not predict acquisition of data from the operational Mark I ranging equipment at the 26-m antenna stations much beyond 800,000 km, certainly not to planetary distances. Metric data were required for determination of the spacecraft trajectory and the required trajectory corrections. The required accuracies for metric data are listed in Tables 11 and 12.

2. Data acquisition and handling. Radio metric data requirements included angle data during the initial phase of the mission, but omitted this requirement later; range in two-way doppler was required throughout all phases. The data were required in real time, except that the one sample/s rate, during critical phases, displayed on printers and plotters in the SFOF and recorded on magnetic tape. During cruise, or non-critical phases, radio metric data were required to be recorded on magnetic tape and to be immediately available if needed. All radio metric data received in the SFOF in real time were required to be displayed on teletype printers.

Telemetry data were required to be processed and recorded in the IBM 7044/7094 computer string for display in the SFOF. At each tracking station, telemetry data were required to be processed in the telemetry and command processor (TCP) for local display of selected spacecraft parameters and for preparation of the data for transmission to the SFOF. The digital output of the TCP was required to be recorded.

Requirements for delivery of magnetic and paper tapes from the Deep Space Station (DSS) were:

(1) From Goldstone — available in the SFOF within 24 h.

(2) From Overseas Stations — shipped within 1 week and available in the SFOF within 2 weeks.

Records from the DSS, including strip-chart recordings, operations logs, and calibration sheets, were required to be available from microfilm records and DSN document control.

Since it appeared that the Mariner 1969 Project would be the first with a high probability of two spacecraft successfully launched, the Project agreed to schedule operations of the two spacecraft such that when one was in a critical phase, the other would be in a quiescent state. The intent was to scale the requirement to stay within the capability of the IBM 7044 computer redesign to handle two missions or data streams simultaneously in one IBM 7044/7094 computer string. The project was aware that DSN resources would permit the operation of but two such strings so that scaling the requirement in this manner permitted achieving the project goal of having block redundancy in major portions of the data system during mission operations.

An additional requirement was a capability to operate a double-precision orbit-determination program (DPODP) using an IBM 7040/7094 computer direct couple arrangement to be provided on a research and development basis; i.e., no backup. Computer support requirements in the SFOF are summarized in Table 13.

3. Communications. Project requirements for ground communications assumed that the DSN would provide sufficient voice circuits between the DSS to execute mission operations. The same assumption was made concerning provision by the DSN of teletype channels and high-speed data lines for the transmission of metric, telemetry, and command data.

A specific requirement was two voice channels between the SFOF and the Spacecraft Assembly Facility (SAF) at JPL for the purpose of conducting spacecraft compatibility tests and permitting support of mission operations from the SAF.

4. Ground command requirements. Starting at approximately launch + 1 h, command capability was required during any phase of the mission. The command system required use of Read, Write, Verify (RWV) equipment provided by the spacecraft system and maintained and operated by the DSN. The project assumed the commands would be sent using the 10-kW transmitter capability at the 26-m antenna stations. The project also required backup command capability from the 20-kW transmitter and the 64-m antenna from 30 days before encounter through completion of playback in the event of non-standard spacecraft performance.

5. Simulation. The DSN was required to provide a simulation capability which the project assumed was to be provided by the DSN Simulation Data Conversion Center, a primary element of which was an ASI 6050 computer. The center was required for the generation of simulated spacecraft telemetry and radio metric data during computer program testing and mission operations testing.

By means of mission operational functional requirements, the project required that the capability exist to simulate simultaneously two operating spacecraft in the cruise mode as well as one in the cruise mode and the other in a critical phase such as launch, maneuver, encounter, or non-standard condition. The simulation system was required to be capable of inserting simulated data at various points in the data system, including each prime tracking station.

6. Mission support area. The project requested a total of 640 m^2 of space in the SFOF in which to conduct mission operations. Separate rooms were requested for the functions of project management, mission control, flight path analysis, spacecraft performance analysis, space science analysis, and conference.

Assistance was also required in interfacing with and providing data to Complementary Analysis Team (CAT) areas outside the SFOF. All areas were located in other buildings at JPL.

7. Compatibility testing. Support from TDS facility was required to design, plan, and conduct radio frequency and data compatibility tests between the spacecraft and the TDS facilities. The project based this requirement on the assumed availability of a DSN Compatibility Test Area (CTA-21) at JPL. This capability was required to perform telecommunications subsystem tests and computer program checkout.

Table 1. Launch vehicle telemetry data coverage requirements

Links	Class I	Class II	Class III	Remarks
All (229.9, 225.7, 259.7 mHz)	Prelaunch calibration and launch - 75 min to launch - 5 min	Launch - 5 min to LOS of the stations supporting the Class I requirements	Same as Class II	
229.9 mHz (Atlas)	Launch - 5 min to launch + 5 min	Class I interval extended to LOS	Same as Class II	
225.7 mHz 259.7 mHz (Centaur)	Launch - 5 min to Centaur/spacecraft separation + 5 s[a]	Launch - 5 min to launch + 42.6 min	Launch - 5 min to launch + 4.5 h	Evaluation of Centaur systems, spacecraft status, Centaur/spacecraft separation

[a] Real-time transmission to Bldg AE until Antigua set; near real-time to AE after Antigua set.

Table 2. Atlas telemetry link (229.9 mHz, PAM/FM/FM)

Channel			Measurement Rate
No.	Frequency, kHz	No. of Segments	
1	0.4	-	Continuous
2	0.56	-	Continuous
3	0.73	-	Continuous
4	0.96	-	Continuous
5	1.3	-	Continuous
6	1.7	-	Continuous
7	2.3	-	Continuous
8	3.0	-	Continuous
9	3.9	-	Continuous
10	5.4	-	Continuous
11	7.35	60	2.5 rev/s
12	10.5	-	Continuous
13	14.5	60	5 rev/s
14	22.0	-	Continuous
15	30.0	60	10 rev/s
16	40.0	60	10 rev/s
17	52.5	-	Continuous
18	70.0	60	30 rev/s

Table 3. Centaur telemetry link (225.7 mHz, PAM/FM/FM)

Channel			Measurement Rate
No.	Frequency, kHz	No. of Segments	
1	0.4	-	Continuous
2	0.56	-	Continuous
3	0.73	-	Continuous
4	0.96	-	Continuous
5	1.3	-	Continuous
6	1.7	-	Continuous
7	2.3	-	Continuous
8	3.0	60	1 rev/s
9	3.9	60	1 rev/s
10	5.4	-	Continuous
11	7.35	60	1 rev/s
12	10.5	60	2.5 rev/s
13	14.5	PCM	33-1/3 bits/s
14	22.0	-	Continuous
15	30.0	60	5 rev/s
16	40.0	PCM	800 bits/s
17	52.5	-	Continuous
18	70.0	60	20 rev/s

Table 4. Centaur telemetry link (259.9 mHz, PAM/FM/FM)

Channel		Measurement Rate
No.	Frequency, kHz	
11	7.35	Continuous
12	10.5	Continuous
13	14.5	Continuous
14	22.0	Continuous
15	30.0	Continuous
16	40.0	Continuous
17	52.5	Continuous
18	70.0	Continuous

Table 5. Launch vehicle metric data coverage requirements

Class I	Class II	Class III	Remarks
Launch to MECO + 30 s	Launch to MECO + 30 s	Launch to MECO + 30 s	For Atlas performance analysis
Any 120 s between MECO + 5 s (injection) and Centaur deflection maneuver start[a]	First continuous 120 s between injection (MECO + 5 s) and Centaur deflection maneuver start	All of interval from injection to Centaur start deflection	For RF link analysis and Centaur performance analysis
	Any 120 s between MECO + 40 min and MECO + 50 min	Any 120 s between MECO + 40 min and MECO + 50 min	To determine Centaur orbit for possible Canopus acquisition analysis, verification of planetary quarantine criteria, and TDS acquisition information
	From MECO + 60 min to MECO + 70 min, any continuous 120 s	MECO + 60 min to MECO + 70 min, any continuous 120 s	
		Any continuous 120 s, starting at MECO + 5000 s	

[a] Data transmitted to Bldg AO in real time.

Table 6. Launch vehicle metric data accuracy requirements[a]

	Reduced data accuracy[b]		
	Class I	Class II	Class III
Position	± 305 m	± 15 m	± 3 m
Velocity	± 9.2 m/s	± 15 mm/s	± 1.5 mm/s

[a] 6 samples/s.

[b] C-band radar tracking.

Table 7. Orbital tracking data accuracy requirements[a]

Class	Data type	Data errors		Station timing requirements to WWV, s
		Bias	Random	
1	Range, m	200	30	0.003
	Angles, deg	0.15	0.05	
2	Range, m	100	6	0.001
	Angles, deg	0.045	0.045	
3	Range, m	10	1	0.0005
	Angles, deg	0.007	0.005	

[a] C-band radar tracking of Centaur.

Table 8. Spacecraft telemetry and S-band metric data requirements

Links	Class I	Class II	Class III
225.7 mHz (Centaur)	Prelaunch calibrations[1]	Same as Class I	Same as Class I
225.7 mHz (Centaur)	Launch minus 75 min to Centaur/spacecraft separation[1]	Same as Class I	Same as Class I
2295 mHz (S/C)	Prelaunch calibrations	Same as Class I	Same as Class I
	From separation minus 5 sec to midcourse maneuver plus 5 days[2]	Same as Class I	Same as Class I
		Launch to launch plus 30 min[3]	Same as Class II
S-Band Tracking Data	MSFN/ACN rise plus 30 sec to midcourse maneuver plus 5 days	Same as Class I	Same as Class I

[1] Data transmitted to DSS 71/Building AO in real time

[2] Data transmitted to SFOF in real time

[3] Telemetry data recorded on magnetic tape and returned in 24 hours, tracking data delivered to the SFOF in real time

Table 9. Spacecraft telemetry channel characteristics[a]

Channel	Subcarrier frequency, kHz	Data bandwidth about subcarrier, Hz	Maximum bit error rate
Science (66 2/3 bits/s)	34.286	± 200	5 in 10^3
Science (270 bits/s)	34.286	± 810	5 in 10^3
Engineering (8 1/3 bits/s)	24.0	± 25	5 in 10^3
Engineering (33 1/3 bits/s)	24.0	± 100	5 in 10^3
High rate (16.2 k bits/s)	259.2	a	5 in 10^3

[a] The encoded signal was transmitted at a rate of 86,600 symbols/s, requiring a data bandwidth of ± 1.5 mHz about the carrier frequency.

Table 10. Deep space phase tracking and telemetry coverage requirements

Mission interval	Radio metric data required		Telemetry coverage required	Remarks
	Type	Sample rate		
First acquisition to launch + 3 h	Range, doppler (two-way) angles	Continuous at 1 sample/min 1 sample/10 s	Continuous	
Launch + 3 h to midcourse maneuver + 5 days	Range doppler	Continuous at 1 sample/15 min 1 sample/min	Continuous	Mark I ranging expected only to about lunar distance. Assumes R&D ranging thereafter at 64-m antenna only; one pass every 2 weeks per spacecraft desired to meet secondary objective
Cruise	Range doppler	To be specified during operations 1 sample/min	Two complete S/C commutator cycles separated by no more than 5.6 h	Metric data requirement is for one complete horizon-to-horizon pass every 4 days, separated by not more than 90 h. No single station shall be used for more than three consecutive passes. At 8 1/3 bits/s, two commutator cycles are of 112 min duration; at 33 1/2 bits/s, 28 min
Second midcourse maneuver - 10 days to + 5 days	Range doppler	Continuous at 1 sample/15 min 1 sample/min (1 sample/s during maneuver)	Continuous	May not be performed
Encounter (1) E - 14 days to E - 1 day	Range	1 sample/15 min	Continuous - (8 1/3 or 33 1/3 bits/s and 66 2/3 or 270 or 16,200 bits/s)	Mission design assumes three 26-m antennas and one 64-m antenna for standard operations and plans to take advantage of any additional support that may become available
E + 1 day to E + 15 days	doppler	1 sample/min		
(2) E - 1 day to E - 1 h	Range	1 sample/min		
Exit occultation + 1 h to E + 1 day	doppler	1 sample/min		
(3) IRS gas jetting - 30 min to occultation	Range	1 sample/s		1 sample/s data required in real time
Exit occultation + 20 min to exit occultation + 1 h	doppler	1 sample/s		

Table 11. Doppler and angle data accuracy requirements

Data Accuracy	Correlation Width, T (min)	$2\ \sigma$ Noise[a]		
		Two-Way Doppler (Hz)[b]	Three-Way Doppler (Hz)[b]	Angles (deg)
To support primary mission objectives	$T_p < 10^m$	0.01	0.01	0.05
	$T_p \geq 10^m$	0.01	0.01[c]	0.2
To support secondary mission objectives	$T_p < 10^m$	0.005	0.005	0.01
	$T_p \geq 10^m$	0.005	0.005[c]	0.06

[a] All $1\ \sigma$ standard deviations are for tracking data taken above 5° local elevation.

[b] Based on 1 sample per minute.

[c] Deviation from a constant bias, bias < 0.01 cps for primary mission objectives and < 0.003 cps for secondary mission objectives, throughout the pass.

Table 12. Ranging data accuracy requirements

Characteristic	Particular Case	To Support Primary Mission Requirements Noise ($1\ \sigma$)	To Support Secondary Mission Requirements Noise ($1\ \sigma$)
Stability	Sample Period:		
	10^2 sec	0.7 ns - 0.1 m	0.3 ns
	10^4 sec	5 ns - 0.8 m	1 ns
	10^5 sec (1-2 days)	40 ns - 6 m	8 ns
Absolute accuracy	S/N:		
	Strong	100 ns - 15 m	10 ns
	Weak	300 ns - 45 m	200 ns

Note: 1 manosecond (ns) = 10^{-9} sec = 0.15 meters (m)

Table 13. SFOF computer requirements

Mission phase	Computer configuration	Requirement	Remarks
Launch through midcourse, second midcourse, encounter, and tracking periods during cruise	7044	Continuous real-time processing of telemetry. Periodic processing of metric data	
Tracking periods during cruise	7044/7094	Two 6-h periods/week prior to encounter. Six 6-h periods between E + 23 and E + 33 days, and one 6-h and one 12-h period between E + 33 days to E + 90 days	
Cruise	7040/7094 (direct coupled mode)	Two 12-h periods/week	
Prelaunch and launch	7044/7094	Real-time processing	Data acquired by DSS 71 at ETR during prelaunch tests and first phase of launch
Mission operations testing	7044/7094	Process data from compatibility test between the spacecraft system and the DSN test capability in CTA-21	

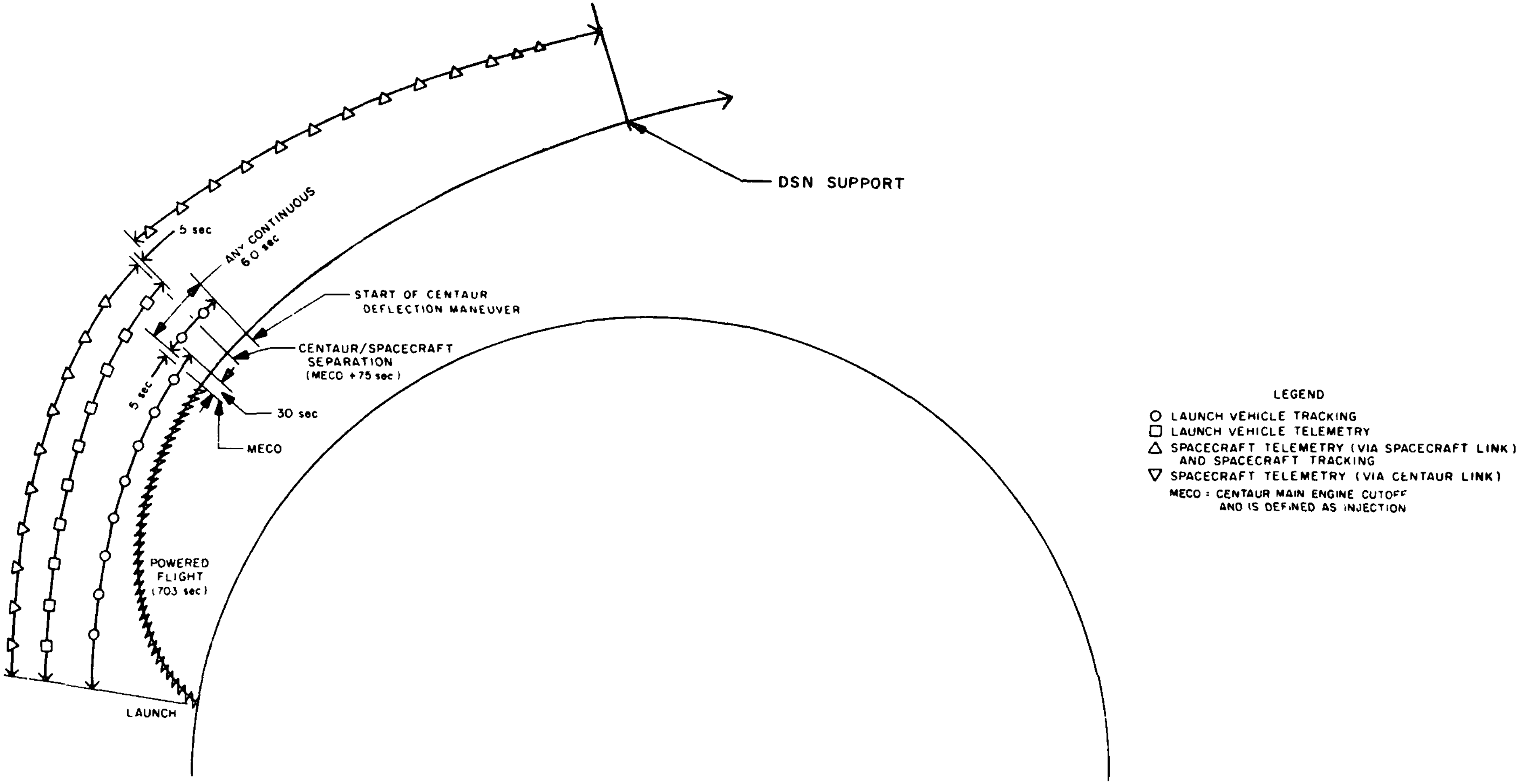

Fig. 10. Near-earth Class I TDA requirements

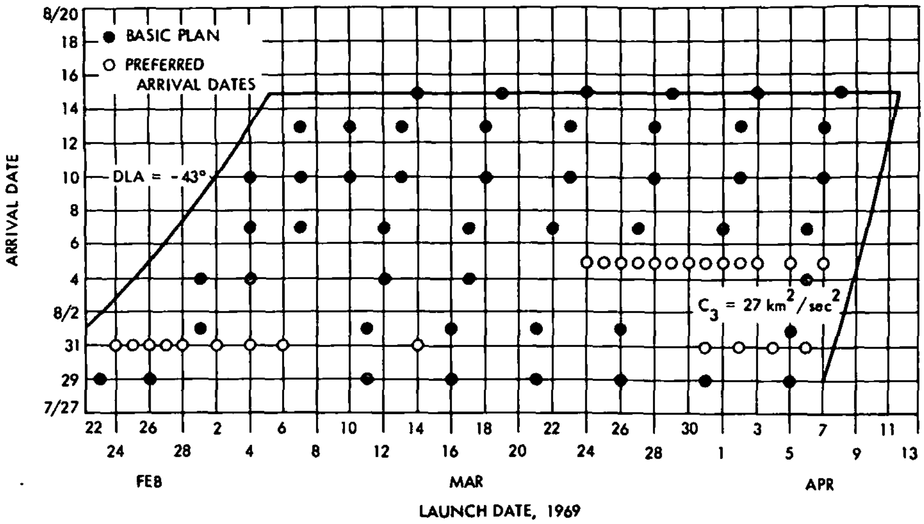

Fig. 11. Launch/arrival target plan

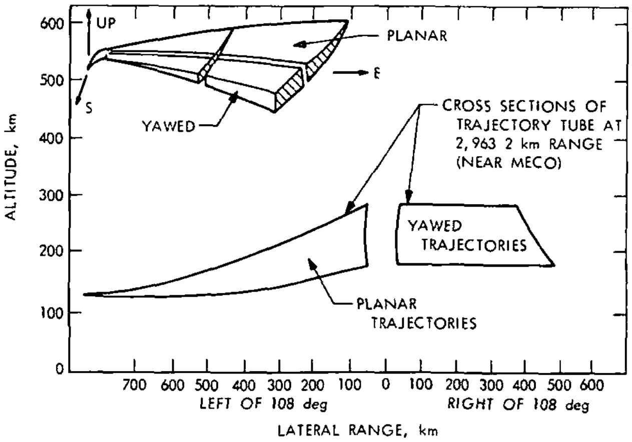

Fig. 12. Powered trajectory envelope

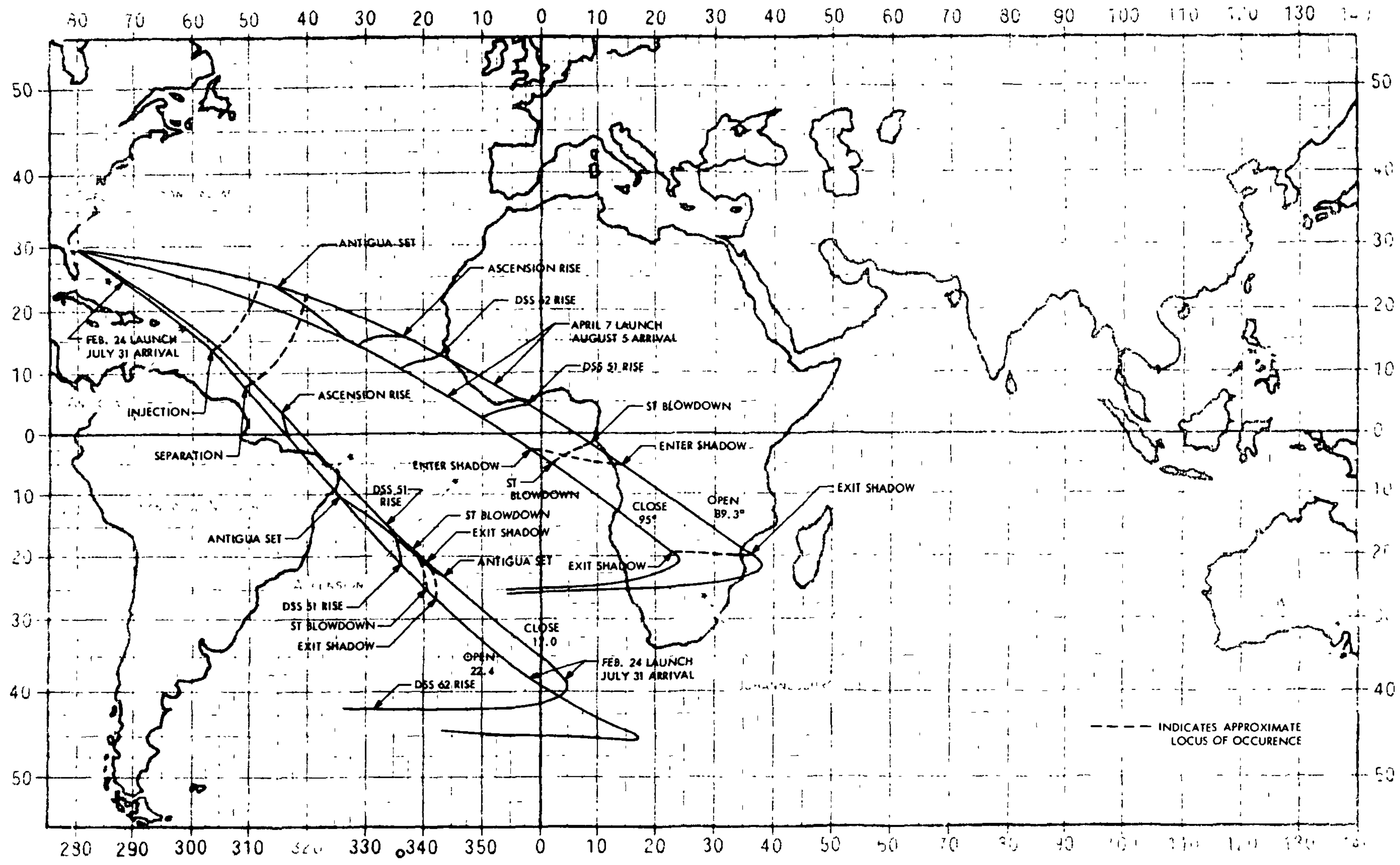

Fig. 13. Earth tracks for two cases bounding launch azimuths

III. TRACKING AND DATA SYSTEM OPERATIONS PLAN

A. Planning Activities

1. Support of mission design. The flight project requirements on the TDS summarized in the previous section resulted ultimately in a Tracking and Data System Operations Plan. Although the plan is the anticipated support of the project in response to the requirements, the formulation of the plan was part of a closely coordinated effort in support of the total mission operation and design. Mission Operations was defined as an activity distinct from the management element, MOS, and included (1) a Data System, (2) a Software System, and (3) an Operations System. Since the Data System was defined to include all earth-based equipment provided by all systems of the project for the receipt, handling, transmission, processing, and display of spacecraft data and related data during Mission Operations, the TDS constituted the major portion of the Data System, excepting only some relatively small amounts of mission-dependent equipment supplied by the flight project. In the near-earth phase, facilities of the AFETR and MSFN were included. The Software System included all computer programs and associated documentation provided by either the MOS or TDS for the accomplishment of Mission Operations. The Operations System was defined to include the personnel, plans, and procedures provided by the MOS and TDS required for the execution of the Mission Operations. The responsibilities and management arrangements for these three areas are shown in Fig. 14. The design activities for the Data System were conducted by the DSN Project Engineering Team. Table 14 shows that each Design Team included representatives from each of the three technical systems supporting the project Mission Operations.

The Mission Operations design process which the DSN supported through these three teams is shown in Fig. 15. The Mission Operations Design Team formulated system-level functional requirements for the Data, Software, and Operations Systems. From these requirements, as well as from the project requirements stated in the Support Instrumentation Requirements Document (SIRD), the DSN Design Team formulated the DSN configuration and the near-earth coordinator formulated the Launch Support Plan. These plans, taken together, constituted the TDS Operations Plan.

2. Support plans. The principal elements of the TDS planning are set forth in the NASA Support Plan, DSN Operations Plan for the Mariner 1969 Project, DSN Test Plan for the Mariner 1969 Project, and the Near-Earth Phase Operations Plan for the Mariner 1969 Project. Additional provisions of the plan included interface descriptions between the deep space and near-earth phases of the TDS with the Spacecraft and Mission Operations Systems and Compatibility Test Plan for testing the interface design. Support by the MSFN was covered separately by an Operations Plan for Mariner Mars 1969.

The NASA Support Plan (NSP) stated the general capabilities to be supplied by the TDS, in response to the project requirements stated in the SIRD. All the major and significant project requirements were met by operational capabilities of the TDS, or in some cases, experimental DSN equipment such as planetary ranging or time synchronization. Although the plan could not commit 24-h tracking coverage of two spacecraft during the periods originally requested, it did include provisions for equipping DSS 42 and 61 with equipment for support of Mariner 1969 when they were not required for supporting other projects. Details of the support are set forth in the individual Operations Plans of the AFETR, MSFN, and DSN (Tables 15, 16, and 17).

B. Near-Earth Phase Configuration

1. AFETR telemetry data system. Spacecraft telemetry data acquired by AFETR stations or range instrumentation ships were routed to the DSN via DSS 71 at Cape Kennedy from where they were transmitted to the SFOF in Pasadena. As shown in Fig. 16, the down-range stations at Ascension Island, Grand Bahama Island, Antigua, and the range instrumentation ships transmitted data to TEL-4 on Merrit Island via COMSAT, submarine cable, or high-frequency transmissions. At TEL-4, the AFETR Telemetry Coordinator, under the direction of the JPL Telemetry Coordinator, selected the best source for transmission using the routing and switching capabilities shown in Fig. 17.

As shown in Fig. 18, data were also routed to Building AO for use by the spacecraft test team at the System Test Complex. This capability was required for pre-launch tests and flight analysis.

As shown in Fig. 18, two lines and modems were used from TEL-4 to provide redundancy. Data from the TCP in DSS 71 were transmitted to the SFOF as well as Bldg AO via a NASCOM high-speed data line. Figure 19 shows the full launch configuration.

Table 18 shows the prime source of real-time spacecraft data, optimized for station view. No AFETR backup was provided for the Twin Falls instrumentation ship or the Ascension Station.

2. AFETR tracking system for generating radar metric data. Metric data during powered flight for range safety support was to be provided by the AFETR radars at Cape Kennedy (1.16, MOD-IV), Patrick Air Force Base (0.18), Kennedy Space Center (19.18), Grand Turk (7.18), Antigua (91.18), and Grand Bahama Island (see Fig. 20.) The MSFN Bermuda radar was also used for this support.

The radars that should be scheduled to provide real-time data on the initial injection orbit were located at Bermuda, Grand Turk, Antigua, Ascension, and the Twin Falls. The Antigua radar was primarily for providing free-flight data after injection for most launch azimuths. Grand Turk was also capable of providing data coverage for trajectories with large, positive flight-path angles. In the event of a launch near the end of the launch period, the Twin Falls radar would be primarily for providing real-time data on the initial injection orbit due to the northern launch azimuth.

The Centaur postdeflection near real-time data coverage was provided by Ascension (12.18) and Pretoria (13.16). DSS 51 and the MSFN S-band site at Ascension provided actual spacecraft tracking data to the SFOF and the Real-Time Computing System (RTCS) after Centaur/Spacecraft separation (Fig. 20)

The RTCS 3100 computer was required to reformat 38-character octal teletype data from Bermuda, Grand Turk, Antigua, Twin Falls, Ascension, and Pretoria to the JPL decimal format and transmit these to Bldg AO for relay to the SFOF at Pasadena.

The RTCS was to compute updated acquisition data using the initial injection orbit data to provide the IRV for Ascension, Pretoria, and Twin Falls, and predicts for DSS 51, DSS 62, and Ascension It was also to compute injection orbits and Centaur deflection orbits from available tracking data and provide them to Bldg AO for relay to the SFOF in the following forms:

(1) AFETR standard orbital parameter message.

(2) Standard JPL orbital message.

(3) Mapping to Mars encounter

(4) I-Matrixes (on selected orbits only).

Table 19 lists the planned RTCS orbit computations.

Real-time 480 pulses/s acquisition data were distributed through the AFETR Radar Acquisition Data Distribution and Control Center (Fig. 21). The AFETR radar trajectory acquisition system also permitted real-time acquisition data to be interchanged between different AFETR radars through Antigua.

C. Manned Space Flight Network

Support from the MSFN station at Ascension Island (Fig. 22) was required in the near-earth phase to obtain metric data and spacecraft S-band telemetry. It was also required in the first part of the Deep Space Phase (defined as starting with two-way acquisition) to provide additional metric data and telemetry coverage. As shown in Figs. 23 and 24, the period between DSS 51 set and DSS 41 rise, although covered by DSS 12, was expected to have possibly degraded data as a result of the low elevation angles from the northern hemisphere stations. The Ascension station partially filled this gap when near-earth metric data were important to orbit-determination accuracy. A command capability was also required to back up DSS 51 in South Africa.

1. MSFN telemetry system. The MSFN Telemetry System was required to process only engineering telemetry at 33 1/3 bits/s. Since the MSFN employs the Unified S-Band System (USB), RF carrier reception and detection are the same as in the DSN. The telemetry signal, however, was handled by different equipment; the composite telemetry signal was provided to the demodulator and PCM telemetry equipment for processing. Figure 25 shows telemetry data flow from the receiver through the telemetry remote site data processor, the output of which is transmitted via NASCOM to the SFOF.

The operations performed by the MSFN Telemetry System were:

(1) Synchronization of all telemetry data as required.

(2) Identification of the spacecraft.

(3) Time-tagging of data.

(4) Detection of engineering telemetry frames.

(5) Selective decommutation of engineering telemetry data.

(6) Output and display of selected engineering parameters for station operation.

(7) Formatting and output of all telemetry data received by the station for transmission to the SFOF via high-speed data line. Figure 26 shows that these data are capable of being transmitted either via COMSAT to GSFC or by high-frequency channel via Antigua and Kennedy Space Center directly to the SFOF.

2. MSFN command system. The MSFN Command System shown in Fig. 27 made use of the RWV equipment supplied by the project and a configuration essentially the same as that of a DSN station. The functions required were maintenance of the command tape library, receipt of command instructions from the DSIF Network Controller, verification of command contents, and transmission of commands to the spacecraft.

The interface between the project and the stations existed in the remote site data processor program, specifically at the block header in the data stream.

3. MSFN tracking system. The MSFN Tracking System consisted of the MSFN elements which provided Ascension unified S-Band radio metric data to the DSN, the AFETR RTCS, and the Goddard Real-Time System (GRTS) Figure 28 shows the station configuration for the Tracking System. Data were transmitted via teletype to the SFOF, GRTS, and the RTCS. The GRTS was capable of generating angle predicts based on project estimates of the spacecraft trajectory parameters.

Radio metric data acquired and placed on punched paper tape were edited and converted to a uniform internal computer form and stored in the master radio metric data files (Fig. 29) which later became the Master Data Record. Interfaces with the project were the Radio metric data Master File, validated trajectory estimates supplied by the project for predicts, and the RF interface with the spacecraft transponder.

4. MSFN simulation system. The simulation system for TDS tests with the MSFN used the SDCC in the SFOF, and elements at Ascension, GSFC, and NASCOM. The simulation system was then supplemented as required by special, mission-dependent simulation hardware and software, consistent with agreements between the Mariner Mars 1969 Project and the TDS. Figures 30 and 31 show the configuration for Mariner Mars 1969.

The primary function of the simulation system was to provide a means of exercising the elements of ACN, GSFC, and NASCOM in a realistic operational configuration for the purposes of testing hardware and computer programs, training personnel, and providing certification of ACN readiness for the support of the Mariner Mars 1969 Project. To accomplish these overall objectives, the system provided interfaces through which simulated data, representative of that received during the actual mission, could be inserted into ACN for processing and transmission to GSFC and the SFOF. In addition, the simulation system provided those interfaces which were necessary for the control of test sequencing. The simulation system consisted of the following elements:

(1) The SDCC, located in the SFOF.

(2) Facilities for acquisition testing, angle tracking simulation, and spacecraft telemetry simulation located at ACN.

(3) Ground communication facilities provided data transfer between the SFOF, GSFC, and ACN.

The simulation system was also designed to support various types of tests. These tests did not preclude a further subdivision of test modes as required to meet specific requirements, but served as a guide in the usage of the simulation system capabilities.

The ACN Interval Tests were designed to evaluate the hardware and operational capabilities of ACN as an entity. Support for such tests was provided in the form of recorded data packages produced in the SFOF SDCC.

The DSN/ACN Systems Tests were designed to aid in the development and evaluation of overall DSN/ACN operational capabilities such as monitoring, communications, or flight-path analysis. Such tests were normally conducted at the discretion of the TDS Manager, and made use of the SFOF SDCC, NASCOM, and the on-site simulation capabilities in an integrated manner to achieve test goals.

The SDCC prepared simulated data packages in the form of magnetic and paper tape recordings for later use in ACN tests. In addition, the SDCC provided a coordination center for the control and sequencing of simulations, tests, and exercises.

The SDCC had the capability to prepare analog magnetic tapes containing simulated telemetry data. Telemetry data were recorded on 7-channel or 14-channel analog tape, containing voice labeling, a time track, pilot tones for servo speed control and flutter compensation, and simulated data.

Acquisition testing and training made use of a test transponder carried by a transport aircraft or a satellite.

Tracking simulation for angles only was accomplished using the Antenna Position Programmer. In this technique, a set of time-tagged pointing angles were recorded on punched paper tape. By the use of a digital computer, the punched paper tape was read in real time, actual antenna angles were sensed, and an antenna-pointing error was developed. This error signal was applied to the Antenna Servo Subsystem, causing the ground antenna to track in accordance with the taped data. The Tracking Data Processor was used in its normal operational configuration to sense the resulting angles, and to format and transmit them by teletype to GSFC and the SFOF. In addition, simulated radio metric data, including time, angles, doppler, and range were generated and recorded on punched paper tape at GSFC and transmitted from ACN to the SFOF.

Telemetry simulation at the stations was characterized by the sources from which it was derived. These sources were, in order of their importance:

(1) Analog magnetic tape containing raw PCM data, base-band data synchronizing signals, voice labeling, a time track, recorder servo speed control line, and a flutter compensation tome.

(2) Data generated at stations by special mission dependent test equipment.

(3) The composite telemetry signal resulting from the application of the techniques described could be introduced into the ACN data stream at any one of several points. Insertion of this signal as modulation in the S-Band Transponder/Transmitter Subsystem resulted in a modulated RF signal which was passed through the entire ACN RF system, resulting in a realistic entry of the data into the various data processing elements. However, various other alternatives existed.

A capability was provided for playing prerecorded analog telemetry tapes. Data derived from this source could be used to modulate a test transponder or could be transmitted to mission-dependent equipment.

The Test Transponder/Transmitter Subsystem was used as a means of introducing simulated telemetry modulation into the RF System, and of providing closed-loop RF test capabilities.

A mission-dependent telemetry simulator for generation, formatting and insertion of telemetry data into the simulation system was used where this function was not adequately provided by the mission-independent capabilities.

5. MSFN operations control system. The MSFN Operations Control System provided information for operational control of the MSFN, for management planning, and for MSFN systems analysis. This information was supplied by operations documentation systems status reporting, configuration control, and scheduling.

The Operations Control System ensured that two functions were accomplished (1) preparing the network for mission support, and (2) providing network support. The first of these functions was accomplished through the ad hoc committee for the Mariner Mars 1969 Project. The second function was provided through the network direction group.

The network was prepared for support to meet the requirements in the SIRD and supplementary documentation. The composition of the network (stations, station systems, ground communications, computer systems) was determined by the ad hoc committee. When a change to the stations' existing configuration was required, it was documented and controlled through the MSFN Configuration Management System. The facilities required for support were scheduled on the Six-Month Mission Forecast by the committee chairman. The means by which the support was provided were defined in operations documentation prepared by the committee.

For Mariner Mars 1969, station configuration changes were required at ACN These changes were approved by the MSFN Configuration Control Committee composed of chiefs of the major line organizations within the Manned Flight Support Directorate. The detailed changes were described in Engineering Instructions (EI). After EI were approved, they were released to ACN and the network direction group for scheduling and implementation.

The Six-Month Mission Forecast was prepared weekly and transmitted by teletype by the MSFN Operations Center. Inputs to the forecast were provided by the chairman of the ad hoc committees for each mission requiring MSFN support. The forecast served to identify potential conflicts and provided planning information for the stations, NASA centers, and the network direction group.

Four operation documents were prepared for the Mariner Mars 1969 Project and were provided to the TDS Manager (as a commitment of MSFN support), network direction group, and stations (as an instruction specifying how support is to be provided). The documents were as follows:

(1) System Description. Described the configurations required to provide the committed support.

(2) Test Plan. Described the tests to be conducted to verify that ACN was ready for interface tests with the SFOF and the Mariner Mars 1969 Project.

(3) Operations and Engineering Interface Agreement. Described the detailed operations and engineering interfaces between ACN and the Mariner Mars 1969 Project.

(4) Network Operations Plan (NOP). Decribed how the required support was to be provided by elements of MSFN to the Mariner Mars 1969 Project.

Operational support of Mariner Mars 1969 by the MSFN was provided under the direction of the Network Director. The control over elements of the MSFN was exercised by the Network Controller, to schedule the elements as requested by the Mariner Mars 1969 Project, to determine the operational status of the systems required for support, and direct the activities of the elements such that the support was provided in accordance with the NOP. For Mariner Mars 1969, direct voice coordination between the SFOF and ACN was planned to minimize time between a Mariner Mars 1969 Project instruction and initiation of the ACN supporting action. However, the overall operational control of the MSFN (including ACN) remained with the Network Controller

The MSFN facilities were scheduled on the weekly test and mission schedule. This schedule was transmitted by the MSFN Operations Center each Thursday for the following Monday through Sunday. Inputs were due at MSFN Operations Center (via teletype to GCEN) by 1300 GMT[1] on Wednesday.

Starting at launch -5 (L -5) days, the status of the MSFN support for Mariner Mars 1969 was provided to the TDS Manager with information to the DSIF Operations Planning Project Engineer each day by teletype. The report defined the MSFN as green except with a listing of "red - can support" and "red - cannot support" systems.

In addition to the line organization, which provided administrative control of the MSFN elements, the MSFN had two functional organizations which were responsible for MSFN support mission operations. The first of these organizations was the ad hoc committee which was formed to prepare the MSFN for support of the mission The second functional organization was the network direction group which operationally directed the network during mission support.

a. Ad hoc committee. This committee was composed of representatives from organizations within GSFC which influenced network configuration and operation. For the Mariner Mars 1969 Project, the committee members and their areas of responsibility are as follows:

Members	Responsibility
W. Bradley	Mission Planning (Chairman)
S. Norman	Contractor Representative
R. Mazur	Central Computer Support
A. Dyka	Engineering Support
R. Capo	Postmission Data Handling Support
L. Stewart	NASCOM Support
D. Richards	On-Site Systems Operations Support

b. Network direction group. This group was composed of personnel which directed the support provided by operational elements of the MSFN. Members of the Network Direction Group had the following titles:

(1) Network Director.

(2) Network Controller

(3) Network Support Team

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[1] All times in this report are expressed in Greenwich Mean Time.

(a) USB Advisor (RF)

(b) USB Advisor (Digital)

(c) Status Monitor

(d) Schedules

(e) Documentation Coordinator

(f) Telemetry Advisor

(g) Radar Advisor

(h) RSDP Advisor

(4) Communications Manager.

(5) Computer (GSFC) Advisor.

The interfaces between the Mariner Mars 1969 Project and the MSFN Operations Control System were as follows:

(1) SIRD, supplementary Mariner Mars 1969 Project documentation, and MSFN commitment documentation.

(2) Mariner Mars 1969 Project weekly schedule input.

(3) MSFN daily status report.

D. Deep Space Network

The DSN Operations Plan includes the configuration of the Network Systems, configuration and implementation of the Facilities Systems, and operational procedures formulated for support of the specific project. The system design formulated for support of the project is presented most clearly in terms of the configurations of the DSN Network Systems. The six Network Systems are Telemetry, Tracking, Command, Simulation, Monitor, and Operations Control. The implementation of these systems is accomplished primarily by the three facilities of the DSN, the Deep Space Instrumentation Facility (DSIF), the Ground Communications Facility (GCF), and the SFOF. Each of the facilities designed, implemented, and operated facility subsystems which performed the functions required by the Network System Design.

The DSN also accepted for operation and maintenance, some project-supplied, mission-dependent hardware and software. As part of the overall Telemetry System, the project supplied telemetry simulators for DSN checkout, TCP computer programs for operation at the DSS and the mission-dependent portion of the computer program for the real-time telemetry processing in the SFOF. In the Command System, mission-dependent hardware (RWV equipment) was supplied. Other project-supplied and operated computer programs for telemetry analysis and use of the DSN Simulation System were integrated by the DSN into the overall software and data system.

1. DSN telemetry system. The DSN telemetry System provides the capability for acquisition, conversion, handling, display, distribution, processing, and selection of telemetry data. Telemetry data are defined as the engineering and science information, including video, received from flight spacecraft via the telecommunications links. Telemetry data may be coded or uncoded; in the case of the Mariner Mars 1969 Project, a Telemetry System for deep space flight for the first time included a block-coded channel.

Figure 32 sets forth the functions performed by the DSN Telemetry System. At the DSS of the DSIF, data are recovered from the carrier and subcarrier. The data stream is synchronized, some of it may be decommutated for display at the station for local operational control, an original data record (ODR) is recorded and the data are formatted for transmission by high-speed data line or TTY through the GCF to the SFOF. At the SFOF, a Master Data Record is generated, data are decommutated and displayed to the project for mission analysis and control, and to the DSN for DSN System control and performance evaluation.

Figure 33 shows the configuration at the DSS equipped with 26-m antennas. During cruise, a single receiver, subcarrier demodulator assembly (SDA) and TCP chain suffice to handle the engineering telemetry channel at 33 1/3 or 8 1/3 bits/s. The second channel was available as a backup. During encounter, however, the second channel was designed to handle science data at either 66 2/3 or 270 bits/s. The output of the two channels was then combined in a block multiplexer and forwarded to the GCF through the error-detector-encoder-decoder (EDED). The ODR could also be played back through the TCP to provide non-real-time data in the event of a communications circuit interruption.

Prime telemetry data were routed by high-speed data line (Fig. 34) to the SFOF where the IBM 7044 computer of the Central Processing System formatted and outputed the data for display on 100-words/min teletypes in the Mission Support Area. The TTY circuits were provided as backup for telemetry data and reached the SFOF via the communications processors for display as raw data.

The configuration at the Mars station at Goldstone, equipped with the 64-m antenna (DSS 14), is shown in Fig. 35. Four instead of two subcarrier SDA units were provided there. The configuration also included the two experimental high-rate correlator units for processing video data at 16,200 bits/s. In order to handle these data, each TCP was equipped with two, instead of one, digital recorders.

A significant innovation to the DSN Telemetry System's support of the Mariner Mars 1969 Project was the implementation of multi-mission telemetry demodulation equipment. In the past, spacecraft tracked by JPL had a telemetry system with wide ranges of subcarrier frequencies, data rates, and types of modulation. Because each project usually selected different parameters for its telemetry design, the ground demodulation equipment differed. Ground stations assigned to a particular mission were equipped with mission-dependent demodulation equipment varying from 5 to 20 racks/station. Although providing greater design freedom, the system was costly in equipment, installation and training time. The inflexibility was also limited since the mission could be supported only at stations containing that equipment.

Mariner IV, Pioneer, Lunar Orbiter, Apollo, Mariner Venus 1967, Mariner Mars 1969, and future spacecraft used, or will use, PCM-PM-PM as the telemetry mode. Recognition of this mode by most projects as a standard for telemetry transmission makes possible general-purpose mission-independent equipment capable of meeting the requirements of all of these projects at each DSN station.

The Multiple-Mission Telemetry System (MMTS) at the DSS consists of a subcarrier demodulation loop which accepts 10-MHz signals from the receiver, phase-modulated with one or more squarewave subcarriers which, in turn, are phase-modulated with data. The demodulation is accomplished in a manner that does not lose power in the squarewave harmonics. In the design implemented for support of the Mariner 1969 Project bit synchronization is accomplished by software in a computer operating in conjunction with special-purpose digital equipment. To change from one spacecraft to another, it is only necessary to change the computer program and reset the subcarrier VCO, certain bandwidths, and time constants. A separate channel for subcarrier and bit synchronization is not required from the spacecraft; therefore, this power may be used to increase the power in the information channels. A fixed-phase relationship between subcarrier and bit timing is no longer required. This removes the requirement for rigid bit timing in the various spacecraft data sources and results in simplification of the spacecraft subsystem interfaces.

As originally installed, the system will handle the following signals:

Function	Subcarrier, kHz	Data Rate, bits/s
Engineering Telemetry	20 to 40	8 to 500
Non-video Science data	40 to 80	32 to 512

In addition to the above requirements, the subcarrier demodulation only is designed to handle video science data at subcarriers of 80 to 1,000 kHz and rates of 512 bits to 100 kbits/s This capability is included to handle future high-data rate requirements and was actually used on this project to meet the requirement to handle 16,200 bits/s. Figure 36 shows the functional block diagram of the MMTS equipment. The equipment consists of three major hardware elements: (1) Subcarrier Demodulator Assembly (SDA), (2) Computer and Peripheral Digital Equipment Assembly, and (3) a rack of test equipment. The input signal is an RF signal at the IF frequency (10 MHz) of the DSS receiver. The signal contains telemetry data in the form of a binary waveform which biphase-modulates a squarewave subcarrier. The modulated subcarrier, also of a binary waveform, in turn modulates the carrier. The MMTS SDA recovers the original binary telemetry waveform by synchronously demodulating both the carrier and subcarrier. The DSS receiver provides a reference signal at 10 MHz to demodulate the carrier. The reference signal to demodulate the subcarrier is provided by the subcarrier demodulator loop. Since the subcarrier is detected before the 10 MHz IF signal, power in the squarewave subcarrier harmonics is not lost. The computer and peripheral digital equipment assembly accepts the data stream output from the SDA. It generates a clock at the data rate frequency, and in phase with the telemetry data transitions (bit synchronizations), detects the telemetry data bits at each data clock time (bit detection), searches for telemetry data frame synchronization, and decommutates, formats, and outputs the telemetry data in real-time to the GCF for transmission to the SFOF. The computer and peripheral digital equipment form part of the telemetry and command data handling subsystem (TCD) of the DSS and is designated as the TCP. Functional, design, development, and test details are given in Refs. 1 through 6.

The implementation of the MMTS was handled as a project within the DSN and established early in 1967. Prototype equipment was assembled and tested during the remainder of that year. The first operational type equipment was installed in the Compatibility Laboratory (CTA-21) in the first quarter of 1968. During the next two quarters, equipment was installed in the three 26-m antenna stations which provided prime support (DSS 12, 41, and 62), at Cape Kennedy (DSS 71), and at the 64-m antenna at Goldstone (DSS 14). Later in the year, equipment was installed at the backup stations at Tidbinbilla, Australia (DSS 42) and Pioneer Station at Goldstone (DSS 11). The equipment was ready to support mission operations testing in November 1968. During the testing phases, it was shown that the equipment met its specifications and was characteristically within a few tenths of a dB of its design parameters.

The achievement of a 16,200-bits/s data rate was made possible by careful examination of the telecommunications system design and implementation of some recommended changes and improvements. The results of the study are summarized in Table 20 which is the comparison of simplified design control tables for the 270- and 16,200 - bits/s channels with the 8 1/3-bits/s channel from Mariner IV included to extend the comparison. The quantities in Table 20 are related by the standard communication equation

$$S = P_T M \quad G_T L_S \quad G_R \quad L_R$$

An unusually fruitful engineering experiment on the Mariner Mars 1969 Project which resulted in a significant advance in space communications was the provision of a high-rate telemetry (HRT) system capable of transmission rates of 16,200 bits/s. In addition to advancing the technology of deep space communications, the purpose of the experiment was to permit additional flexibility in mission operations by providing the capability to return a full spacecraft tape recorder load of TV pictures in 2 to 3 h. The standard mission was designed to return the data at 270 bits/s, requiring about 8 days of steady transmission for one playback from one spacecraft.

The data rate of 16,200 bits/s derives from the parameters of the spacecraft tape recorder. It is the record rate of the digital tape recorder (DTR). The DTR records the non-video science data and every seventh picture element of the TV pictures. The HRT made possible real-time reception of these data which contained low-resolution TV pictures.

All of the TV data, or high-resolution TV pictures, were recorded on an analog tape recorder (ATR). The capacity of this recorder was 1.8×10^8 bits, contrasted with the 5.6×10^7 bits capacity of the DTR. The standard plan required the DTR to be played back first at 270 bits/s to obtain non-video data, and then to be refilled and played back as often as necessary to empty the ATR. This process would have required about 8 days. Since the ATR transfers data to the DTR at 16,200 bits/s, the HRT provided the capability to play back all of the ATR data directly in approximately 2 1/2 h. This was actually accomplished for each spacecraft several times.

In Table 20, the received sideband power is multiplied by the duration of a bit T_B to give the received signal energy per bit. The receiver system noise temperature is multiplied by Boltzmann's constant to give the receiver noise spectral density. Dividing the receiver energy per bit by the noise spectral density yields the appropriate figure of merit for a digital communication system ST_B/N_O. Dividing the figure of merit achieved by that required for a specified bit error rate gives the margin. The two columns labeled Δ give the change from one system to the next with the change considered as positive if it favors the second system.

The increase in capability from 8 1/3 bits/s on the Mariner IV to 16,200 bits/s for the high-rate channel on the Mariner Mars 1969 is due to many factors. These are discussed for each line in Table 20.

The transmitter power has been approximately doubled since the Mariner IV. This factor, of course, results in a doubling of the capability.

The modulation index was changed to increase the sideband power from -5.3 to -1.80 dB relative to the total power, in going from column 1 to 2 in Table 20. This was possible for two reasons. First, the Mariner Mars 1969 telemetry system does not use a separate synchronizing channel, so the power which was devoted to that in Mariner IV is available for the data signal. The second reason has to do with providing enough power in the carrier for the receiver to track in order to produce a reference signal for synchronous demodulation. If the data rate is comparable to the bandwidth of the carrier tracking loop, the power allocated to the carrier must be comparable to that allocated to the data signal. That, of course, was the case for Mariner IV, which used a 12-Hz carrier loop bandwidth. In the 270- and 16,200 bits/s channels the carrier loop used still has a bandwidth of 12 Hz, so much less relative power must be allocated to the carrier.[2]

The design control table does not show a significant change in the antenna gain even though a larger antenna is used for the Mariner Mars 1969 mission. This is mostly because the increased antenna gain was traded off against some other factors, such as using a single pointing angle for the antennas on two spacecraft even though they arrive at Mars on different days.

The range at encounter for Mariner Mars 1969 will be about half what it was for Mariner IV. This increases the communications capability by 6.84 dB even though it is not a change in the communications technology per se.

The antenna gain does not change from column 1 to 2 in Table 20 because both Mariners are designed to operate with a network of 26-m ground antennas. The 16,200-bits/s channel is intended to operate only with the 64-m antenna at DSS 14. The increase in gain of 8.50 dB is slightly more than the area increase because of the way that tolerances are handled. In the detailed design control table, each parameter is assigned a nominal value and a favorable and an unfavorable tolerance. The system design is constrained to provide adequate performance with all of the parameters having their full unfavorable tolerances. This is the same philosophy that is usually followed in engineering work; e.g., in designing a structure where all elements are derated by an appropriate factor. The unfavorable tolerances are included in all parameters in Table 20. Because there is only one 64-m antenna, and it is under the direct supervision of the JPL antenna engineers, it has a lower unfavorable tolerance than that which must be used in dealing with the worst of a network of antennas located around the world. There is another reason why the tolerance is less in this particular case. When an antenna is moved from pointing at the zenith to pointing at the horizon, the sag due to gravity changes and the gain changes. The reflector plates are usually set at an elevation angle of 45 deg, and a tolerance is assigned to cover the effects of sag at both higher and lower angles. When the 26-m antennas are used, continuous operation must be provided and tolerances are assigned to cover the effects of sag down to within a few degrees of the horizon. In the case of the 16,200-bits/s channel, the total time required to play back the data from the analog recorder in the spacecraft is less than 3 h. Moreover, the playback time can be selected to take place when the antenna angle is above 25 deg, which further reduces the required unfavorable tolerance. In addition, if there were an unusually high wind, say above 72 km/h on the day when playback was desired, the playback could be delayed for a day. This also allows a lower unfavorable tolerance than that required for an 85-ft-diam antenna which must operate continuously. The effectof these several factors is to give the 64-m diam antenna a higher usable gain. The cost of this gain is a set of restrictions on the operations. Since the playback time is both short and selectable, the restrictions are acceptable.

The entry in Table 20 labeled receiver loss includes several factors. The most important is the degradation in the process of demodulation from the carrier due to the fact that the carrier tracking loop provides a noisy reference. The Mariner IV was constrained to have a low signal-to-noise ratio in the carrier tracking loop, and even though the power allocation was optimized, the effect was equivalent to a loss of more than 2 dB. In the 270-bits/s channel, even though the power allocation is reoptimized with proportionately less power in the carrier, the carrier has more absolute power, and the effect of the

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[2] This point is treated more fully in JPL Space Programs Summary 37-45, Vol. IV, pp 276-289.

reference produced by the carrier loop is equivalent to a loss of less than 0.5 dB. The effect of the carrier loop is similarly small in the case of 16,200-bits/s channel. A second factor is the signal-to-noise ratio in the bandwidth of the subcarrier tracking loop. In the case of the Mariner IV, this loop was constrained to have a poor signal-to-noise ratio. In addition, although a squarewave subcarrier was used, the demodulation process recovered only the power that was carried in the fundamental of the squarewave. The total result was equivalent to a loss of more than 1 dB. In the Mariner Mars 1969, a different method of tracking the subcarrier is used; this method uses the entire sideband power, and thus inherently has a higher signal-to-noise ratio. In addition, the demodulation process recovers the power in all of the harmonics of the subcarrier up through at least the fifth and thus loses very little. The combined result is to have a much smaller equivalent signal loss for either channel. Finally, there are small losses associated with bit or symbol tracking, data detection, and circuitry imperfections in all three channels. In summary, the higher ratio of data rate to carrier loop bandwidth permits the reduction in effective loss due to a noisy carrier reference, and improved methods of tracking the subcarrier and bits or symbols and of detecting the data permits the recovery of more of the sideband power.

The system temperature is decreased significantly in the case of the 16,200-bits/s channel. This is due to two factors. The first is that, because the 64-m diam antenna will not be required to transmit during the short time while it is receiving the high-rate data, no diplexer is required and a listen-only feed system of advanced design can be used. The second is that, since the minimum elevation angle is 25 deg, the antenna need not look obliquely through the atmosphere. It should be noted that this also implies some operational restrictions, namely, the antenna cannot be used for transmitting during the reception of high-rate data and the channel is operable only above a 25-deg elevation angle. The latter restriction is the same as that imposed by the antenna gain tolerance. There is an additional restriction: the temperature of the receiving system will begin to rise if the rainfall rate exceeds 2.5 mm/h but this is unlikely in the Mojave desert in August.

The final factor to be considered is the required ST_B/N_O. In all cases the channel is required to transmit data with an error rate not exceeding 5×10^{-3}. If bit by bit detection is used, the required ST_B/N_O is 5.20 dB after all losses or equivalent losses are considered. If the data are encoded into a biorthogonal code in blocks of 6 bits, the required ST_B/N_O is reduced to 3.0 dB for a word error rate of 10^{-2}, which is equivalent to a bit error rate of 5×10^{-3}. Thus, all other factors being equal, the block coding reduces the signal level required by 2.2 dB.

The margin shown for each channel is the margin at encounter. The margin generally decreases after encounter. Sufficient margin must be provided to maintain a positive margin over the playback period. Since the 16,200-bits/s channel recovers the data in 3 h, only a small margin is required even if it is desired to play the data back on several successive days.

The purpose of this discussion has been to show the rationale used in the study which indicated the feasibility of a high-rate channel for the Mariner Mars 1969 Project. The data in Table 20 are considered illustrative. Subsequent to the study, the data were refined as development proceeded. The end results are discussed in Section VI. However, the principal factors permitting the higher data rate are use of (1) a 64-m antenna instead of a 26-m antenna, (2) a 20-W instead of a 10-W TWT amplifier in the spacecraft, (3) an improved ground receiving system noise temperature, and (4) block coding of the data stream. The code used is a biorthogonal, comma-free (32, 6) Reed-Muller code (Ref. 13). Each 6 bits of the serial bit telemetry stream are encoded into one of 64, 32-symbol words. These words are transmitted by the spacecraft radio system at a rate of 86,400 symbols/s. On the ground, the carrier and subcarrier are detected by the receiver and SDA, and the data are fed to the high-rate correlator (HRC) (Fig. 37). In the HRC, the symbol loop tracks the transitions in the data waveform and provides symbol timing to the word timer, which triggers the cross-correlation detector. In essence, the cross-correlator compares the incoming word with each of the 64 words which could have been received. The maximum correlation of this process is determined in the largest selector which then causes the appropriate 6 bits to be issued from the decoder for recording on magnetic tape.

Whereas in the MMTS many of the functions were implemented in the software of a general-purpose computer, in the HRT the high symbol rates require most functions to be implemented in special-purpose digital equipment. In Fig. 37, only the functions marked ([a]) were implemented by software. As shown in Fig. 36, these functions were implemented in the SDS 920 computers of the TCP. In the HRT configuration, however, the computer is not configured as a TCP; instead, it is fully occupied formatting and recording the data and accomplishing the acquisition control and filter functions shown. References 7 through 13 provide additional system details.

Implementation of the high-rate telemetry system was accomplished by a project established for that purpose. Three units were designed and fabricated. A laboratory/prototype set was completed in October 1967 and made available for testing in January 1968 in CTA-21. When two field sets became available, they replaced the laboratory set in CTA-21, which was removed for further testing in the development laboratories. One field set was sent to DSS 71 for pre-launch checkout; the other remained at CTA-21 to support spacecraft system testing. After launch, both field sets were installed at DSS 14.

Telemetry data acquired by the DSIF was transmitted to the SFOF for processing by the GCF. The GCF equipment was located both at the DSS and in the SFOF; data were transmitted via circuits provided by NASCOM. Telemetry data transmitted via the high-speed data line were considered prime; the TTY data processed through the communications processors provided a backup capability.

Figures 38 and 39 show the high-speed data line terminals at the DSS and the SFOF. At the DSS, the block multiplexer permits time-sharing of the high-speed data (HSD) line by the two data streams provided by the dual TCP units at each station. The dual string capability was not required until encounter when the science subsystem of the spacecraft was turned on. During cruise, it was only necessary to process engineering data at 8 1/3 or 33 1/3 bits/s. The block multiplexer provides the capability to permit up to four computers to time-share the transmit side of the HSD interface. Time-sharing is accomplished by multiplexing the block formatted data generated by each computer with filter blocks generated by the block multiplexer.

The encoder controls the flow of data from the selected source by providing a "clear to send" signal to that source. The encoder commences encoding and checks the first 24 bits for correct sync pattern. It inserts the appropriate information for use by the decoder. The data set transmits the bit stream from the encoder over voice frequency circuits.

The data set is a full duplex device so that, at the SFOF, it accepts audio signals from the voice frequency circuits and delivers serial binary data. One data set contains both transmitter and receiver. The decoder performs a continuous decoding function and indicates when a transmission error has occurred in a block of data. Data blocks on Mariner Mars 1969 were 1200 bits.

Figure 34 shows that TTY data were transmitted by the GCF through the appropriate communications processors for display in the SFOF as raw data. These data were a backup to the formatted data provided through the high-speed data lines. The communications processors handled tracking as well as telemetry data. Their capabilities are described under the overall GCF configuration description.

In the SFOF, the telemetry functions indicated in Fig. 40 were accomplished using the data processing system configuration shown in Fig. 34. In accomplishing these functions, spacecraft telemetry data received at the SFOF Data Processing System (DPS) were processed in real time, near-real time, and non-real time.

Real time processing was accomplished in the IBM 7044 computer. Processing included logging of the data, identification by spacecraft, DSS, and data type, routing of the data to correct destination, display of status indicators in the Mission Support Area, complete decommutation of all telemetry data, alarm checking on selected data, detection and tagging of CC&S readout data, and a provision of raw and processed data to various project support areas.

Near-real time processing included maintenance of a running history of the most recent values for each measurement on the spacecraft, and display of these data upon command in the Mission Support Area. It also included reconstruction of the CC&S program whenever the memory of that spacecraft subsystem was read out.

Non-real-time processing included provision by the DSN of a validated original data record and analysis of telemetry parameters, including telecommunications predictions and measurements, star identification, and generation of tabulated printouts, graphical plots, and punched cards.

Teletype data were routed to the Mission Support Area without processing in the 7044 computer.

The functions were performed by the DPS shown in Figs. 40 through 42 and its associated computer programs. It is described here, although other DSN systems are also implemented by some of its capabilities. Although only two computer strings were used (X and Y), some equipment is designed to operate with three or more strings, and some of this capability is shown in the description.

The input-output subsystem is shown in Fig. 40. The decoder/synchronizer selection panel controls the interface between the GCF HSD circuits and the DPS of the SFOF. Four of the six inputs may be selected for connection to the HSD synchronizer assemblies. The HSD synchronizers convert the data format from that compatible with the high-speed circuits of the GCF to that compatible with the IBM computers of the DPS. The input is normally a 1200-bit block made up of fifty 24-bit words. The block is converted into 36-bit words which are transmitted in parallel to the 7288 data communication channel (DCC). The synchronizer generates a data identification word which *follows each block and identifies the EDED and* synchronizer from which it originated, the condition of the block sync code, and the presence or absence of the data carrier detected signal. It also activates indicators which inform operations controllers of the status and condition of the data and control signal and the response of the computers to the I/O request for transfer of data.

The Communications Processor (CP) interface allows the CP to transmit and receive data to and from the DPS computers on a demand-and-response basis via the DCC. The data are transferred in the serial mode at 40.8 kbits/s. Interlock lines provide a status signal to the DPS which prevents overflow or loss of data at any time the systems are not prepared to handle data across the interface. Careful management of message traffic across the interface is required to prevent closing of the interface and possible overflow of the DPS output buffers. Distribution of formatted data from the DPS to SFOF teleprinters is made through the CP/DPS interface. The TTY messages to the DSS, generated by the DPS, also are switched through the CP and its NASCOM and TTY interfaces.

The central timing subsystem furnishes time information for universal time (GMT) and the time since past or until future mission events. The information is presented to the computers for data time-tagging and to visual displays in the operational areas for users reference. Through this unit, SFOF-received data blocks can be synchronized with Goldstone clocks and the JPL time standard.

The status sense unit senses and reports the status of the major active I/O elements of the DPS. Upon request from the Equipment Status Monitor Program (ESMP) of the 7044 computer information is provided on a maximum of 119 user area I/O devices (bulk printers, plotters, I/O console, card readers, and administrative printers). The information indicates whether the device is operational, in use or not, and assigned to X or Y string. The status sense unit also reports status of the 7044 and 7094 computers themselves, subsystem assignments of the HSD inputs, string assignments of the clock, interval timer, HSD and CP subchannels, and multiple device drivers.

Control of the computer configurations and their peripheral equipment is exercised through the data-processing switching subassembly (Fig. 43). Major elements of the subassembly are the switch control unit (SCU) and the user area I/O interface assembly. The SCU permits configuring and switching up to three strings of IBM equipment consisting of 7044/1301/7040/7094 units, as shown in Fig. 41. Figure 44 shows the three modes employed during operations, two stand-alone and one direct-couple system. The Mode 2 stand-alone configuration is employed during the high activity, critical phase activities of the mission operations. Mode 3/4 stand-alone configuration is used during less-critical operations and when the 7094 computer is used for analysis activity. At this time, the 7044 computer continues its real-time telemetry function. The direct-couple system is used during orbit-determination activities as an adjunct to the DSN Tracking System. Availability of the 1301 disk file in each of these configurations is indicated by the switch positions in Fig. 41.

The user area I/O interface assembly provides the interface between the computing system and the peripheral administrative printers, card readers, user area I/O consoles, and printers and plotters.

The computer programs that operated in the DPS in support of the telemetry system functions were as follows:

(1) DSN 7044 Mission-Independent Processor Programs.

Card input pre-processor

Display driver

Input message processor

I/O executor

Mode change control

Milgo plot formatter

Recovery

SC 3070 (high-speed) printer formatter

Simulation I/O monitor

System operation control

Table and program change

Telemetry station input processor

Track supervisory

Teletype output formatter

Teletype input formatter

(2) IBM 7044 Mission-Dependent Processor.

(3) IBM 7094 Processor.

An important set of agreements between the DSN and the Mariner Mars 1969 Project regarding the DSN telemetry system was the definition of some specific interfaces. Spacecraft transponder and telemetry modulation/synchronization techniques in the DSN RF and demodulation characteristics were required to be compatible. The project required certain status and performance parameters from the DSS such as received-AGC and signal level; the DSN required from the project, spacecraft AGC, and static phase error. These latter items were decommutated by the TCP at the DSS. Since the TCP computer program was mission-dependent and supplied by the project, an interface existed within the software at the HSD synchronizer block header to perform telemetry stream monitoring and data accountability. A similar interface existed for the NASCOM teletype header. Mission-dependent computer programs of the project were required to conform to the 7044 and 7094 computers design specifications and requirements.

2. <u>DSN tracking system</u>. The DSN Tracking System provides the capability for generation, handling, editing, calibration, display, distribution, validation, and prediction of precision radio metric data. Radio metric data are defined as range, angle, and doppler data as well as associated data such as lock status, time, frequency, data condition, and calibration information. Figure 45 shows the functions performed by the DSN Tracking System. Doppler range and angle data are generated at the DSS and, during the Mariner Mars 1969 Project, these data are recorded on punched paper tape. The paper tape is then read into the DCS and returned to the SFOF for display and logging on magnetic tape (Figs. 46 and 47).

The Tracking System provides a one-way, two-way, or three-way doppler. A one-way doppler is generated when the ground receiver is locked to the spacecraft transmitter signal, but the transmitter frequency is determined by its internal auxiliary oscillator. When the spacecraft receiver is locked to the ground transmitter, and the spacecraft transmitter is controlled by the receiver-voltage control oscillator in the transponder mode, two-way doppler is obtained. If one DSS is tracking the spacecraft in a two-way mode, a second station which also has the spacecraft in view may lock its ground receiver to the spacecraft transmitter signal in a three-way mode. Three-way doppler data have proven quite useful because of the high stability of the ground station frequency reference even though the frequency references of the two ground stations are not coherent. The frequencies, however, are compared by the time-synchronization system.

Angle data may be provided by closed-loop tracking throughout the flight. However, that provided early in the mission is usually the most useful. At later times, it is convenient to drive the antenna with the antenna-pointing system, particularly when the signal level is low.

The operational ranging system (Mark I-A) is operable only up to approximately 1,600,000 km. In the case of Mariner 1969, therefore, it was capable of providing data only for the first few days of flight. Ranging data to planetary distances was provided by an experimental planetary ranging system at the 64-m antenna (DSS 14) only. Both systems provide range data by measuring the roundtrip transit time of the signal by measuring the phase shift in a pseudo-random code sequence. Data condition codes are also provided indicating doppler, angle and ranging modes, and gross data quality (good/bad depending on receiver in and out of lock).

The accuracy requirements stated by the project (Table 11) could in general be met. Table 21 shows the exceptions and the accuracies which the DSN was able to provide. The ranging delay errors are usually smaller than those due to the spacecraft transponder in which the delay varies with the function of the signal level. The time synchronization of the operational system was adequate to meet the prime requirement for 2 ms. An experimental time synchronization system was used to meet the secondary requirement of 20 μs.

Data transmitted by TTY to the SFOF were converted and stored in a Master Radio Metric Data File which later became the Master Data Record (MDR) for the DSN Tracking System. The MDR included all auxiliary information such as validation information, transmitter, and receiver frequencies. As shown in Fig. 48, these functions were performed first in the 7044 computer then in the 7094 computer by the mission-independent editor and tracking data processor. The data were then provided to the project for orbit determination in the 7094 computer. The project was required to return estimates of spacecraft trajectory parameters for prediction purposes. The DSN used the project-supplied estimate of these parameters to generate predictions which are estimates of the spacecraft position, velocity, and necessary DSS parameters to permit proper tuning of the ground transmitters for acquisition of the downlinks and uplinks. These predicts were transmitted through the 7044 computer and to the DSS via TTY. The DSN provided the usual sampling rates which met the project requirements. The fastest rate is once/s and was intended for use only during critical phases. Most data were sampled at 1 sample/min or 1 sample/10 min.

The experimental planetary ranging, time synchronization, and occultation equipment are discussed as part of encounter operations.

3. <u>DSN command system</u>. The DSN Command System provides the capabilities to generate and transmit commands to a spacecraft. The functions accomplished by the Command System are shown in Fig. 49. The multi-mission capability envisioned for later projects was not implemented in the TCP and associated equipment in time for Mariner Mars 1969. Therefore, the configuration shown in Fig. 50 was employed, the significant feature of which is the project-supplied, mission-dependent RWV equipment.

The command library was comprised of punched paper tapes, prepared by the DSN to project requirements, containing direct commands and quantitative commands. Use of these commands was directed by voice over TTY messages. Coded commands were generated in the 7094 computer and forwarded as a TTY message by the 7044 computer from the magnetic tape as shown in Fig. 50 or obtained from the shared disk file in the Mode 2 configuration (Fig. 44). The paper tape capability in the SFOF was provided as a backup.

Since the project was unable to provide a sufficient number of RWV units for two to be located at each station at all times, an allocation plan was devised as shown in Fig. 51. After launch, units located at DSS 71 and Bldg. AO at Cape Kennedy and at Ascension Island and the unit in the SAF at JPL were moved to provide dual units at all the prime tracking stations.

Command generation in the 7094 computer was accomplished by the mission-dependent project-supplied program (COMGEN). COMGEN is used to prepare CC&S flight programs and to generate coded commands used entirely by the CC&S to control the sequencer, reprogram the computer portion, or select specific memory words for telemetry readout.

4. <u>DSN simulation system</u>. The DSN Simulation System provides the capability to simulate some elements of the DSN for the purpose of testing hardware and computer programs and training of personnel. The capability consists primarily of the ability to generate and insert into the DSN at various points, simulated radio-metric, telemetry, and command data. The various functions performed by the DSN Simulation System in the three facilities, DSIF, GCF, and SFOF, are shown in Fig. 52. The configurations which accomplish these functions are shown in Figs. 53 and 54. Table 22 sets forth the character of the data inserted at various points of these configurations. Since the capabilities of existing subsystems at the various facilities were utilized by the simulation system, only the system data conversion center (SDCC) exists as a separate simulation facility. The SDCC generated simulated data packages in the form of magnetic and paper tape recordings, and also furnished real-time simulated telemetry or metric data for two missions simultaneously.

Simulated radio metric data could be produced in the SDCC to reflect real-time changes in tracking parameters such as RF lock status and sampling rates. Simulated telemetry data could contain effects of errors in the GCF due to noise. Simulated DSN monitor messages were provided by the SDCC under real-time control. Simulated response to commands was a manual operation. When in the SFOF simulation configuration (Fig. 53), personnel and equipment in the SDCC simulated the remote DSS.

The SDCC had the capability to prepare analog magnetic tapes containing simulated engineering and science telemetry data. The data were recorded on seven-channel analog instrumentation tape, containing voice labeling, time tracks, private tones for serial speed control and flutter compensation, and simulated data. Simulated metric data were recorded on punched paper tape. Real time simulated telemetry data could be generated in the SDCC and transmitted via high-speed data lines to DSS 12, 41, 51, and 62. At the DSS, the DSIF/GCF interface equipment (DGI) buffers, demultiplexes, and outputs the data at the required bit rate into the station.

An executive-type program (SIMSYS) in the ASI 6050 computer of the SDCC provides modular, mission-independent functions such as console I/O, commutation, and teletype formatting. Either tracking or telemetry simulation data may be produced using the program blocks available in that program (SIMSYS). Simulated tracking data are produced by first running a mission-dependent orbit-determination program which produces a tape containing simulated ephemeris data points for a given period. This tape is then used as the input to an ASI 6050 computer program controlled from the operator's console. The program produces formatted tracking data for up to four DSS with the additional capabilities of adding a variable amount of noise and/or biased data in realistically simulating one-, two-, and three-way doppler data. The teletype output of the ASI 6050 computer program is normally inserted directly into the SFOF communications processor for use in real-time by the Flight Path Analysis and Control Team, but may be stored on paper tapes for playback at the SDCC or DSS.

Simulated telemetry data are produced at all spacecraft rates except the high data rate (16, 200 bits/s), by mission-dependent computer programs. The project-supplied programs provided the necessary outputs for a pre-planned mission profile. Spacecraft commands could not be inserted, deleted, nor slipped in time from the planned sequence. Simulation system operator response to commands resulting from anomaly investigations by the spacecraft analysis team was quite restricted. As the research and development effort to investigate simulation techniques, the DSN provided a more comprehensive program. It was to accomplish the same objectives except that telemetry data were to follow mission sequences automatically by means of mathematical models of the spacecraft with full automatic response to all ground commands and external events. It provided a more realistic source of data and was available for the operational readiness test shortly before launch.

5. DSN monitor system. The DSN Monitor System consists of hardware, software, and personnel to provide the capability for sensing certain characteristics of various elements of the DSN, for processing and displaying these data for use by DSN Operations personnel, and for storing these data for later analysis and reference. Monitor data are used for determining DSN status and configurations, for guiding and directing DSN Operations, for furnishing alarms for non-standard conditions, and for analysis of the quality and quantity of data provided to the projects. There is no direct interface between the Monitor System and the flight project. The DSN Operations Control System provides the operational interface between the Project Mission Control and the DSN Monitor System. The purpose of the Monitor System is to determine whether the DSN is functioning correctly and indicate the corrective actions required. The functions performed by the Monitor System in meeting this purpose are shown in Fig. 55.

The Monitor System configuration during support of the Mariner Project is shown in Fig. 56. Some of this configuration was implemented by launch although the full configuration was not ready until after launch, in time for encounter. The system was composed of a local monitor and control subsystem for each DSN facility and a DSN monitor area in the SFOF. The DSIF, GCF, and SFOF Monitor Subsystems gathered system performance data from local monitor instrumentation, and data quality alarms from error detectors within other subsystems at each facility. The data were then differenced by a monitor program against predetermined criteria and performance standards, and appropriate alarms produced for local control. Each facility forwarded a pre-specified subset of its performance measurements to the DSN monitor area. The DSN monitor area provided hard copy, displays, and alarms for selected performance and data quality parameters, and advised DSN Operations and Control of conditions requiring corrective action.

At each facility, monitor functions were implemented by several subsystems. At the DSS, monitor information was generated and handled by the Digital Instrumentation Subsystem (DIS), Station Control and Monitor Console (SMC), the DSIF Phase 1 Monitor Computer Program residing in the DIS, and all station subsystems reporting information to the DIS. Monitor functions were implemented in the GCF by DGI equipment, teletype and high-speed data channels of NASCOM, the GCF monitor program residing in the communications processor, and the SFOF/GCF interface equipment. In the SFOF, monitor functions were implemented by the IBM 7044/7094 computer system, mission-dependent processor program in the 7044 computer, the criteria generation program in the 7094 computer, the CDC 3100 display buffer, and the I/O and display devices of the monitor area.

The DIS scanned performance and configuration outputs from the DSIF ground equipment, such as Microwave, Receiver, and Transmitter Subsystems, for processing and recording on magnetic tape. In addition, the DIS received data or functional operating information from the Tracking Data Handling Subsystem, the Station Monitor and Control Console, and the Antenna Pointing Subsystem. This information typically consisted of tracking, doppler, angle, and range data, and other information.

Monitor data examined by the DIS were compared to data consisting primarily of specified station configurations and nominal station performance specifications and tolerances. The criteria were provided to the individual DSS monitoring elements as a function of mission phase. Performance data, out-of-tolerance alarms, and failure alarms were displayed at the Station Monitor and Control Console. The Station Monitor and Control Console served as the centralized location for the DSS Monitor Subsystem computer-driven displays. The DIS output to the Station Monitor and Control Console provided real-time performance data to the DSS Station Manager to aid in instituting corrective action in the event of failure or non-nominal performance.

Automatic diagnostic self-check and alarm verification were provided in the DSS Monitor Program to minimize the number of false alarm conditions.

The monitoring of the GCF consisted mainly of observation of circuit activity and limited performance measurements of parity and/or format checking of portions of the mission-dependent data by the Communications Processor in the SFOF. The capability to monitor the block error rate of high-speed data was accomplished at data block level by use of separate error detection encoders (Fig. 38). The block error detection outputs of the decoders were processed by the Communications Processor to provide outputs to the GCF Monitor Subsystem and DSN Monitor Area.

The SFOF Monitor Subsystem was basically a reworking and expansion of the Data Processing Control Console already in existence, with extensions in capability to meet the requirements of the DSN Monitor Area Subsystem. The SFOF Monitor Subsystem monitored the operational status of all major hardware elements in the SFOF DPS, the status of the programs operating in the I/O (7044) computer, and the flow of data through the various elements of the DPS. Items such as DPS configuration, program mode, data loss during processing, and program failure to execute were monitored.

The major elements of the DSN Monitor Area Subsystem consisted of the DSN Monitor Area in the SFOF with its associated display devices, a DSN Monitor and Analysis Team, and the DSN Monitor Area Subsystem software in the display buffer and the I/O computer. The Monitor Area Subsystem utilized monitor data outputs from the other monitoring subsystems and, therefore, was the primary user of monitor data provided for overall DSN performance. The Monitor Area Subsystem controlled and provided monitor criterion data.

The Monitor System required certain status and data quality alarms to be provided by the mission-dependent software in the TCP and the I/O computer.

6. <u>DSN operations control system</u>. The DSN Operations Control System is the mechanism for directing the operation of the DSN facilities and systems in support of flight operations; it provides information to aid in DSN operations planning and efficient utilization of the DSN. Functions performed by the system are shown in Fig. 57. In summary, control system activities are as follows:

(1) Ensure that operational configurations and performance of the DSN follow mission plans.

(2) Allocate resources.

(3) Resolve resource and operations conflicts.

(4) Change DSN performance configurations as necessary.

(5) Direct overall DSN corrective action to restore operational capability in the event of DSN operational problems.

(6) Respond to project direction during spacecraft emergencies.

(7) Respond to project real-time requests for additional support.

(8) Provide analysis and coordinate with the project to aid in trouble-shooting combined DSN/Spacecraft emergencies.

(9) Coordinate operations with other tracking networks in support of the project.

The operational structure during flight operations was as shown in Fig. 58. During the planning and testing phases prior to flight operations and for non-operational matters during flight operations, activities were related as shown in Fig. 59; information was provided for overall, long-term control instead of minute-to-minute guidance of operations.

A significant feature of the DSN Operations Control System for support of the Mariner Mars 1969 Project is the organization of the DSN Operations Control Team (OCT). During mission operations, this team was to support the project organization shown in Fig. 60. The DSN OCT was organized as shown in Fig. 61. Although the DSN Project Engineer (PE) carried the responsibility for the operation of the DSN, operational direction of the control team was exercised by a DSN Operations Director (OD) for Mariner Mars 1969. The OD interfaced directly with the SFOD during the conduct of mission operations. The DSN PE maintained surveillance of the activities of the OCT, redirecting allocation of resources as required to meet the needs of the OD.

The working relationships between members of the OCT are indicated in Figs. 62 and 63 which are depicted in terms of the communications structure. In this arrangement, the duties of the OD are:

(1) Receive direction from the SFOD and translate the request into appropriate instructions for the three DSN facilities.

(2) Receive status reports from the facilities and input these to the SFOD or his assistant.

(3) Designate a coordinator from the facility representative for all tasks requiring inter-facility coordination, and monitor execution of the delegated tasks.

(4) Hold briefings required to provide information relating actual flight sequences to planned sequences.

In immediate and most frequent contact with the OD are the Track Chief controlling the DSS, the Communications Manager controlling the GCF, and the Data Controller controlling the DPS in the SFOF. As shown in Fig. 63, these three operational positions are supported by PE from the DSN Interface Design Team for Mariner Mars 1969 acting as an advisory group providing technical information upon request.

In addition, a Network Analyst Team (NAT) was set up as an ad hoc activity for Mariner Mars 1969. The team functioned during critical mission phases staffed with selected individuals from the development organizations. The team was directed by a Chief who acted as an advisor to the OD. The NAT worked on problems to isolate a difficulty to a station or facility, and then worked directly with the appropriate advisor to isolate the problem. The OD was advised of a recommended course of action.

The DSN Monitor System provided information to the NAT by CRT and TTY displays. System problems were reported by the Monitor Project Engineer to the appropriate NAT member. During non-critical operations, primarily the cruise, the Monitor Chief reported directly to the OD.

The Support Chief was responsible directly to the OD for operational tasks. However, it was expected that with proper planning very little operational direction would be required regarding voice nets, closed circuit TV, building services, distribution of processed data, and other support activities.

The OCT was located in the DSN Operations Area (Figs. 64 through 66) with the exception of the OD during critical phases when his position was with the SFOD in the Mission Control Area for Mariner 1969. The Track Chief, Data Controller (DACON), and Communications Manager conduct their activities from the main DSN operations console. During high activity phases, two Track Chiefs and DACONS are provided. Control of the DSN for all projects is provided from this position by the Operations Control Chief (OCC). He oversees the use of the DSN by the Mariner 1969 Project and controls the support being provided simultaneously to other projects. During low activity phases of the Mariner 1969 Project, the OD function is assumed by the OCC. It should be noted that this particular arrangement and the provision of the OD function was instituted for Mariner 1969 and was an interim operations control configuration.

The Track Chief controlled the DSS through the station controllers seated at the other round consoles. The remaining consoles are assigned to the various advisors and managers as indicated.

It is apparent that control of the DSN is through its facilities and preparation for support of mission operations includes organization of the control functions and the training of the personnel who conduct them. Control of the DSS is exercised from the SFOF and extends down to the operators at the DSS. Preparations for the mission require operations planning and operator training. Whereas preparation of the station configuration is the responsibility of the DSS Operations Engineering Project Engineer, training and procedures are the responsibility of the DSS Operations Planning Project Engineer. The Systems Data Analysis Project Engineer handled procedures regulating tracking predictions and the analysis of tracking data.

Control of the DSS was exercised somewhat differently than in previous projects in keeping with the interim control configuration leading to a more mission-independent arrangement. The operational call sign "Track Chief," formerly assigned to the DSS Operations Planning Project Engineer, was assigned to the DSS Chief. As shown in Fig. 67, the Operations Planning PE provided advisory support to the DSS Chief. When it was found that more than one DSS Chief was needed to handle critical command activities and to coordinate activities of the DSS controllers, an Assistant Operations Planning PE was assigned to work as an Assistant DSIF Chief. His usual duties were to conduct the command activity while the DSIF Chief handled other activities with the OD and other members of the OCT. This arrangement was convenient since the Mariner 1969 Command System employs mission-dependent equipment and procedures with which the Operations Planning PE were more familiar than the mission-independent DSIF Chiefs. This role indicates more clearly the interim nature of the operations configuration in Mariner 1969 in which the Operations Planning PE, instead of being strictly an advisor, had to provide some direction activities through his assistants.

The roles of the Operations Engineering and SDA PE were essentially unchanged. They functioned as advisors during critical or high-activity periods.

Control of the DSS was exercised by mission-independent and mission-dependent procedures. The latter were formulated by the operations planning activity as a section of the DSN Operations Plan. It included the following types of information:

(1) Spacecraft designators and frequency.

(2) Instructions for handling various kinds of data.

(3) Instructions for handling predicts.

(4) Pre-pass procedures.

(5) Acquisition procedures.

(6) Special tracking procedures including data rates, formats, command procedures, recording instructions, station transfer procedures, and reporting procedures.

A number of operational procedures were devised and improved. One of the more important changes was the reduction of the preparation time prior to sending a command. Formerly, a maximum of 38 min was required to zero spacecraft static phase error prior to turning on command modulation, and obtaining and confirming command loop lock. The ability to generate better frequency predicts permitted setting of the ground transmitters such that it was not necessary to zero the static phase error, and command modulation could be turned on shortly after two-way acquisition. Turning on of command modulation was regarded by earlier projects as a very major action subject to unknown dangerous possibilities; command modulation was turned on only when absolutely necessary. Subsequent experience gave the projects greater confidence in spacecraft component reliability and the operational procedures designed to safeguard against spurious commands. The Mariner 1969 Project, desirous of a more active command capability, adopted the recommendation and the procedures were used successfully.

Station countdown procedures for obtaining AGC curves were simplified to permit shorter station countdown time. A limited amount of data obtained during each pre-pass countdown was used to correct the AGC curves generated during periodic longer countdowns.

The method and strategy for providing preflight nominal predictions were modified for Mariner Mars 1969. Previously, it was the practice to publish predicts for all launch days. This was not a difficult task for a fixed launch azimuth and the results served as a source for backup predicts during an actual launch. Mariner 1969 employed a direct ascent involving a large number of nominal trajectories. The same approach to predicts would have produced a very bulky, expensive predict book. The DSN Operations Plan, therefore, provided only selected representative trajectories. The preflight nominal predicts to be used for backup were generated three at a time and teletyped to the stations at least one day in advance of a particular launch date. For the actual mission, this involved only nine predict sets for three different days. The Operations Plan provided information to the stations on nominal injection conditions to permit practice acquisitions, frequency measurement procedures, and explanation of predicts strategy. A standard operating procedure was written which includes the most successful methods previously used for predict transmission. The procedure flowed as shown in Fig. 68.

Predict strategy for the launch phase was based on the three sets of predicts normally used:

(1) Preflight nominals generated a day in advance at JPL and sent to the stations by teletype.

(2) JPL near-real-time predicts which are usually generated at 30 min and at 5 min before launch, based on the latest frequency measurements and best trajectory information available.

(3) ETR near-real-time predicts generated after launch, based on latest frequency measurements and actual launch vehicle performance.

The predicts set to be used for acquisition should arrive at least 10 min before the expected acquisition. The number of predicts generated near acquisition should be kept to a minimum to avoid confusion at the station. The ETR predicts would be the only available accurate information in the event of an anomalous launch trajectory since the data are derived from down-range stations.

The strategy adopted was to use first the predicts generated at JPL at launch -5 min and transmitted at liftoff. These predicts would arrive 10 to 15 min before DSS 51 rise, and would contain the correct launch time to within seconds, and the best available spacecraft frequency information. A special set was required for the MSFN station at Ascension Island since not enough time was available before rise at that station. Table 23 summarizes the strategy showing the priority of use of the various predict sets at various times. Table 24 shows the priority in case of an anomalous trajectory. The predict strategies for each trajectory correction maneuver were based on the stations not having to change predicts during the motor burn and having a pseudo-residual program to compare the actual doppler data against the predicts without a burn. Figure 69 shows that the pseudo-residual program and the tracking stations used three successive sets of predicts. The first set did not contain the doppler shift due to the maneuver and was used by the pseudo-residual program to monitor the doppler shift; the pseudo-residuals are the differences between the actual and predicted doppler frequencies. When the final maneuver parameters were calculated, they were introduced into the predicts program which produced the second predict set. The third predict set was produced when the orbit-determination group had gathered enough data to produce a good post-burn orbit.

An important element of the Operations Plan is the strategy for initial acquisition of the spacecraft signal by the DSN. The study actually involved two stations, DSS 51, at Johannesburg, South Africa, and the MSFN station at Ascension Island. Initial acquisition phase is defined as the time starting at spacecraft booster liftoff and ending when the DSN station has acquired the spacecraft signal in two-way lock and generated a short period of continuous angle and doppler data which may then be used to compute a trajectory of sufficient accuracy for other DSN stations to acquire and track the spacecraft.

Initial acquisition was subject to a number of constraints. An S-band acquisition aid (SAA) antenna system was required. The SAA system consisted of a 1.2-m (4 f) paraboloid mounted on the tip of the quadripod feed structure of the 26-m antenna at DSS 51. Although the signal could be received earlier, initial auto-track attempts on the SAA antenna could not begin until the spacecraft was more than 10 deg in elevation above the local land mask and within the antenna mechanical limits. In order to auto-track with the SAA, transfer auto-tracking to the main 26-m antenna, and establish the two-way, coherent RF lock, 20 min must be allowed for the station to complete these operations, and an additional 10 min to obtain and verify good angle and doppler data. Although the angle is capable of higher angular tracking rates, 0.5 deg/s is specified as the maximum rate permitted during initial acquisition to permit the acceleration necessary to point the antenna to the spacecraft. Transfering from SAA auto-track to the 26-m antenna auto-track is not made until angle-tracking rates are less than 0.1 deg/s. The received carrier level through the SAA antenna must be greater than -135 dBm. The receiver, carrier-loop phase error must not exceed 30 deg RMS during the acquisition phase; the phase error is a function of doppler rate, receiver-loop bandwidth and signal level, all of which must be consistent to maintain the required error level. During this activity, commands may be sent to the spacecraft and telemetry data can be provided after two-way lock has been established. With these constraints, the expected performance was analyzed.

A portion of the initial pass view period at DSS 51 during the initial acquisition sequence is shown in Fig. 70. The trajectories shown are for launch times corresponding to window opening (Trajectory A) and window closing (Trajectory B). A study of the trajectory plots revealed no station view problems. The dispersion of station pointing angle due to trajectory variations is very small. Figure 70 also shows, if the spacecraft attitude is favorable, all acquisition operations should be completed by 46 min from launch, and time is available to obtain required doppler and angle data for both cases analyzed.

The initial acquisition period takes place during the time the spacecraft is attempting sun acquisition. For both trajectories, the spacecraft emerges from the earth shadow at approximately the same time as it rises above DSS 51 land mask. DSS 51 would always be in the forward hemisphere of the spacecraft antenna pattern although the spacecraft might have its attitude randomly positioned within this hemisphere. This implies the cone angle will be 90 deg. Since sun acquisition sequence could take up to 30 min, the attitude would not be definitely known until approximately 53 min after launch. A worst case (cone angle = 90 deg) analysis was performed. Figure 71 shows the nominal and minimum carrier levels (sum of negative tolerances) the station could expect based on a constant 90-deg cone angle for both trajectories. The minimum signal level curve for either trajectory is below the acquisition criteria. Table 25 shows expected performance at the beginning of the acquisition period (L + 26 min) for DSS 51 for the window-open trajectory. Figure 72 and Table 26 display the same information as Fig. 71 and Table 25 except the cone angle is fixed at 60 deg. Since it was evident a signal level problem might exist, Fig. 73 was drawn to show the maximum allowable cone angle which would produce a -135 dBm signal at DSS 51 in a maximum negative tolerance condition.

Angle tracking rates predicted during acquisition are shown in Fig. 74; they are within DSS 51 tracking capability.

Two-way doppler rates expected during acquisition are shown in Fig. 75. Figure 76 shows the doppler tracking rates of the DSS receiver using a loop bandwidth of 48 Hz. The highest doppler rate expected was well within the receiver capability. During initial one-way acquisition, only a one-way doppler shift is experienced. This results in a rate of change of doppler that is only one-half the value shown in Fig. 75.

Because of spacecraft radio subsystem requirements, the stations were requested to limit spacecraft receiver total power input to -100 dBm on the first pass. Figure 77 gives the value of transmitted power versus time that limits the spacecraft total power input to -100 dBm regardless of spacecraft attitude. The maximum input to the spacecraft would be -100 dBm if the curve is followed.

The early portion of the initial pass view periods at Ascension is shown in Fig. 78. The spacecraft rises 7 to 8 min sooner than at DSS 51. However, Ascension must acquire using a 9.2-m (30 f) dish rather than a broad-beam acquisition-aid antenna. After the spacecraft rises over Green Mountain, there are no station view period restrictions.

Approximate carrier levels for Ascension on the window-open trajectory are shown in Fig. 79. The window-close trajectory has slightly greater ranges, consequently the signal level is degraded by approximately 2 dB.

Initial pass angle tracking rates do not exceed 0.2 deg/s in either axis.

The two-way doppler rate for the window-open trajectory is shown in Fig. 80. While higher than at DSS 51, it is still not excessive.

The transmitter power profile, for Ascension, to produce -100 dBm at the spacecraft regardless of attitude is shown in Fig. 81. At L + 56 min, the spacecraft is stabilized. The power level is low because Ascension does not have a low-gain transmit antenna. The gain differential between the SAA at DSS 51 and the 9.2-m dish at Ascension is on the order of +22 dB; therefore, for the same uplink conditions, DSS 51 requires approximately 160 times more power than Ascension.

The results of this study were as follows:

(1) For a nominal launch where the spacecraft cone angle remains less than 60 deg, DSS 51 would begin initial one-way acquisition approximately 26 min after launch and complete two-way RF acquisition not later than 46 to 52 min after launch.

(2) For a launch where the spacecraft attitude produces high-cone angles, DSS 51 initial acquisition might be delayed until the spacecraft achieves a favorable

cone angle or until sun acquisition is accomplished. Since sun acquisition may not take place until L + 53 min, DSS 51 initial two-way RF acquisition may be delayed to L + 73 min. This worst-case condition was considered highly unlikely (5%).

(3) For standard trajectories, Ascension should have started one-way acquisition not later than 17 min after launch.

(4) For all standard trajectories, Ascension would delay start of uplink acquisition until approximately L + 36 min due to -100 dBm power limitation at spacecraft which will result in completion of acquisition at L + 46 min.

If the project required Ascension uplink acquisition before L + 46 min, the -100 dBm uplink constraint at the spacecraft would have to be removed. If this constraint were removed, uplink acquisition could be accomplished at Ascension by L + 37 min.

These results are summarized in Table 27.

Most criteria for initial acquisition were easily satisfied by DSS 51. The only problem appeared to be the downlink signal level required to initially auto-track the spacecraft with the acquisition-aid antenna. If the worst-possible spacecraft attitude (low-antenna gain) existed at station rise, then the initial acquisition process at DSS 51 would not be completed until after spacecraft sun acquisition. However, this is the worst-case assumption, and Fig. 70, taking a more optimistic view, showed that the initial acquisition procedure could be completed 46 min after launch. However, if the spacecraft attitude at the time of scheduled two-way acquisition results in maximum antenna gain, the initiation of two-way acquisition would have to be delayed until L + 42 min. In this case, the initial acquisition phase would extend to L + 52 min.

The situation is almost identical for Ascension except that the worst-case transmitter turn-on time is L + 36 min (assumes 0.6 W).

For a normal launch, it was recommended that DSS 51 be used for initial two-way acquisition. This conclusion is based on the premise that DSS 51 was better equipped for Mariner than Ascension, and that no appreciable time was saved using Ascension because of the -100 dBm uplink power constraint. However, Ascension was a good backup for the launch.

This initial acquisition study of Mariner VII launch includes the results of investigating the initial acquisition conditions at DSS 51, Ascension, and DSS 62, based on a nominal launch at the opening and closing of the launch window on March 24, 1969. The study for Mariner 1969 did not consider DSS 62 since predicted elevation angles were at, or below, the DSS 62 land mask. General results of this analysis are not significantly different than for the February 25, 1969 launch.

Figure 82 shows the spacecraft ground track over DSS 51 for the March 24, 1969 launch. The station's pointing-angle dispersion due to trajectory variation is insignificant. Acquisition operations would be completed by L + 44 min assuming spacecraft cone angles were as predicted.

Figure 83 shows the predicted signal level with a spacecraft cone angle fixed at 60 deg. The predicted signal level meets the required -135 dBm minimum and acquisition should be completed by L + 44 min. Figure 84 shows predicted signal level with the cone angle at 90 deg (worst case); DSIF requirements are not met. It was expected that sun acquisition would be accomplished before the spacecraft reentered the earth's shadow. If sun acquisition were accomplished and then the spacecraft re-entered the earth's shadow, the spacecraft attitude would then drift off at a rate of 100 deg/h. If the drift rate is no larger, the effective antenna gain would still provide the required signal level. Figure 85 shows the allowable cone angle.

Figure 86 shows the expected angle rates for both window-open and window-close launches. The maximum angle rates of 0.06 deg/s are within the station capability.

The initial two-way doppler rates are shown in Fig. 87. The 150 Hz/s is well within the receiving systems doppler tracking capability for a loop bandwidth of 48 Hz, as shown in Fig. 76.

Figure 88 is a curve of permissible ground transmitter power. The spacecraft antenna gain used was 7.0 dB with 0-dB cone angle pointing loss. If this worst-case condition prevails, initiation of two-way acquisition would be delayed until 36 min after launch. Plans were to initiate two-way acquisition at L + 30 min.

Figures 89 and 90 show the spacecraft ground track over Ascension. The trajectories are for the March 24, 1969 launch. All acquisition operations would be completed by L + 35 min. The good data requirements would be met by L + 46 min.

Figures 91 and 92 show the approximate carrier levels expected at Ascension for window-open and window-close launches. As shown, expected signal levels meet the initial acquisition requirements.

The highest angle rate at Ascension occurs on the window-close launch which produces a maximum azimuth angle rate of 2.784 deg/s which is within the Ascension angle tracking capability of 5 deg/s.

For the window-open launch, Fig. 93 shows that maximum doppler rate reaches approximately 650 Hz/s. Although this is far more than other stations will experience at the strong signal levels expected, the receiver is capable of accommodating this high rate. Figure 94, the window-close doppler curve, shows that the doppler rate will be somewhat lower than window-open.

Figure 95 shows the maximum power to be transmitted to the spacecraft because of the -100 dBm spacecraft constraint. Ascension would not be able to initiate two-way acquisition until approximately 35 min after launch.

Figure 96 shows the spacecraft ground track over DSS 62. As shown, the DSS 62 look angle is extremely close to the horizon mask. Automatic angle tracking would be, at best, marginal if attempted at that low angle. At Point 5, the DSS 62 antenna (no SAA antenna at DSS 62) could initiate one-way acquisition with a reasonable degree of confidence. There is sufficient horizon mask clearance for the remainder of the pass. Figure 97 shows the ground track for a mid-window launch. Horizon mask clearance, as from spacecraft rise through the pass, is sufficient to allow one-way acquisition. Figure 98, window-close launch, shows that horizon mask is again sufficient for one-way acquisition.

Figure 99 (spacecraft cone angle = 90 deg) and Fig. 100 (spacecraft cone angle = 60 deg) show the expected carrier levels for window-open and window-close launches. The signal levels exceed the initial acquisition requirements.

Figure 101 shows the angle-tracking rates to be expected for the launch window. All angle rates are well within the station's capability.

Doppler rates, as shown in Fig. 102 for DSS 62, are within the receiver's capability.

Figure 103 shows the maximum allowable power into the spacecraft from DSS 62. Since DSS 62 has no SAA, two-way acquisition was not possible from DSS 62 unless the -100 dBm restriction were removed.

The results of this study are as follows:

(1) Since spacecraft predicts show the cone angle to be less than 60 deg for the launch phase, DSS 51 would begin initial one-way acquisition at L + 24 min 30 s and would have completed two-way acquisition at L + 44 min. Initial telemetry and tracking data requirements would be met by L + 54 min and the capability to transmit commands to the spacecraft would be effected at L + 52 to 54 min. The times quoted above are for the window-open launch; the window-close launch times are not significantly different.

(2) For a nominal launch, sun acquisition was expected to begin at Centaur separation when the spacecraft has emerged from the earth's shadow and to be completed before re-entering the earth's shadow. Therefore, high-cone angles are not anticipated.

(3) It was expected that Ascension would begin a one-way acquisition at 16 min after window-open launch and 14 min after window-close launch.

(4) For a nominal launch, Ascension could not begin two-way acquisition procedures until L + 35 min because of -100 dBm limitation at the spacecraft receiver. Two-way acquisition could be completed by L + 45 min.

If the -100 dBm constraint were waived, then Ascension could complete two-way acquisition at L + 36 min.

(5) For a window-open launch, spacecraft rise at DSS 62 was predicted at 30 min after launch; however, the look angle is not sufficiently clear of the land mask to rely on DSS 62 acquisition to begin until about 50 min after launch.

For a window-close launch, it appears that DSS 62 could begin one-way acquisition at L + 21 min or just after spacecraft rise. Unless the -100 dBm input to the spacecraft receiver constraint was waived, two-way acquisition from DSS 62 would not be possible until well past the critical phases of the launch or well past L + 372 min.

Based on predicted trajectories and spacecraft attitude, DSS 51 could complete a two-way acquisition not later than L + 54 min which included providing valid tracking data to the SFOF. Also, continuous telemetry data could be available from DSS 51 from L + 25 min until the end of the pass. Command capability could be effected 54 min after launch. If the spacecraft restriction of -100 dBm was lifted, DSS 51 could initiate a two-way acquisition sooner.

One-way acquisition at Ascension could be made not later than 16 min after launch.

The fact that DSS 62 did not have an acquisition antenna precluded DSS 62 from acquiring the spacecraft in the two-way mode. However, in an emergency, two-way acquisition could be accomplished at approximately 50 min after launch on a window-open launch to 24 min after launch for a window-close launch.

For a normal launch, DSS 51 was to be used for the initial two-way acquisition.

Control of the GCF for support of the Mariner Mars 1969 Project was exercised by the Comm man with advice for the one or more Comm project engineers (Fig. 104). As shown in Fig. 105, he controlled communications activities within the SFOF and at Goldstone directly, and with the overseas stations through NASCOM. Real-time control was primarily by voice net, other control was by TTY. The SFOF Communications Facility Control, TTY Switching Center, and Message Center are all located in the basement of the SFOF (Fig. 106).

Figure 107 shows the SFOF Operations Control positions. The DACON coordinate all data-processing system activities and direct them through the Data Chief located on the floor above the Operations Area with the computers. His advisors are the Project Engineers for data processing, the Data System, and data hardware. During low activity, the Data Chief performs the functions of the data controller, working directly with the OD or OCC.

The Support Chief directs his activities from the DSN Operations Area.

Use and control of the DSN in support of various projects is achieved by the DSN Network Allocation Schedule. Although rudiments of this system were employed for earlier projects, particularly Surveyor, Lunar Orbiter, and Mariner V, it evolved to nearly its present form during the Mariner Mars 1969 Project. Figure 108 shows the flow employed to produce the 72-Week Network Allocation Schedule, the mid-range or 12-Week Schedule, and the 7-Day (short-range) Schedule. Such a system was necessary to schedule such complex resources in support of several projects inasmuch as several Pioneers as well as Apollo missions were flown during the Mariner 1969 activities.

Preparation for mission operations included the test program described in the next section and a training program for personnel. The TDS prepared, with the MOS, a joint Mission Operations Training Plan, the purpose of which was, (1) to familiarize mission operations personnel (both TDS and MOS) with equipment, software, data formats, and facilities to be used during operations, and (2) to train mission operations personnel in executing mission-dependent operational procedures and to act as an integrated team. This approach was adopted as an effort to make a clear distinction between the training of personnel in the use of equipment, software and procedures, and the testing of the equipment, software and procedures, and in the ability of the personnel to use them. Therefore, MOS personnel commenced training with orientation lectures on the DSN, tour of the SFOF, and lectures on intercommunications system, software system, display equipment telemetry data formats, telemetry and tracking data flow, command flow and procedures, and operations interfaces Such lectures were conducted by the DSN PE and members of his design team. Further training of MOS personnel was outside the responsibility of the TDS, but was usually conducted in the mission support areas in the SFOF

Training of TDS personnel for support of Mariner 1969 included lectures on the Mariner Mars 1969 Project, spacecraft design, and spaceflight operations plan. Training of station operators was accomplished by first bringing Goldstone key personnel from each station for familiarization with equipment and procedures. These persons then returned to their respective stations and conducted the training of other station personnel. The training program commenced in September 1968 at Goldstone. Following a series of lectures and familiarization, practice sessions were conducted at CTA-21, each station group acting as an operating team. The representatives from each station were the operations supervisor or senior shift supervisor, a TCP operator, and receiver/SDA operator, and a command or RWV operator who is also trained in the use of the telemetry simulator. On-site training was conducted by these personnel after they returned to their station to training plans developed by the Station Managers. During this training, the DSIF operations engineering and planning project engineers and the system data analysis engineer visited the stations to observe and assist with the training. As the subsequent testing program showed, this effort was extremely valuable in reducing the amount of testing required to attain the ability to conduct operations smoothly.

The GCF operators required very little special training in preparation for the test program. They already were providing 24 h a day operation of mission-independent equipment.

SFOF training was of primary importance to the DACON who received training in using the data processing system with the version of the software used to support Mariner 1969.

7. DSN facilities support. The primary activities of the three facilities, DSIF, GCF, and SFOF, in preparation for support of the Mariner Mars 1969 Project, are described in the previous sections. Some support in addition to that provided directly by the DSN Systems was furnished.

The communications capabilities provided by the GCF are summarized in Fig. 109. Communications with all stations other than those at JPL and Goldstone were provided through the facilities of NASCOM. Figures 110 and 111 show an overall view of the teletype and high-speed data configurations.

The GCF configurations for launch and cruise phases are shown in Figs. 112 through 114.

As shown in Fig. 110, the JPL communications processor handled teletype data for the DSN Tracking, Telemetry and Command Systems. It also handled teletype data for the Simulation System. In addition, high-speed data processed by the 7044 computer were distributed through the CP to teletypes in the Mission Support Areas. The primary function of the CP is to perform teletype message switching for traffic between the DSS, the GCF, and the SFOF, and the discrete terminals associated with these facilities. As shown in Fig. 115, the switching functions are performed via three interfaces: NASCOM, the data processing system, and the teletype interface. Figure 116 shows the general configuration of CP hardware. All CP operations are compatible with and integrated with NASCOM operations.

The NASCOM interface receives and transmits data via highspeed (2.4 kbits/s) multiplex transmission lines. Teletype data (100 words/min) are multiplexed onto and demultiplexed from these lines by the communication line terminal equipment. The teletype interface receives and transmits data at 100 words/min rates; other rates from 20 to 300 bits/s can be processed, although 100 words/min has been adopted as a standard transmission rate. The interface to the data processing system is through the Univac 490/IBM 7094 adapter via an IBM 7288 data communications channel operating at the rate of 40.8 kbits/s. Reliability is enhanced by the use of redundant units. Real-time message switching is performed under the control of the communications processor's system software (JCOMS). The software is divided into worker and executive categories. The executive programs control switching; the worker programs handle message traffic. The executive program (COMEX) allocates resources of JCOMS on a priority basis. Figure 117 shows the arrangement and listing of worker programs. Input message data are stored in input buffers, transferred to a pack area, and then to a drum. After validation, the message is scheduled for output by making an entry in the proper queue, taken from the drum and transferred to an output buffer for transmission. Routing of traffic from incoming to outgoing lines uses a store-and-forward technique. Messages are forwarded as soon as the last routing indicator is received. All inputs and outputs are in real time, inputs are not polled, nor is there any wait time to input a message or part of a message. As each message is received, a tape research identifier, a time received word, an input address, and a message word count are attached. The message is logged on drums for temporary use and taped for permanent record. The messages may remain on drum for recall up to 24 h, or until overlayed if demand for drum storage dictates. After validation of header information and disposition of messages of invalid headers, the output portion of the program places the message in the queue for output, or stores it until the circuit becomes available.

The SFOF provided technical and operational control areas for use by project personnel during space flight operations. The Mariner Mars 1969 Mission Support Area included a spacecraft performance analysis area, space science analysis area, principal investigator's area, and a mission control room. Also provided were a Mission Director's room for use by the project staff, and an observation room and conference room. Several areas were added later for encounter support. As shown in Fig. 118, the mission control room was contiguous to the spacecraft analysis area to improve interaction and communication between the various functions. Mission control was exercised by the Space Flight Operations Director (SFOD) from a round, six-man conference console used successfully for Pioneer VIII launch operations and Surveyors V through VII. The Mission Director and his staff were positioned so that they could observe all the operations but still be separate when privacy was required. An observation room was included so that visitors could view directly the entire mission without entering the analysis area. The Spacecraft Performance Analysis Area (Figs. 119 and 120) was designed to house the Spacecraft Performance Analysis and Command (SPAC) Director and Deputy Director, two Assistant Directors (one for each spacecraft team), a Test Director and Recorder for each of the teams, and 20 analysts. Display equipment was the same used by all projects since Mariner IV in 1964. Within the areas, communication was accomplished using the nets of the operational voice communications subsystem (OVCS). Figure 121 shows the science analysis area. Figure 122 shows the flight path analysis area. The closed-circuit TV system was used for display of time, updated sequence of events information, and some teletype information (Fig. 122). Modified communications consoles were provided to the area directors and assistants; consoles of lower heights were used as a result of complaints of poor visibility (by individuals) on earlier projects. The individual analysts were seated at desks and tables on which were placed television monitors. Teletype machines were placed next to the tables, as appropriate. Wall-mounted TV monitors, display boards, and high-speed printers were also provided. Several areas were equipped with I/O consoles (Fig. 123) to provide access to the data processing system.

DSN personnel in the SFOF provided assistance to the project by equipping CAT areas located in buildings other than the SFOF. Similar assistance was provided in supplying voice and video lines for dissemination of mission information by the Public Information Office. Five CAT areas were equipped with voice nets, teletype machines, and closed-circuit TV. One area was equipped with high-speed data line output. The circuits between these various areas are outside the DSN operational circuits and were provided from the existing JPL inter-building circuits. Figure 124 shows the extent of these circuits including those used for spacecraft system tests prior to launch.

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Table 14. Technical systems vs design teams

	Design Teams		
Technical systems	Mission operations	Software	DSN
Chairman	SFOD	SSE	DSN PE
Operations	SPAC Director FPAC Director SSAC Director Simulation Director Miss. Profile Anal. Eng	SFOD SPAC Director FPAC Director SSAC Director Simulation Director	DSIF OPNS Plan PE DSIF Sys Data Anal. PE SFOF OCC Rep SFOF Data Sys PE SFOD Rep
Software	SSE	Program Cognizant Engineer Appropriate Div Reps Sect 315 Rep	Data Proc PE
Data	DSN PE	DSN PE	DSIF OPNS Eng PE Communications PE SFOF Data Hdw PE SFOF Simulation PE SFOF Support PE MDE Rep (S/C Sys)

Table 15. Instrumentation summary chart, near-earth phase – DSN and MSFN

Location	Instrumentation	Agency	Use	Remarks
Cape Kennedy	S-band telemetry and command	DSN	Spacecraft/DSN Compatibility Test, spacecraft check-out, telemetry reception in early launch phase, and processing of AFETR telemetry	DSS 71, 1.2-m manually aimed antenna
Ascension Island	S-band tracking and telemetry	MSFN	Spacecraft tracking and telemetry	USB Station, 9.2-m X/Y antenna

Table 16 Instrumentation summary chart near-earth phase--AFETR

Location	Instrumentation	Use	Remarks
Cape Kennedy	C-band radar	Launch vehicle tracking	ETR Station 1.16: FPS-16, monopulse, 3.6-m (12 ft) antenna, 1.0 mW peak power
Merritt Island	C-band radar	Launch vehicle tracking	ETR Station 19.18: TDQ-18, monopulse, 8.8-m (29 ft) antenna, 2.5 mW peak power
	S-band telemetry	Spacecraft telemetry	Tel-4: TAA-3, 10-m (33 ft) antenna
		P-band telemetry	Tel-4: TAA-2A, 26-m antenna
Patrick Air Force Base	C-band radar	Metric data and range safety	PAFB Station 0.18: FPQ-6, monopulse, 8.8-m antenna, 2.5 mW peak power
Grand Bahama Island			ETR Station 3:
	C-band radar	Launch vehicle tracking	FPS-16 and TPQ-18
	S-band telemetry	Spacecraft telemetry	TAA-3, 10-m antenna
	P-band telemetry	Spacecraft and launch vehicle telemetry	TAA-2A, 26-m antenna
Grand Turk			ETR Station 7:
	C-band radar	Launch vehicle tracking	TPQ-18
	S-band telemetry	Spacecraft telemetry	TAA-3
Antigua			ETR Station 9:
	C-band radar	Launch vehicle tracking	FPQ-6
	S-band telemetry	Spacecraft telemetry	TAA-3
	P-band telemetry	Spacecraft and launch vehicle telemetry	TLM-18
Ascension			ETR Station 12:
	C-band radar	Centaur vehicle tracking	TPQ-18 and FPS-16
	S-band telemetry	Spacecraft telemetry	TAA-3
	P-band telemetry	Spacecraft and launch vehicle telemetry	TLM-18
Pretoria	C-band telemetry	Centaur vehicle tracking	MPS-16 1.2-m antenna
	S-band telemetry	Spacecraft telemetry	
	P-band telemetry	Spacecraft and launch vehicle telemetry	
Ship (metric)	C-band radar	Launch vehicle tracking	FPS-16
	S-band telemetry	Spacecraft telemetry	TAA-5-16
	P-band telemetry	Spacecraft and launch vehicle telemetry	Rantec
Ship/Aircraft	S-band telemetry	Spacecraft telemetry	TAA-5-24 (Ships only)
	P-band telemetry	Spacecraft and launch vehicle telemetry	TAA-1 (Ships); NKC135 Aircraft, 2.1-m (7 ft) antenna
Trinidad	UHF radar	Centaur vehicle tracking	

Table 17. Instrumentation summary chart, Deep Space Phase

Location	Instrumentation	Use	Remarks
Goldstone, California	S-band tracking, telemetry, and command	Spacecraft tracking, telemetry, and command	DSS 12, 26-m equatorial antenna
Goldstone, California	S-band tracking, telemetry, and command	Spacecraft tracking, telemetry, and command	DSS 14, 64-m Az/El antenna
Woomera, Australia	S-band tracking, telemetry, and command	Spacecraft tracking, telemetry, and command	DSS 41, 26-m equatorial antenna
Woomera, Australia	S-band tracking, telemetry, and command	Spacecraft tracking, telemetry, and command	DSS 42,[a] 26-m equatorial antenna
Madrid, Spain	S-band tracking, telemetry, and command	Spacecraft tracking, telemetry, and command	DSS 61,[a] 26-m equatorial antenna
Madrid Spain	S-band tracking, telemetry, and command	Spacecraft tracking, telemetry, and command	DSS 62, 26-m equatorial antenna
Ascension Island	S-band tracking, telemetry, and command	Spacecraft tracking, telemetry, and command	MSFN, 9 2-m X/Y antenna
Pasadena, California	Data processing and communications	Mission operations and DSN control	SFOF
Johannesburg, South Africa	S-band tracking, telemetry, and command	Spacecraft tracking, telemetry, and command	DSS 51, 26-m equatorial antenna

[a] DSS 42 and 61 were not available for meeting basic requirements since they were included in the planned support of other projects with uniform schedules. When not used for other projects, these stations could be used by the DSN to provide backup or additional coverage.

Table 18. AFETR station assignments for expected spacecraft data retransmission

Station	Launch/Arrival Date	Spacecraft Data Source for Real-Time Retransmission	Backup Data Source
Tel-4	All days	P-band	S-band
GBI	All days	P-band	S-band
Antigua	2/24 - 3/26	S-band	P-band
	3/27 - 4/7	P-band	S-band
Twin Falls	All days	S-band	None
Ascension	All days	S-band	None
NOTE: All telemetry stations recorded data on-site			

Table 19. Planned RTCS orbit computation

Time of Computation	Type of Orbit	Data to be Used
T+18	Transfer	Antigua, Grand Turk, Twin Falls, Ascension or Bermuda (one station only)
T+45	Transfer	Centaur guidance telemetry
T+70	Centaur post-deflection	Ascension or Pretoria
T+105	Transfer orbit	DSS 51 or ACN S-band
T+150	Transfer orbit	C-band radar or S-band (this orbit computed only if needed)
T+165	Centaur post-deflection	Centaur guidance telemetry
T+180	Centaur post-deflection	Ascension and/or Pretoria C-band (this orbit computed only if needed)

Table 20. Comparison of channels

Parameter	1. *Mariner IV* 8⅓-bit/s channel		Δ	2. *Mariner* Mars 1969 270-bit/s channel		Δ	3. *Mariner* Mars 1969 16,200-bit/s channel	
P_T	8.9 W	+39.5 dBm	+3.10 dB	18.2 W	+42.60 dBm	—	18.2 W	+42.60 dBm
M		−5.3 dB	+3.50 dB		−1.80 dB	+0.46 dB		−1.34 dB
G_T		+20.1 dB	+0.11 dB		+20.21 dB	—		+20.21 dB
L_S	216 × 10⁶ km	−266.2 dB	+6.84 dB	97 × 10⁶ km	−259.36 dB	—	97 × 10⁶ km	−259.36 dB
G_R	85 ft	+52.5 dB	—	85 ft	+52.5 dB	+8.50 dB	210 ft	+61.00 dB
L_R		−3.4 dB	+2.26 dB		−1.14 dB	+0.70 dB		−0.44 dB
S		−162.8 dBm	+15.81 dB		−146.99 dBm	+9.66 dB		−137.33 dBm
T_B	8⅓ bits/s	−9.2 dB/s	−15.11 dB	270 bits/s	−24.31 dB/s	−17.79 dB	16,000 bits/s	−42.10 dB/s
ST_B		−172.0 dBm/s	+0.70 dB		−171.30 dBm/s	−8.13 dB		−179.43 dBm/s
N_0	65°K	−180.5 dBm/Hz	—	65°K	−180.50 dBm/Hz	+4.10 dB	25°K	−184.60 dBm/Hz
ST_B/N_0		+8.5 dB	+0.70 dB		+9.20 dB	−4.03 dB		+5.17 dB
Required ST_B/N_0	5×10^{-6} BER	+5.2 dB	—	5×10^{-6} BER	+5.20 dB	+2.20 dB	1×10^{-2} WER	+3.00 dB
Margin		+3.3 dB	+0.70 dB		+4.00 dB	−1.83 dB		+2.17 dB

P_T = total transmitter power.
M = modulation loss
G_T = antenna gain including circuit loss
L_S = space loss.
G_R = receiver antenna gain
L_R = receiver loss.
S = signal energy.
T_B = bit duration.
N_0 = noise spectral density
BER = bit error rate
WER = word error rate

Table 21. Accuracy requirements met by the DSN

Data	Accuracy
Three-way doppler bias	0.23 Hz
Two-way doppler – two-way effective noise at planetary ranges	0 02 Hz
Planetary ranging delay error	
Strong signals	5 m
Weak signals	15 m
Ranging delay error	5 m
Frequency stability	
Less than 1 year	1×10^{11}
More than 1 year	5×10^{11}
Time synchronization between DSS	2 ms
Ranging high-frequency noise	
Strong signals	5 m
Weak signals	15 m

Table 22. DSN simulation system data insertion information[a]

Insertion point	Insertion data type/source	Output data type/destination
Deep Space Instrumentation Facility – telemetry data		
(1) DSS receiver/exciter subsystem	RF carrier modulated by mission-dependent-equipment subcarrier simulator, with PCM data stream from DSS/GCF interface or analog tape	Data streams into telemetry processor
(2) DSS telemetry and command subsystem	Data streams from DSS/GCF interface or analog tape via integrator of mission-dependent-equipment simulator	(a) ADSS data blocks to DSS communications terminal subsystem for transmission to SFOF (b) Teletype to DSIF communications terminal subsystem for transmission to SFOF
Ground Communications Facility – telemetry data		
(1) GCF SFOF communications terminal subsystem	(a) ADSS formatted blocks of spacecraft telemetry from simulation data conversion center (b) Same as (a), plus DSS function data	(a) Modulated data for high-speed transmission to DSIF (b) Modulated data for insertion into SFOF data processing system
(2) Transmit MODEM of SDCC communications terminal	EDED-like output from simulation data conversion center	SFOF data-processing-system-compatible telemetry data stream plus DSS function data
(3) Communications processor of GCF SFOF communications terminal subsystem	Teletype data directly from ASI 6050 computer in simulation data conversion center	Teletype to page printers of GCF SFOF internal communications and to user areas in SFOF
Ground Communications Facility – tracking data		
(1) Tape readers of GCF DSS communications terminal subsystem	Baudot-coded punched paper tape	Teletype to SFOF via GCF
(2) Input communications processor of GCF SFOF communications terminal subsystem	Teletype data from punched paper tape or directly from ASI 6050 computer	Teletype to SFOF data processing system and teletype page printers of GCF SFOF internal communications
Space Flight Operations Facility – telemetry data		
(1) IBM 7044 data communications channel	SFOF data-processing-system-compatible telemetry and DSS function data	Normal SFOF data-processing-system output

[a] ADSS: Automatic data switching system, EDED: Error detector/encoded-decoder, and PCM: Pulse-code-modulated.

Table 23. Nominal trajectory

Time from launch, min	Preflights generated 1 day in advance	JPL L - 5 min	ETR predicts	Sky coverage
0 to 25	2	1	Not available	---
25 to 90	3	1	2	---
After 90	---	JPL predicts[a]	---	---

[a] Generated as required.

Table 24. Anomalous trajectory[a]

Time from launch, min	Preflights	JPL predicts	ETR predicts	Sky coverage
0 to 25	---	---	Not available	1
25 to 90[b]	---	---	1	2
After 90[b]	---	1	2	---

[a] Trajectory so far off nominal that the stations cannot acquire on nominal trajectory predicts.

[b] JPL predicts would become prime again whenever enough tracking data became available for JPL Orbit Determination to fit the anomalous trajectory.

Table 25. Telecommunications design control table (cone angle = 90 deg)

NO.	PARAMETER	VALUE	TOLERANCE (db)		SOURCE
			FAV	ADV	
1	Total Transmitter Power 8.36 WATTS	+ 39.02 dbm	+1.10	-0.00	PD-94 REV A
2	Transmitting Circuit Loss	- 1.99 db	+0.36	-0.36	PD-94 REV A
3	Transmitting Antenna Gain	+ 7.25 dbi	+1.50	-1.50	PD-94 REV A
4	Transmitting Antenna Pointing Loss	- 18.45 db	+3.11	-3.11	PD-94 REV A
5	Space Loss	-176.87 db	0.00	0.00	
6	@ 2297.22 MC, R = 7243 KM Polarization Loss	- 1.54	+0.22	-0.23	PD-94 REV A
7	Receiving Antenna Gain	+ 22.10 dbi	+1.00	-1.00	DYW-1255-DTL
8	Receiving Antenna Pointing Loss	0.00	+0.00	-0.25	
9	Receiving Circuit Loss	0.00	+0.00	-0.00	
10	Net Circuit Loss	-169.50 db	+6.19	-6.45	
11	Total Received Power	-130.48 dbm	+7.29	-6.45	
12	Receiver Noise Spectral Density (N/B)	-172.37 dbm	0.00	0.00	DYW-1255-DTL
13	T System = 420 deg Kelvin Max. Carrier Modulation Loss	- 2.44 db	+0.56	-0.66	
14	Received Carrier Power	-132.92 dbm	+7.85	-7.11	
15	Carrier APC Noise BW ($2B_{LO}$ = 48 HZ)	+ 16.81db	-0.97	+0.00	ED-435
	CARRIER PERFORMANCE - TRACKING (one-way)				
16	Threshold SNR in $2B_{LO}$	0.00 db	0.00	0.00	
17	Threshold Carrier Power	-155.56 dbm	-0.97	0.00	
18	Performance Margin	+ 22.64 db	+8.82	-7.11	
	CARRIER PERFORMANCE - TRACKING (two-way)				
19	Threshold SNR in $2B_{LO}$	0.00 db	0.00	0.00	
20	Threshold Carrier Power	-155.56 dbm	-0.97	0.00	
21	Performance Margin	+ 22.64 db	+8.82	-7.11	

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Table 26. Telecommunications design control table (cone angle = 60 deg)

NO.	PARAMETER	VALUE	TOLERANCE (db)		SOURCE
			FAV	ADV	
1	Total Transmitter Power 8.36 WATTS	+ 39.02 dbm	+1.10	-0.00	PD-94 REV A
2	Transmitting Circuit Loss	- 1.99 db	+0.36	-0.36	PD-94 REV A
3	Transmitting Antenna Gain	+ 7.25 dbi	+1.50	-1.50	PD-94 REV A
4	Transmitting Antenna Pointing Loss	- 8.75 db	+1.47	-1.47	PD-94 REV A
5	Space Loss	-176.87 db	+0.00	-0.00	
6	● 2297.22 MC, R = 7243 KM Polarization Loss	- 0.50 db	+0.15	-0.15	
7	Receiving Antenna Gain	+ 22.10 dbi	+1.00	-1.00	DYW-1255-DTL
8	Receiving Antenna Pointing Loss	0.00	+0.00	-0.25	
9	Receiving Circuit Loss	0.00	+0.00	-0.00	
10	Net Circuit Loss	-158.76 db	+4.48	-4.73	
11	Total Received Power	-119.74 dbm	+5.58	-4.73	
12	Receiver Noise Spectral Density (N/B)	-172.37 dbm	+0.00	-0.00	
13	T System = 420 DEG KELVIN MAX. Carrier Modulation Loss	- 2.44 db	+0.56	-0.66	PD-94 REV A
14	Received Carrier Power	-122.18 dbm	+6.14	-5.39	
15	Carrier APC Noise BW ($2B_{LO}$ = 48 HZ)	+ 16.81 db	-0.97	+0.00	ED-435
	CARRIER PERFORMANCE - TRACKING (one-way)				
16	Threshold SNR in $2B_{LO}$	0.00 db	0.00	0.00	
17	Threshold Carrier Power	-155.56 dbm	-0.97	0.00	
18	Performance Margin	+ 33.38 db	+7.11	-5.39	
	CARRIER PERFORMANCE - TRACKING (two-way)				
19	Threshold SNR in $2B_{LO}$	0.00 db	0.00	0.00	
20	Threshold Carrier Power	-155.56 dbm	-0.97	0.00	
21	Performance Margin	+ 33.38 db	+7.11	-5.39	

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Table 27. Initial acquisition study results, Mariner VI

	ACN		DSS		S/C Cmd System Locked	Notes
	Begin One-Way Acq	Complete Two-Way Acq	Begin One-Way Acq	Complete Two-Way Acq		
Time in Minutes						
Normal launch cone angle <60°	L+17	N/A	L+26	L+46-52(1)	L+54-58 to 60-64	(1) Ten minutes of tracking data required to confirm trajectory
High cone angle	L+17	N/A	L+26	L+73(2)	L+84-88	(2) Worst case acquisition
Exceed S/C -100 dbm power constraint	L+17	L+37(3)	L+26	N/A	L+45-49	(3) Requires waiver of S/C power constraint
Emergency ACN acquisition	L+17	Decision to use ACN + 10 (3)(4)				(4) Without waiver of S/C power constrain, two-way at ACN will be delayed to L+46M.
Scheduled two-way transfer DSS 51 to ACN		Decision plus 30				

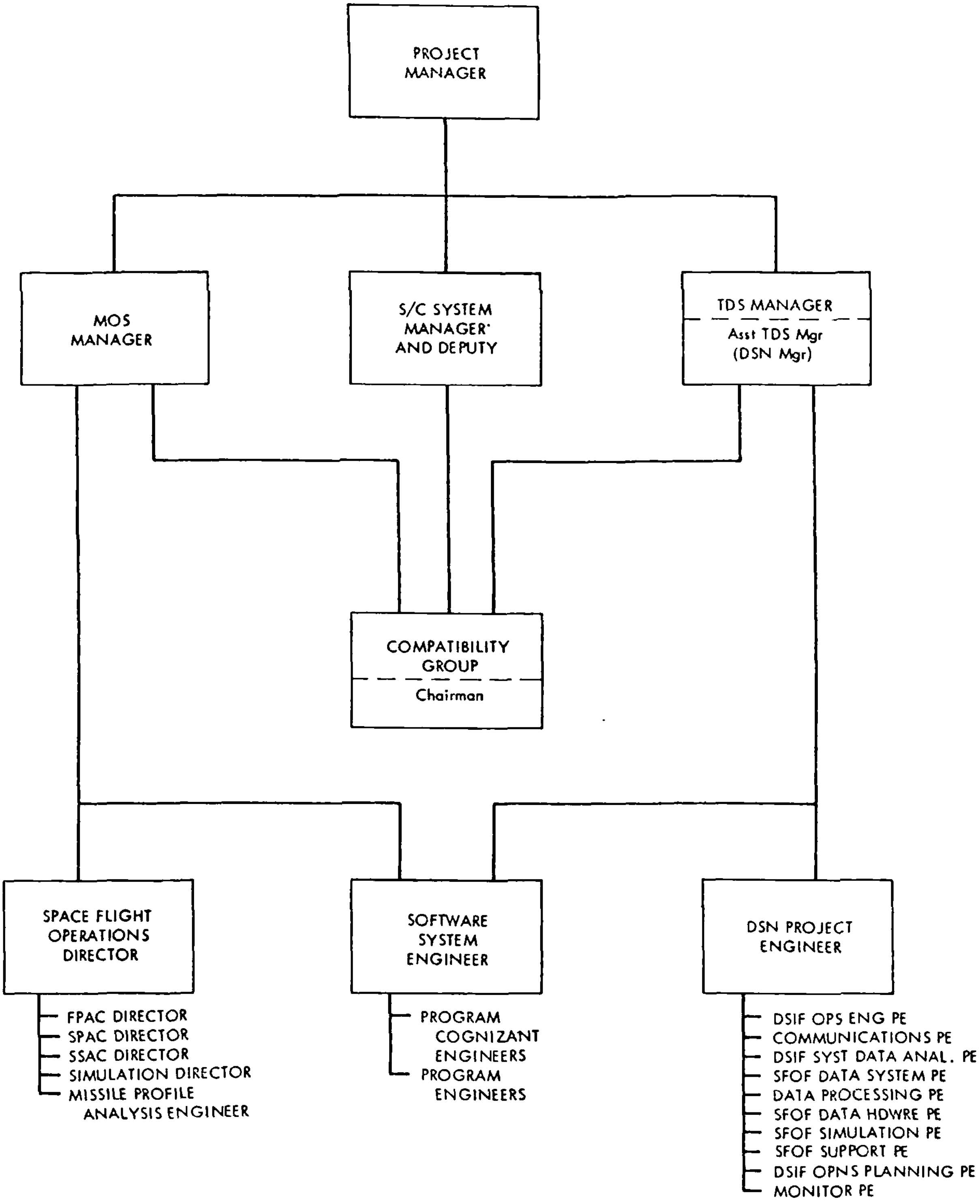
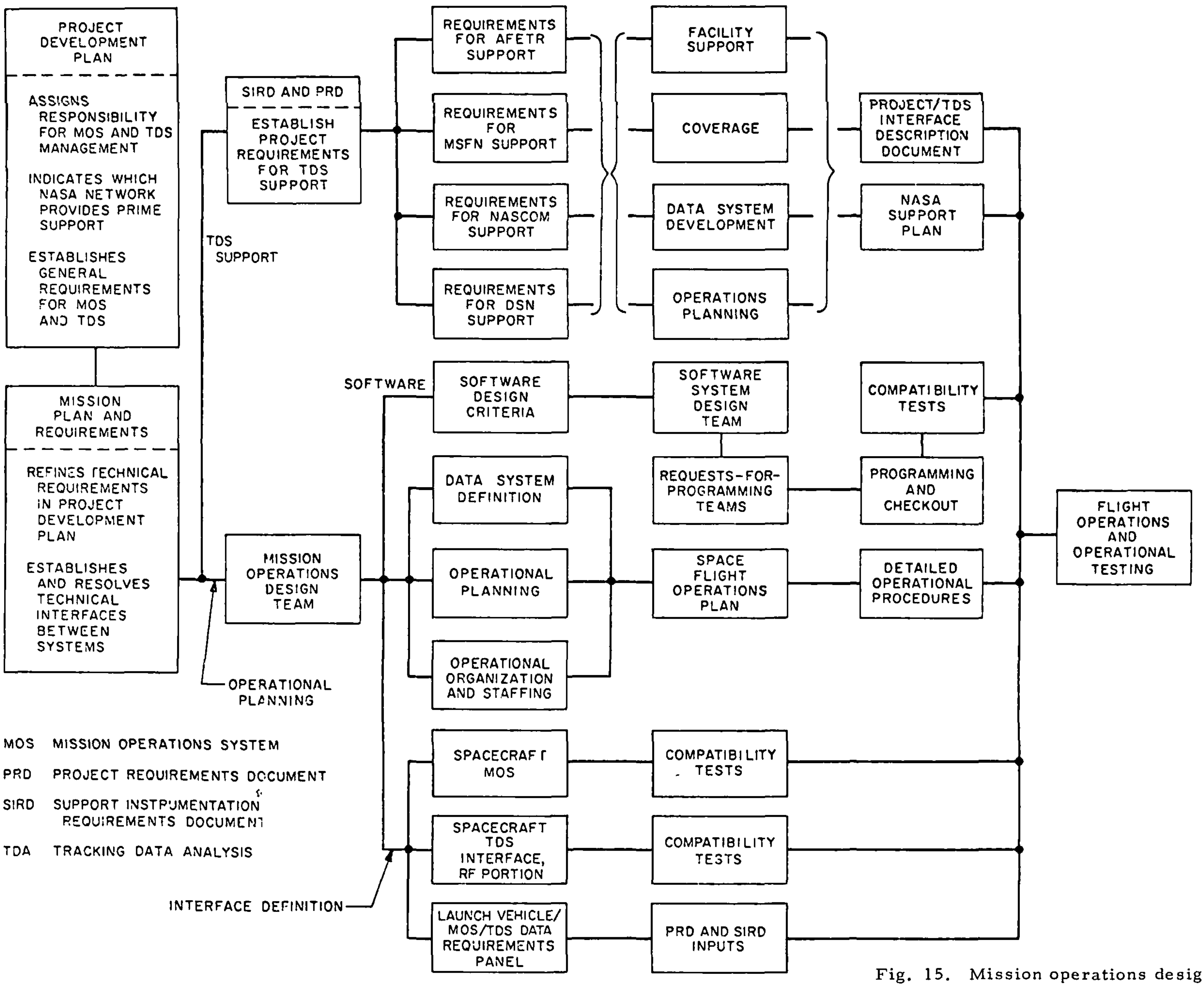


Fig. 14. Mission operations design organization



MOS MISSION OPERATIONS SYSTEM

PRD PROJECT REQUIREMENTS DOCUMENT

SIRD SUPPORT INSTRUMENTATION REQUIREMENTS DOCUMENT

TDA TRACKING DATA ANALYSIS

Fig. 15. Mission operations design process

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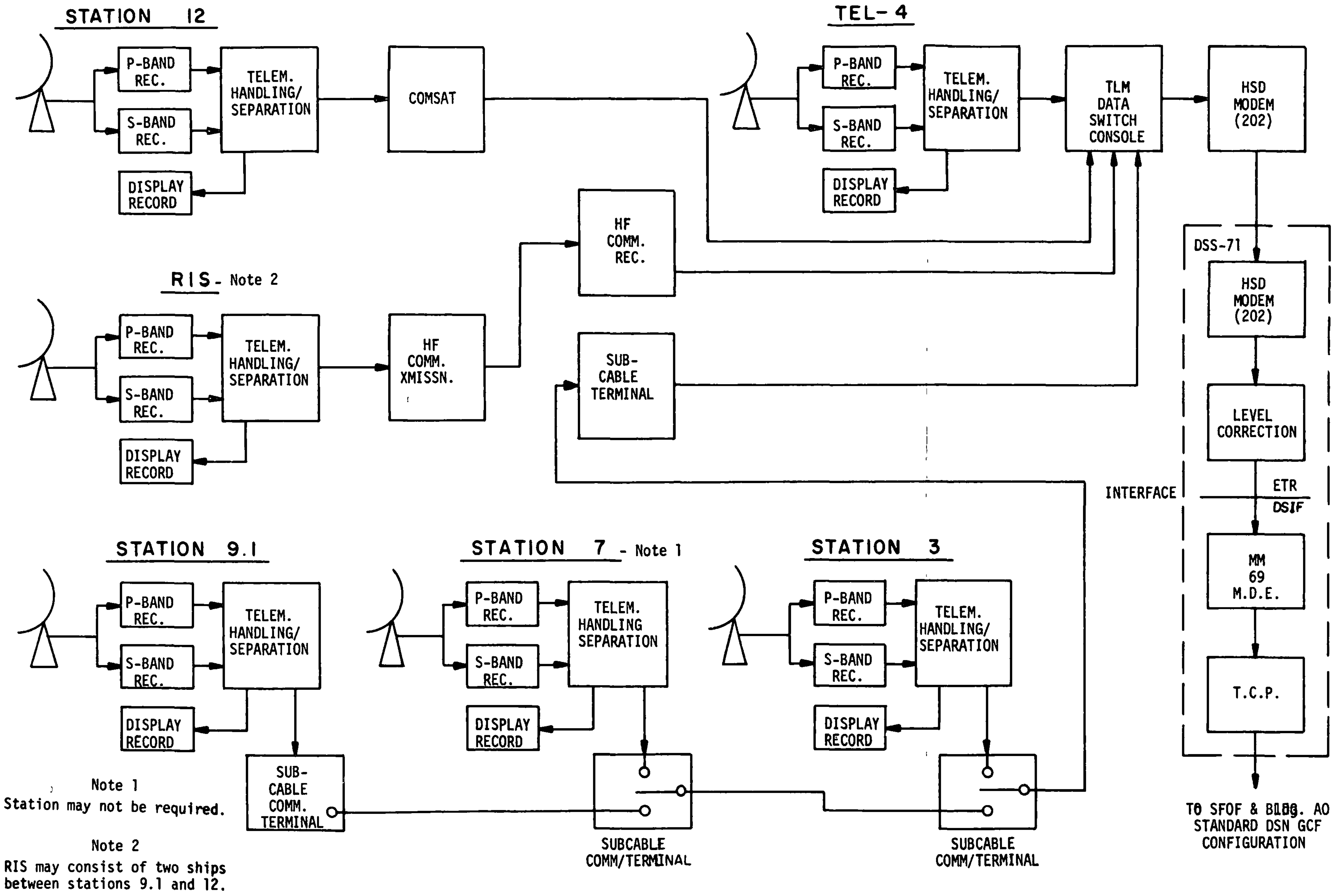


Note 1
Station may not be required.

Note 2
RIS may consist of two ships between stations 9.1 and 12.

Fig. 16. AFETR near-earth ground telemetry system

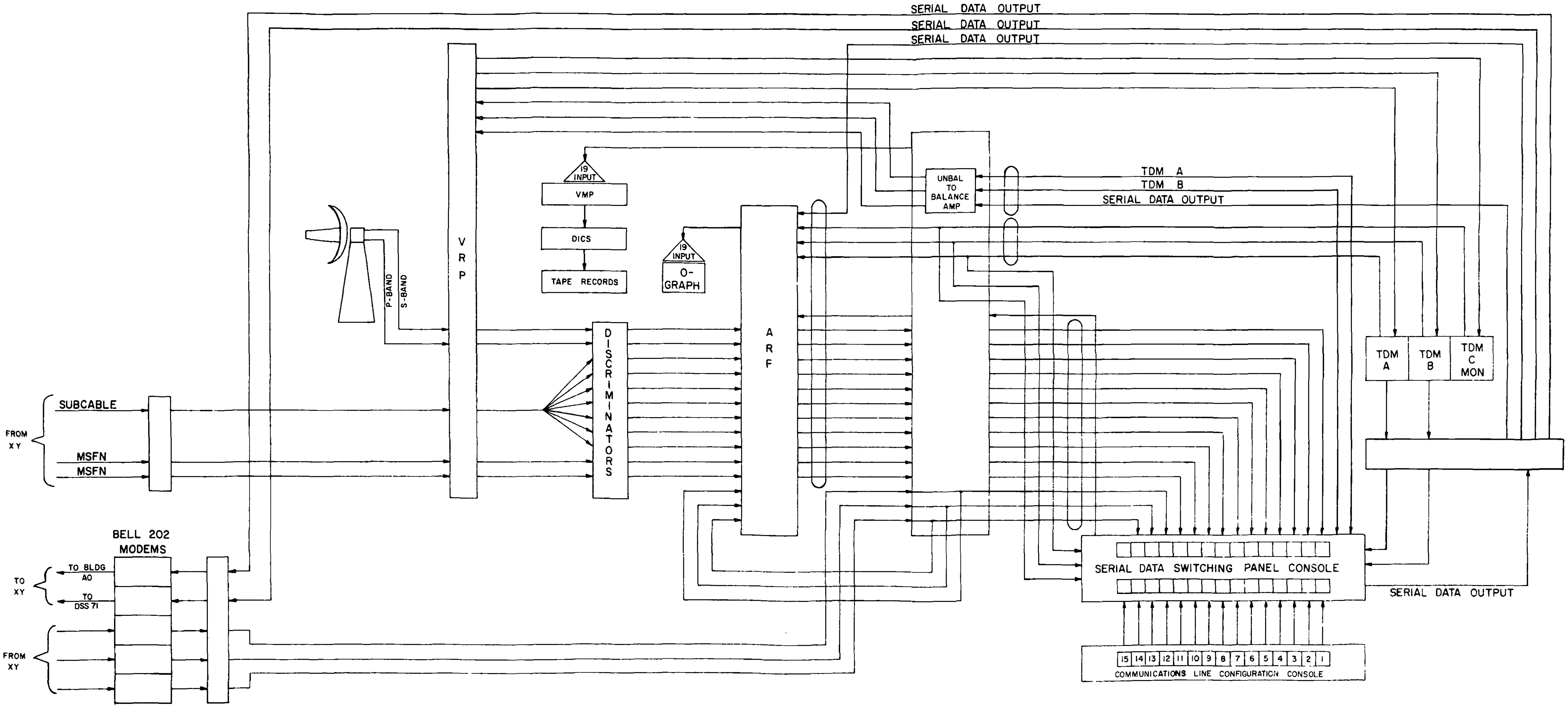


Fig. 17. Tel-4 serial telemetry data routing and switching system

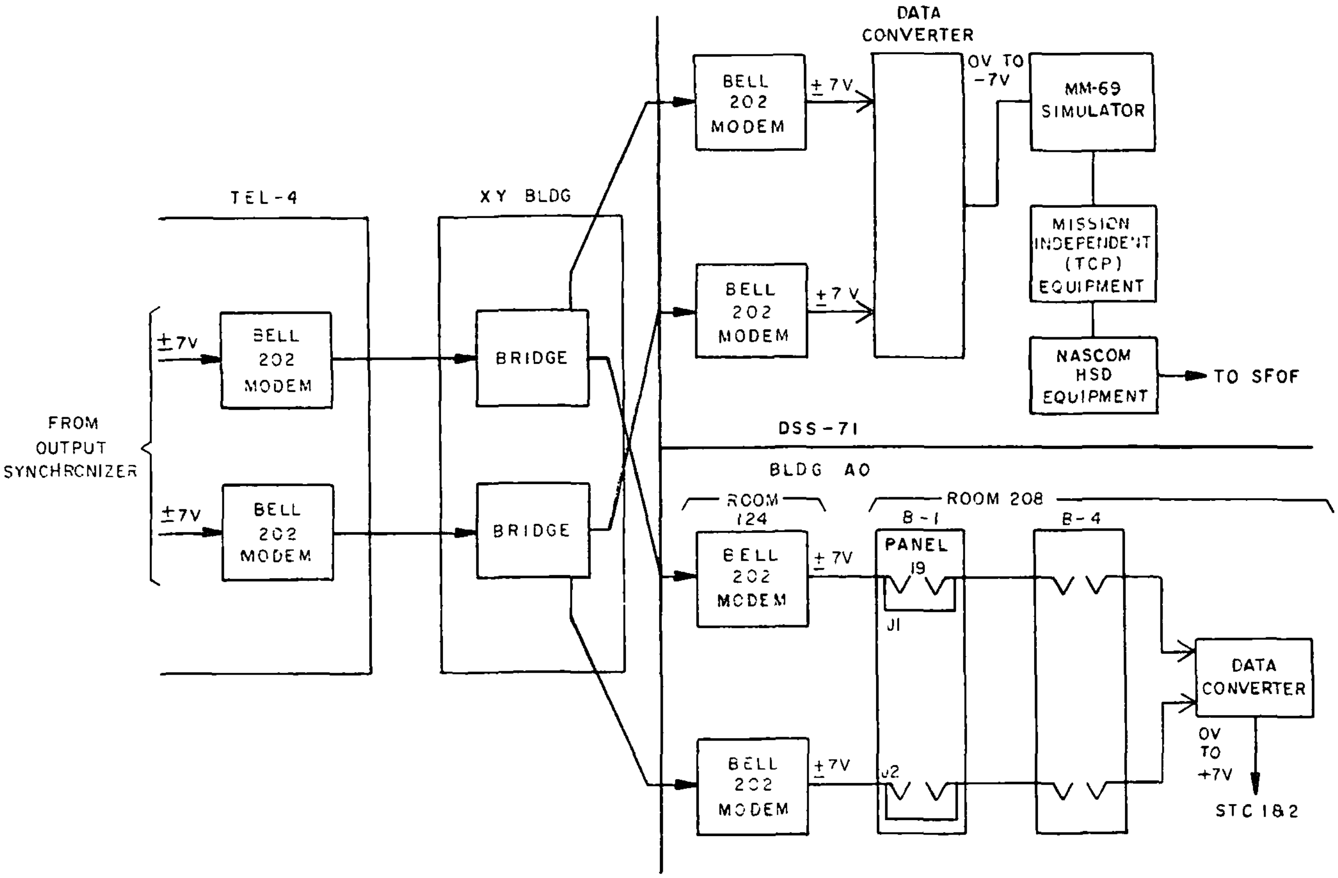


Fig. 18. Mariner telemetry data distribution to Bldg AO and DSS 71

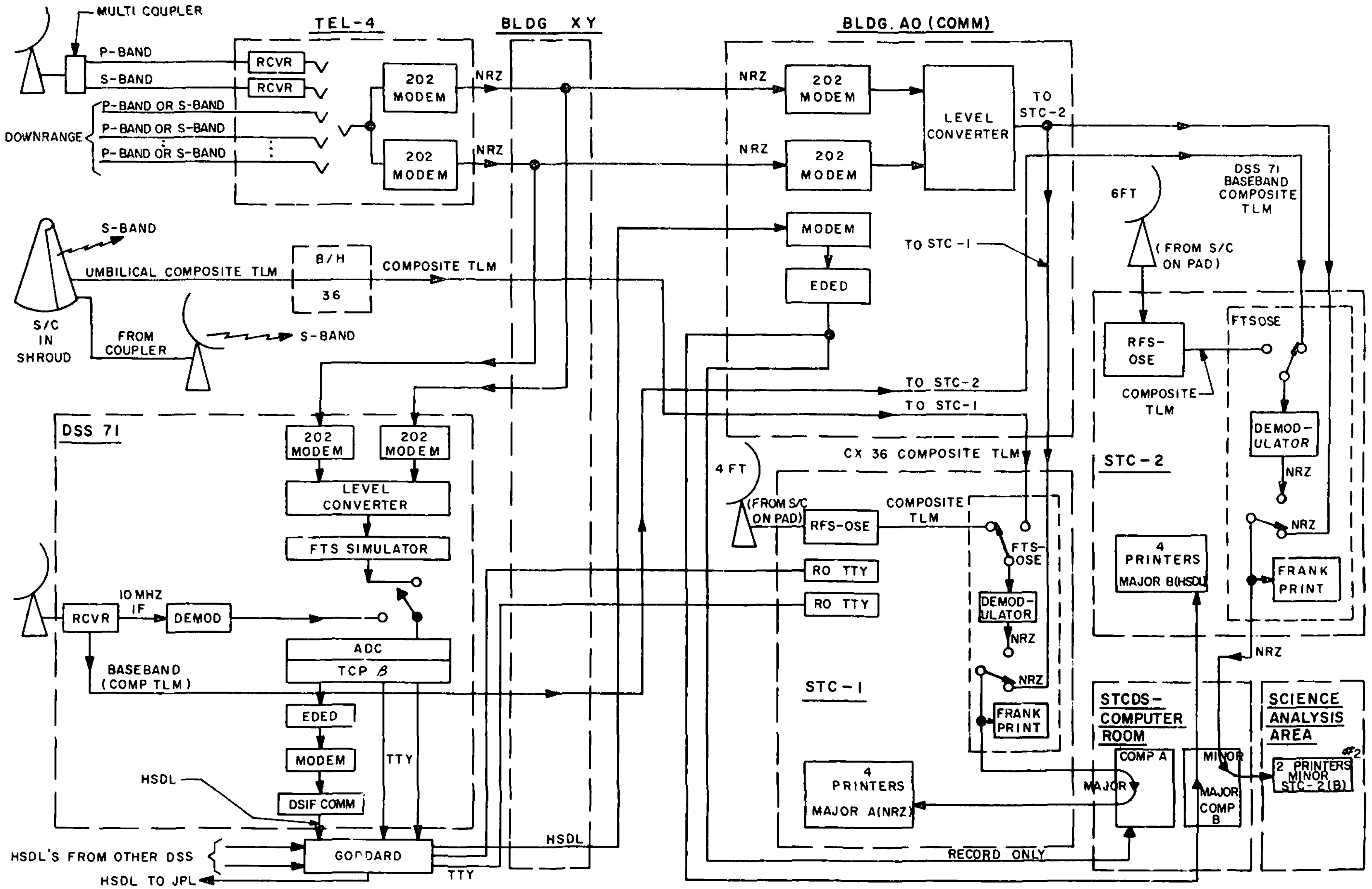


Fig. 19. AFETR launch configuration data flow

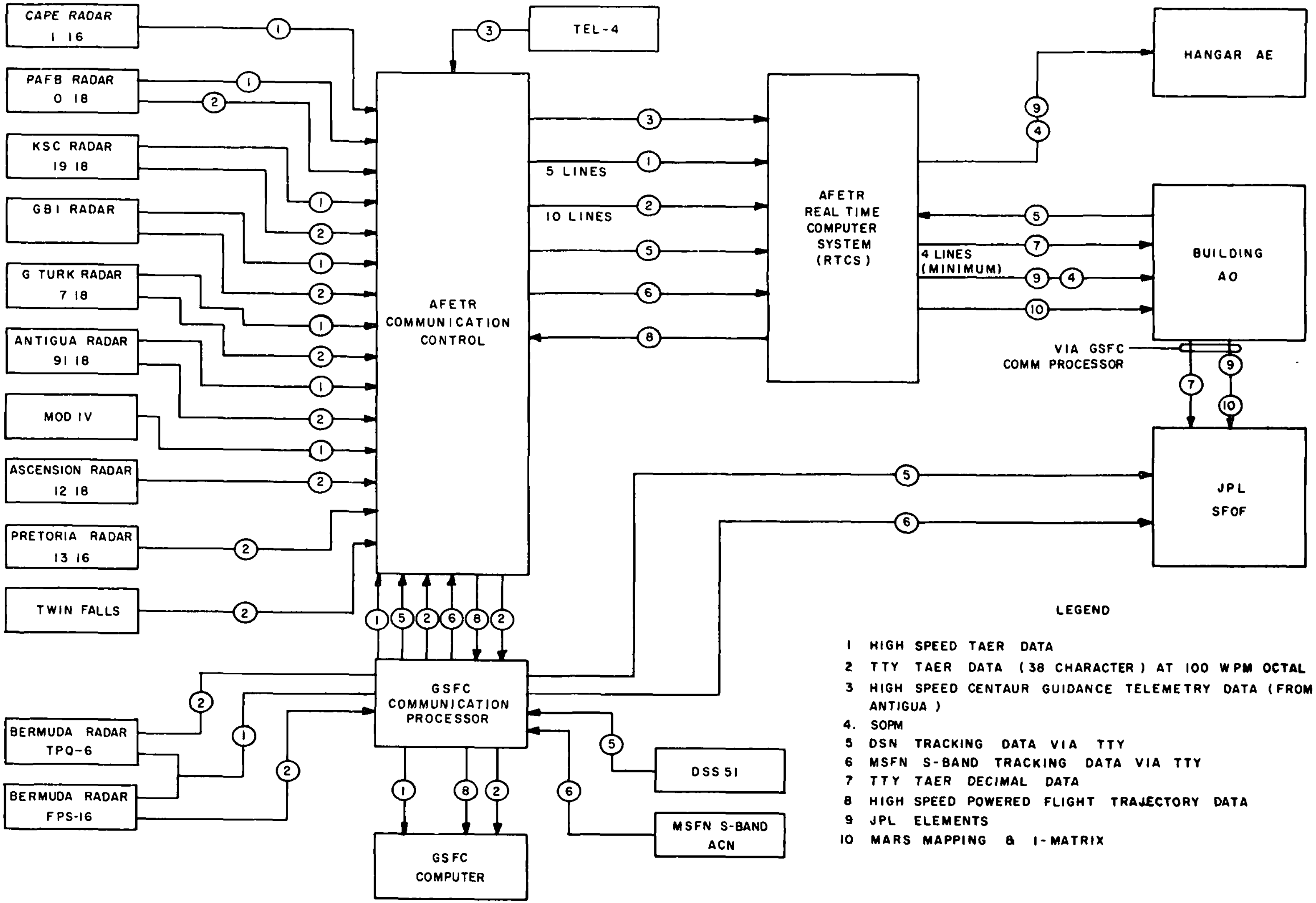


Fig. 20. AFETR radar metric data flow

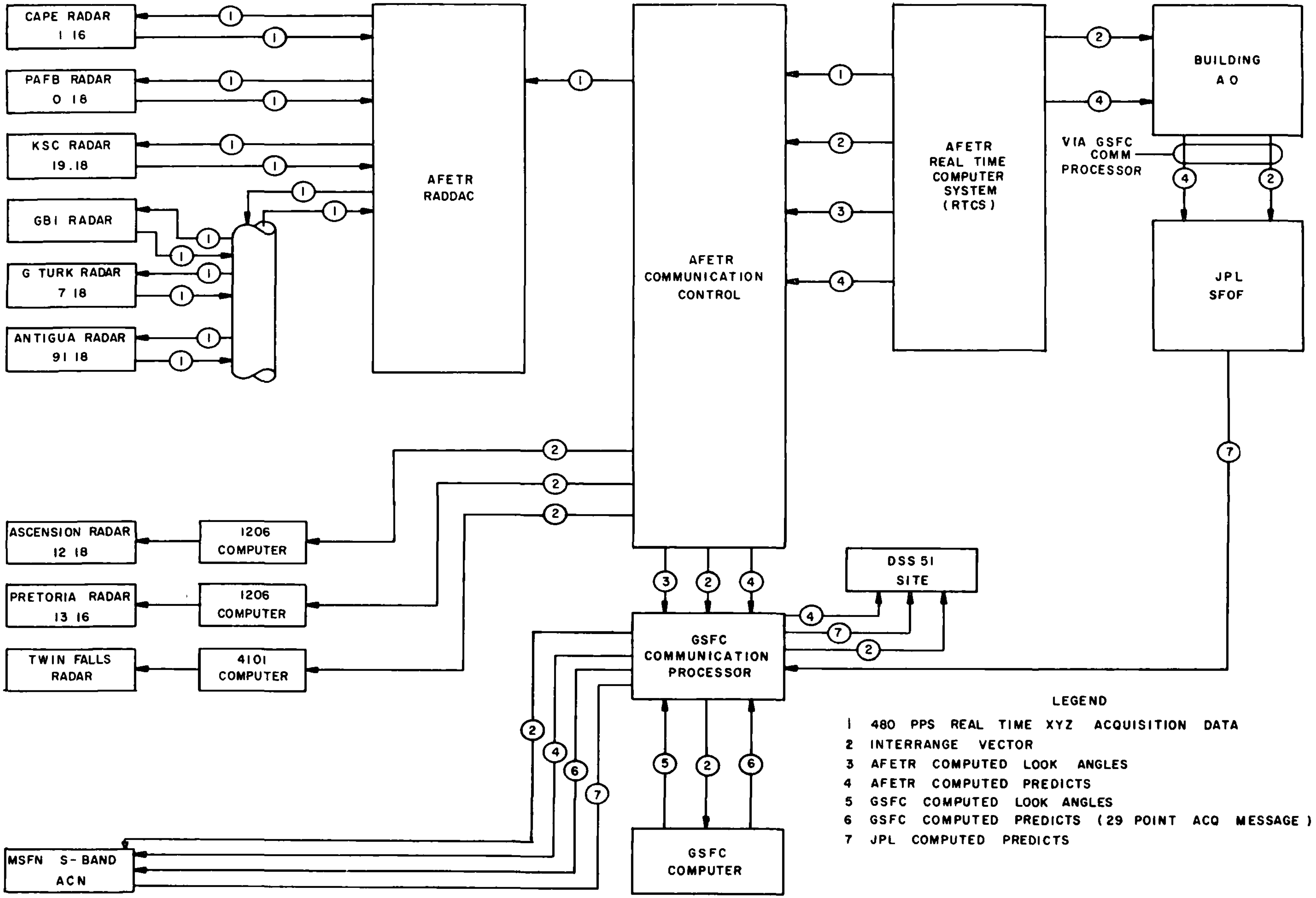


Fig. 21. AFETR acquisition data flow

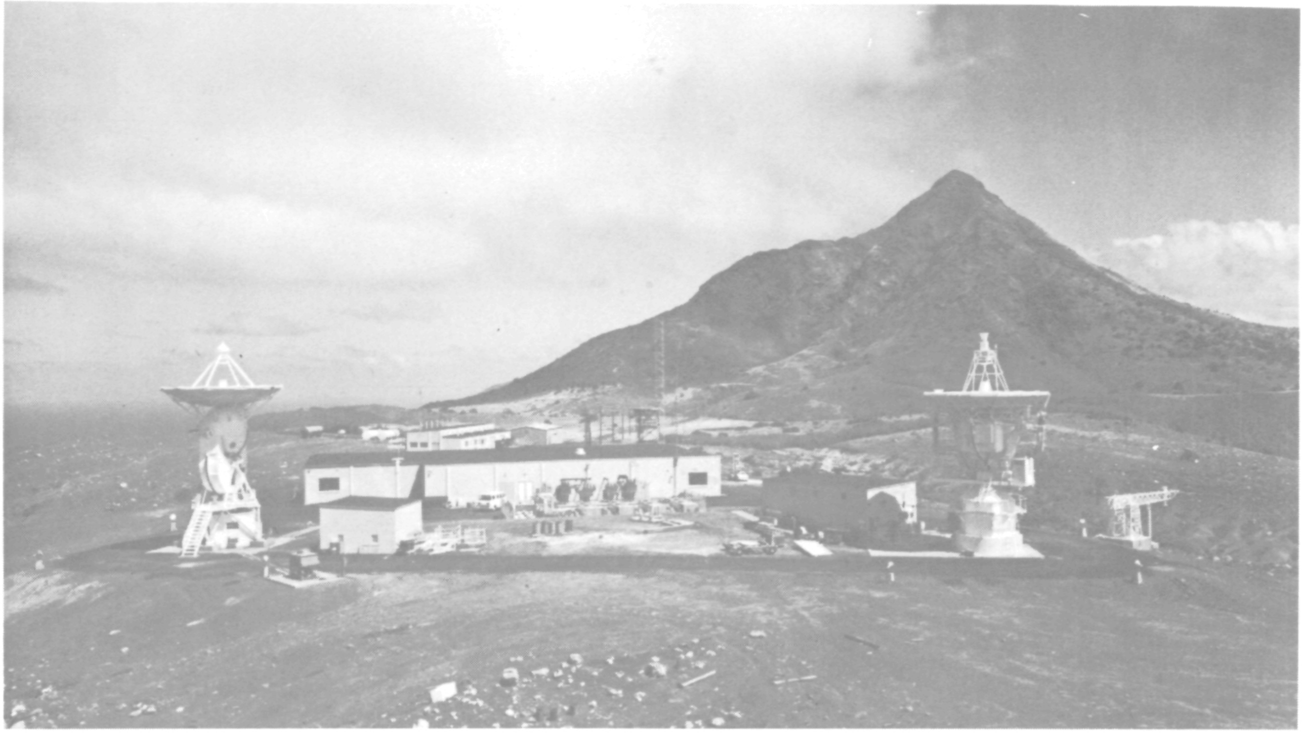


Fig. 22. MSFN station, Ascension Island

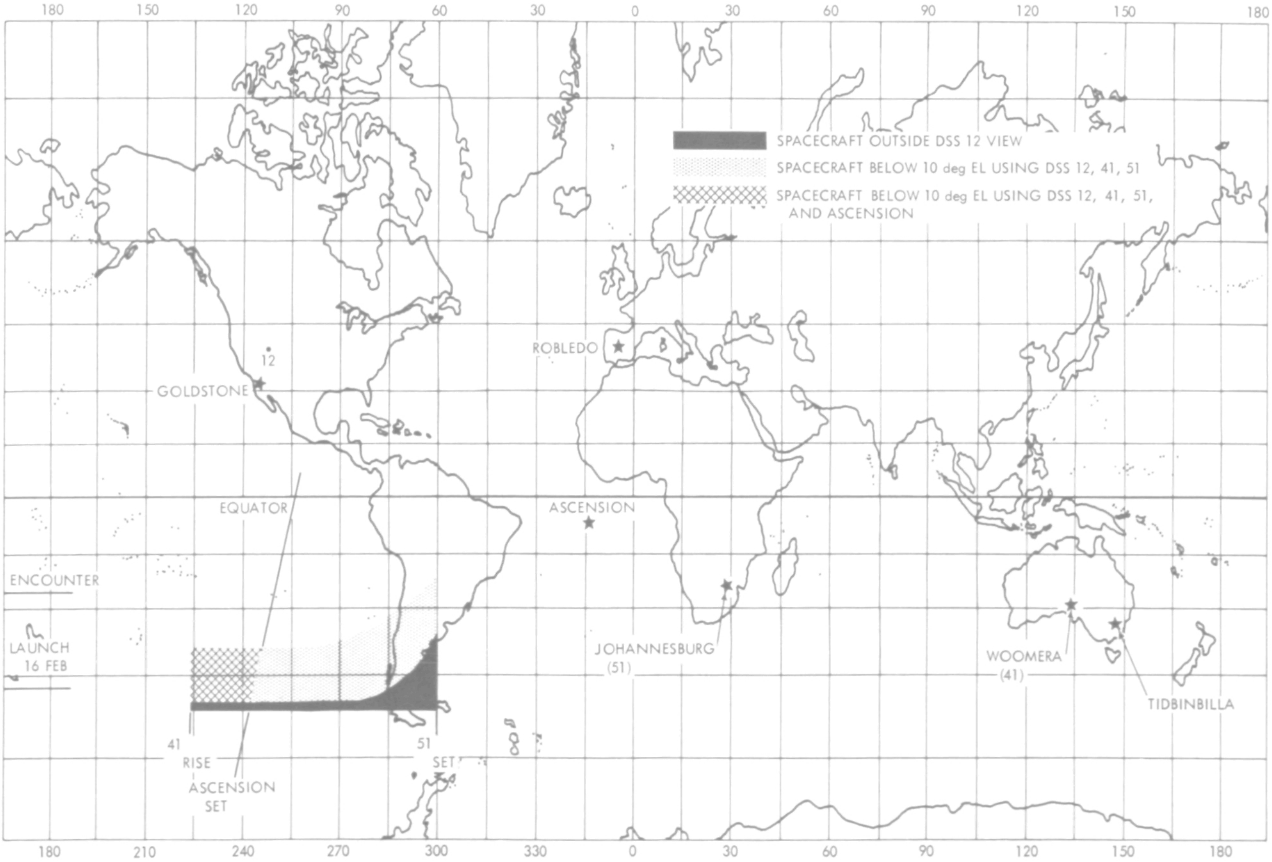


Fig. 23. Unsupported requirements - regions of degraded coverage with DSS 51 (a)

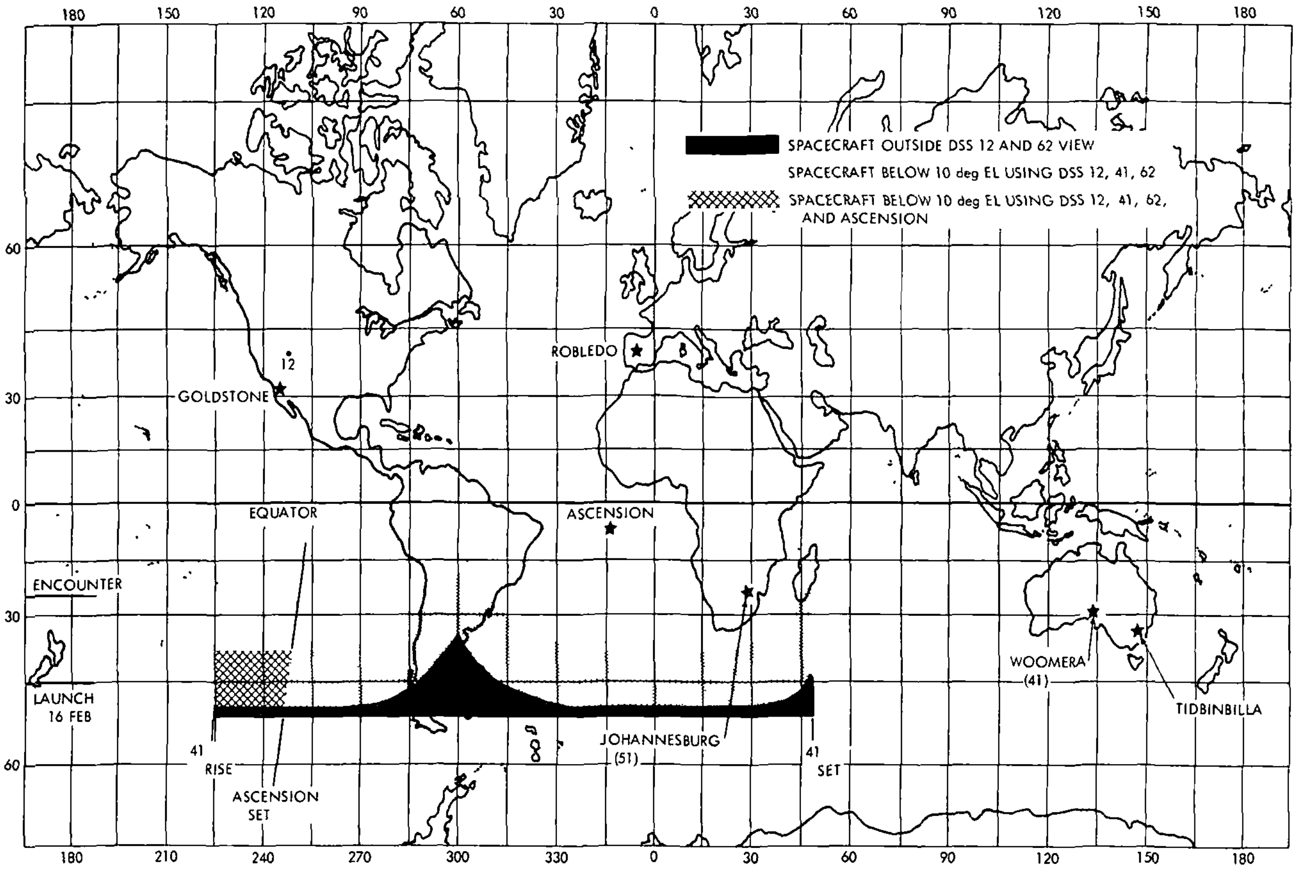


Fig. 24. Unsupported requirements – regions of degraded coverage with DSS 51 (b)

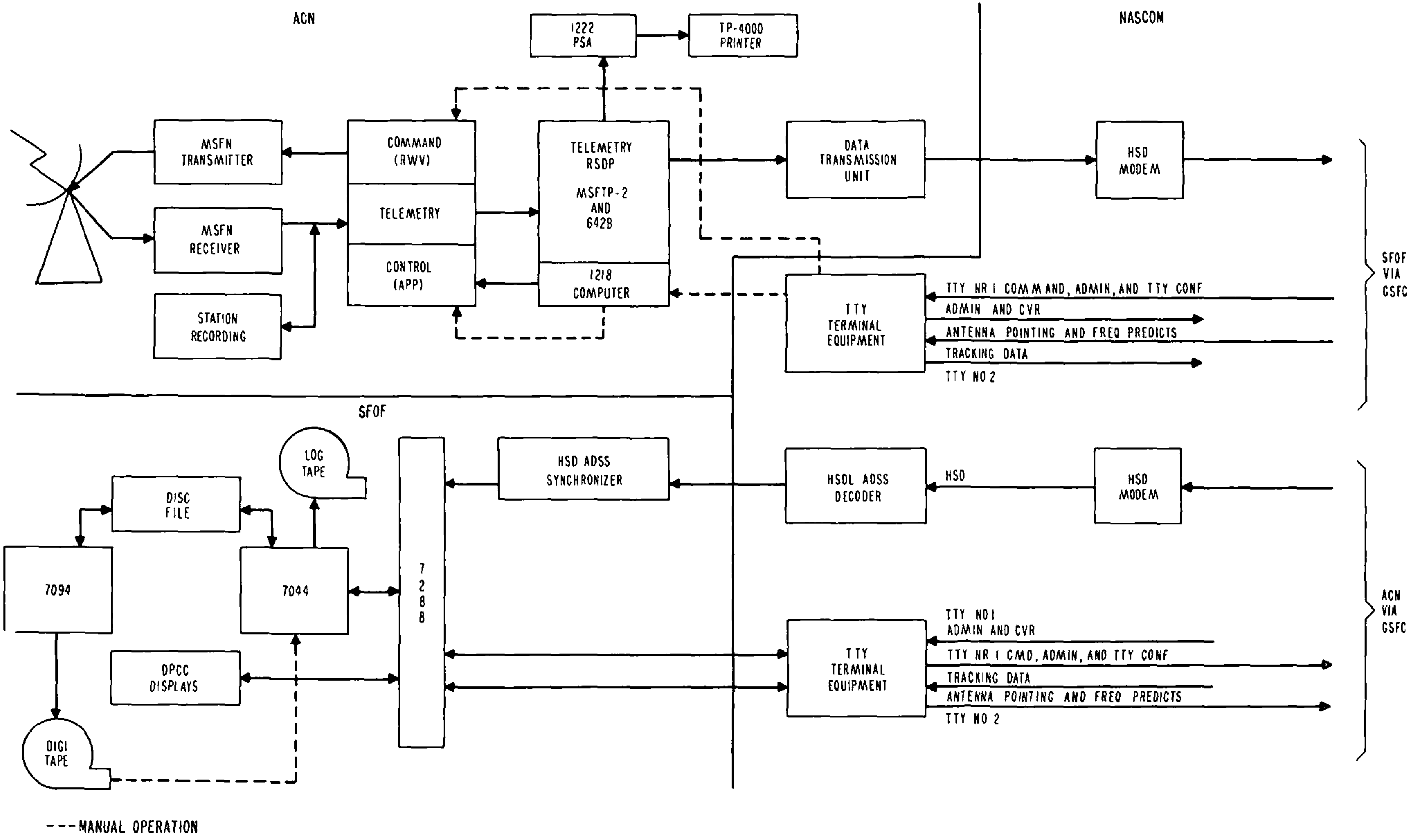


Fig. 25. MSFN/DSN telemetry and command system configuration

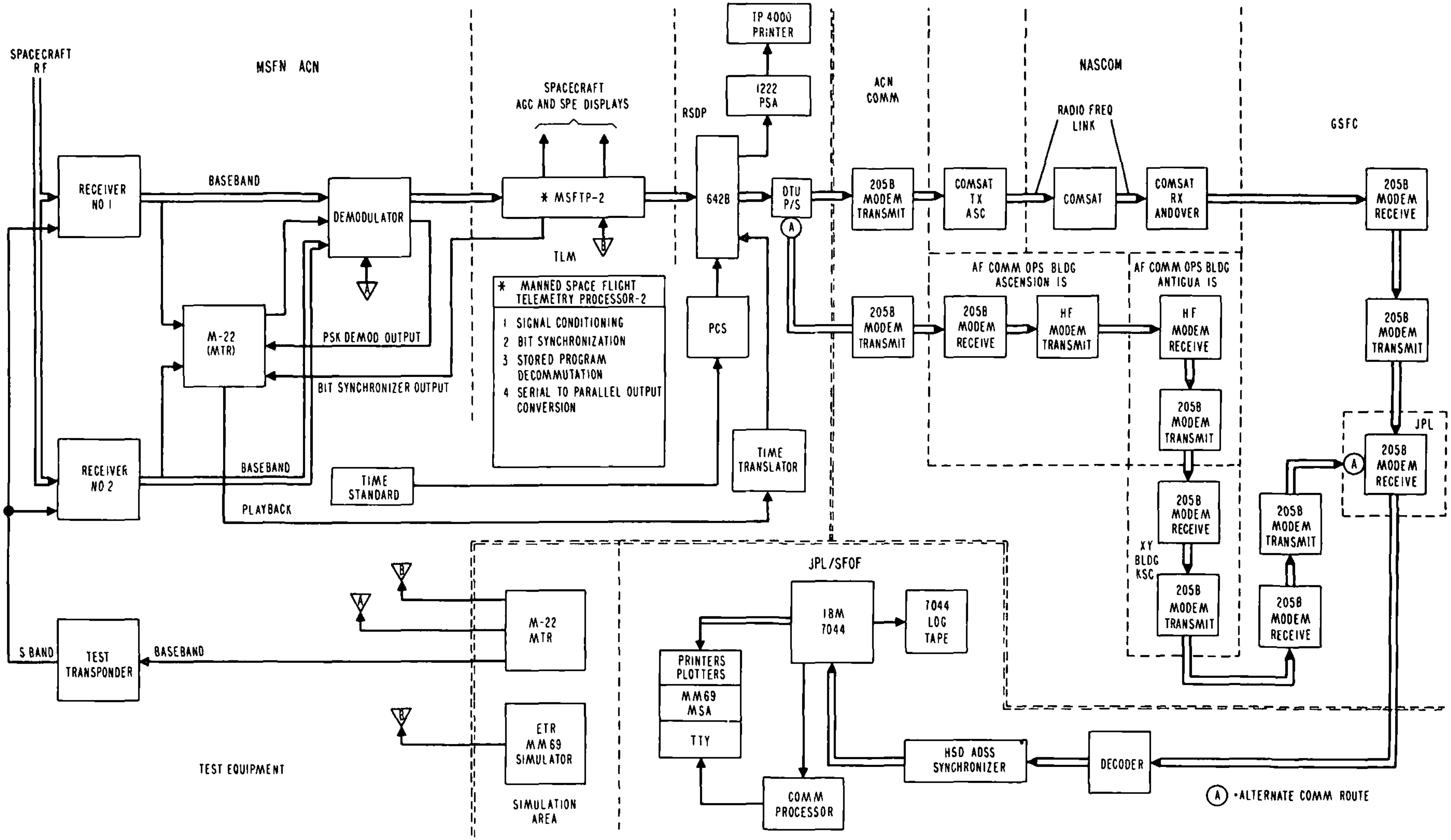


Fig. 26. ACN/DSN telemetry configuration

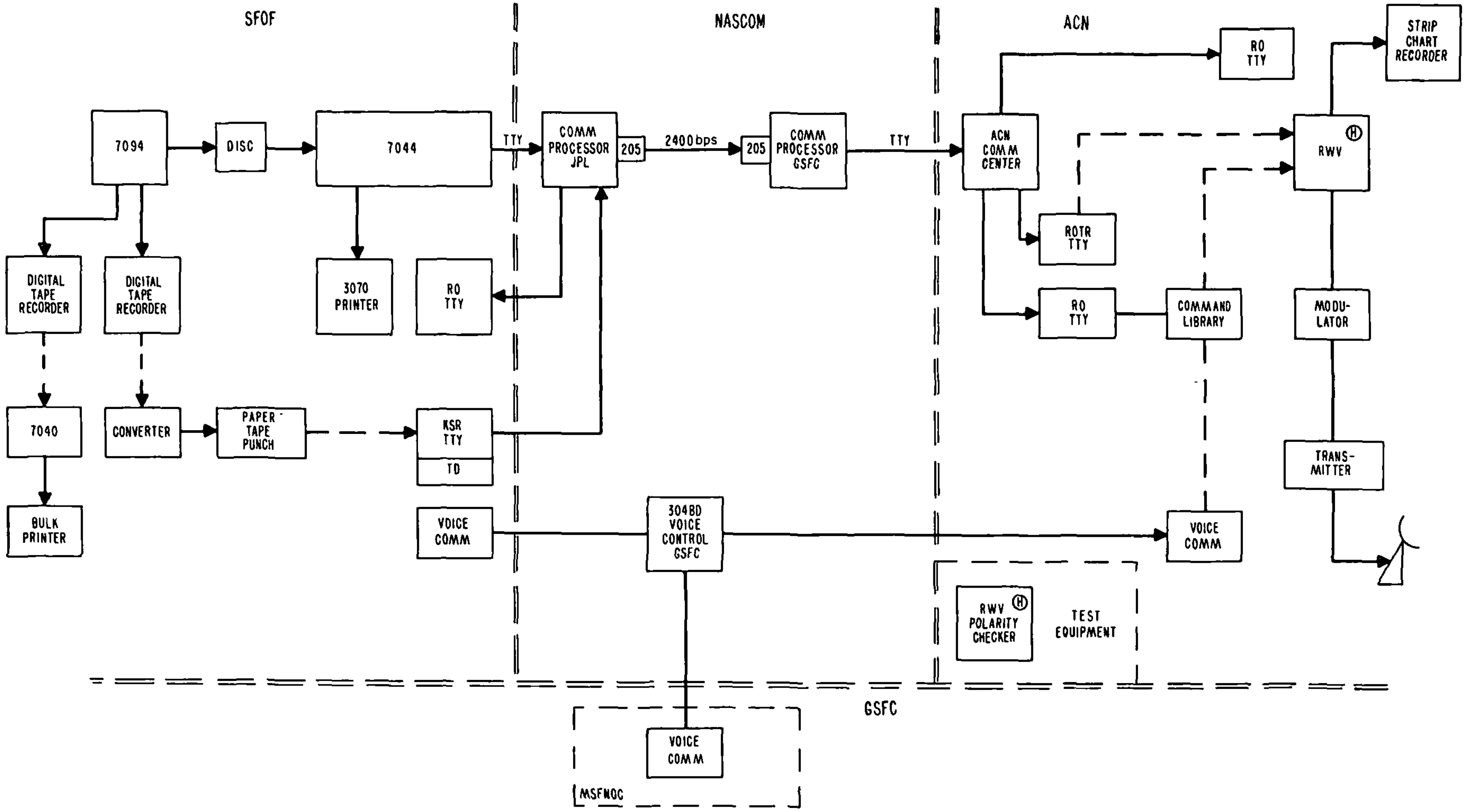


Fig. 27. ACN/DSN command configuration

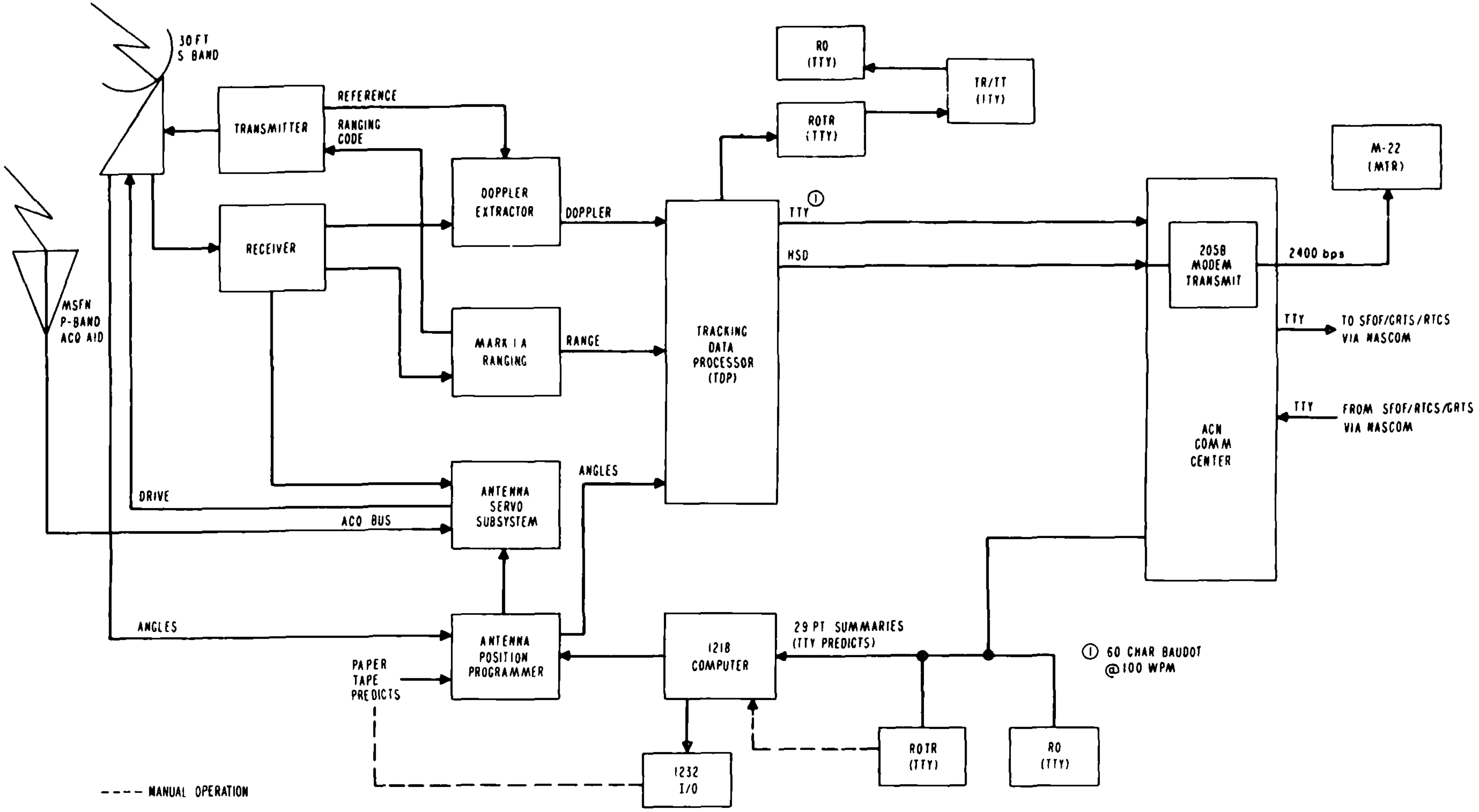


Fig. 28. ACN configuration for radio metric data, 9.2-m (30 ft) X-Y station

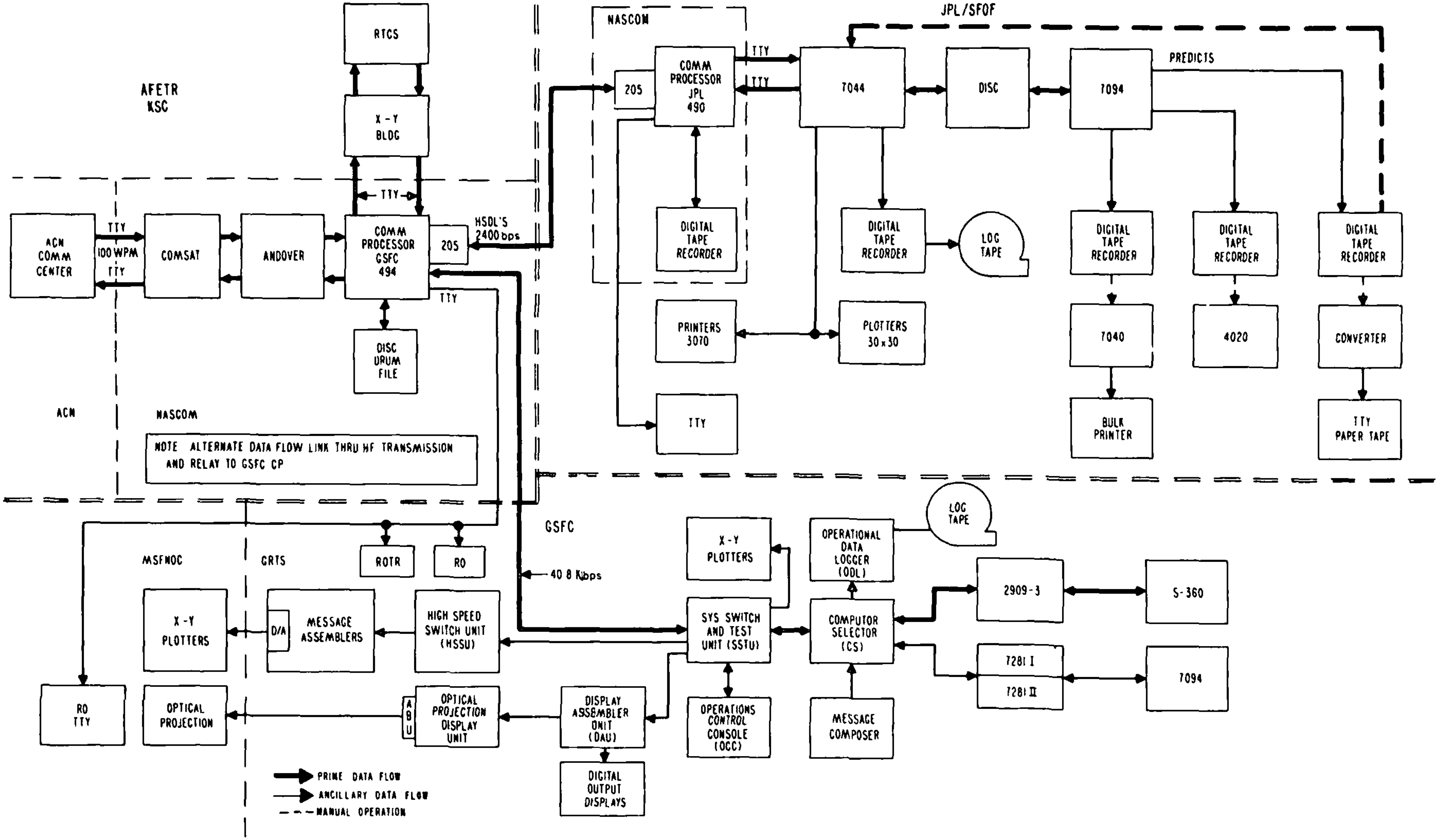


Fig. 29. ACN/GSFC/RTCS/SFOF configuration for metric data

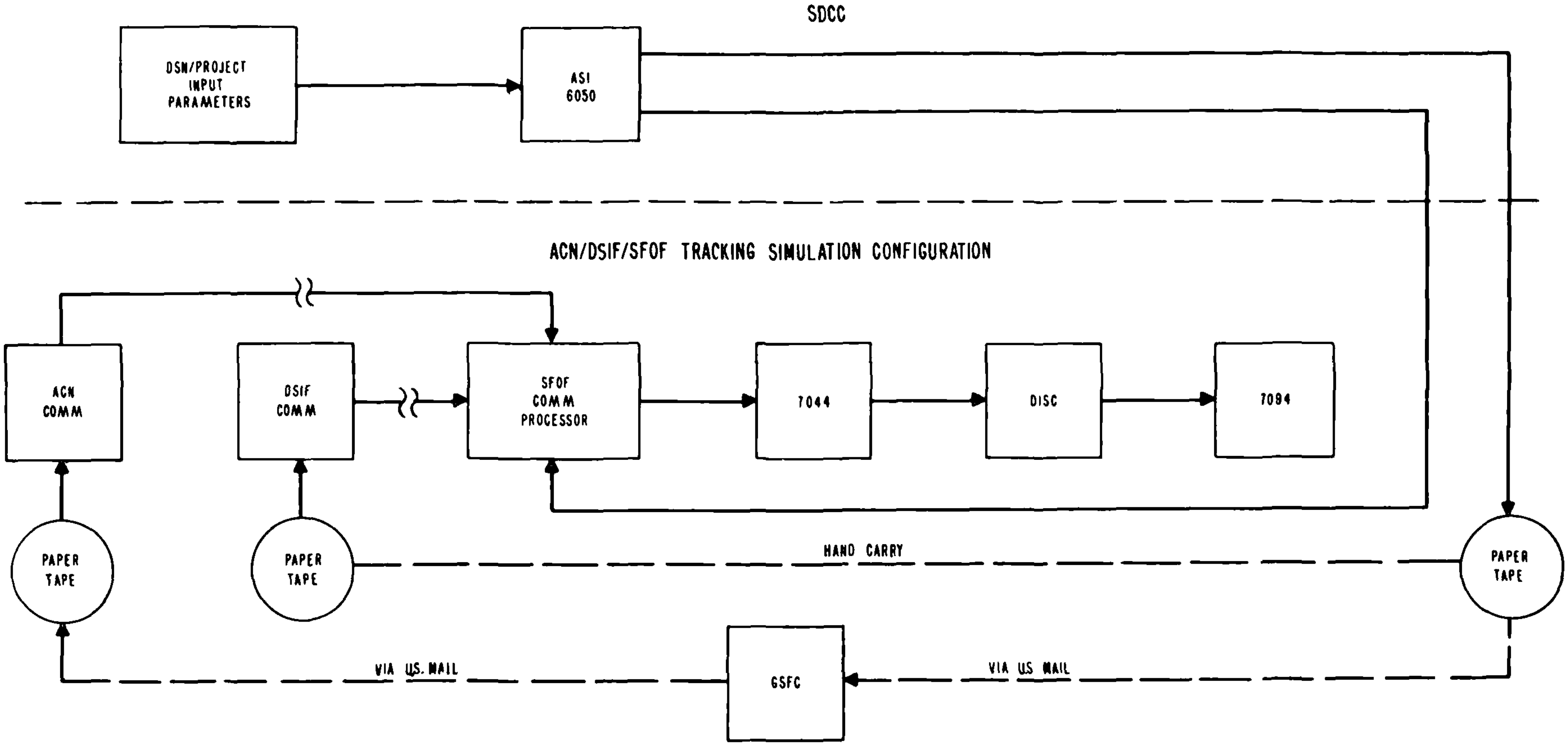


Fig. 30. SFOF tracking simulation configuration

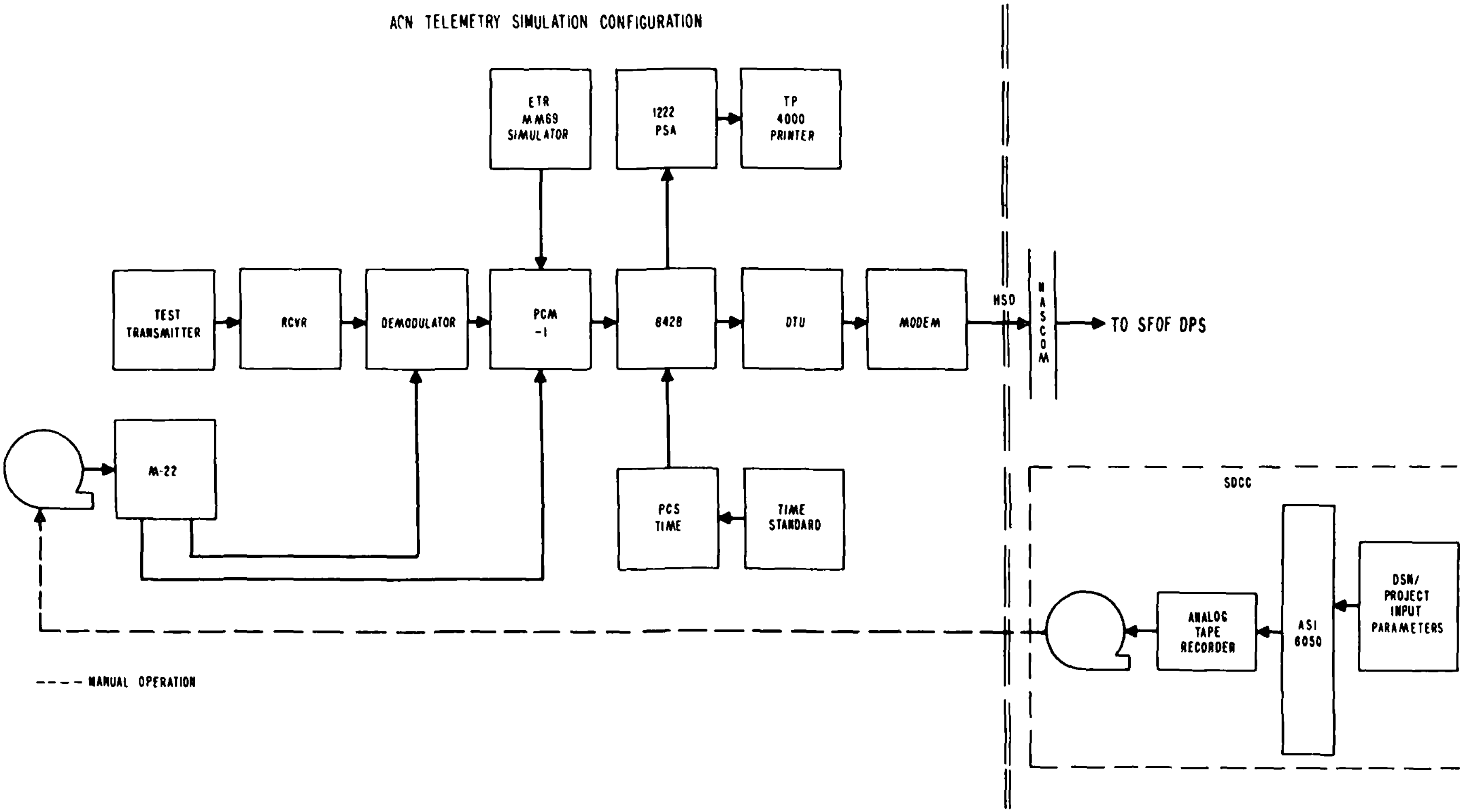


Fig. 31. ACN telemetry simulation configuration

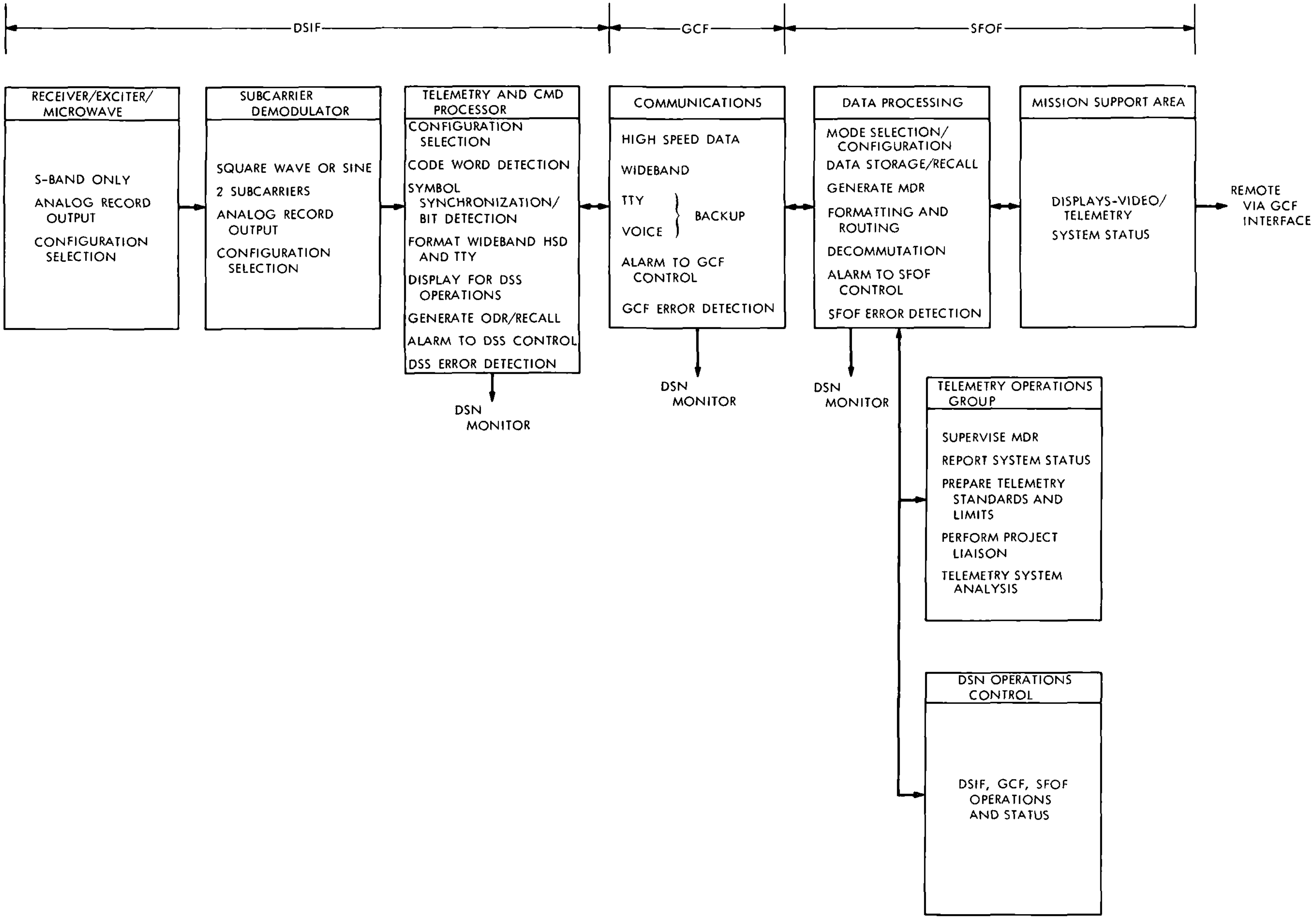


Fig. 32. DSN telemetry system general configuration

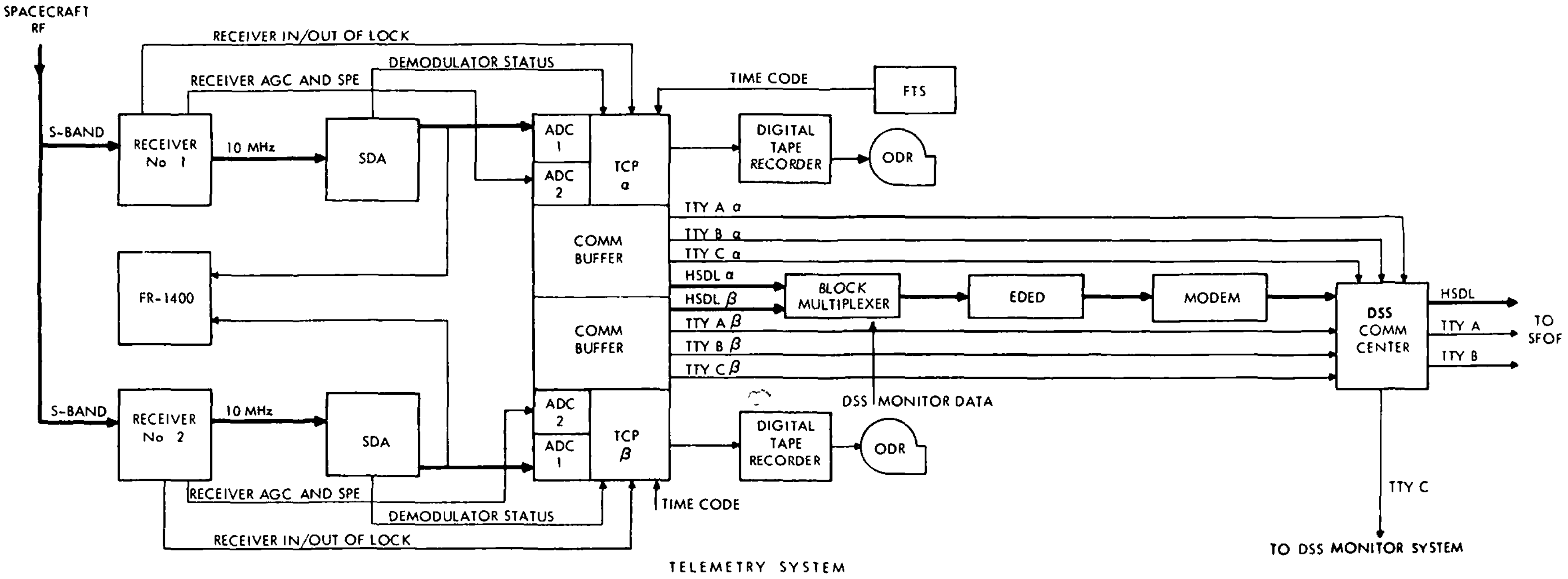


Fig. 33. Telemetry configuration at the 26-m (85 ft) station

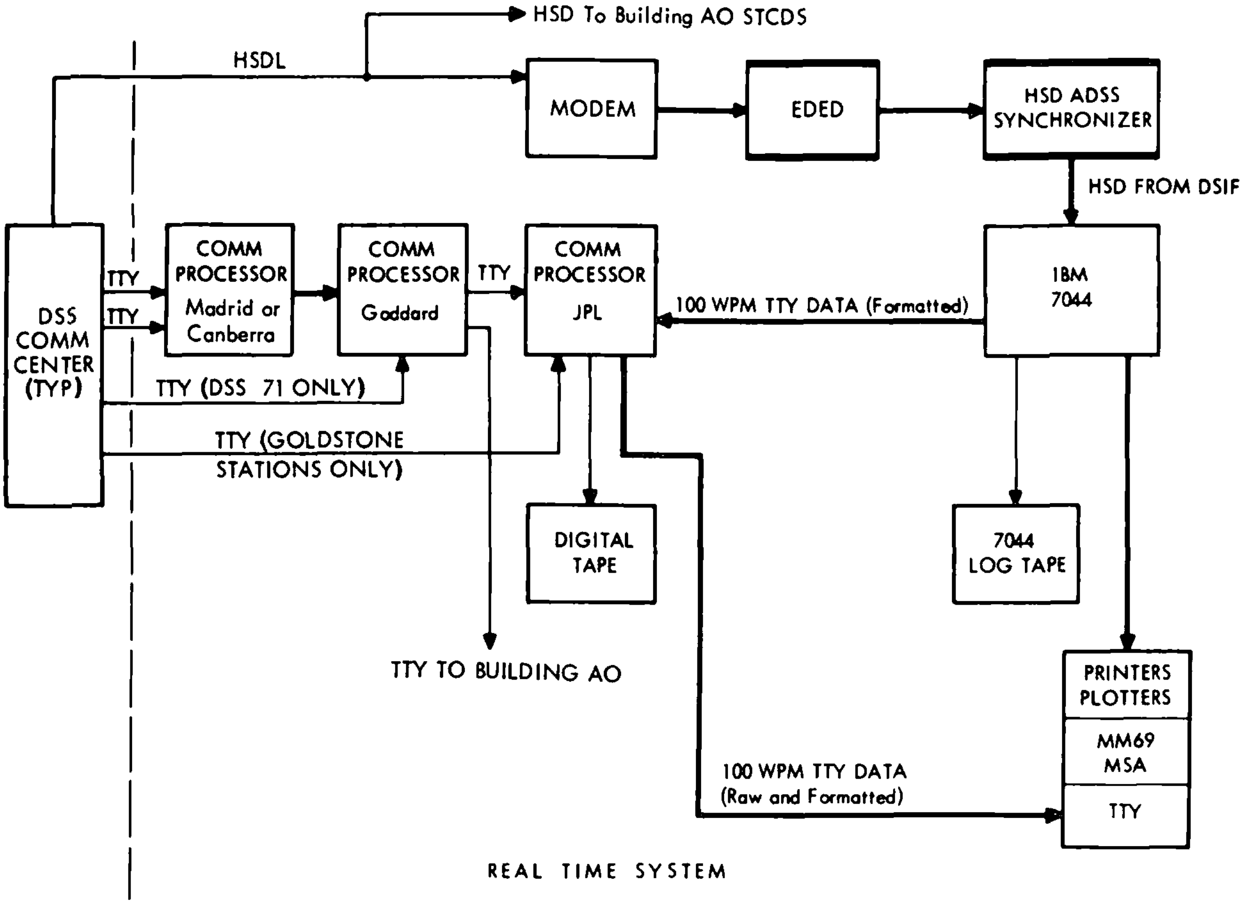


Fig. 34. SFOF/GCF telemetry configuration

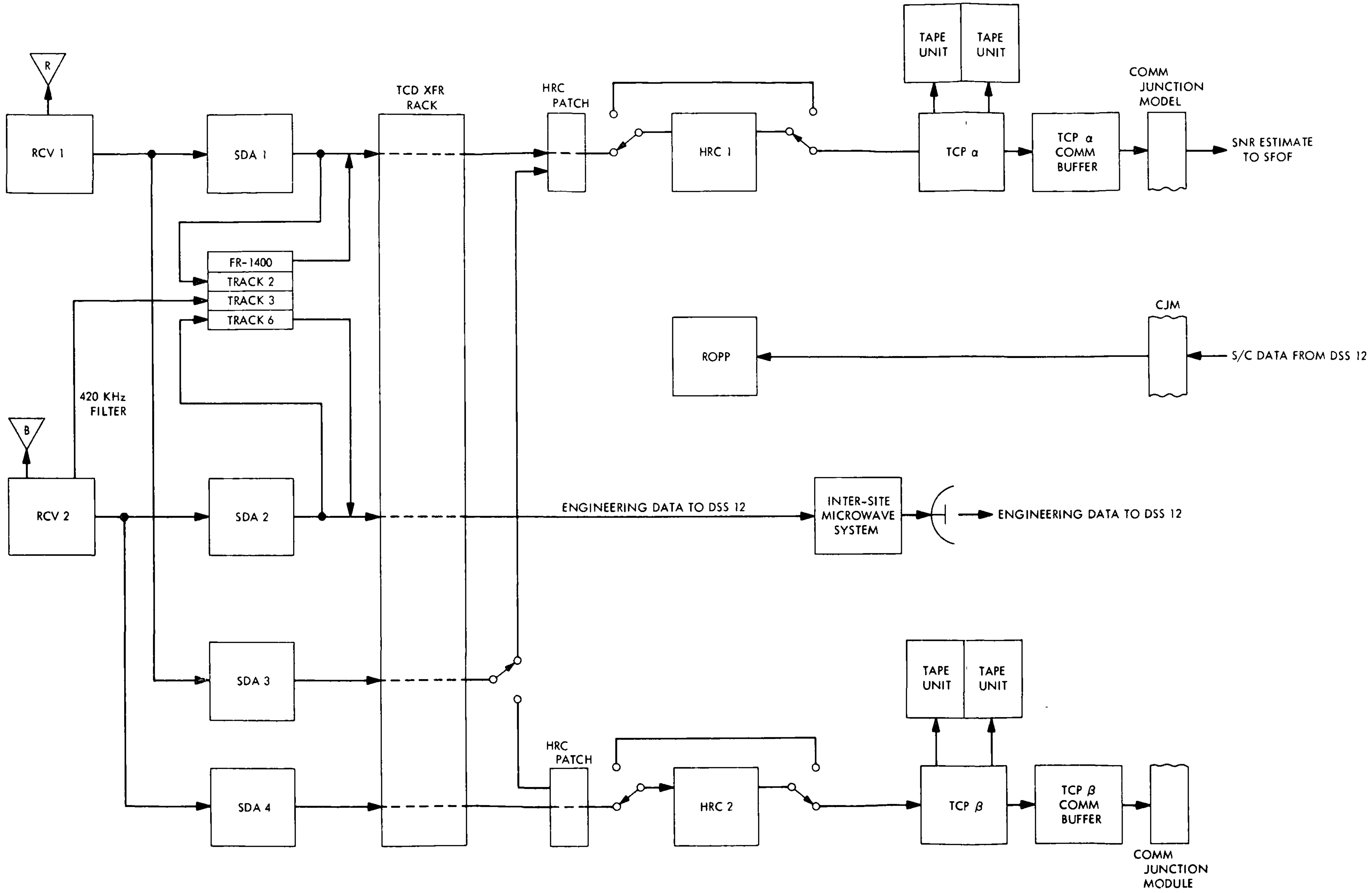


Fig. 35. DSS 14 telemetry configuration

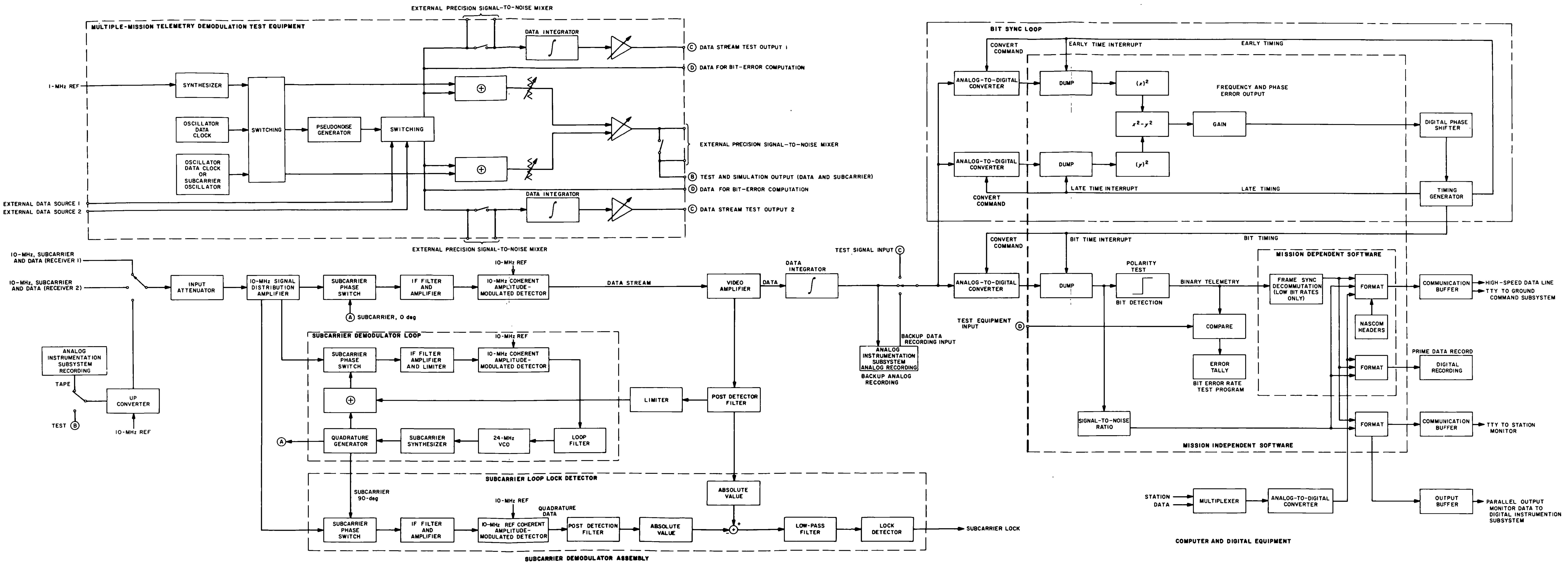


Fig. 36. MMTS functional block diagram at the DSS

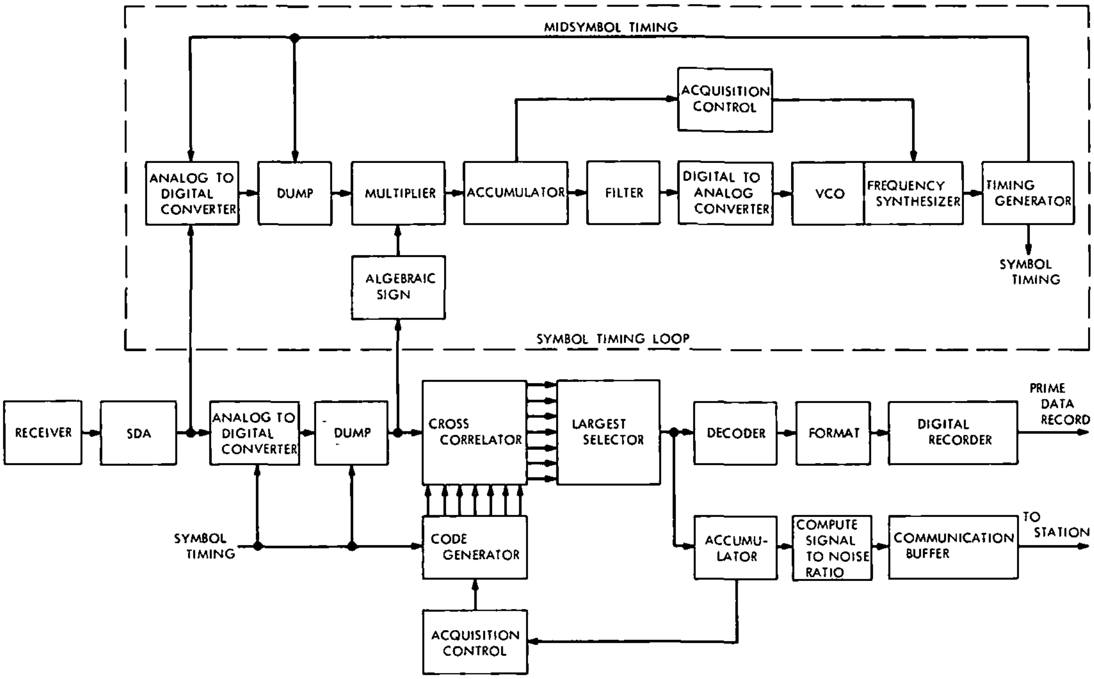


Fig. 37. HRT block diagram at the DSS

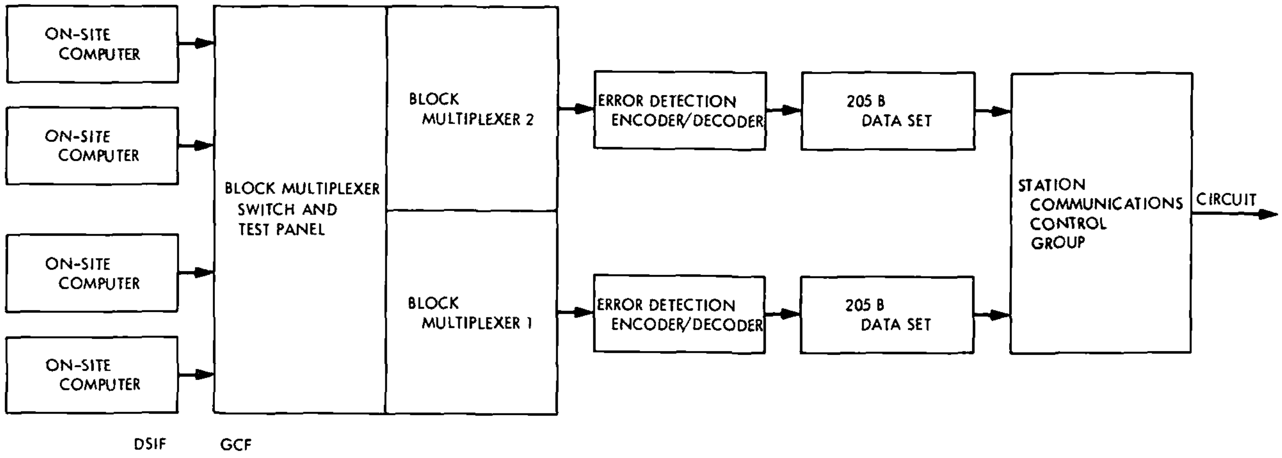


Fig. 38. High-speed communication DSS terminal

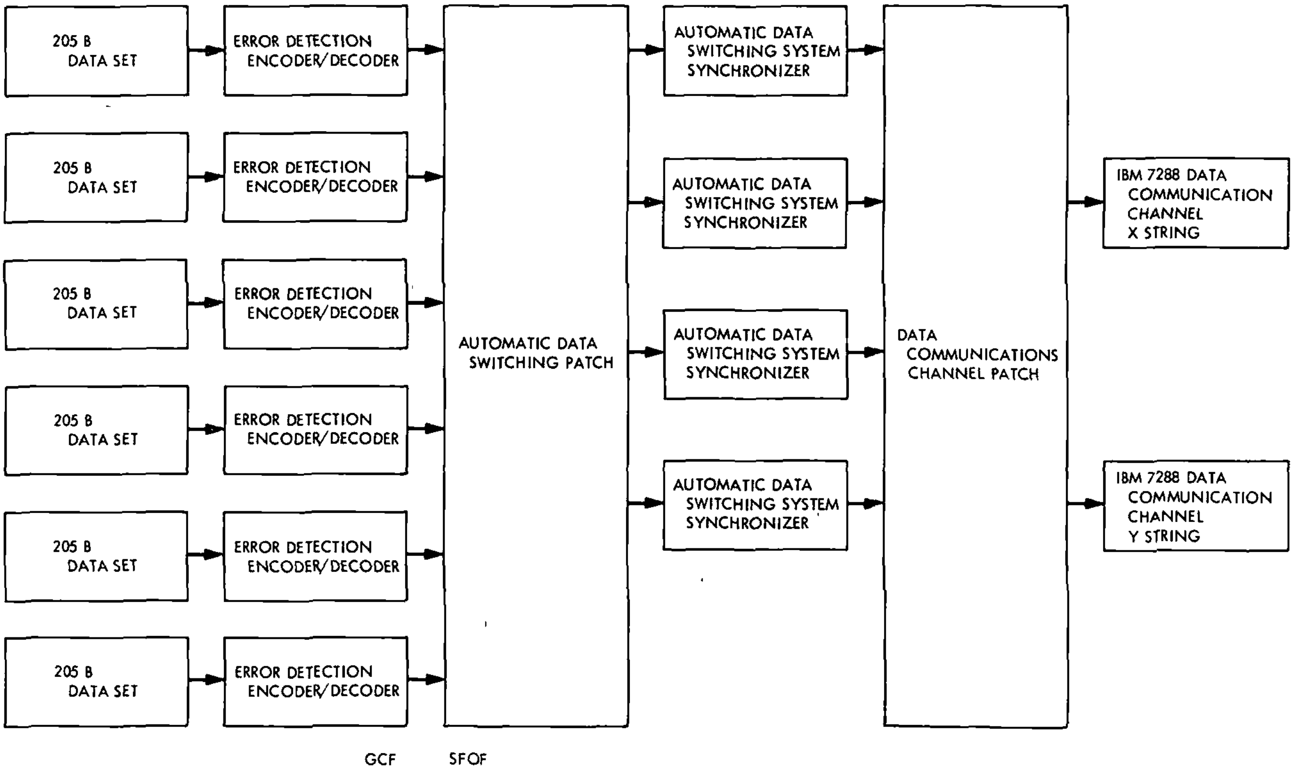


Fig. 39. High-speed communication SFOF terminal

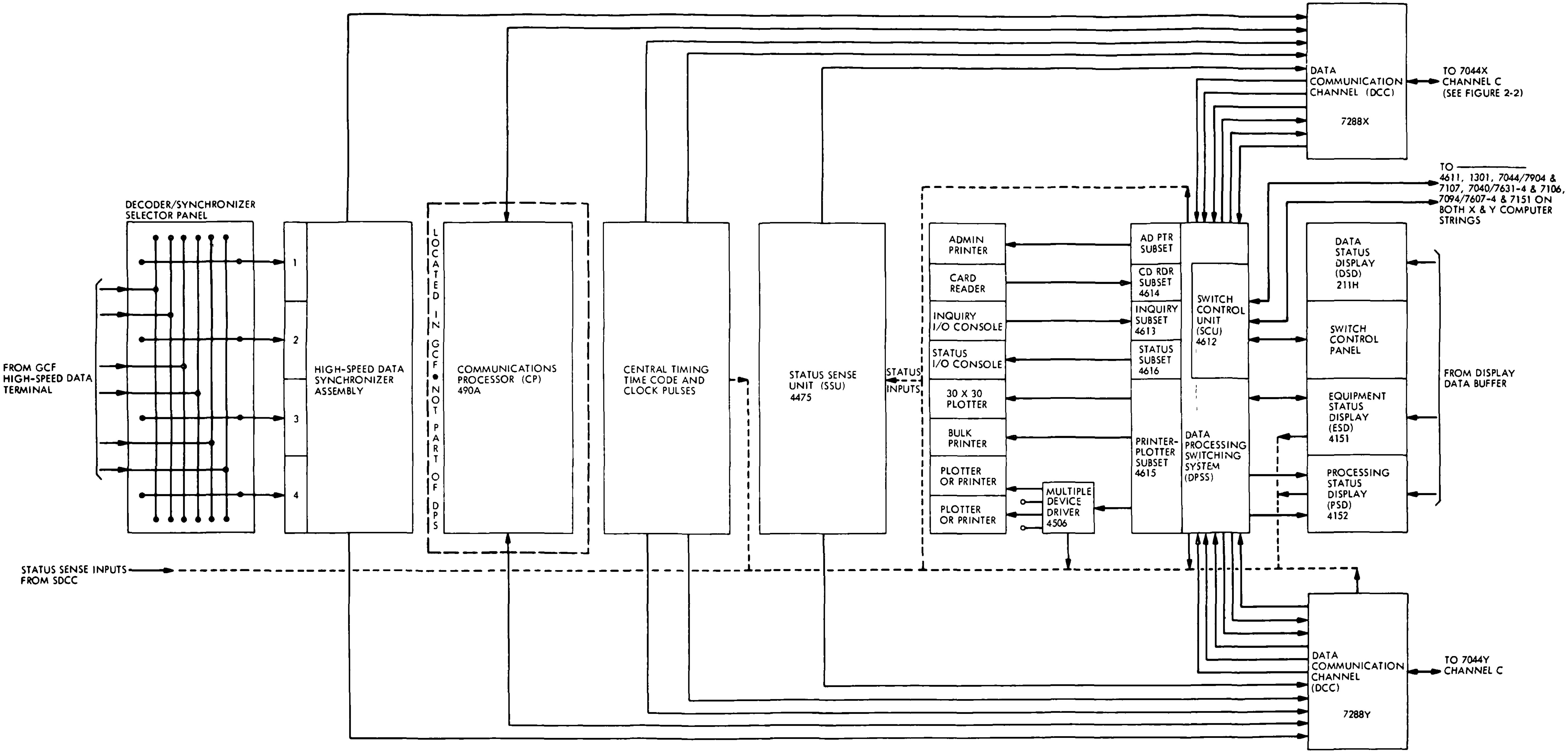
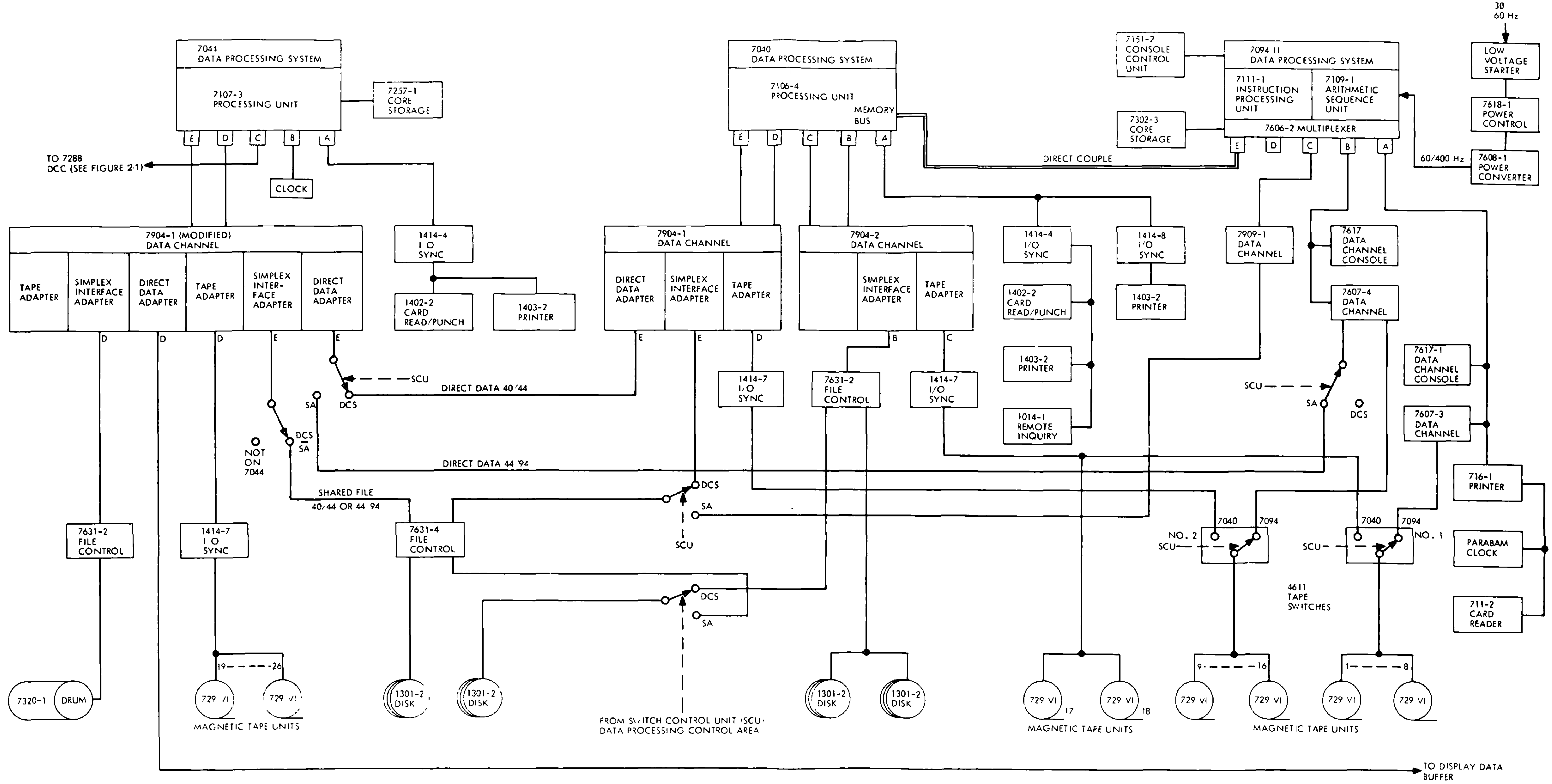


Fig. 40. DSN data processing system I/O subsystem in the SFOF

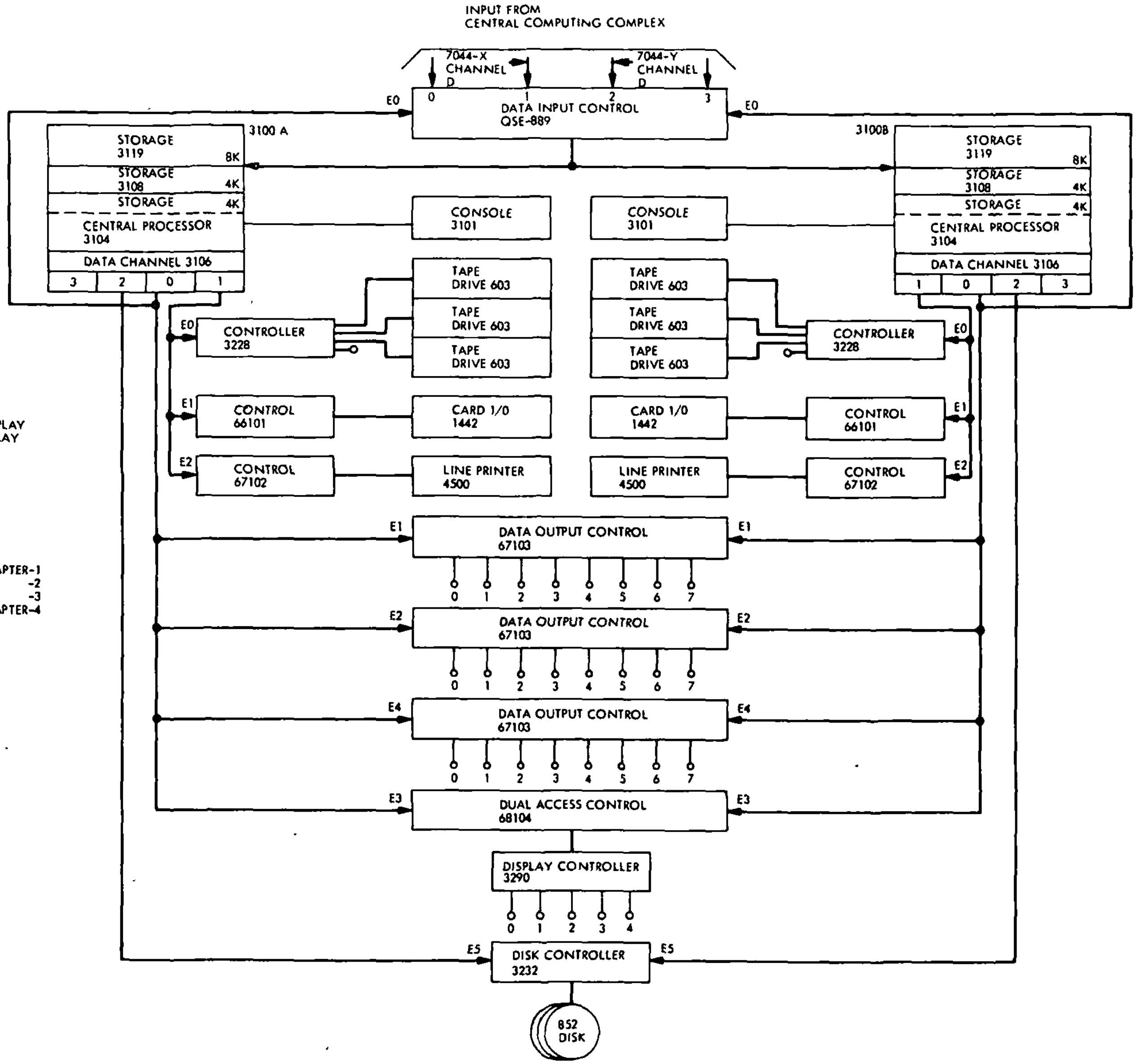


NOTES. UNLESS OTHERWISE SPECIFIED

1. SA =STAND ALONE DCS =DIRECT COUPLE SYSTEM
I/O =INPUT OUTPUT SCU =SWITCH CONTROL UNIT
SYNC =SYNCHRONIZER DCC =DATA COMMUNICATION CHANNEL

2. BOX NUMBERS ARE VENDORS ID.

Fig. 41. DSN DPS central computer complex in the SFOF



DOC NO. E1

OUTPUTS
0 PROCESSING STATUS DISPLAY
1 EQUIPMENT STATUS DISPLAY
2
3
4
5
6
7

DOC NO. E2
OUTPUTS
0 MONITOR CHANNEL ADAPTER-1
1 " " " -2
2 " " " -3
3 MONITOR CHANNEL ADAPTER-4
4
5
6
7

DOC NO. E4
0 UNASSIGNED
1 "
2 "
3 "
4 "
5 "
6 "
7 UNASSIGNED

DISPLAY CONTROLLER
0
1 DATA STATUS DISPLAY-X
2 DATA STATUS DISPLAY-Y
3 CRT FORMAT REQUEST
4

Fig. 42. DSN DPS processing system display data buffer subsystem in the SFOF

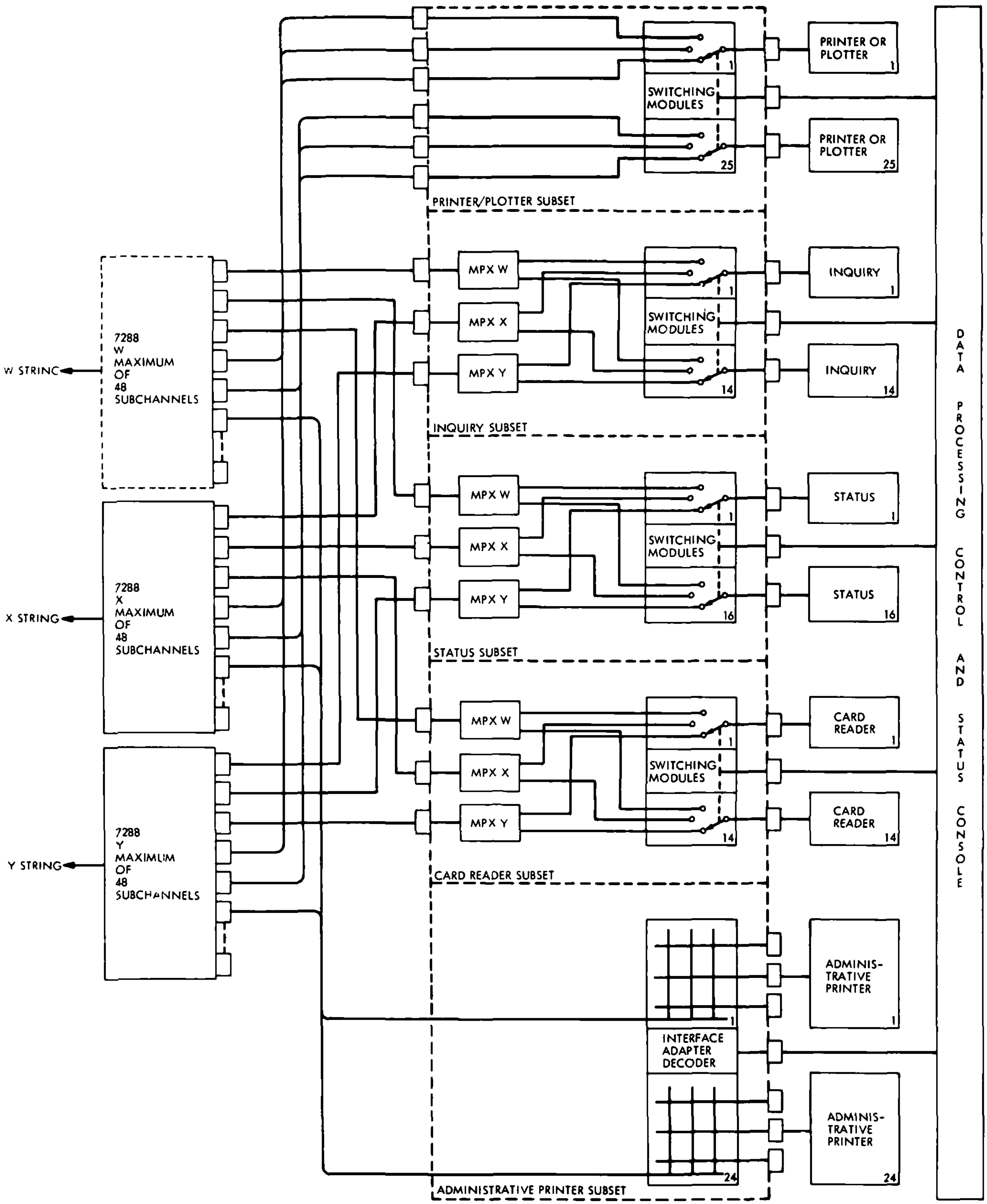


Fig. 43. Data processing switching system, block diagram

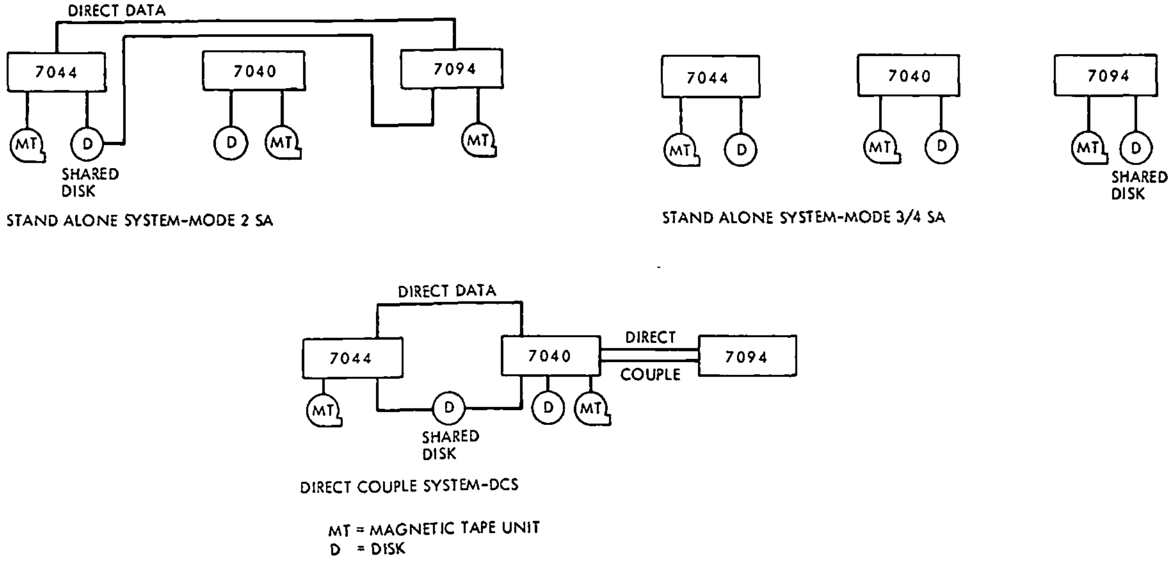


Fig. 44. Central computing complex direct couple system and stand-alone hardware configurations

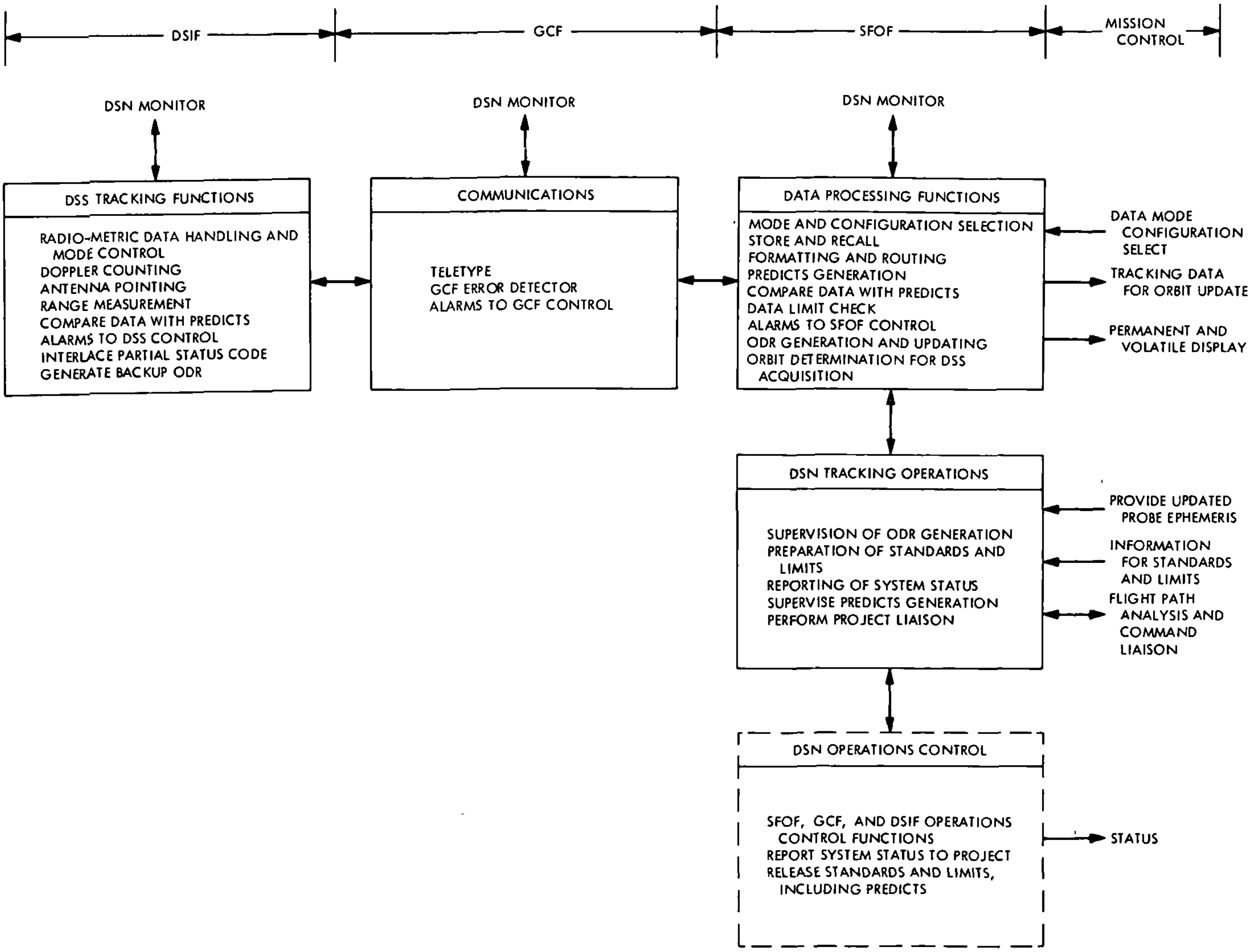


Fig. 45. DSN tracking system

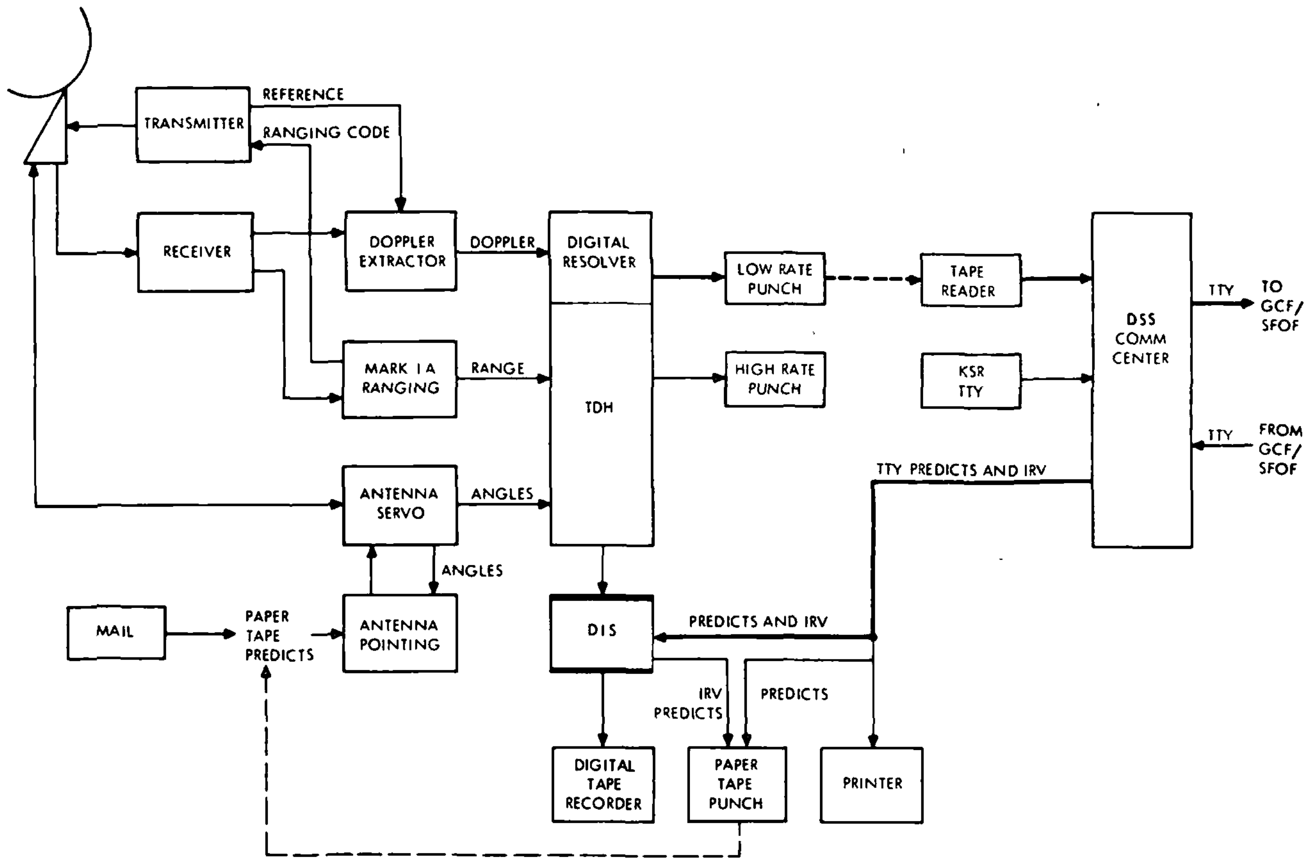


Fig. 46. Tracking configuration at the 26-m (85 ft) DSS

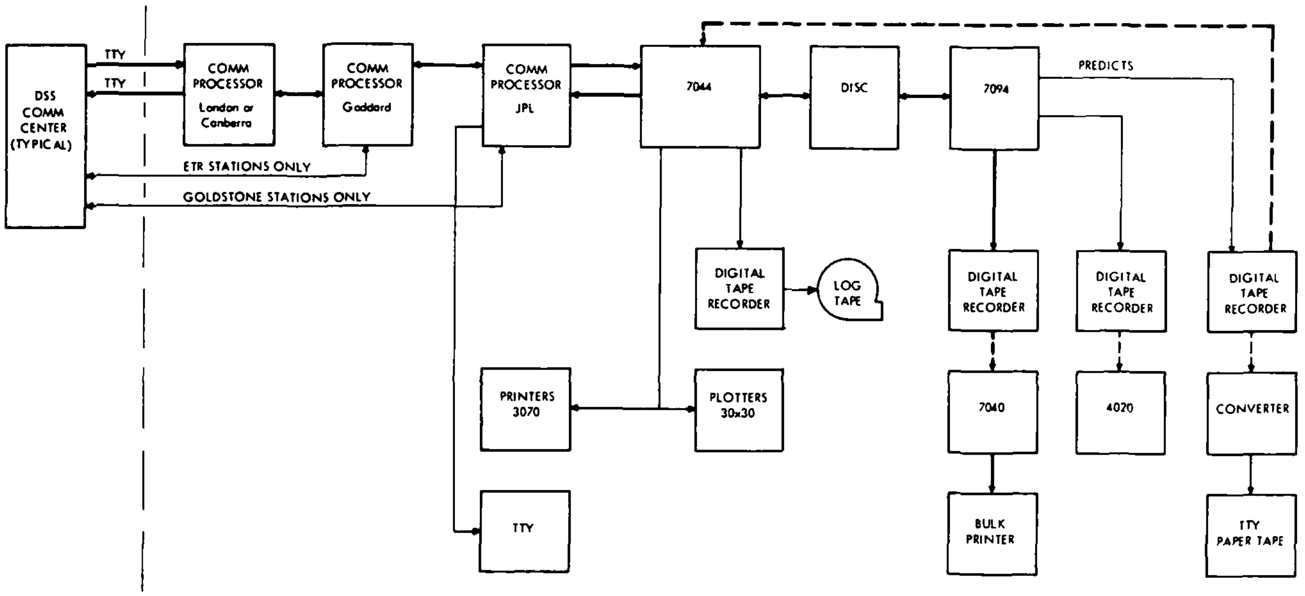


Fig. 47. SFOF/GCF configuration for the flow of radio metric data

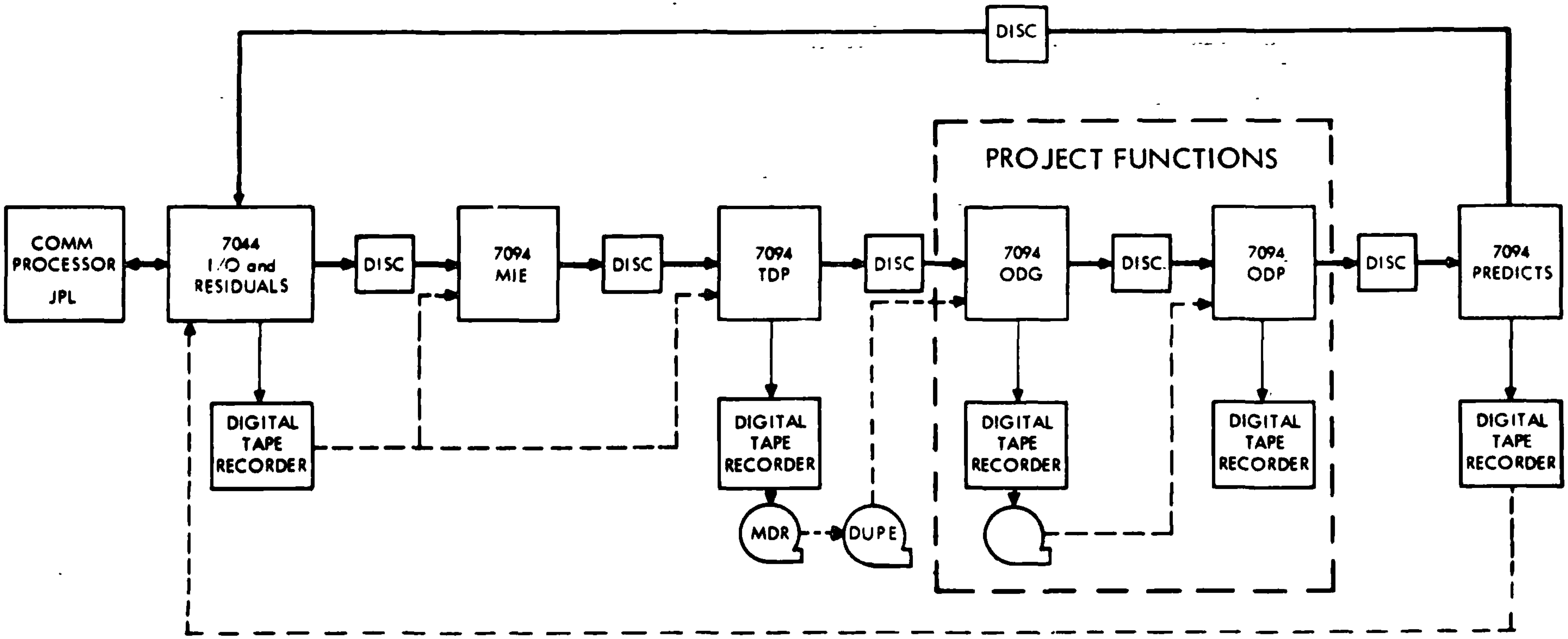


Fig. 48. Radio metric data functions performed in the SFOF by the DSN

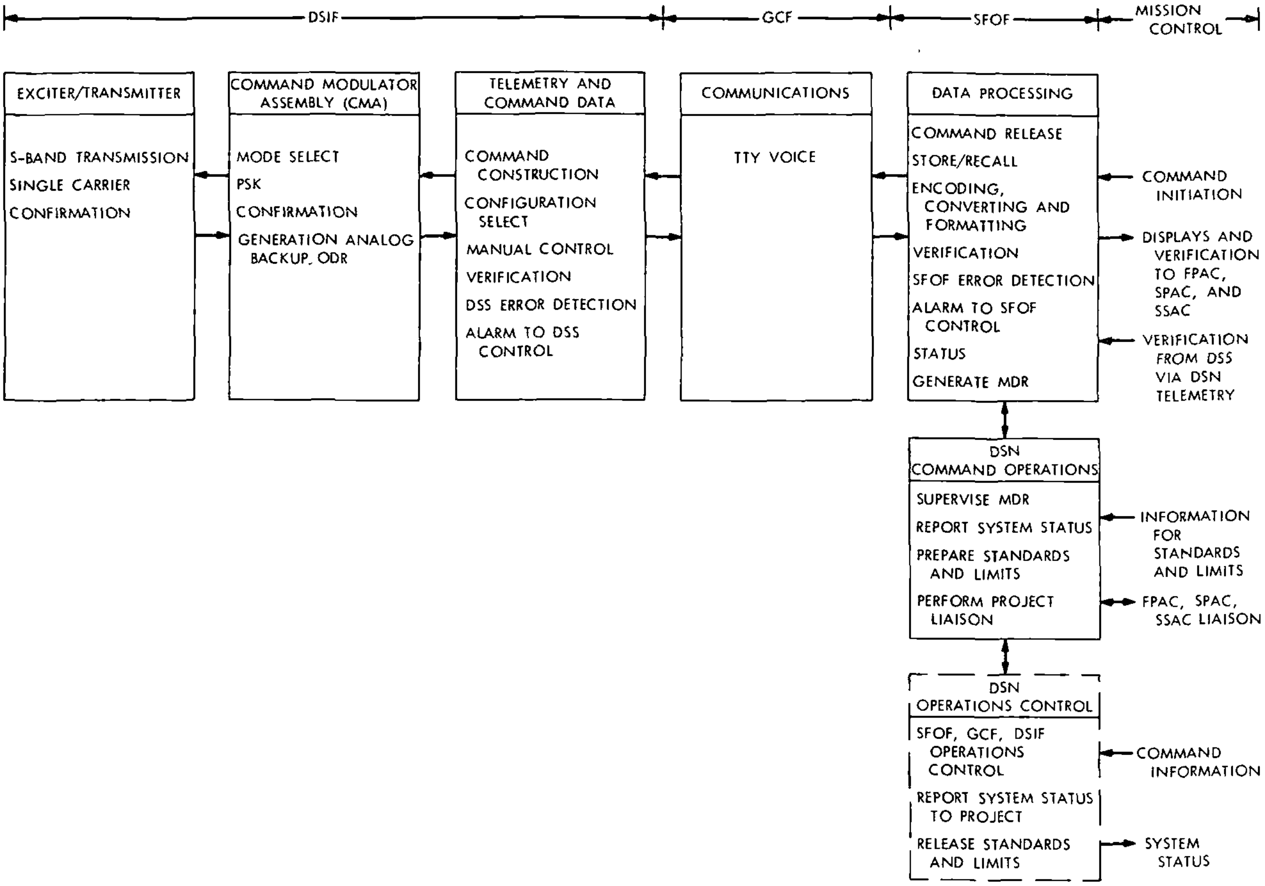


Fig. 49. DSN command system

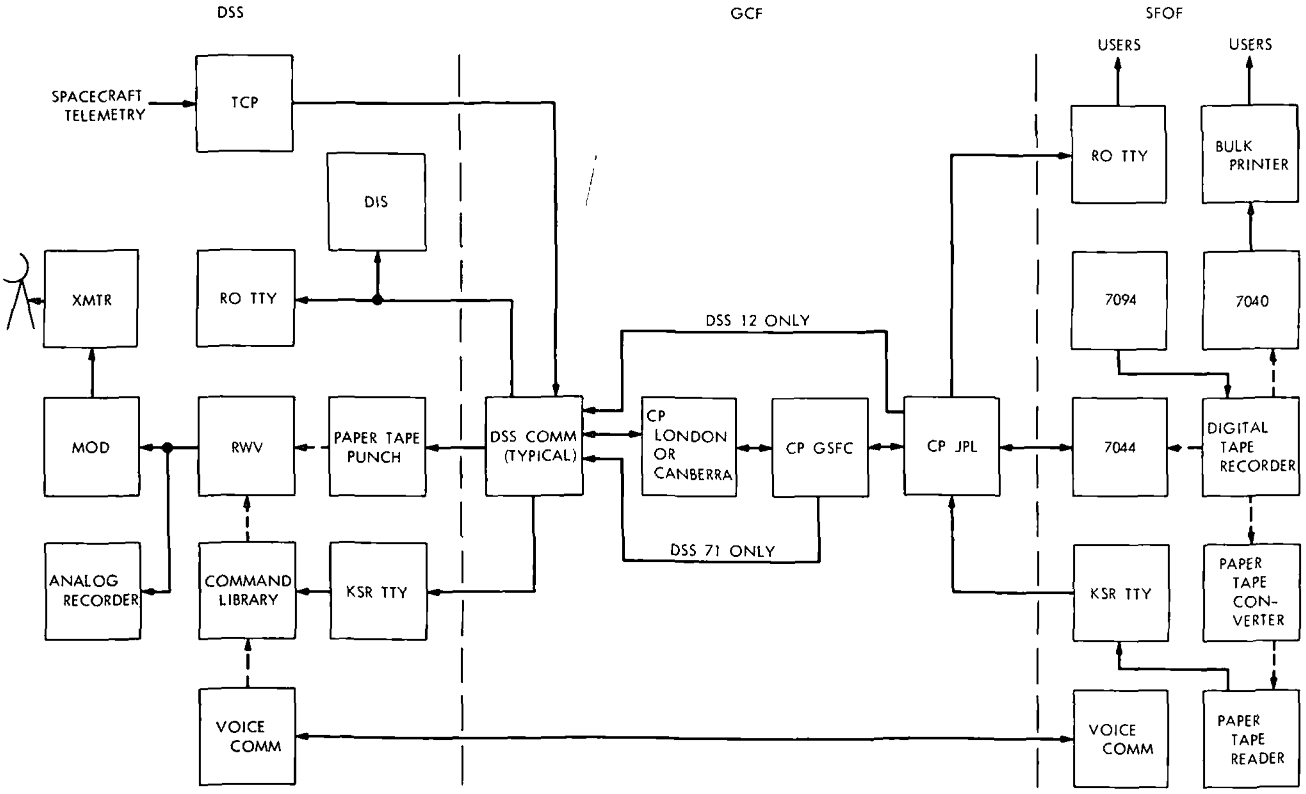


Fig. 50. DSN command configuration

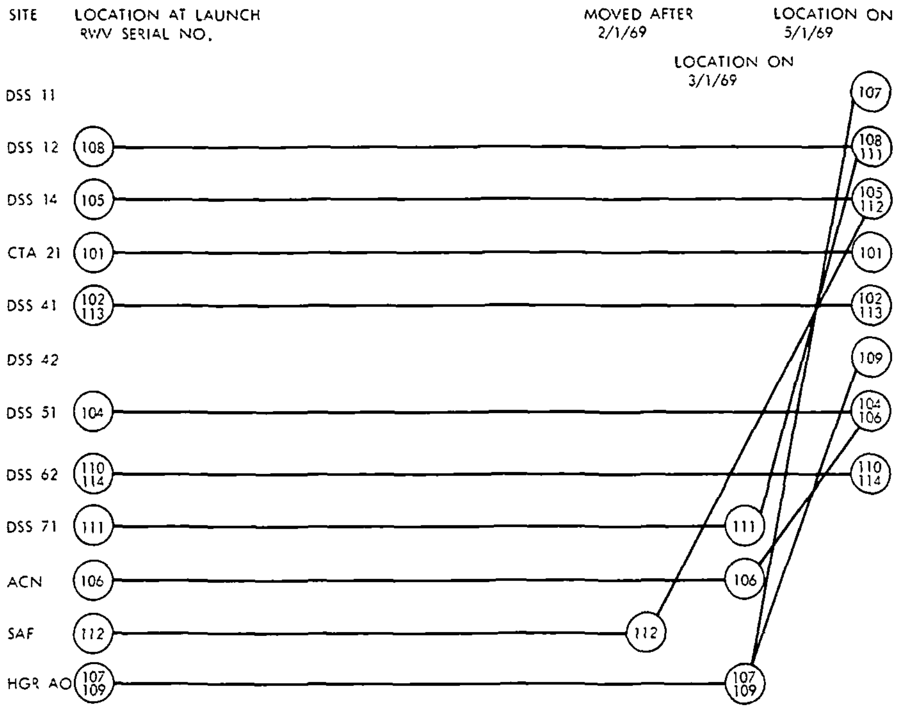


Fig. 51. Mariner Mars 1969 RWV assignments

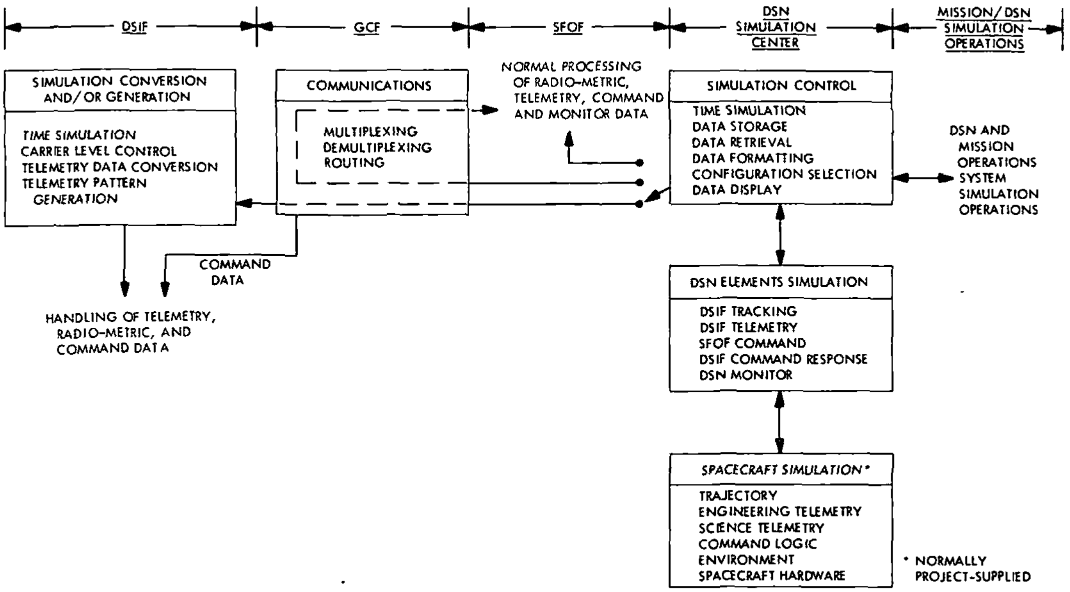


Fig. 52. DSN simulation system

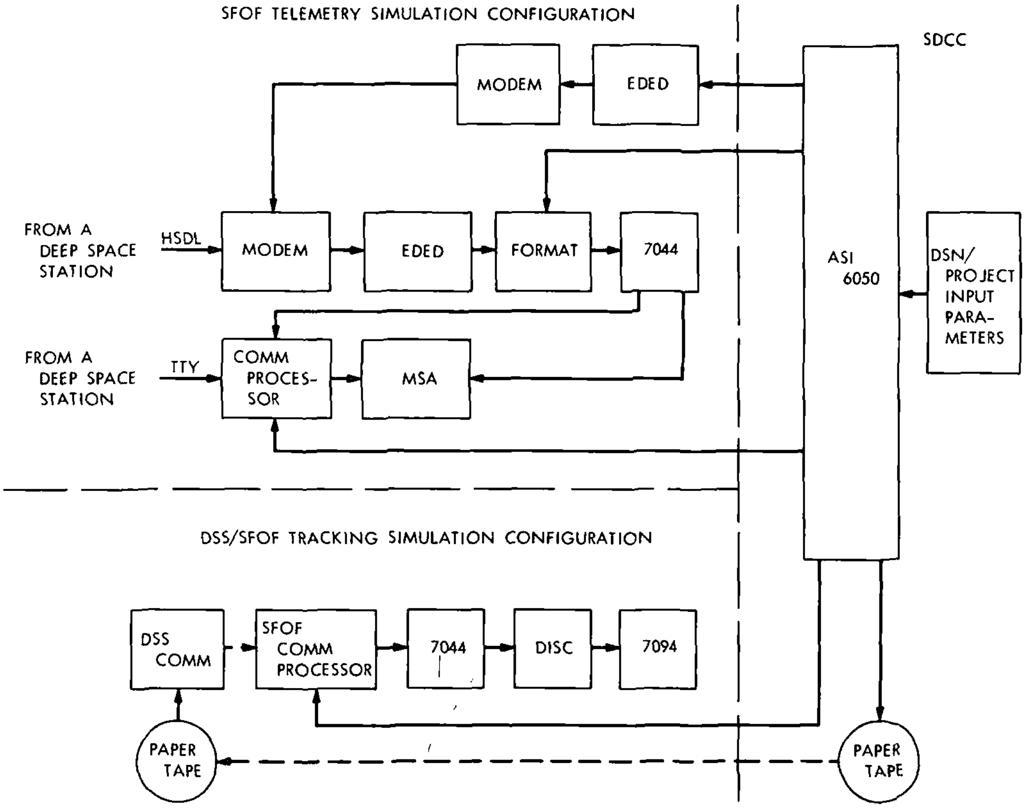


Fig. 53. DSN tracking and telemetry simulation configuration in the SFOF

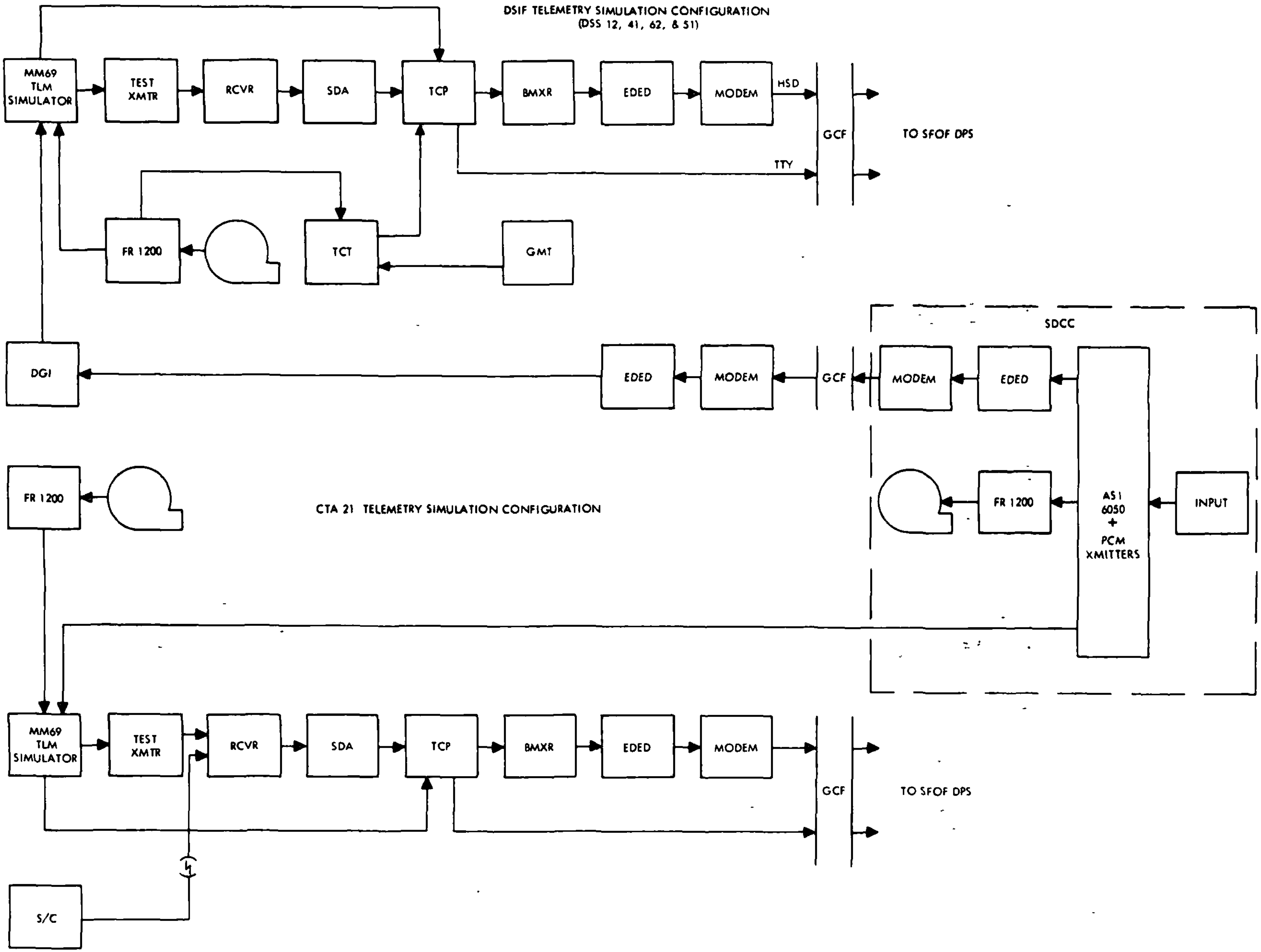


Fig. 54. DSS/CTA-21 telemetry simulation configuration

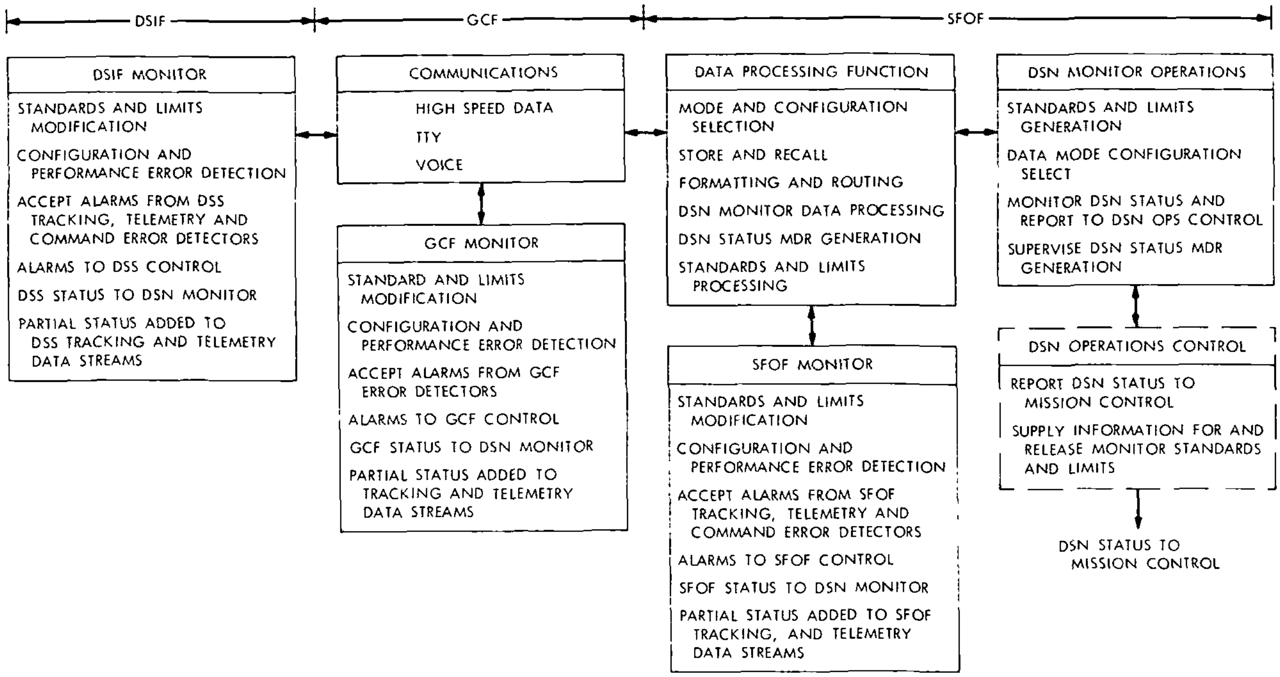


Fig. 55. DSN monitor system

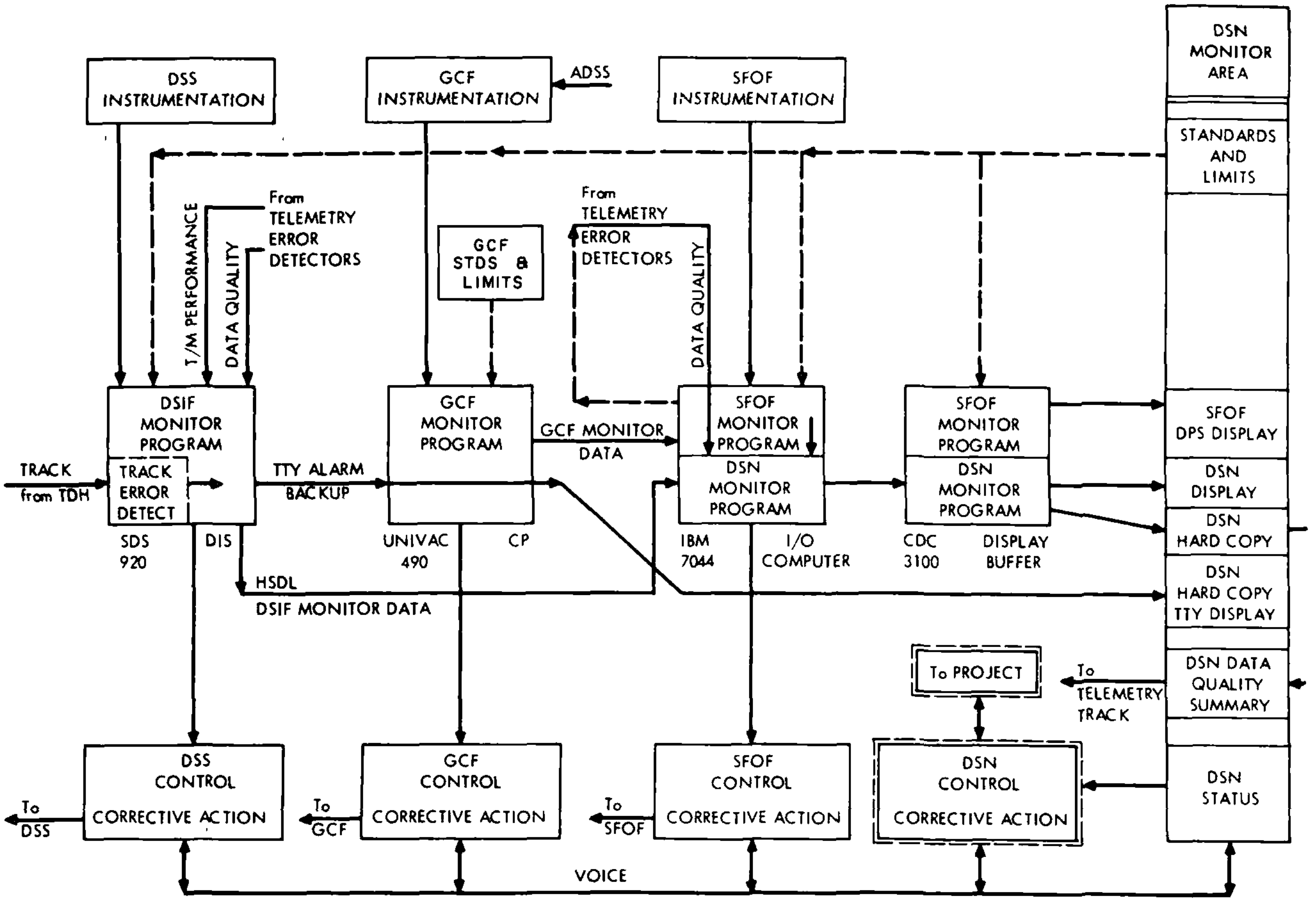


Fig. 56. DSN monitor configuration

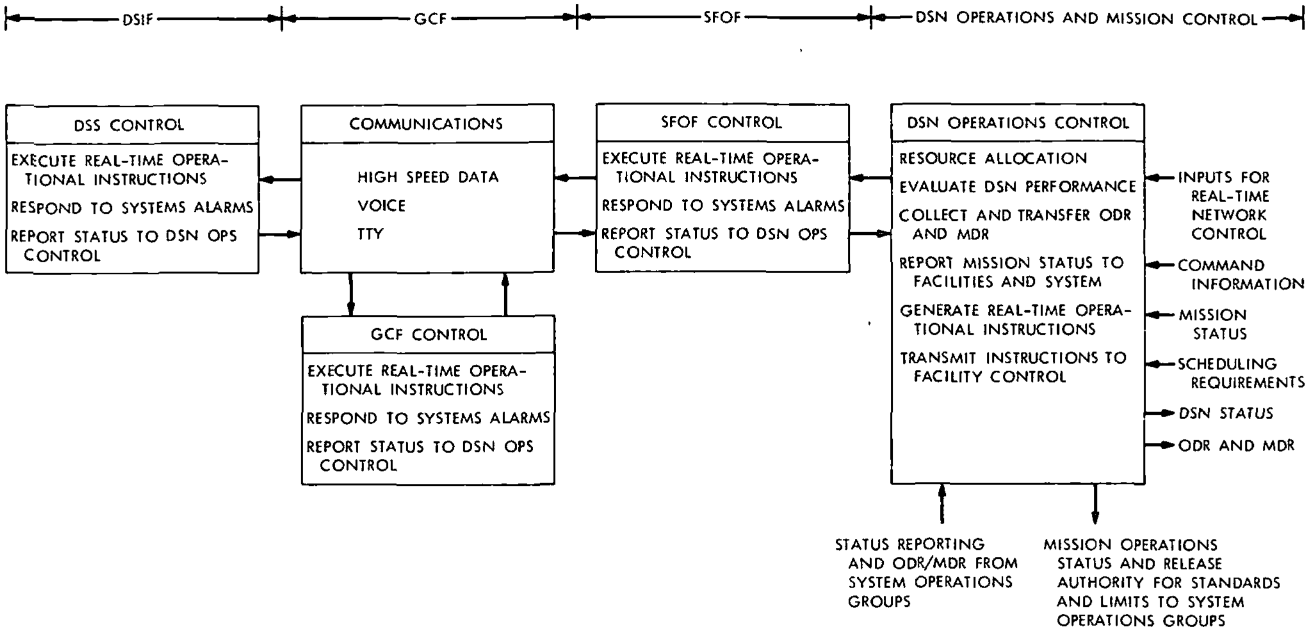


Fig. 57. DSN Operations Control System

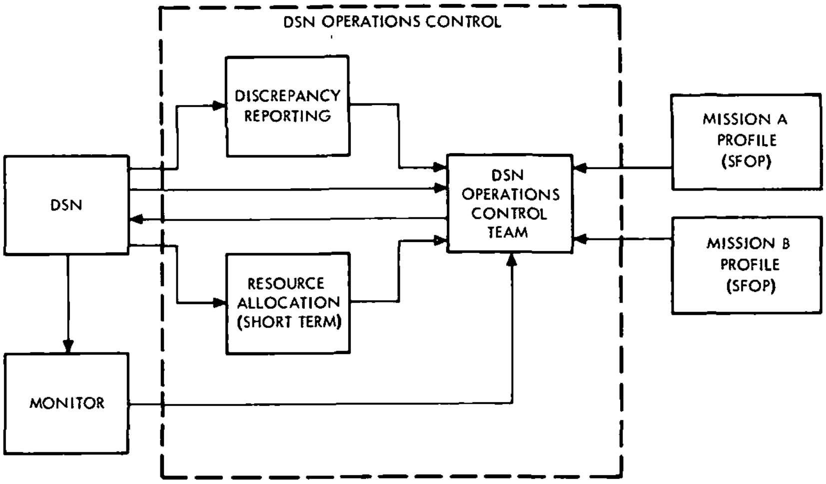


Fig. 58. DSN operations control functions, operational structure

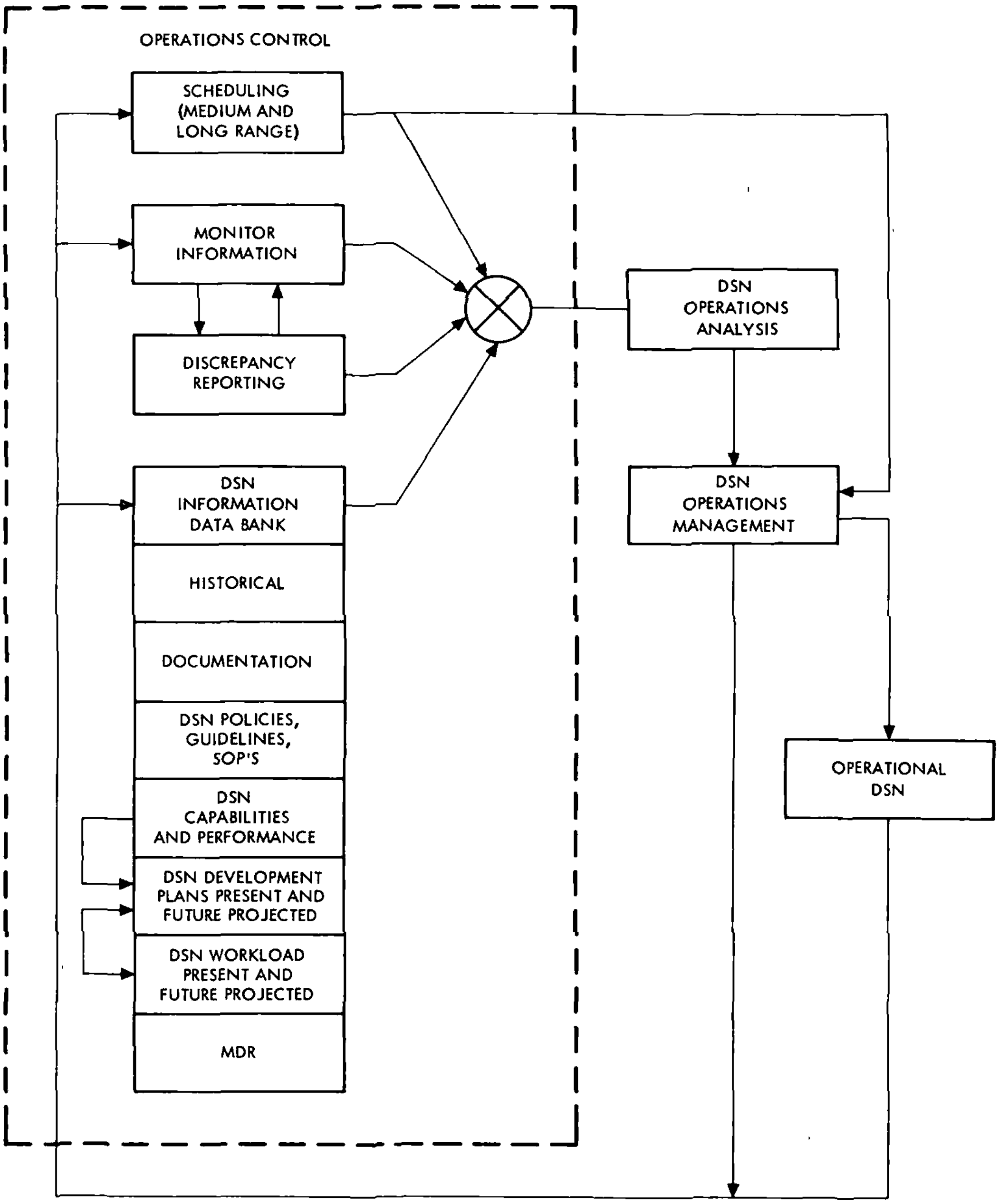


Fig. 59. DSN operations control functions, nonoperational structure

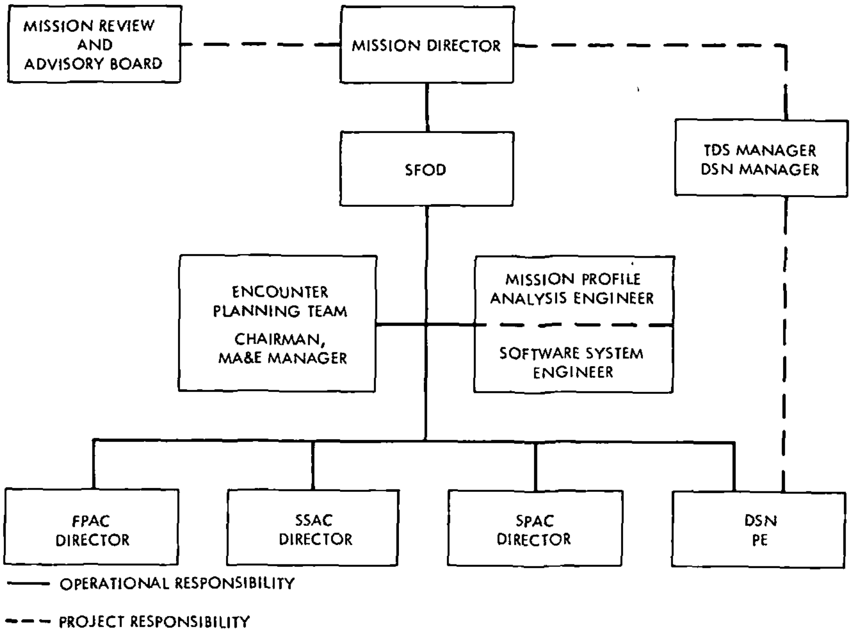


Fig. 60. Mission operations operational organization

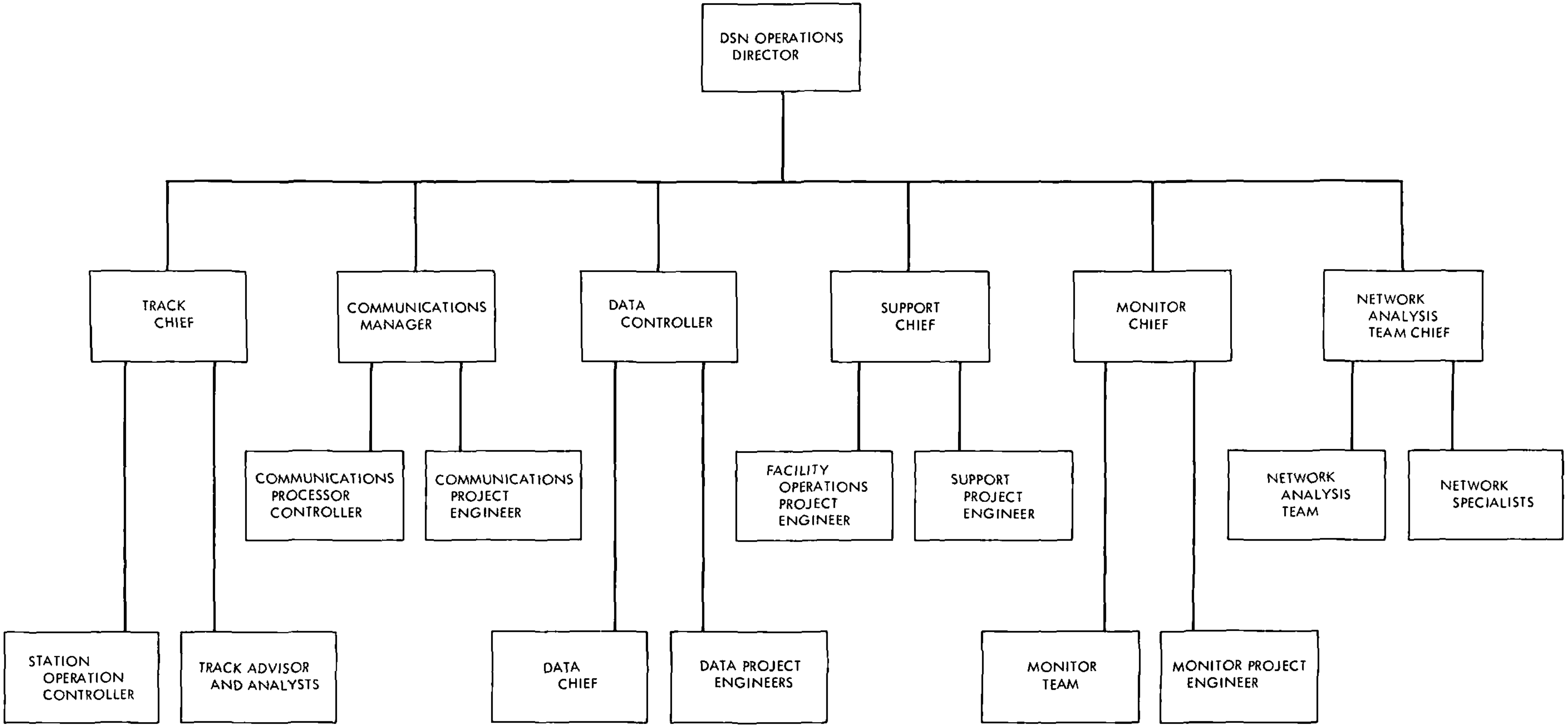


Fig. 61. DSN Operations Control Team

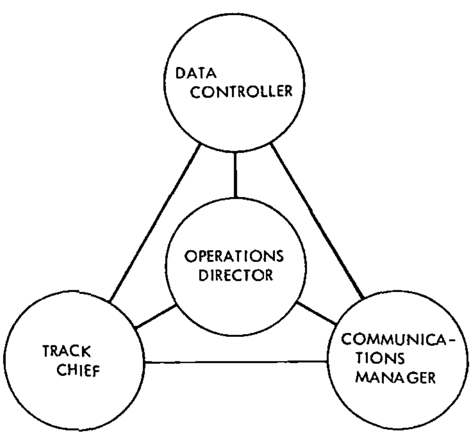


Fig. 62. SFOF first-level operations organization

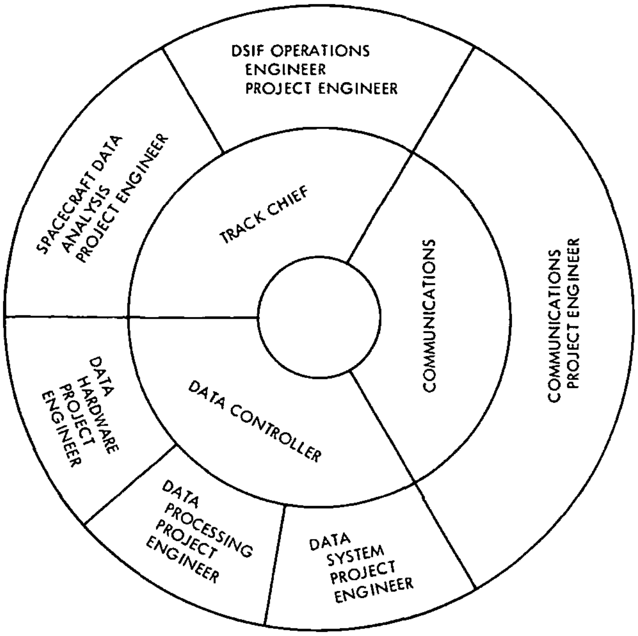


Fig. 63. Advisory organization integration

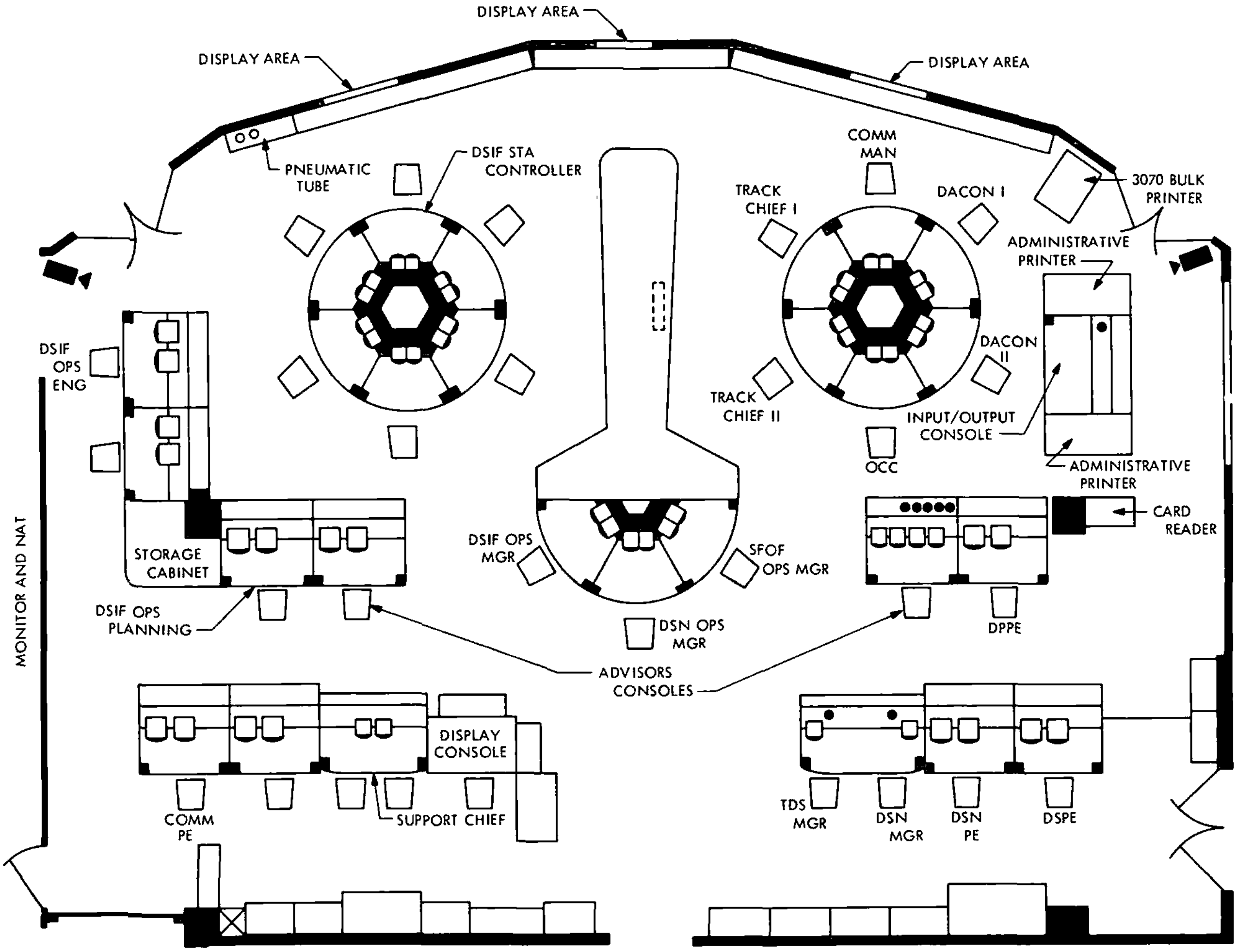


Fig. 64. SFOF operations area (equipment locations)

Fig. 65. Advisor consoles – operations area

Fig. 66. DSN operations console – operations area

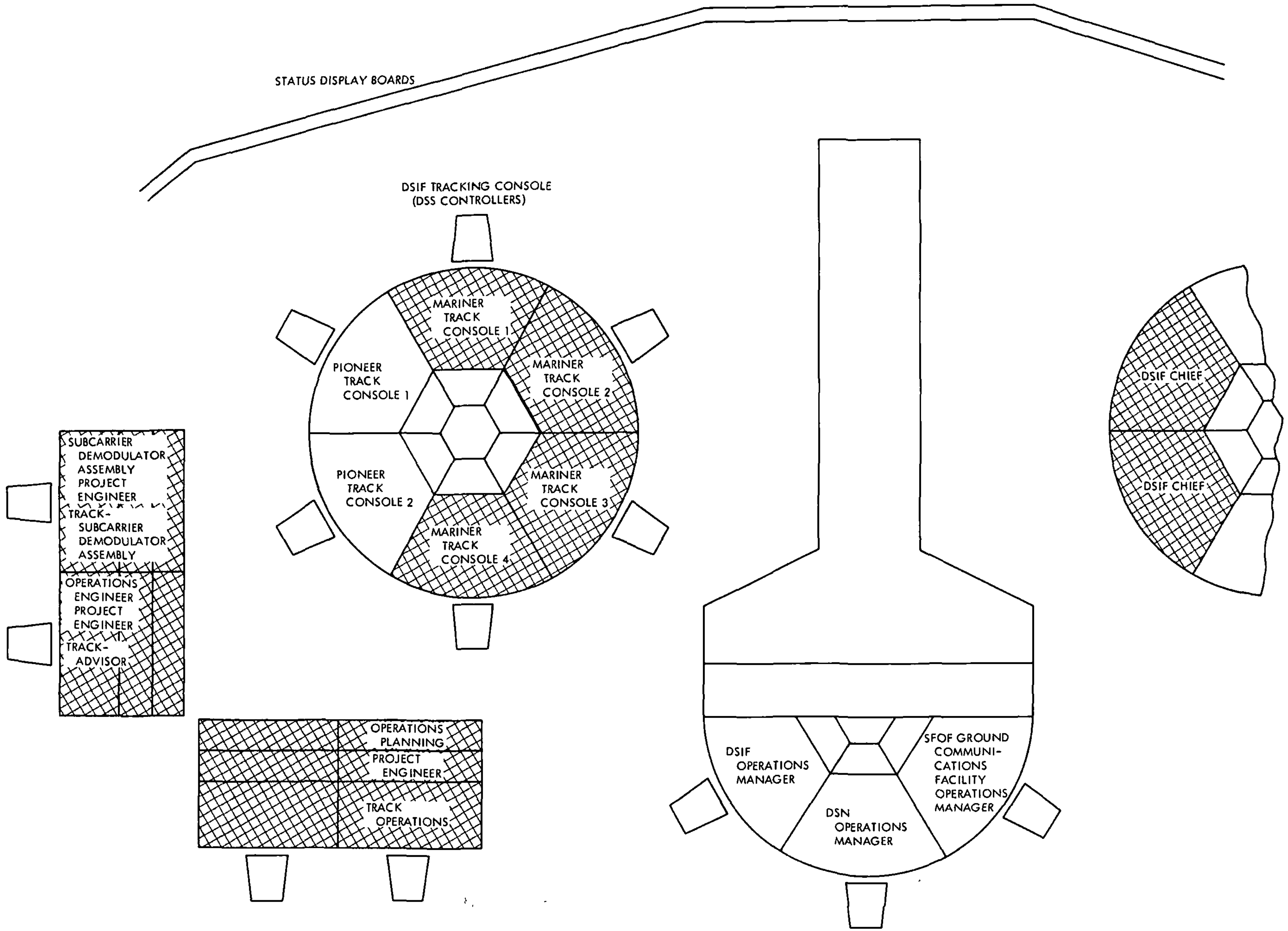


Fig. 67. Operations control positions for station controllers in the network operations area

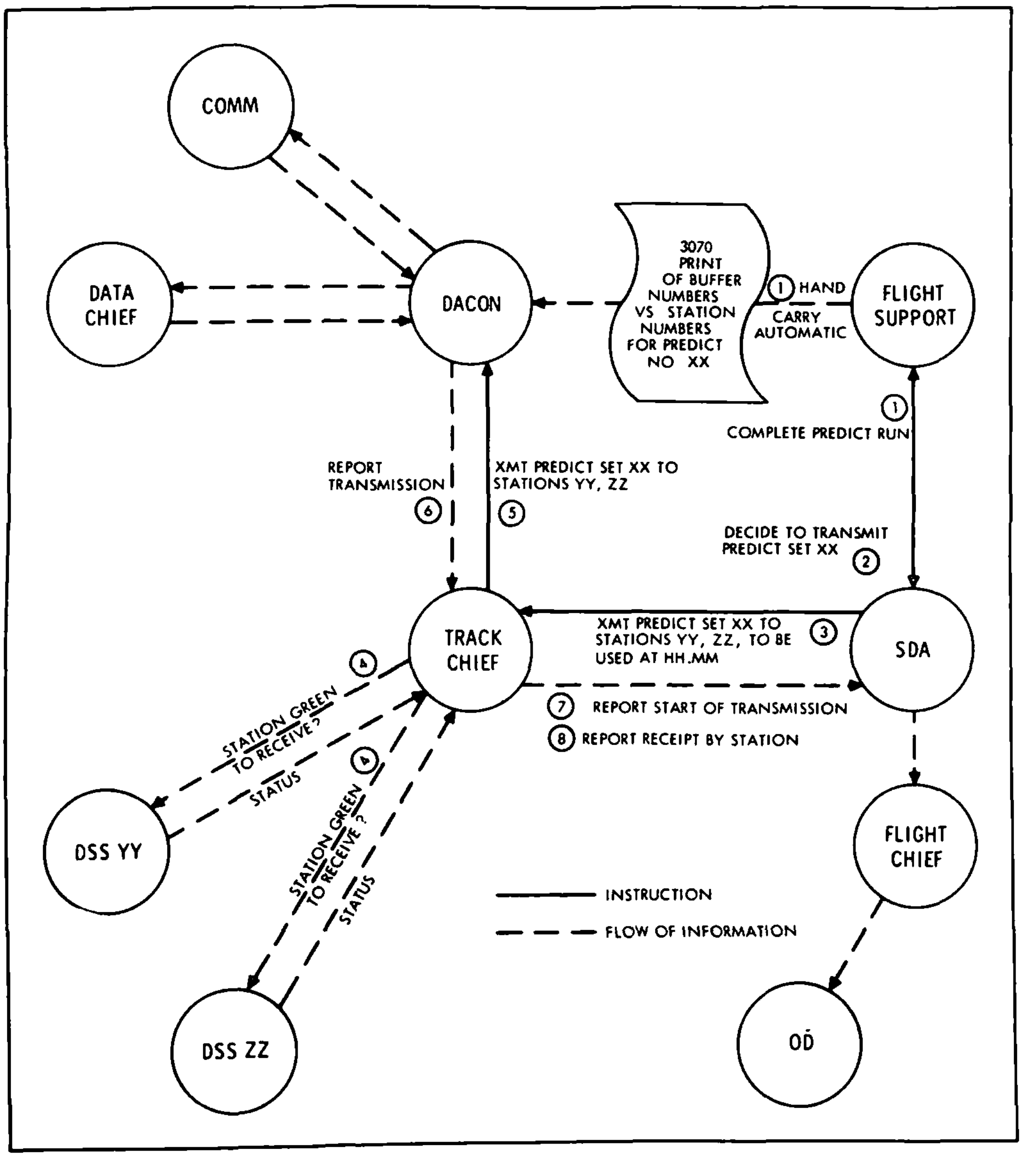
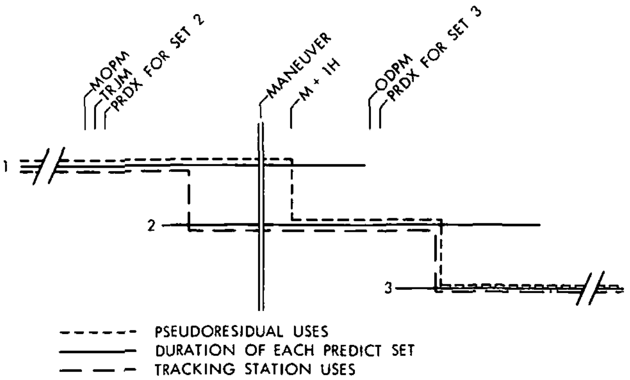


Fig. 68. Predicts procedural flow

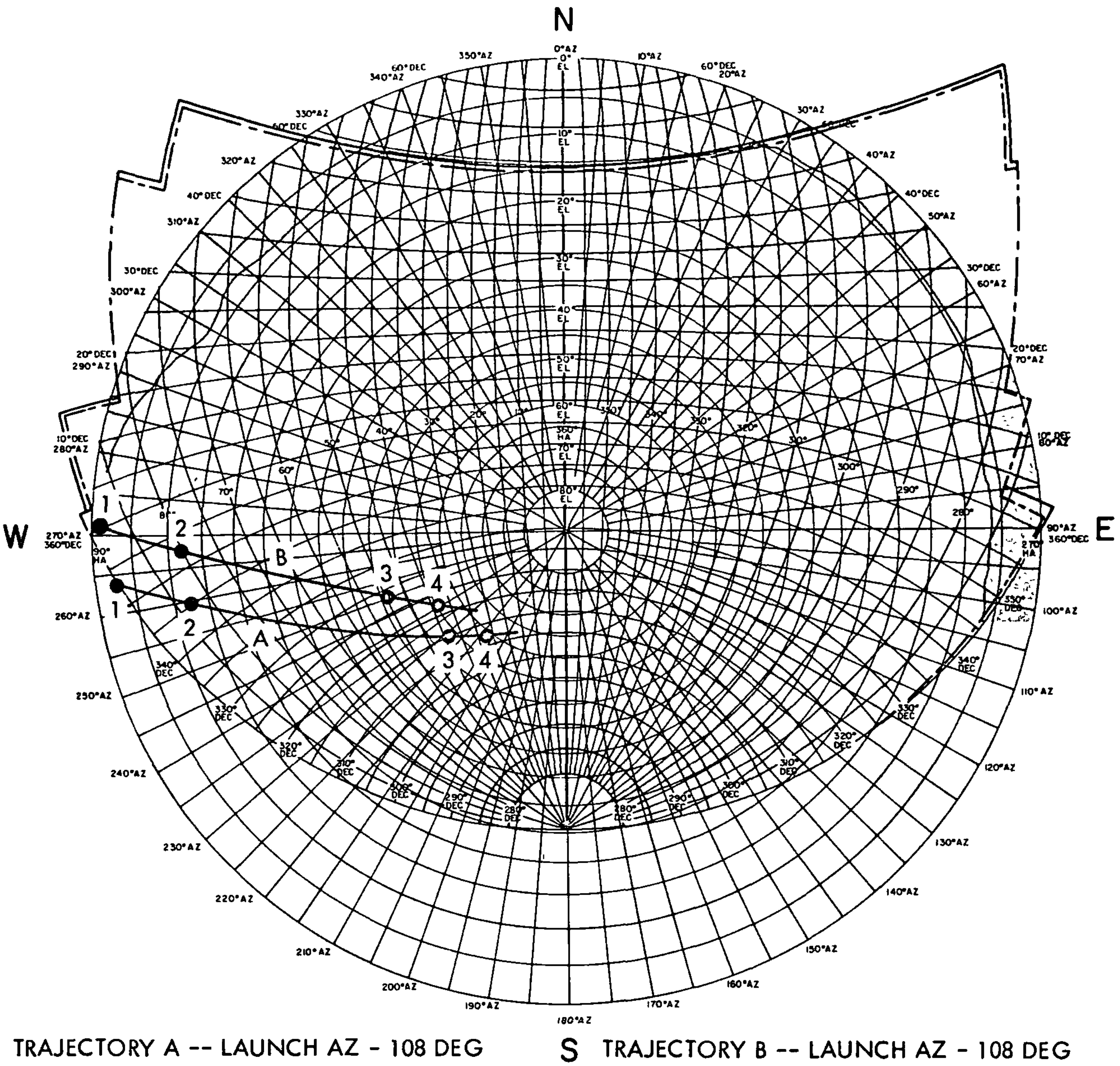


1 PREDICTS THAT DO NOT CONTAIN THE BURN AND ARE RUN WELL IN ADVANCE OF THE MANEUVER

2 PREDICTS THAT INCLUDE THE NOMINAL BURN AND ARE RUN AS SOON AS THE FINAL MANEUVER PARAMETERS ARE AVAILABLE.

3 PREDICTS RUN ON FIRST GOOD ODPM RUN BASED ON DATA AFTER THE BURN.

Fig. 69. Three sets of predicts used by the pseudo-residual program and the tracking stations



TRAJECTORY A -- LAUNCH AZ - 108 DEG
YAW INDEX - 22.4 DEG

TRAJECTORY B -- LAUNCH AZ - 108 DEG
YAW INDEX - 17.0 DEG

TRAJECTORY	POINT	EVENT	TIME FROM LAUNCH (min/sec)
A	1	S/C RISE	23:30
A	2	EARLIEST POSSIBLE ACQ	26:00
A	3	LATEST POSSIBLE ACQ	46:00
A	4	DATA REQUIREMENT MET	56:00
B	1	S/C RISE	23:30
B	2	EARLIEST POSSIBLE ACQ	26:00
B	3	LATEST POSSIBLE ACQ	46:00
B	4	DATA REQUIREMENT MET	56:00

Fig. 70. DSS 51 azimuth (AZ), elevation (EL), and hour-angle declination (HA-DEC) station view

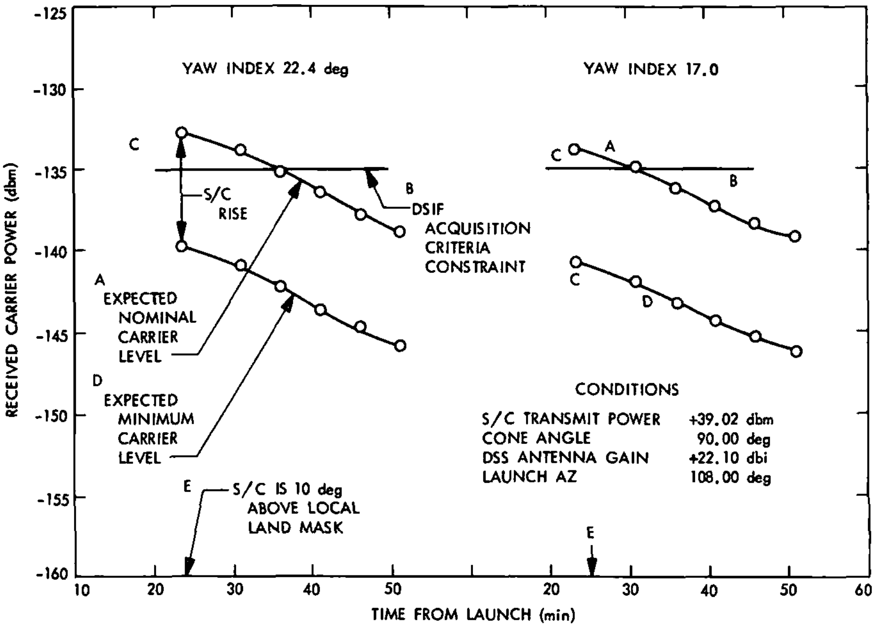


Fig. 71. Nominal and minimum carrier levels, DSS 51, 90-deg cone angle

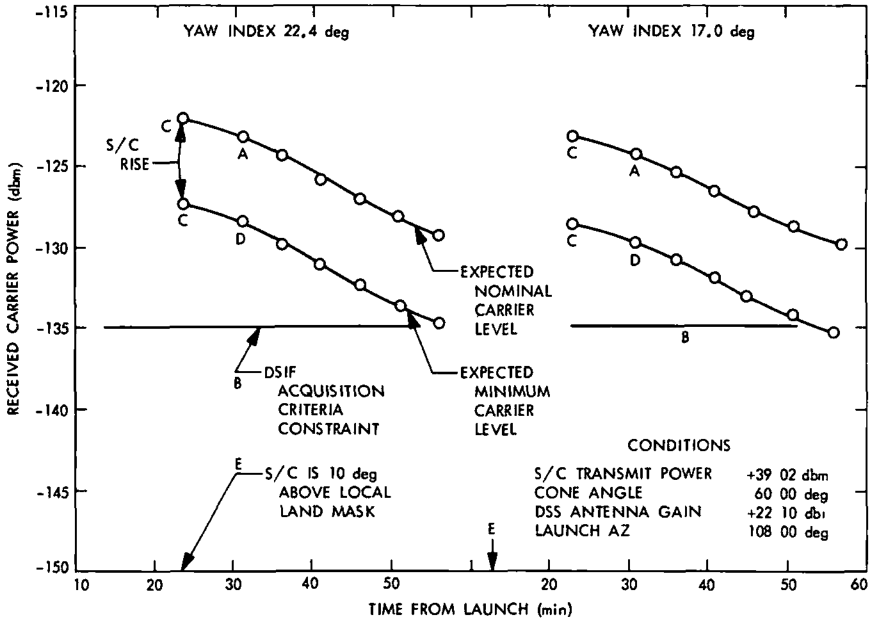


Fig. 72. Nominal and minimum carrier levels, DSS 51, 60-deg cone angle

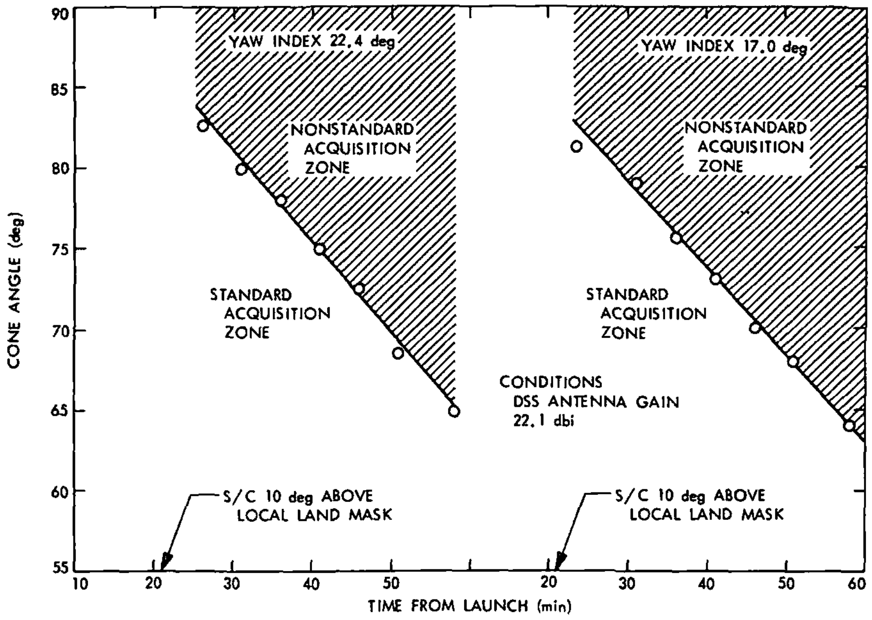


Fig. 73. Maximum allowable cone angle for -135 dBm signal

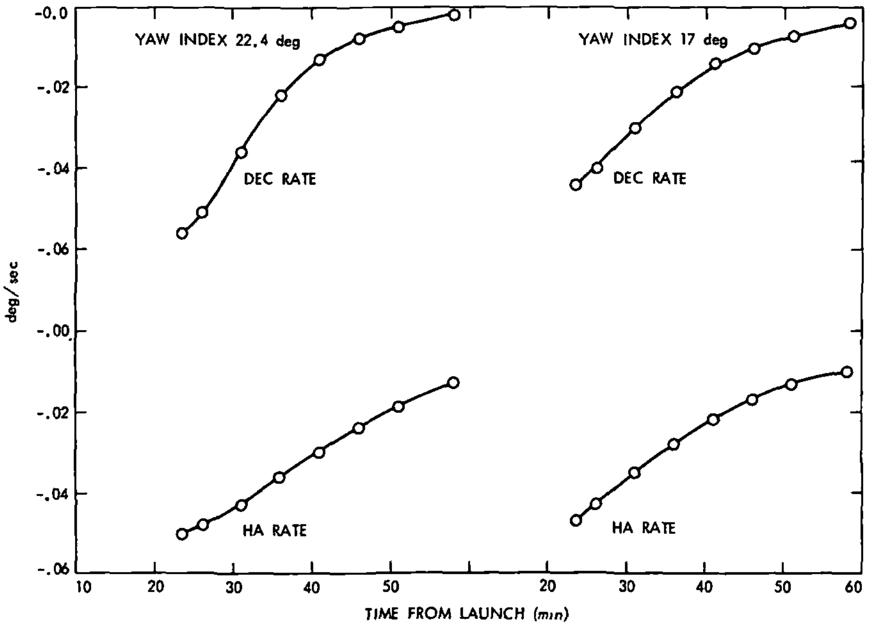


Fig. 74. DSS 51 initial pass-angle tracking rates, launch AZ = 108 deg

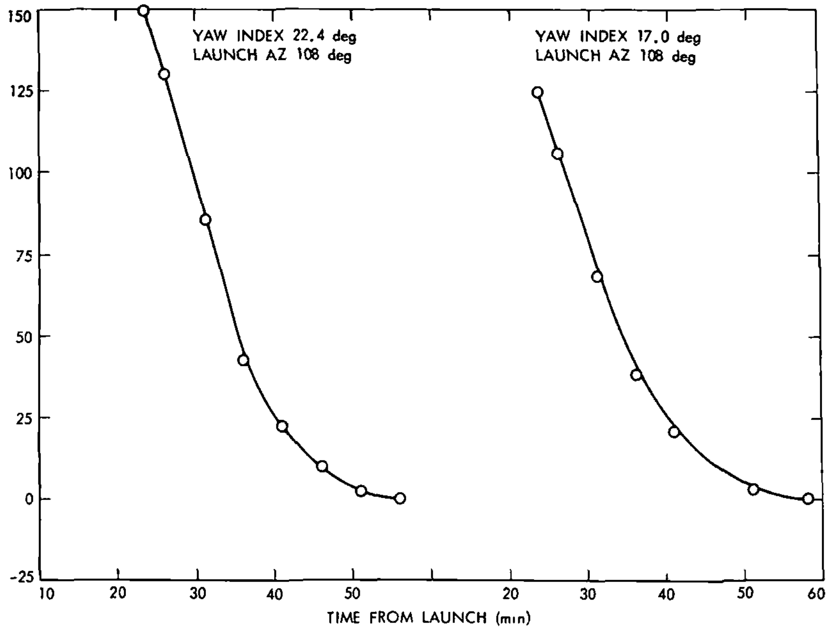


Fig. 75. DSS 51 initial pass two-way doppler rates

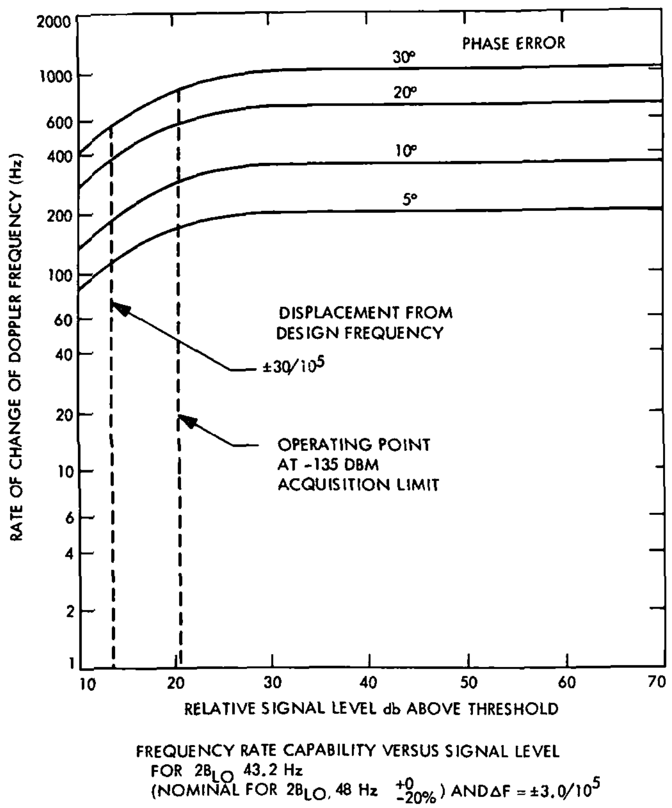


Fig. 76. DSS receiver doppler tracking rates

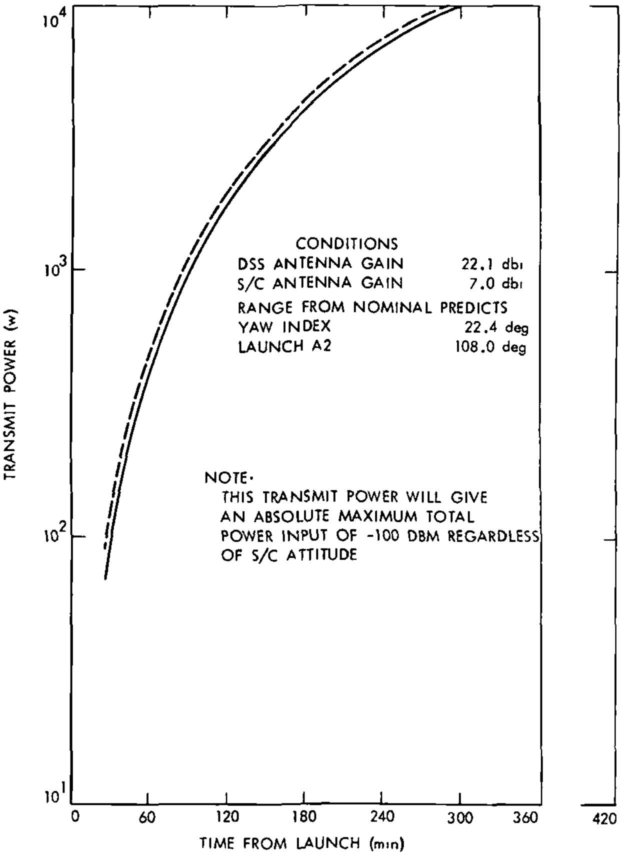
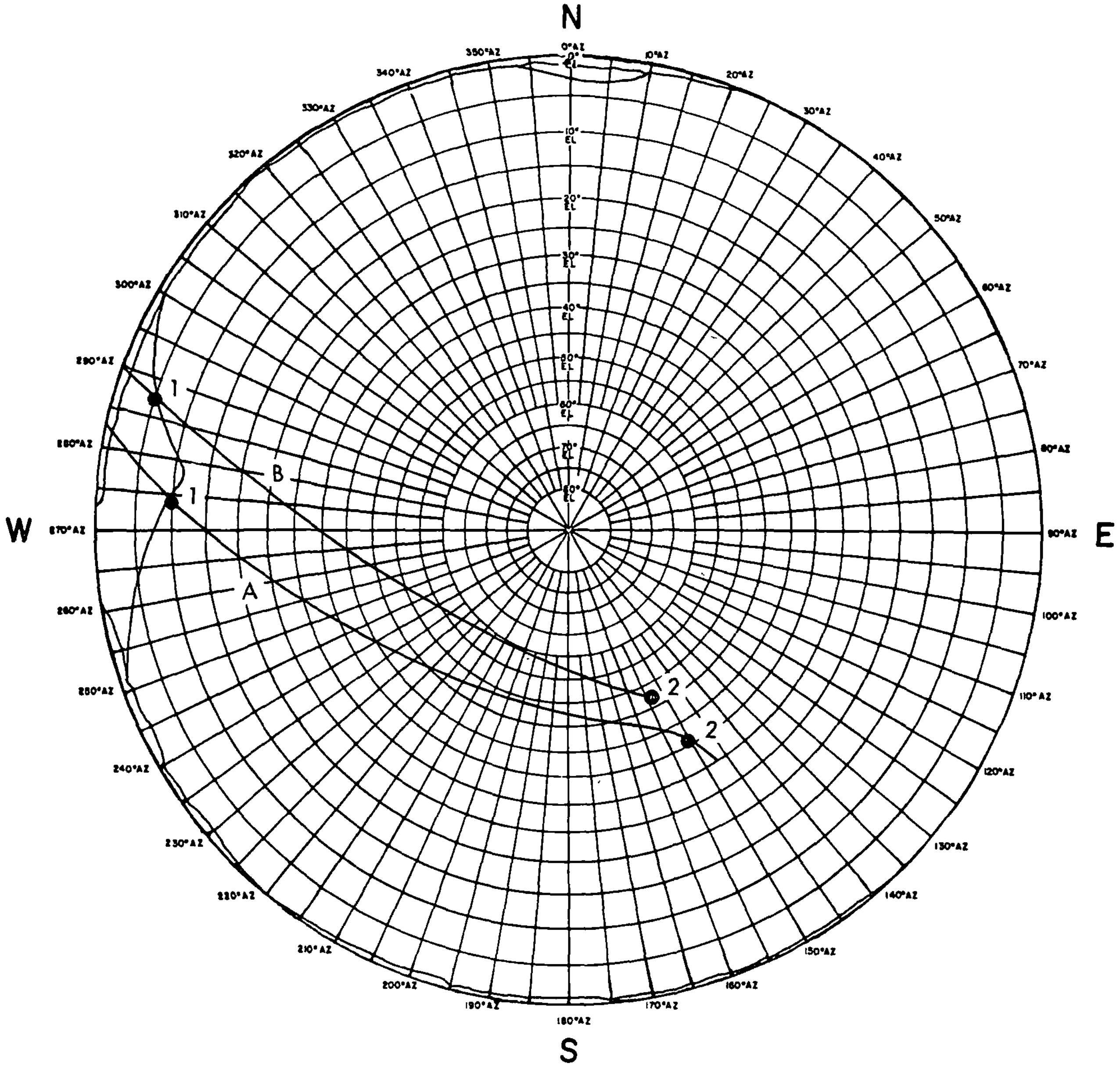


Fig. 77. Worst-case transmit power profile, DSS 51



TRAJECTORY	TIME FROM LAUNCH (min/sec)		LAUNCH AZ (deg)	YAW INDEX (deg)
	S/C RISE[1]	LATEST POSSIBLE ACQUISITION[2]		
A	16:40	101:00	108	22.4
B	15:30	81:00	108	17.0

Fig. 78. Station view, ACN

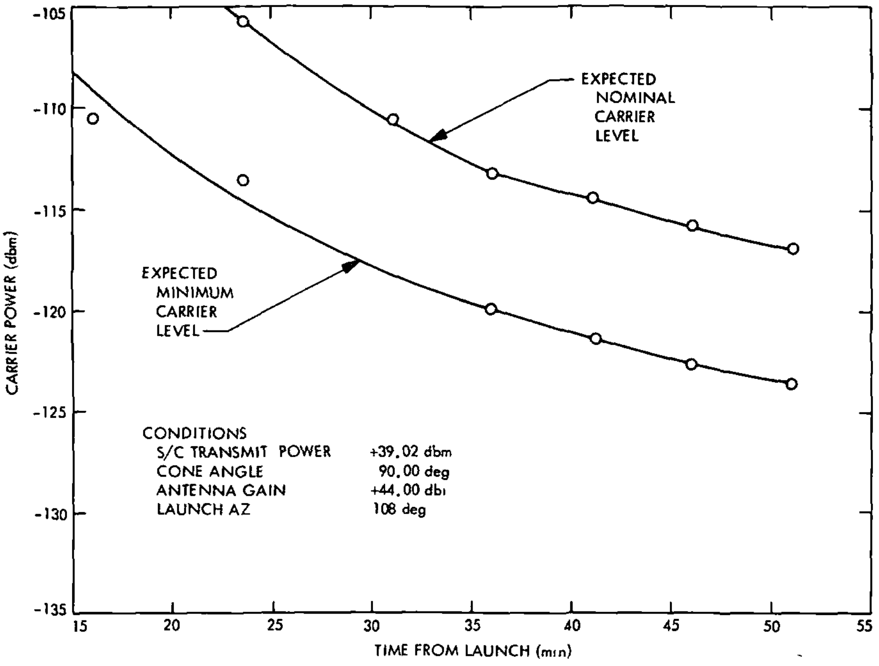


Fig. 79. Nominal and minimum carrier levels, ACN

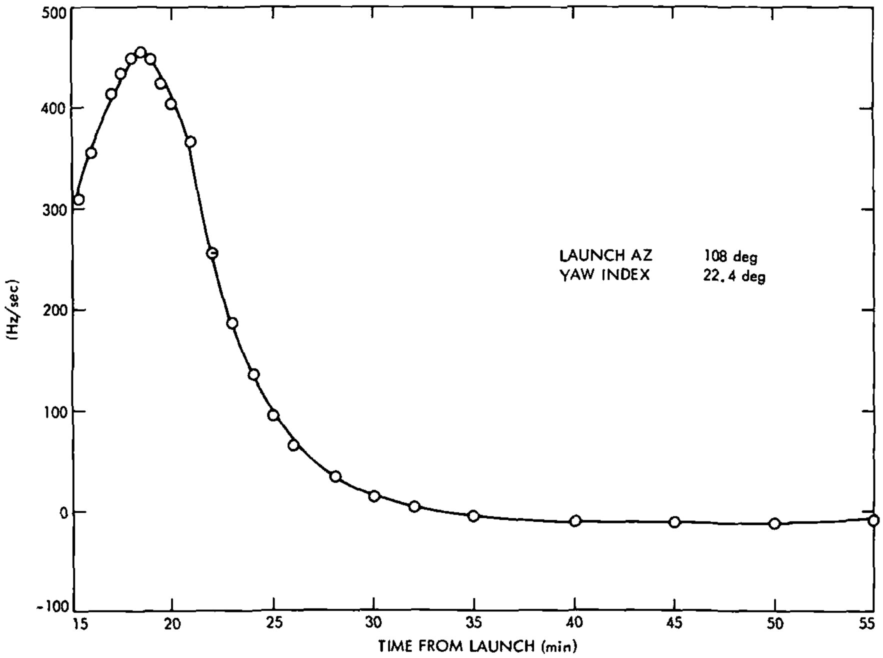


Fig. 80. Initial pass two-way doppler rates, ACN

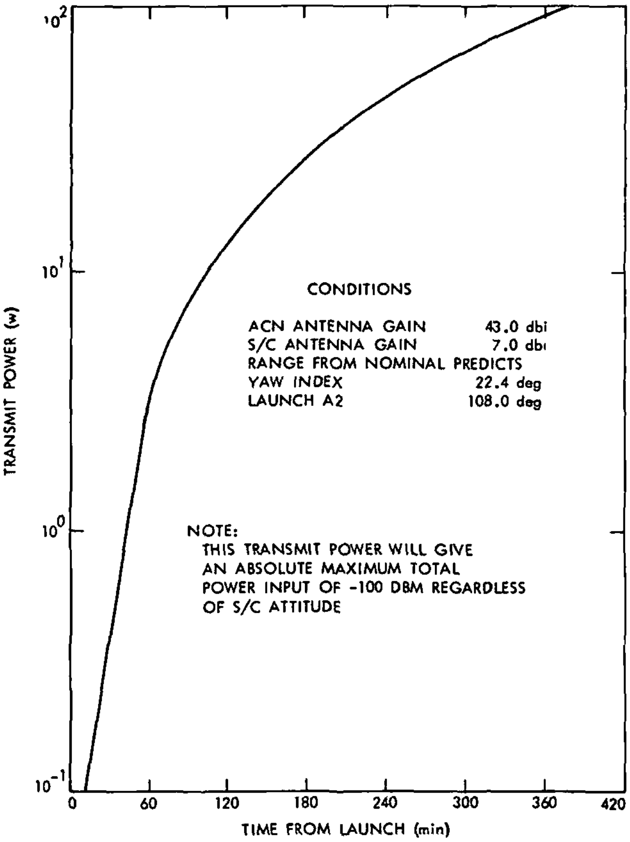
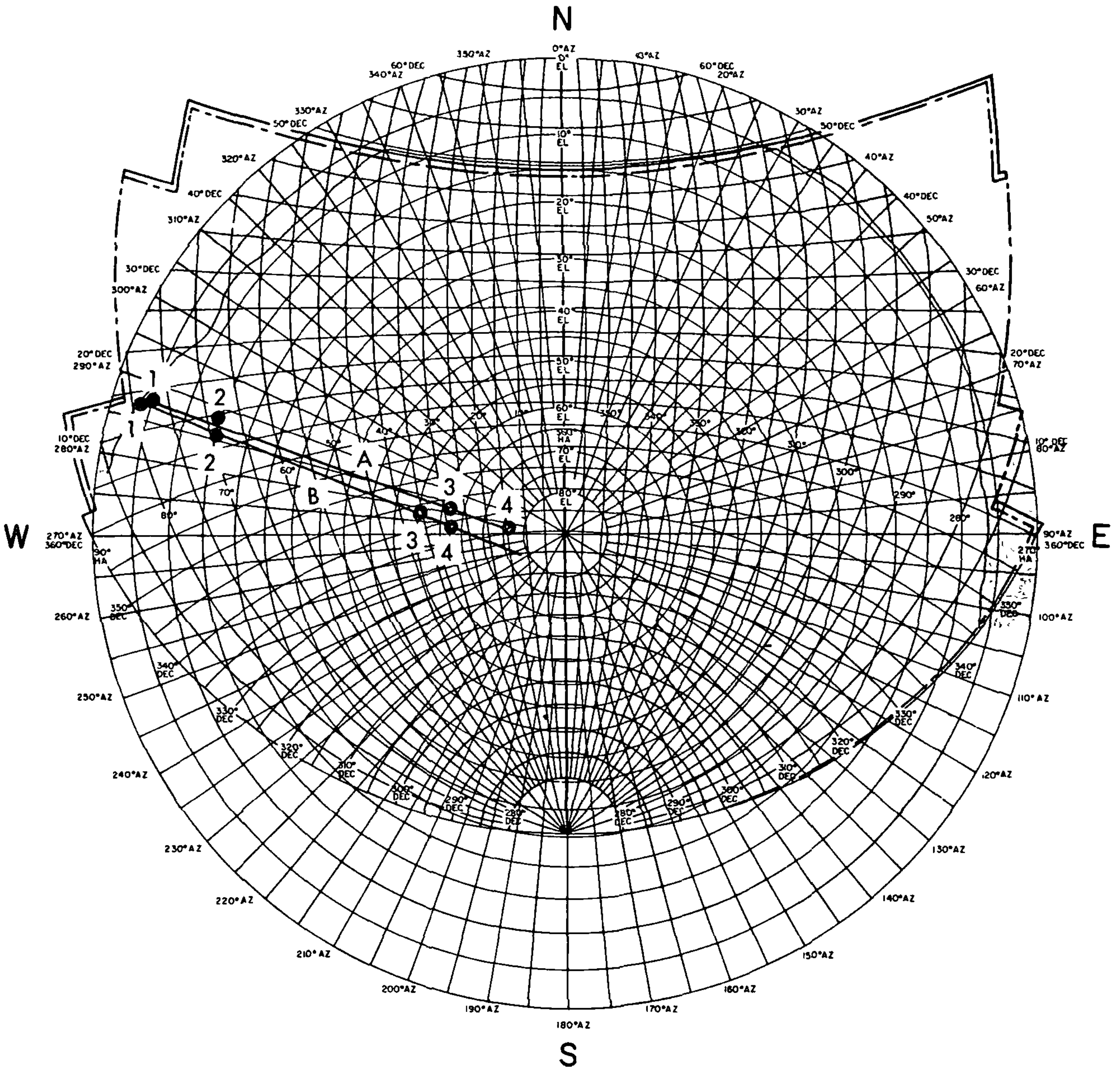


Fig. 81. Worst-case transmit power profile, ACN



TRAJECTORY	POINT	EVENT	TIME FROM LAUNCH (*min/sec*)
A	1	S/C RISE	23:00
A	2	EARLIEST POSSIBLE ACQ	24:30
A	3	LATEST POSSIBLE ACQ	44:00
A	4	DATA REQUIREMENT MET	54:00
B	1	S/C RISE	23:07
B	2	EARLIEST POSSIBLE ACQ	25:30
B	3	LATEST POSSIBLE ACQ	45:00
B	4	DATA REQUIREMENT MET	55:00

Fig. 82. DSS 51 azimuth, elevation, and hour-angle declination

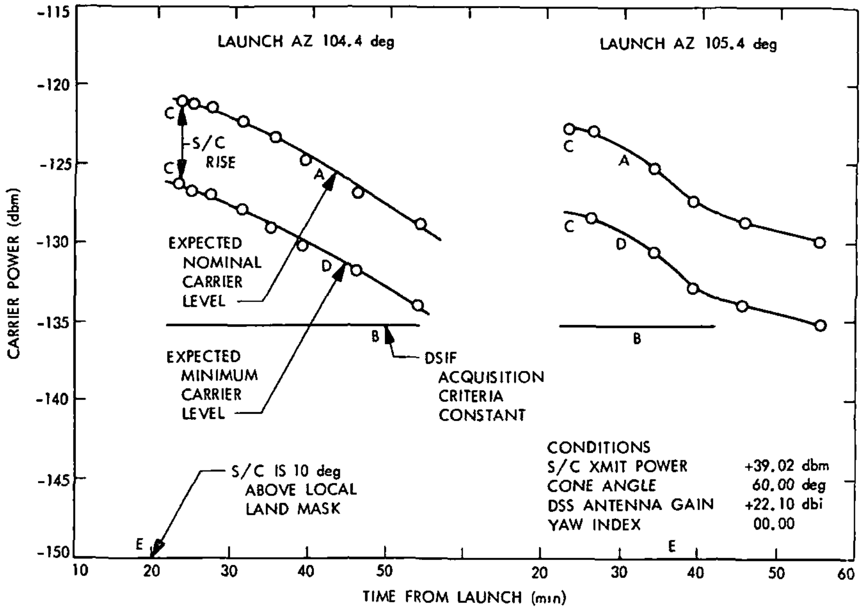


Fig. 83. Nominal and minimum carrier levels, DSS 51, for Mariner VII, 60-deg cone

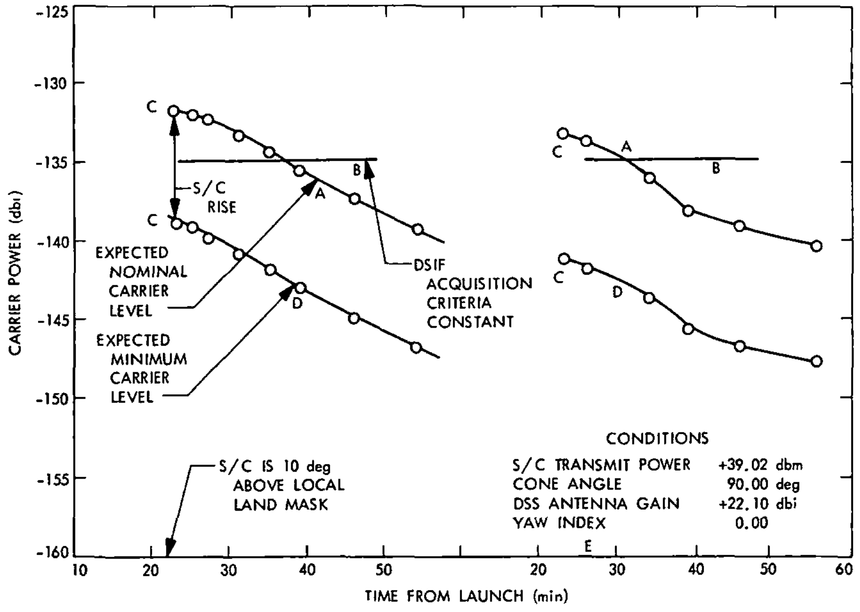


Fig. 84. Nominal and minimum carrier levels, DSS 51, for Mariner VII, 90-deg cone

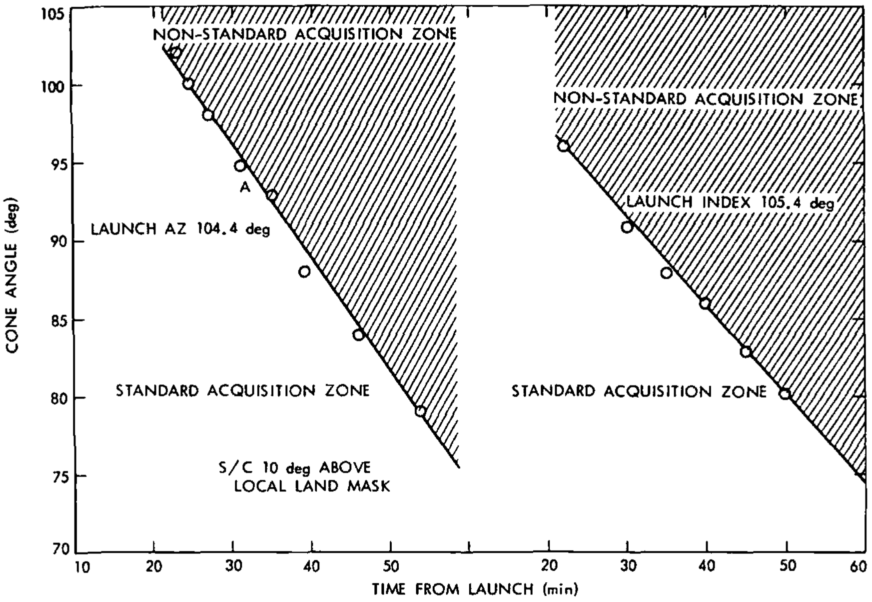


Fig. 85. Nominal allowable cone angle for -135 dBm signal, yaw index nil

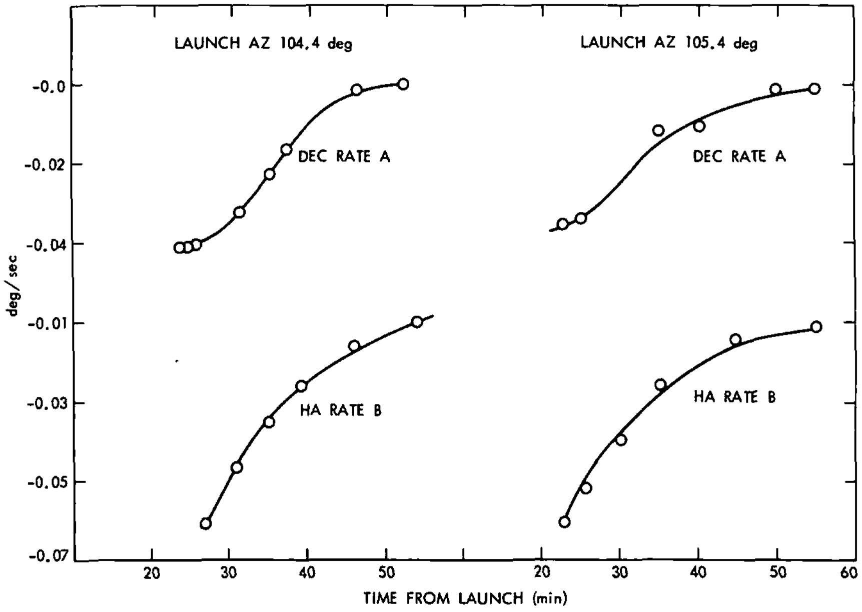


Fig. 86. DSS 51 initial pass-angle tracking rates, yaw index nil

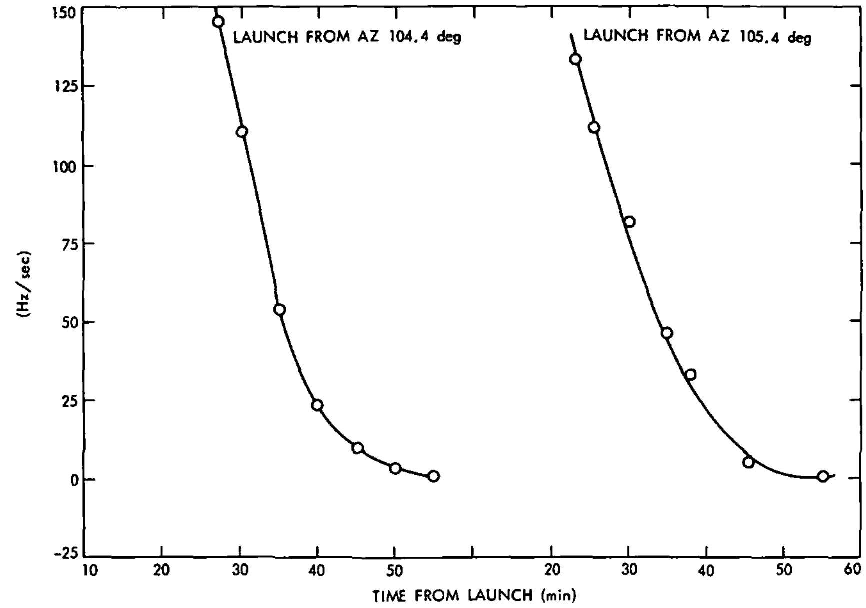


Fig. 87. DSS 51 initial pass two-way doppler rates, yaw index nil

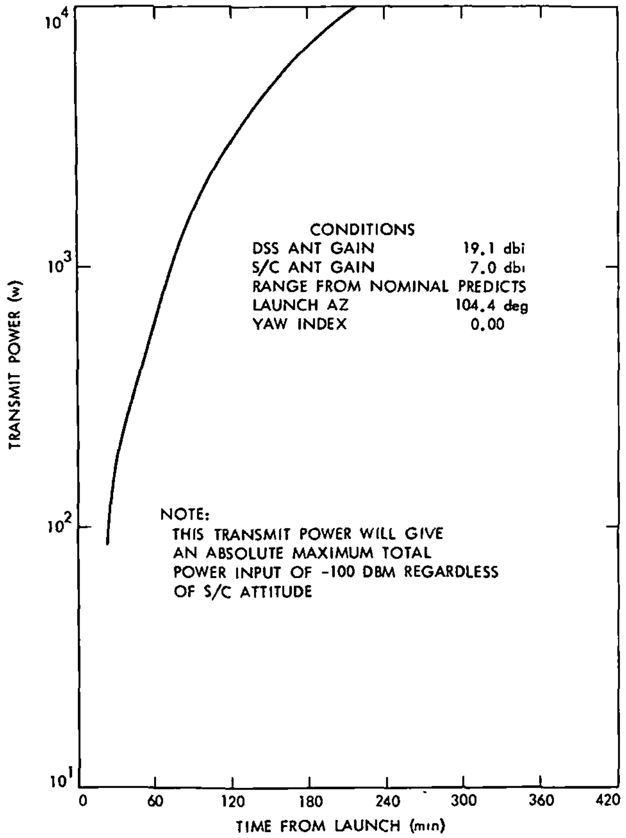
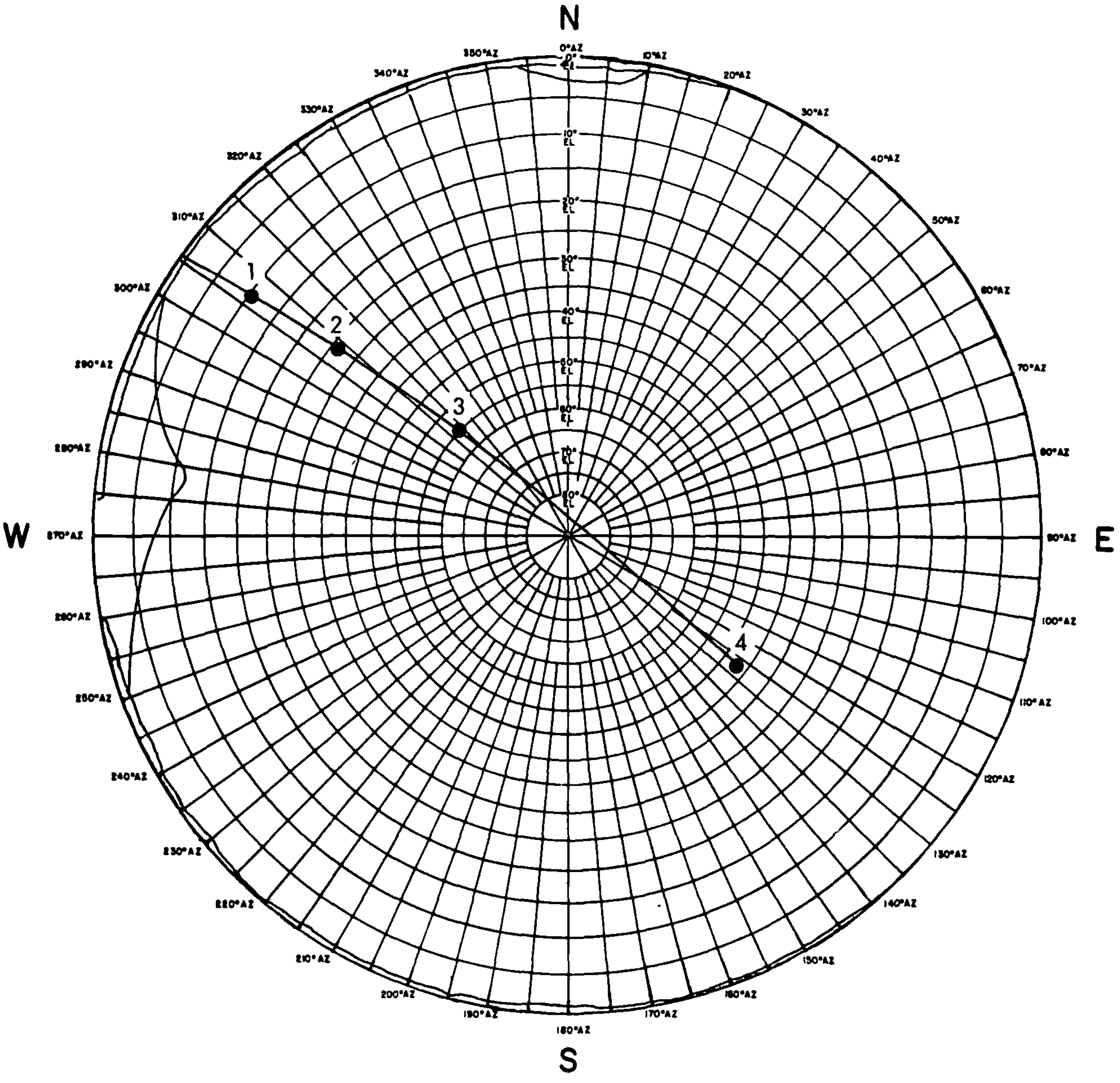
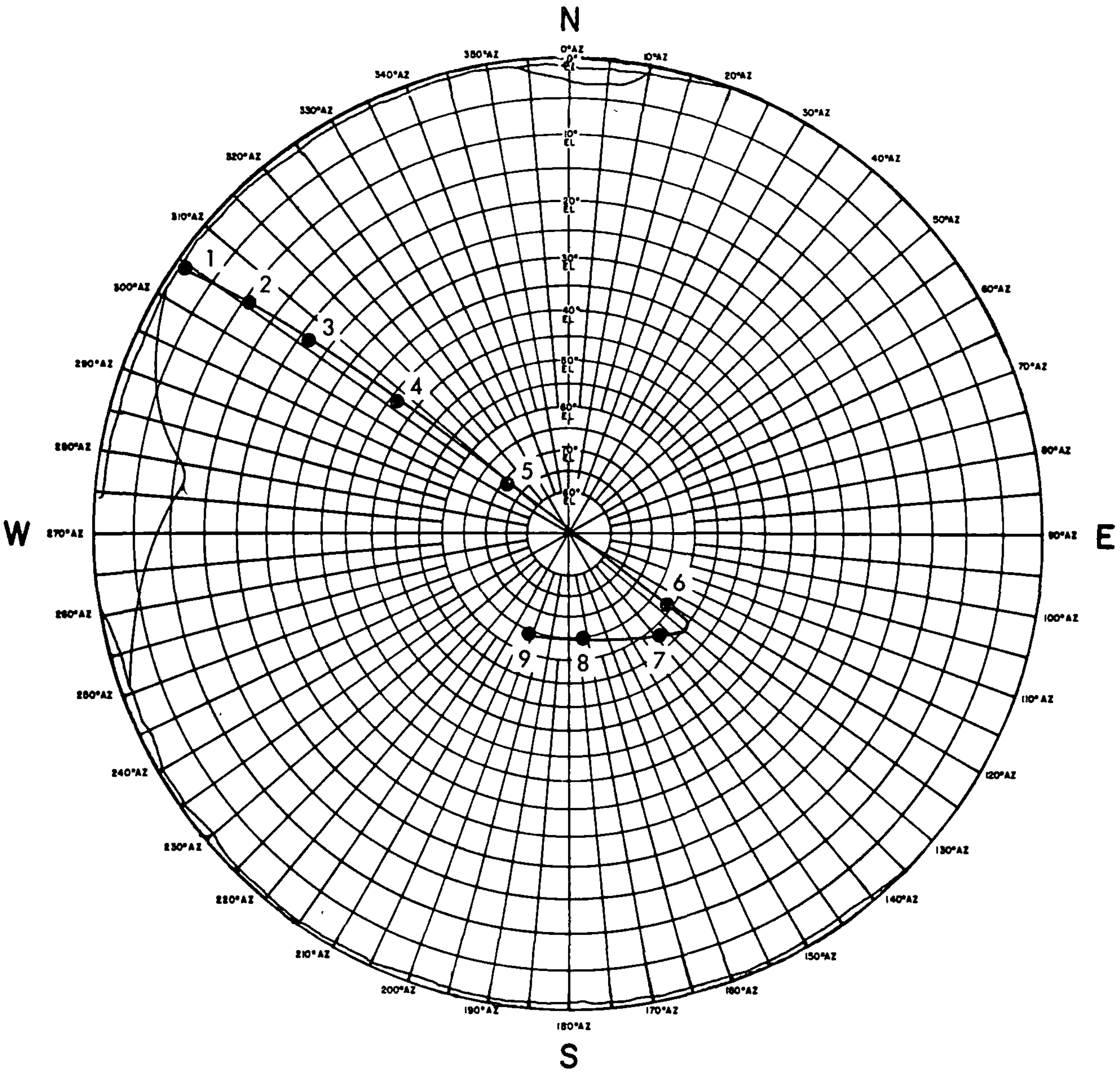


Fig. 88. Worst-case ground transmit power, DSS 51



POINTS	1	2	3	4
TFL (min/sec)	16:00	17:00	19:00	102:00

Fig. 89. Station view ACN, window open



POINTS	1	2	3	4	5	6	7	8	9
TFL (min)	14:05	16	17	19	22	43	222	287	372

Fig. 90. Station view ACN, window-closed

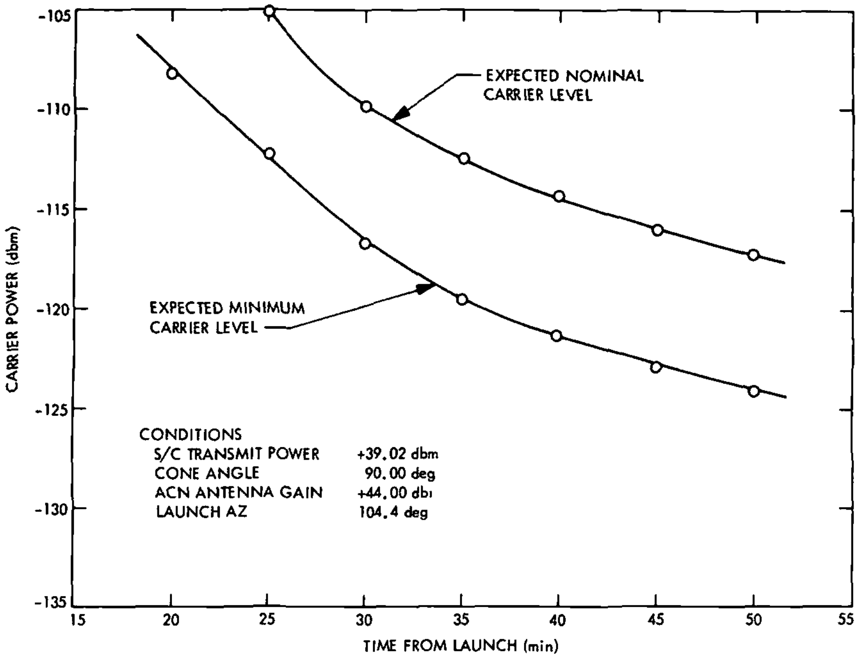


Fig. 91. Nominal and minimum carrier levels, ACN, window open

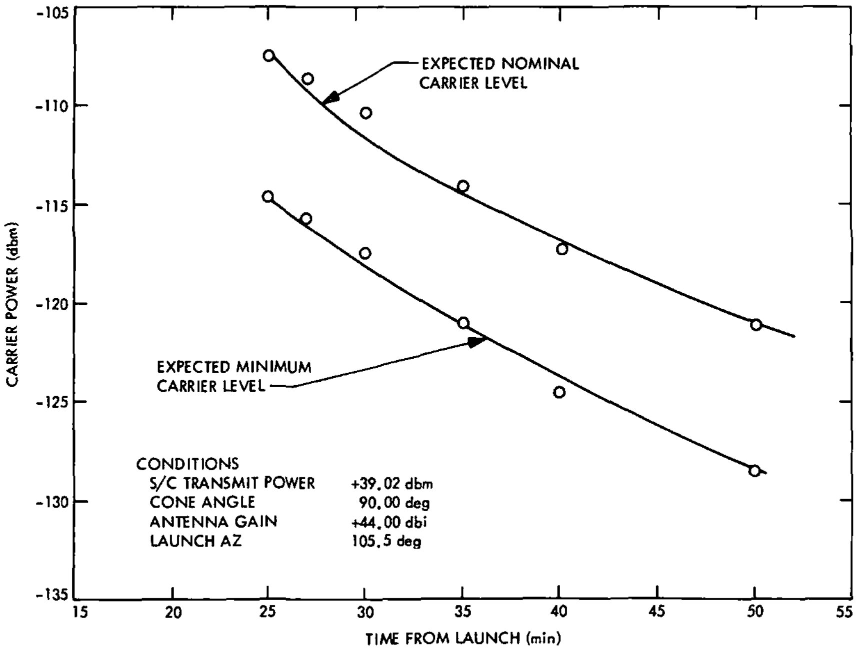


Fig. 92. Nominal and minimum carrier levels, ACN, window closed

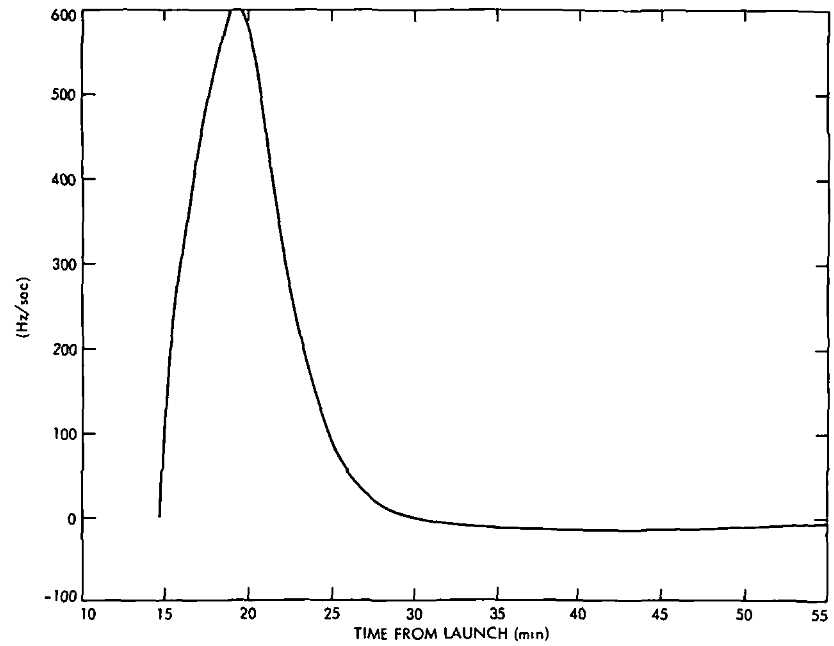


Fig. 93. Initial pass two-way doppler rates, ACN, window open

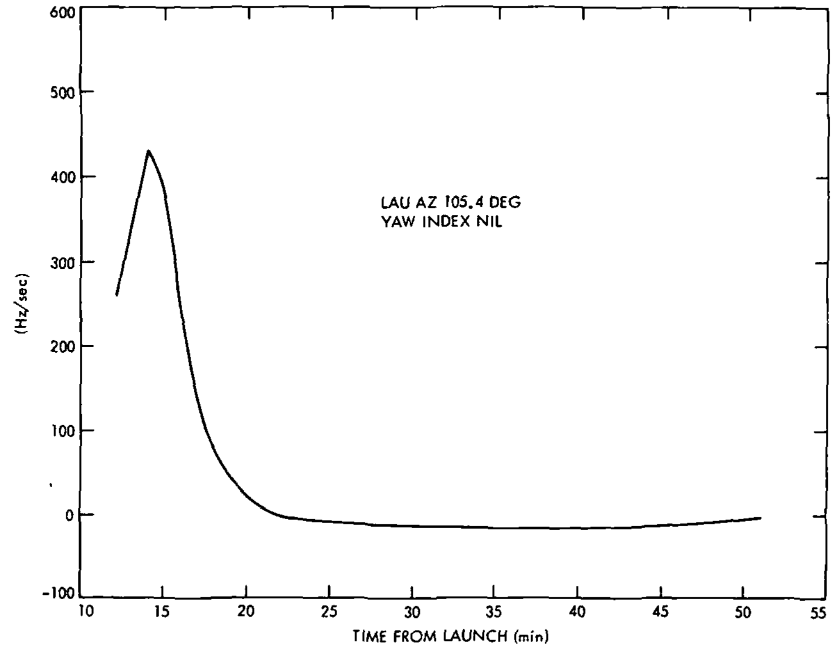
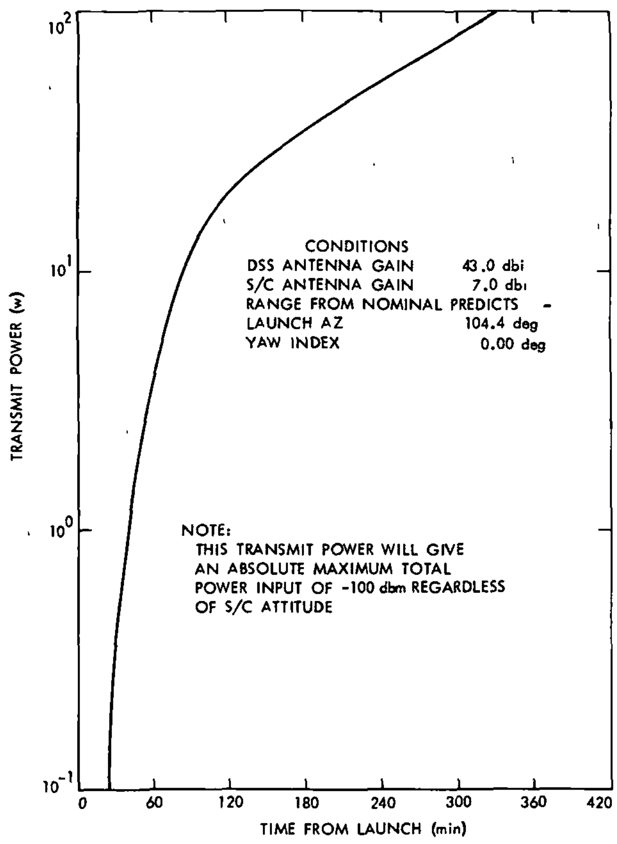


Fig. 94. Initial pass two-way doppler rates, ACN, window closed

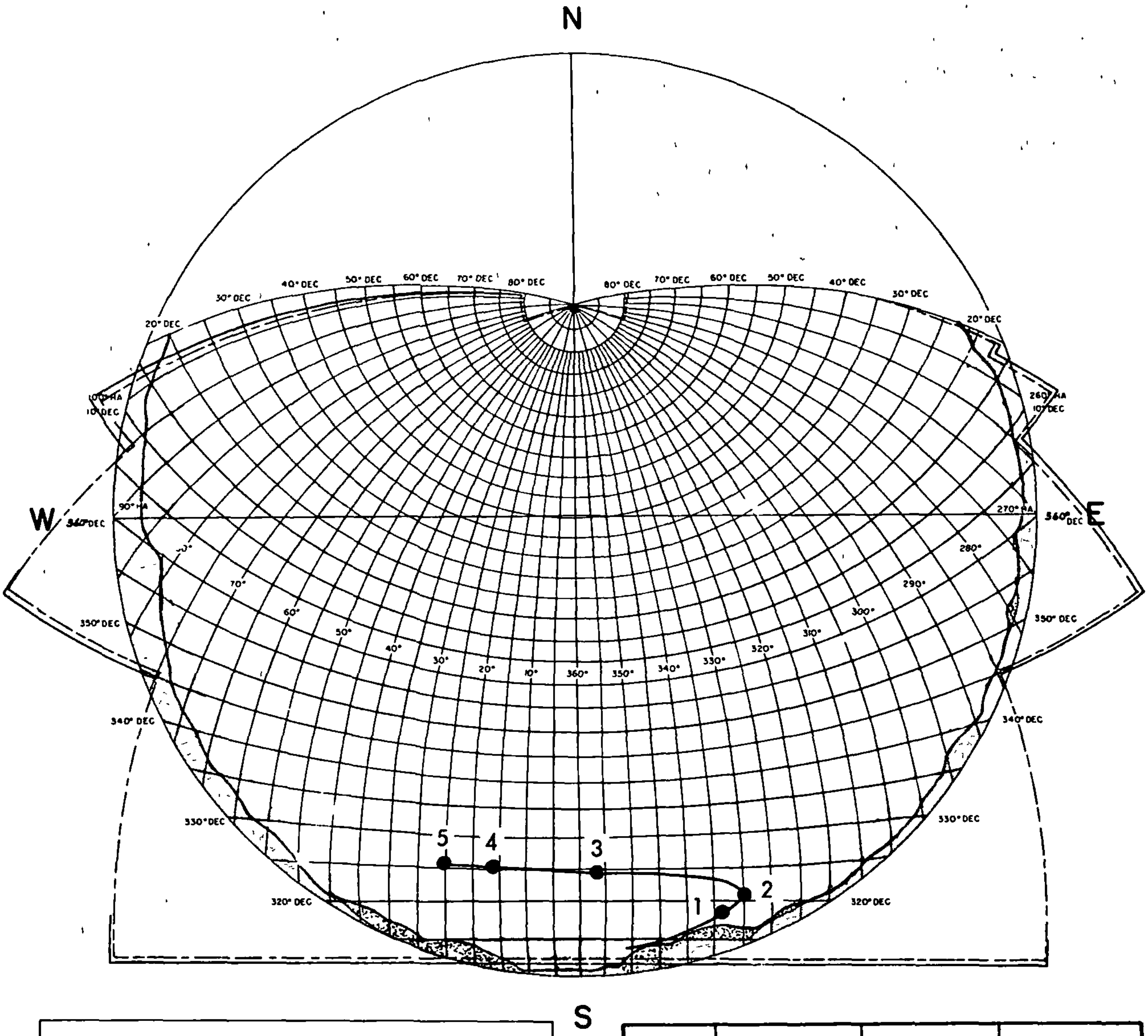


CONDITIONS

DSS ANTENNA GAIN	43.0 dbi
S/C ANTENNA GAIN	7.0 dbi
RANGE FROM NOMINAL PREDICTS	-
LAUNCH AZ	104.4 deg
YAW INDEX	0.00 deg

NOTE:
THIS TRANSMIT POWER WILL GIVE AN ABSOLUTE MAXIMUM TOTAL POWER INPUT OF -100 dbm REGARDLESS OF S/C ATTITUDE

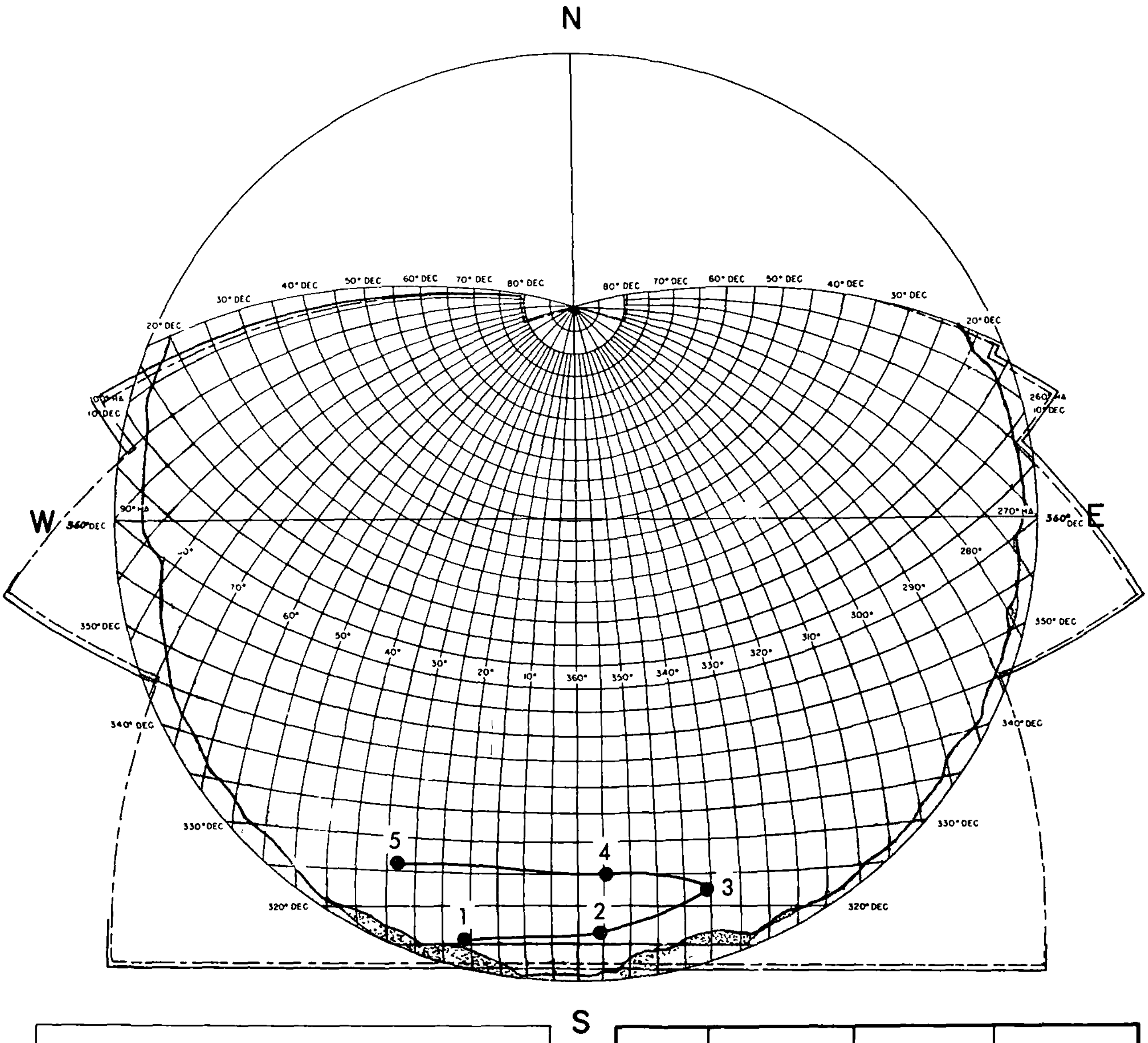
Fig. 95. Maximum permissible ground transmit power



ANTENNA LIMITS					
DEC	PRE	FINAL	HA	PRE	FINAL
DN	088 854	089 480	H1E	284 794	284 316
D2E	079 288	079 288	H2E	255 942	255 470
D3E	017 528	017 010	H3E	257 528	256 934
D4E	007 908	007 368	H4E	265 278	264 778
D5E	345 494	344 954	H5E	SAME AS	H1E
D2W	SAME AS	D2E	H1W	074 560	074 976
D3W	SAME AS	D4E	H2W	101 598	102 176
D4W	SAME AS	D5E	H3W	094 530	094 990
DS	312 420	311 984	H4W	SAME AS	H1W

POINT	TIME FROM LAUNCH (min/sec)	90° CONE (dbm)	60° CONE (dbm
1	52	108.03	97.00
2	77	113.84	99.50
3	252	123.10	113.3
4	342	125.36	114.46
5	372	126.12	115.42

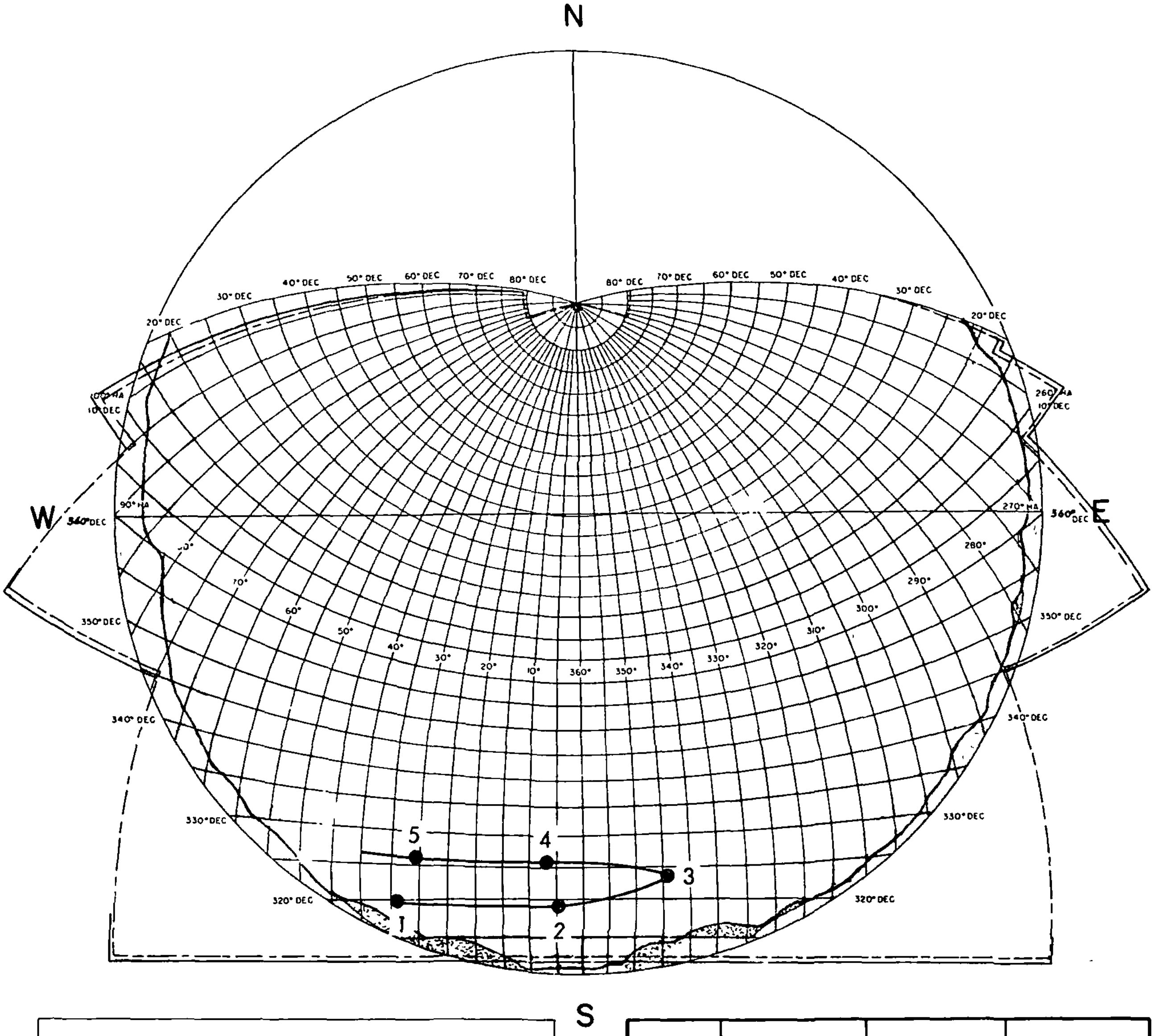
Fig. 96. Spacecraft hour angle-declination groundtrack DSS 51, window-open launch



ANTENNA LIMITS					
DEC	PRE	FINAL	HA	PRE	FINAL
DN	088 854	089 480	H1E	284 794	284 316
D2E	079 288	079 288	H2E	255 942	255 470
D3E	017 528	017 010	H3E	257 528	256 934
D4E	007 908	007 368	H4E	265 278	264 778
D5E	345 494	344 954	H5E	SAME AS	H1E
D2W	SAME AS	D2E	H1W	074 560	074 976
D3W	SAME AS	D4E	H2W	101 598	102 176
D4W	SAME AS	D5E	H3W	094 530	094 990
DS	312 420	311 984	H4W	SAME AS	H1W

POINT	TIME FROM LAUNCH (min/sec)	90° CONE (dbm)	60° CONE (dbm)
1	22:40	102.5	91.30
2	32:00	105.55	94.80
3	62:00	115.59	100.84
4	202:00	121.45	110.7
5	372:00	126.19	115.44

Fig. 97. Spacecraft hour angle-declination groundtrack DSS 51, midwindow launch



ANTENNA LIMITS					
DEC	PRE	FINAL	HA	PRE	FINAL
DN	088 854	089 480	H1E	284 794	284 316
D2E	079 288	079 288	H2E	255 942	255 470
D3E	017 528	017 010	H3E	257 528	256 934
D4E	007 908	007 368	H4E	265 278	264 778
D5E	345 494	344 954	H5E	SAME AS	H1E
D2W	SAME AS	D2E	H1W	074 560	074 976
D3W	SAME AS	D4E	H2W	101 598	102 176
D4W	SAME AS	D5E	H3W	094 530	094 990
DS	312 420	311 984	H4W	SAME AS	H1W

POINT	TIME FROM LAUNCH (min/sec)	90° CONE (dbm)	60° CONE (dbm)
1	20:51	101.26	90.56
2	30:00	105.3	94.60
3	67:00	110.66	99.96
4	222:00	118.48	107.78
5	332:00	122.86	112.16

Fig. 98. Spacecraft hour angle-declination groundtrack DSS 51, window-close launch

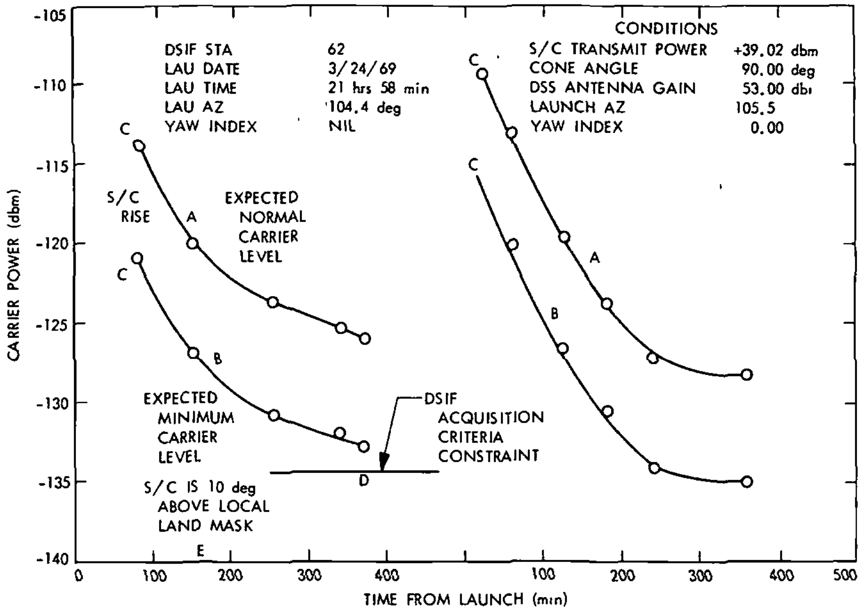


Fig. 99. Nominal and minimum carrier levels, DSS 62, window-open launch

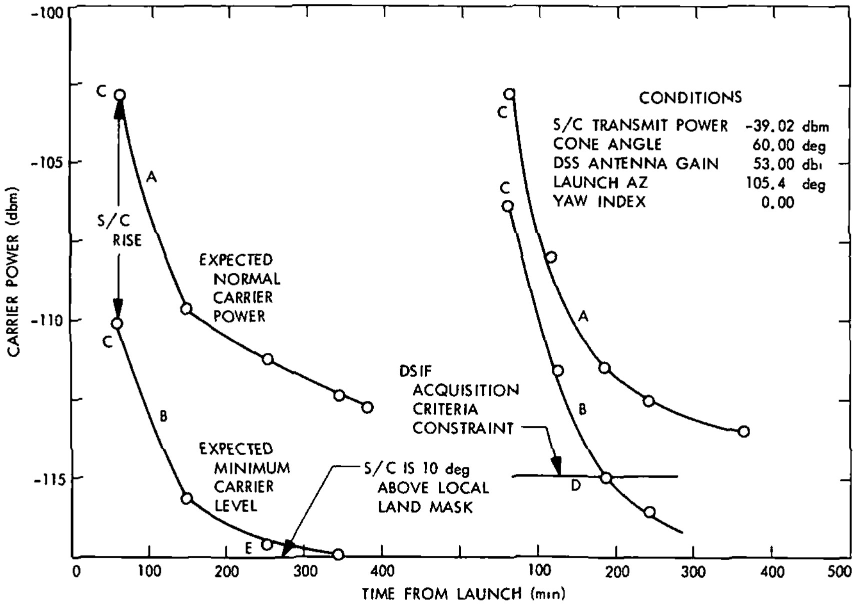


Fig. 100. Nominal and minimum carrier levels, DSS 62, window-close launch

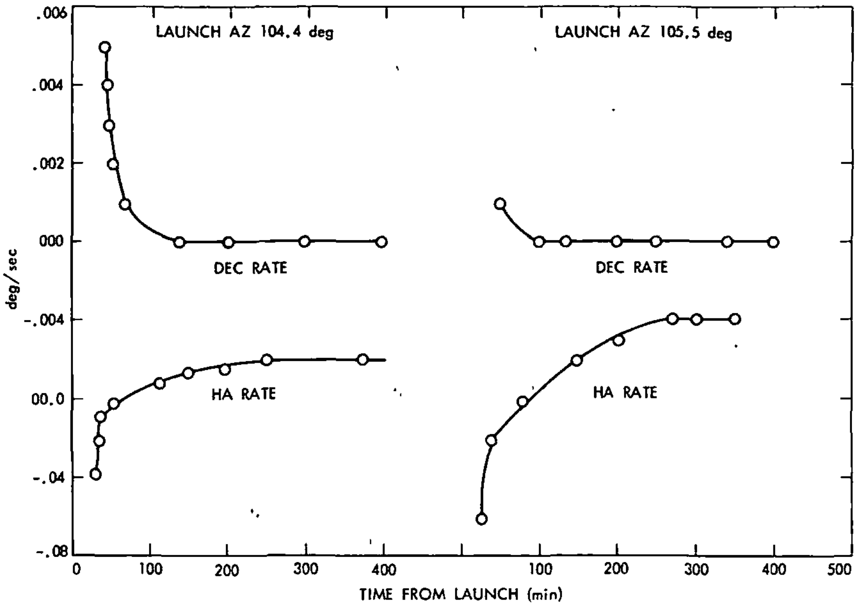


Fig. 101. Initial pass-angle tracking rates, DSS 62

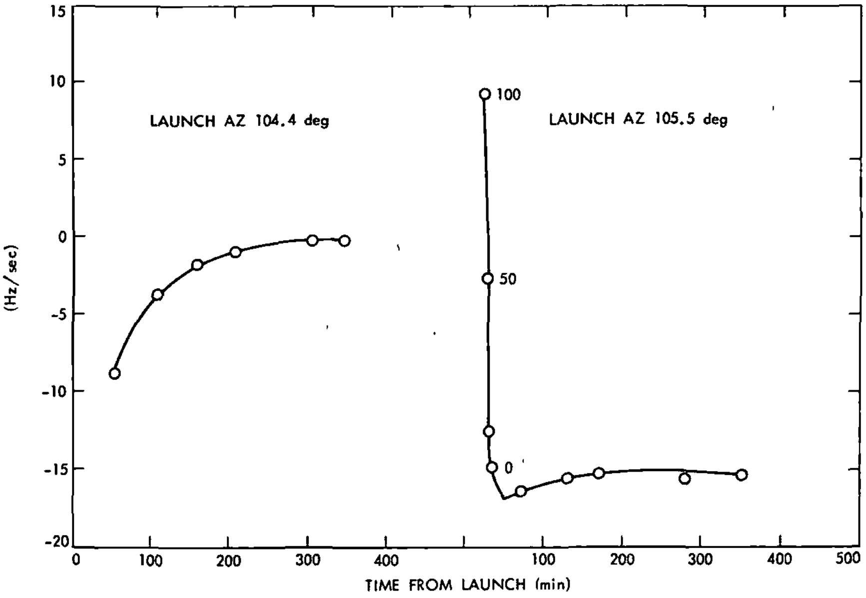


Fig. 102. Initial pass two-way doppler rates, DSS 62, yaw index nil

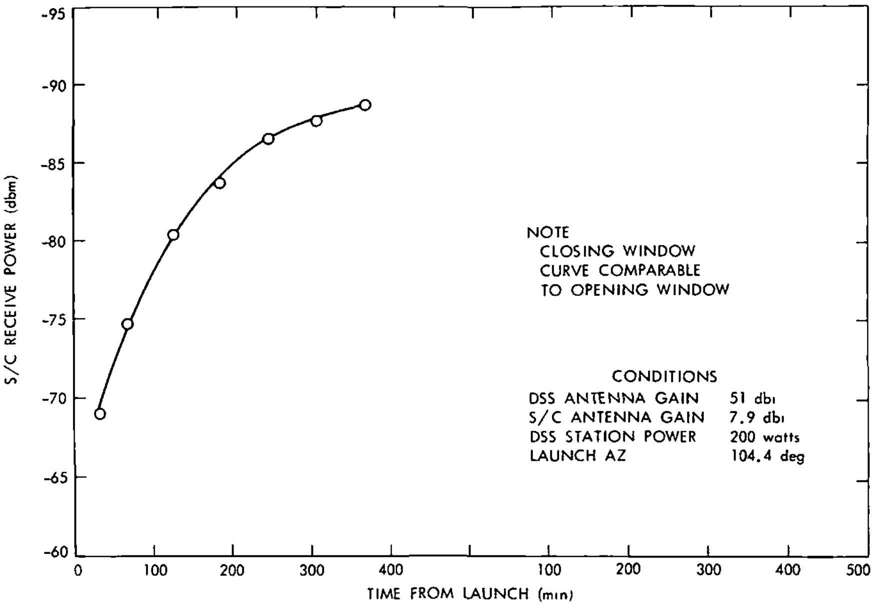


Fig. 103. Maximum allowable ground transmit power, DSS 62

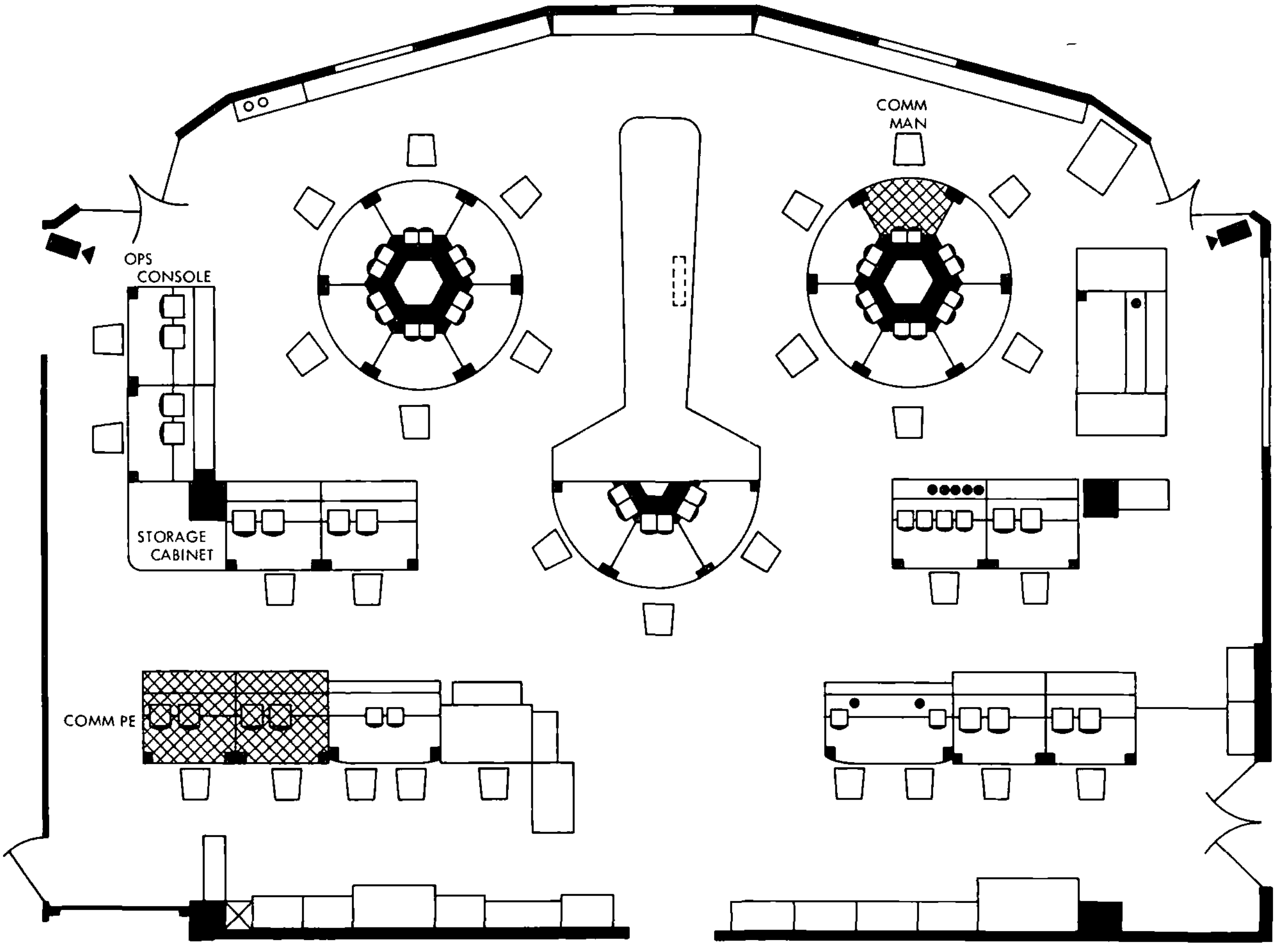


Fig. 104. GCF operations control positions

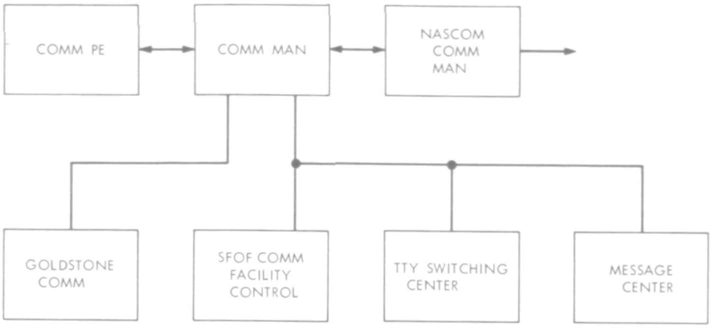


Fig. 105. Control of communications activities

Fig. 106. Mariner Mars 1969 SPAC

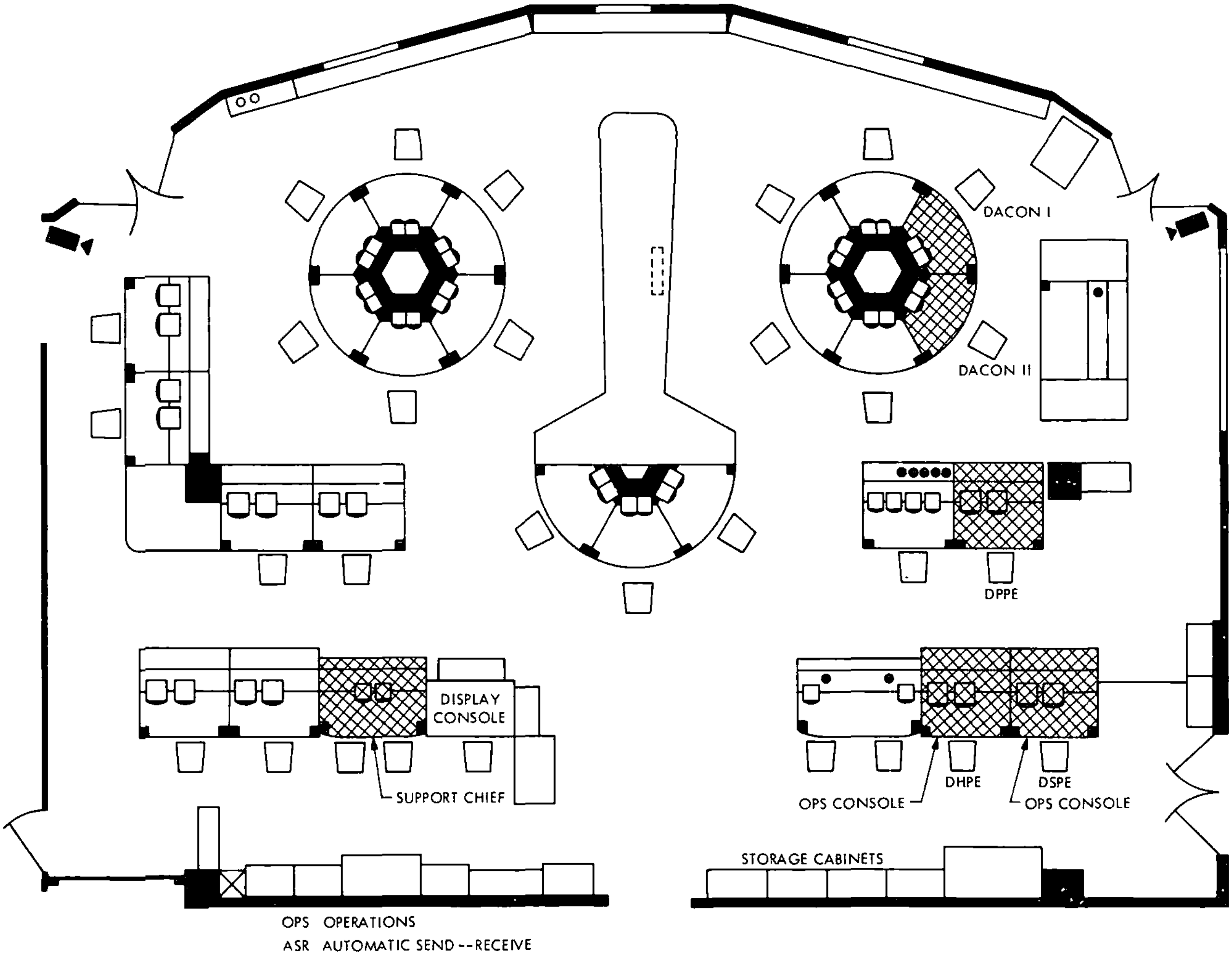


Fig. 107. SFOF operations control positions

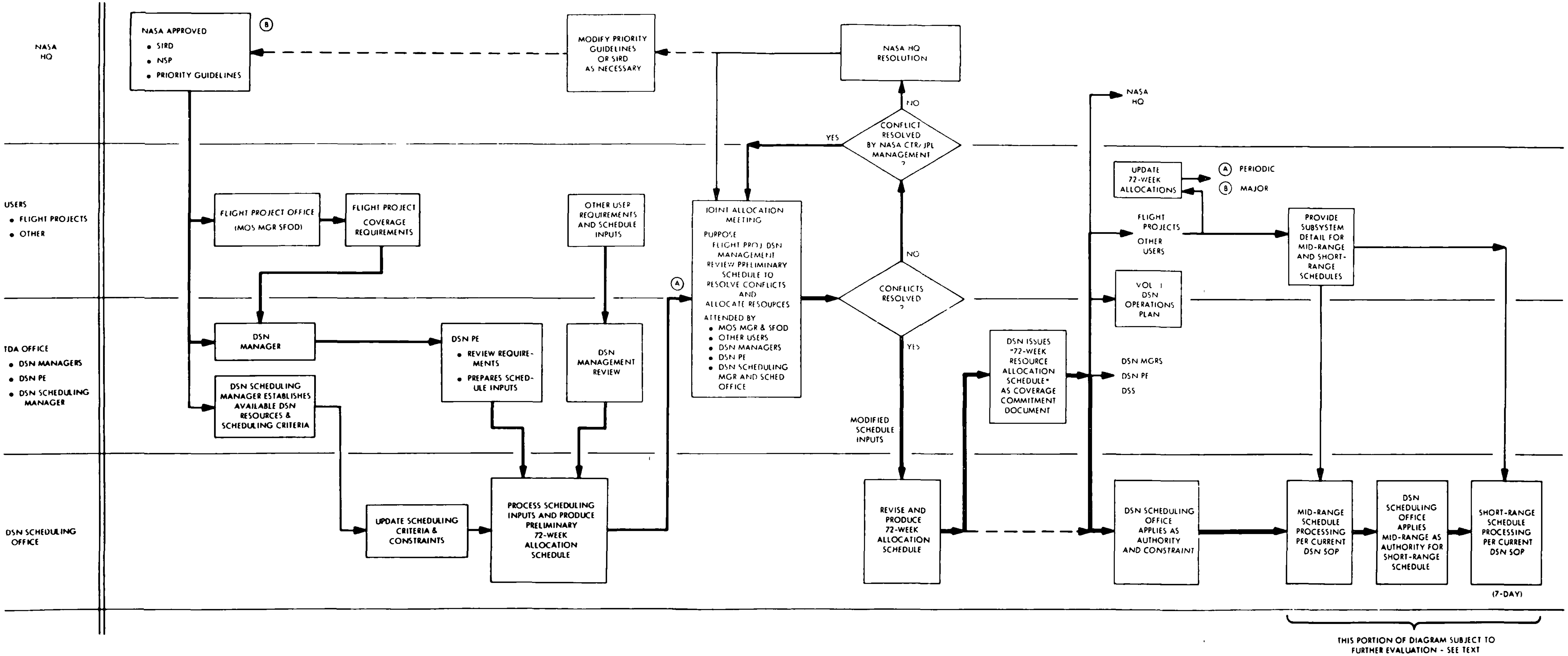


Fig. 108. Network allocation scheduling flow

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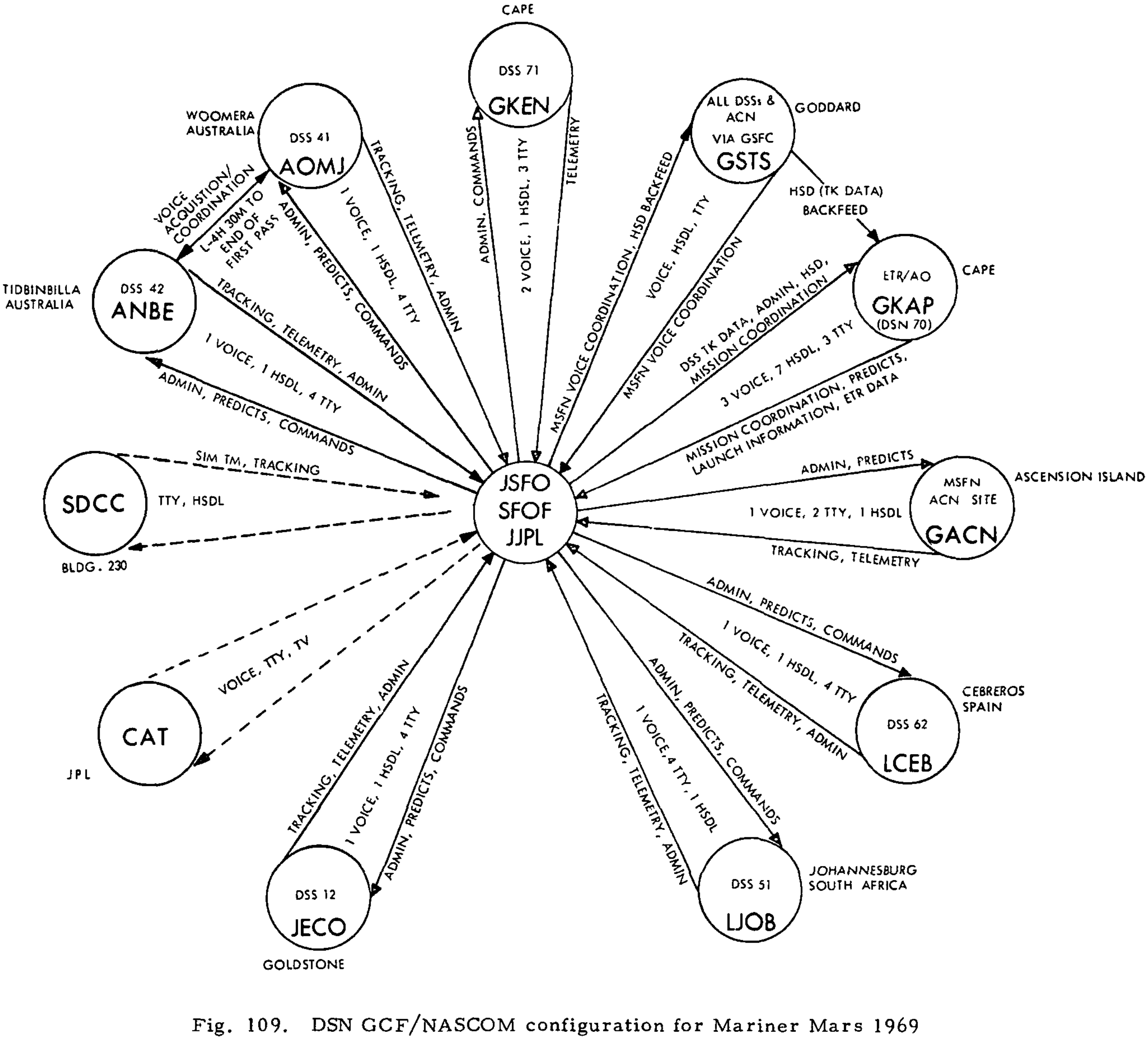

Fig. 109. DSN GCF/NASCOM configuration for Mariner Mars 1969

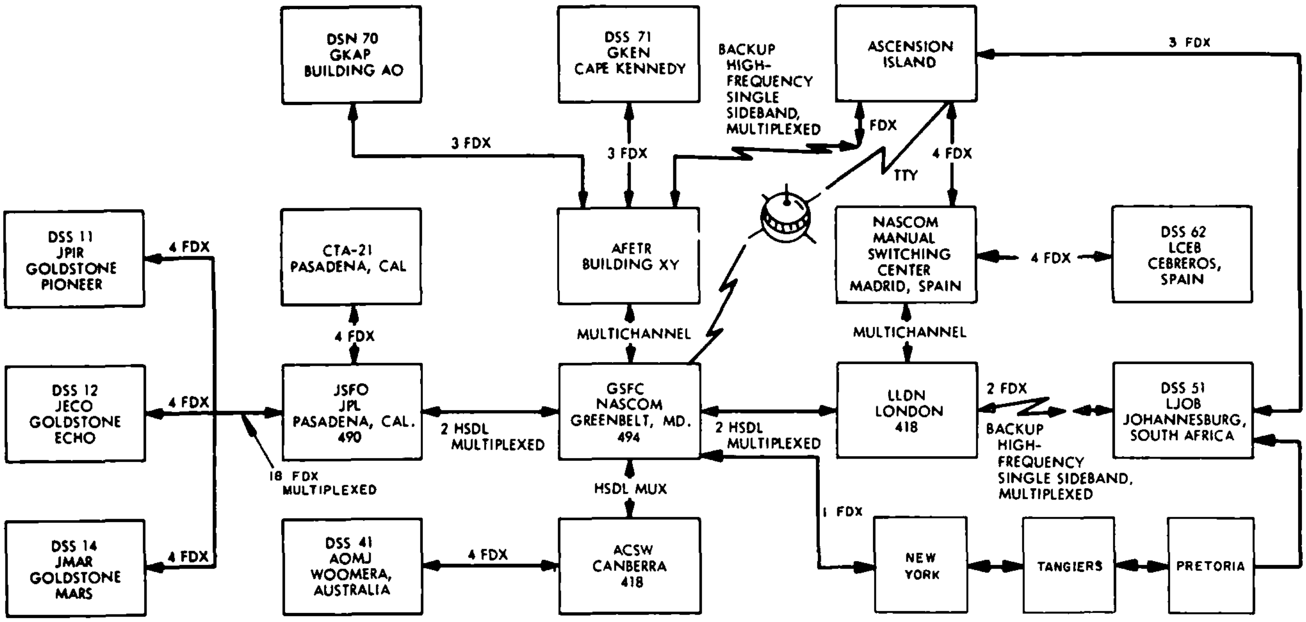

Fig. 110. GCF teletype configuration

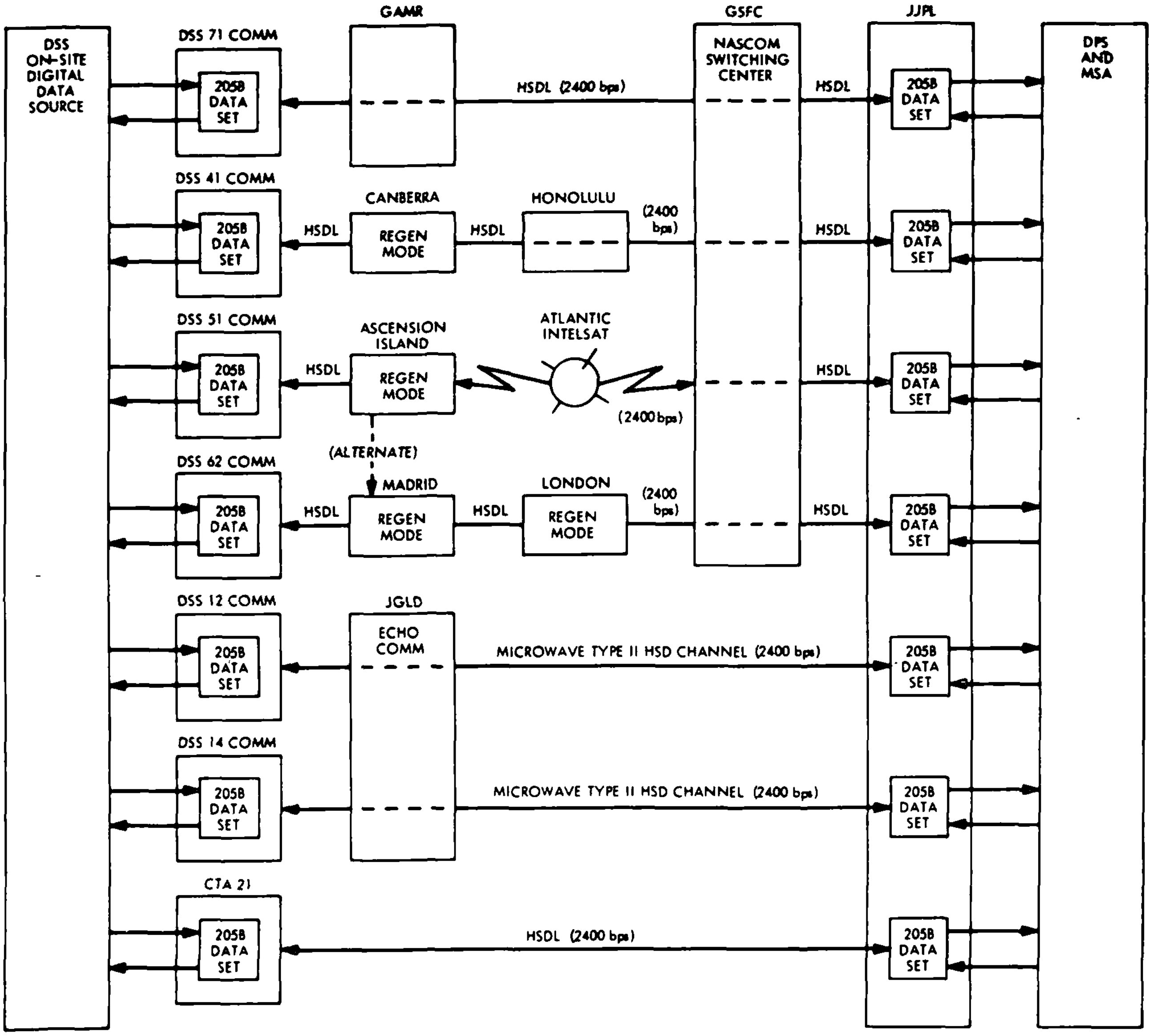

Fig. 111. GCF HSD configuration

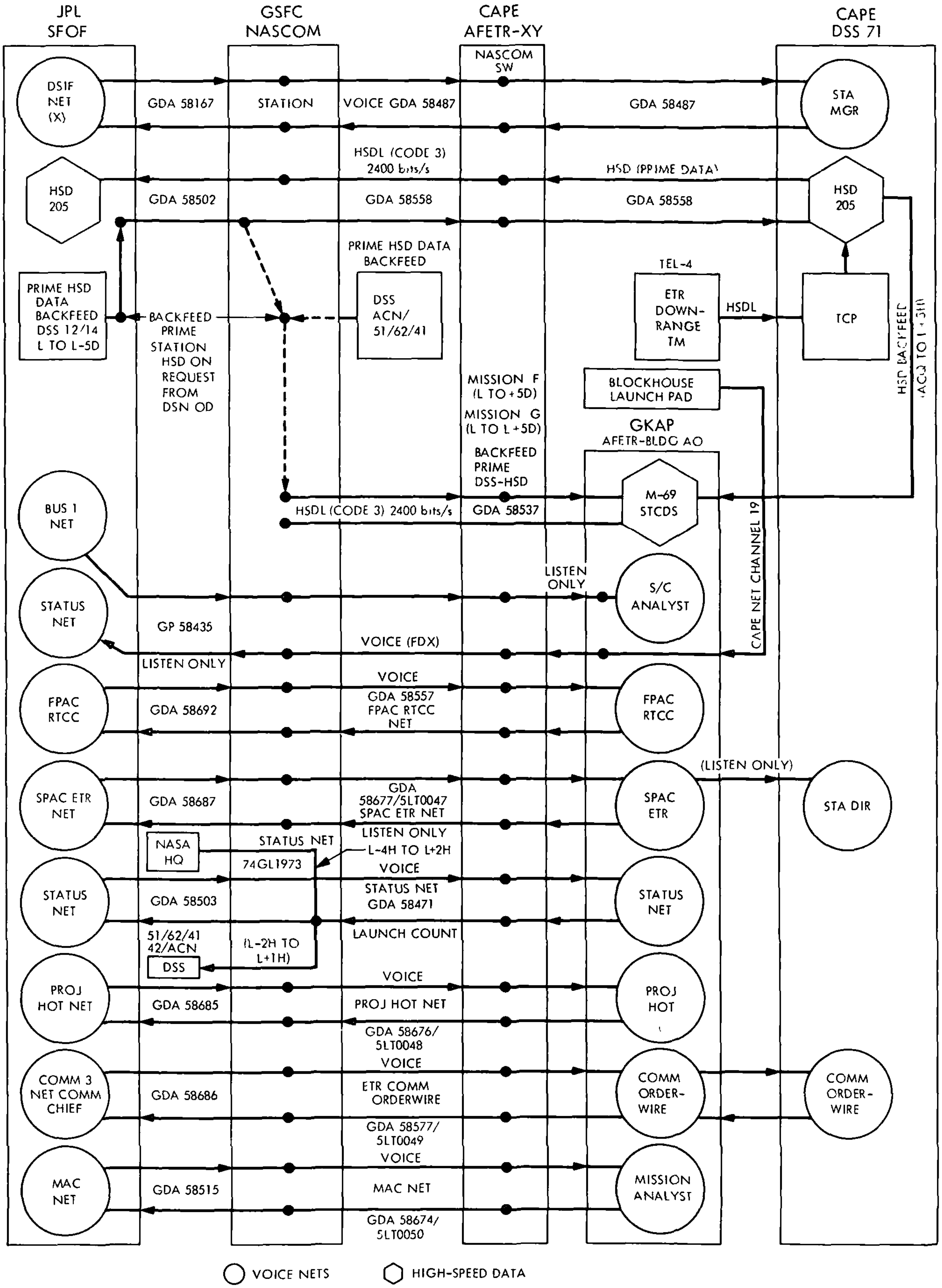

Fig. 112. Launch support configuration involving facilities at Cape Kennedy and the SFOF in Pasadena

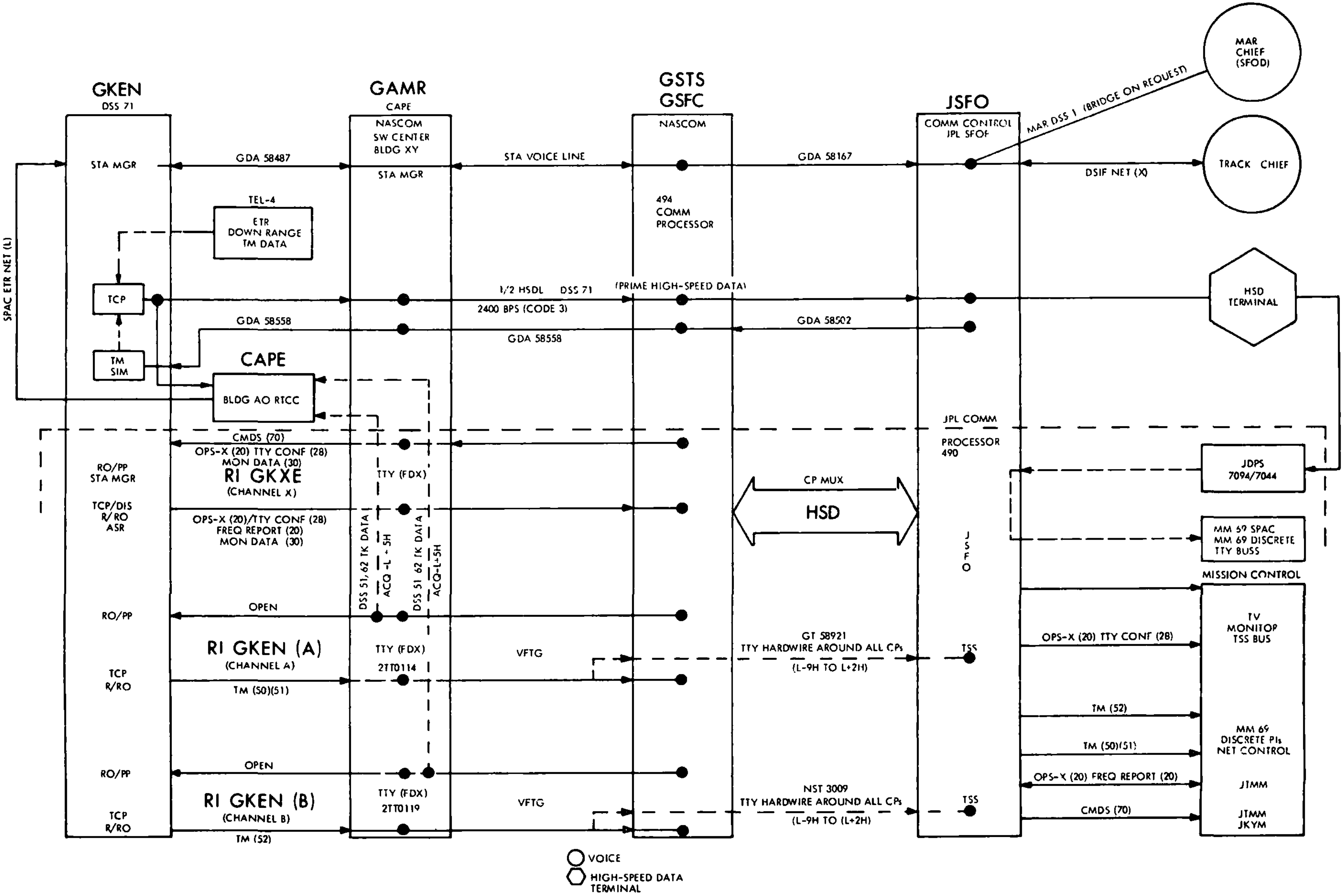

Fig. 113. Launch support configuration involving DSS 71 and SFOF

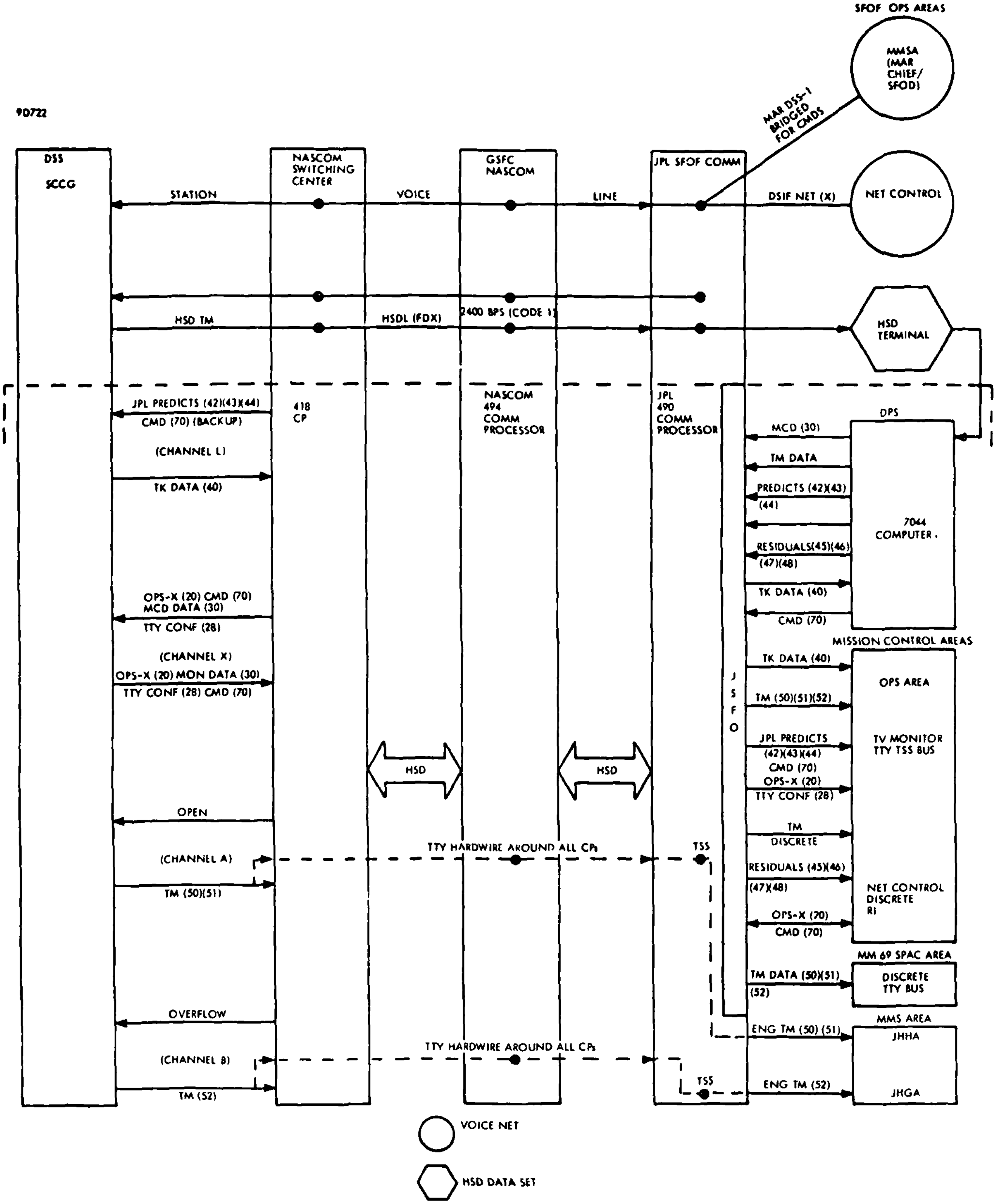

Fig. 114. Typical launch and cruise phase ground communication configuration to a DSS

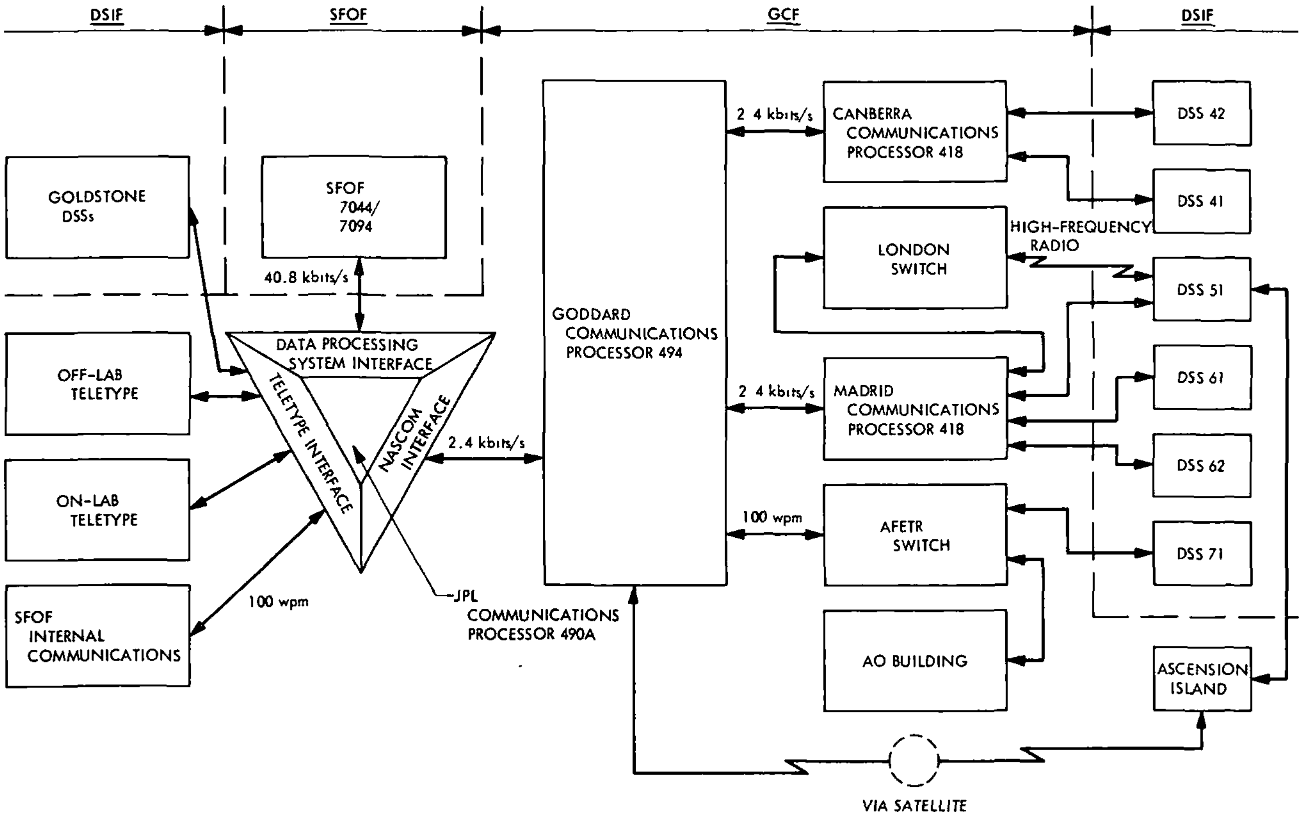

Fig. 115. CP/DSN interface

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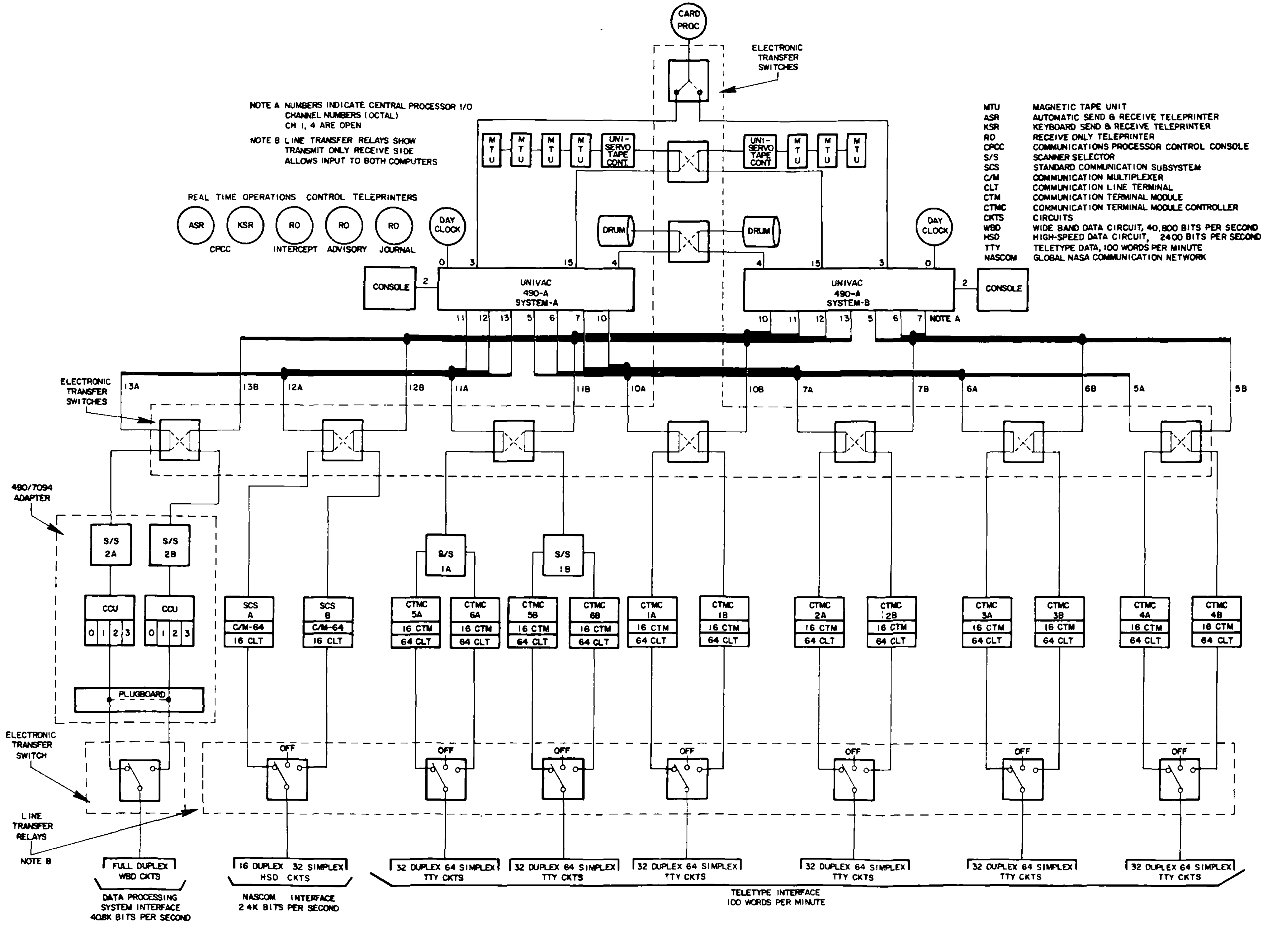
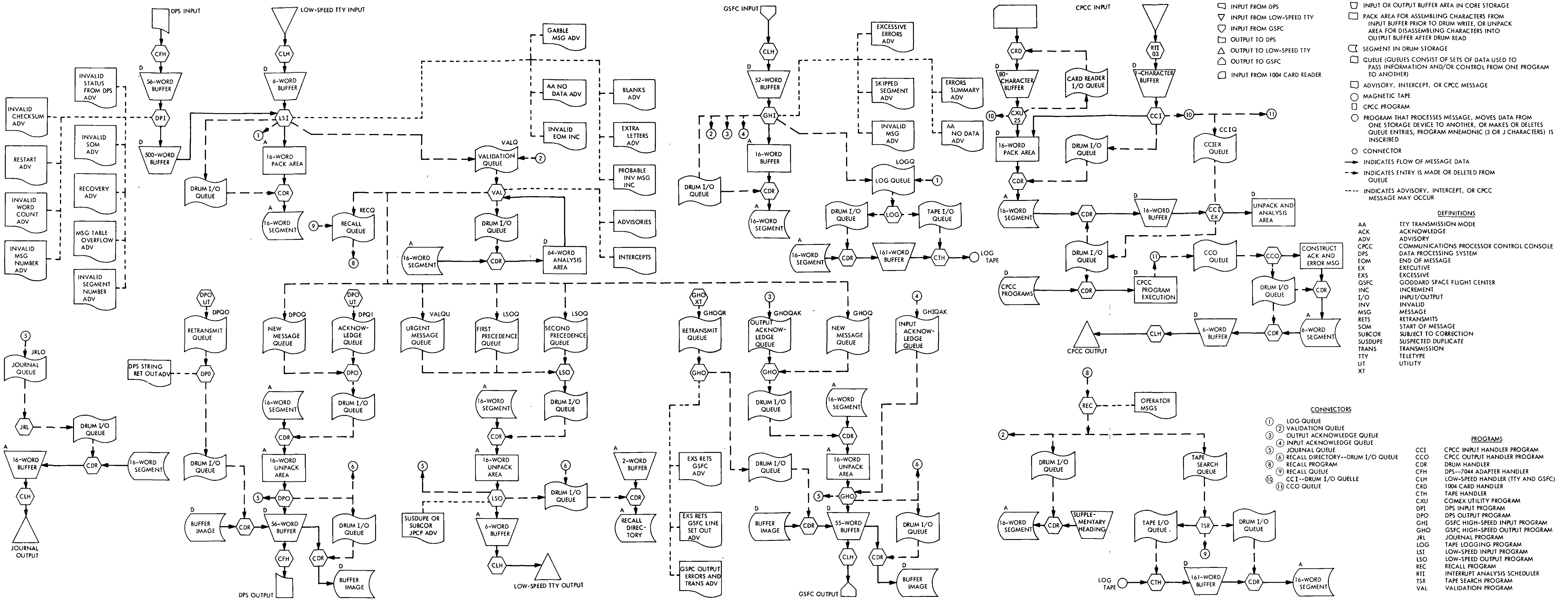


Fig. 116. CP equipment block diagram



- ⌑ INPUT FROM DPS
- ▽ INPUT FROM LOW-SPEED TTY
- ▽ INPUT FROM GSFC
- ☐ OUTPUT TO DPS
- △ OUTPUT TO LOW-SPEED TTY
- ⌂ OUTPUT TO GSFC
- ☐ INPUT FROM 1004 CARD READER

- ▽ INPUT OR OUTPUT BUFFER AREA IN CORE STORAGE
- ☐ PACK AREA FOR ASSEMBLING CHARACTERS FROM INPUT BUFFER PRIOR TO DRUM WRITE, OR UNPACK AREA FOR DISASSEMBLING CHARACTERS INTO OUTPUT BUFFER AFTER DRUM READ
- ☐ SEGMENT IN DRUM STORAGE
- ☐ GUEUE (GUEUES CONSIST OF SETS OF DATA USED TO PASS INFORMATION AND/OR CONTROL FROM ONE PROGRAM TO ANOTHER)
- ☐ ADVISORY, INTERCEPT, OR CPCC MESSAGE
- ○ MAGNETIC TAPE
- ☐ CPCC PROGRAM
- ⬡ PROGRAM THAT PROCESSES MESSAGE, MOVES DATA FROM ONE STORAGE DEVICE TO ANOTHER, OR MAKES OR DELETES QUEUE ENTRIES, PROGRAM MNEMONIC (3 OR J CHARACTERS) IS INSCRIBED
- ○ CONNECTOR
- → INDICATES FLOW OF MESSAGE DATA
- - → INDICATES ENTRY IS MADE OR DELETED FROM QUEUE
- ---- INDICATES ADVISORY, INTERCEPT, OR CPCC MESSAGE MAY OCCUR

DEFINITIONS

AA	TTY TRANSMISSION MODE
ACK	ACKNOWLEDGE
ADV	ADVISORY
CPCC	COMMUNICATIONS PROCESSOR CONTROL CONSOLE
DPS	DATA PROCESSING SYSTEM
EOM	END OF MESSAGE
EX	EXECUTIVE
EXS	EXCESSIVE
GSFC	GODDARD SPACE FLIGHT CENTER
INC	INCREMENT
I/O	INPUT/OUTPUT
INV	INVALID
MSG	MESSAGE
RETS	RETRANSMITS
SOM	START OF MESSAGE
SUBCOR	SUBJECT TO CORRECTION
SUSDUPE	SUSPECTED DUPLICATE
TRANS	TRANSMISSION
TTY	TELETYPE
UT	UTILITY
XT	

CONNECTORS

①	LOG QUEUE
②	VALIDATION QUEUE
③	OUTPUT ACKNOWLEDGE QUEUE
④	INPUT ACKNOWLEDGE QUEUE
⑤	JOURNAL QUEUE
⑥	RECALL DIRECTORY--DRUM I/O QUEUE
⑧	RECALL PROGRAM
⑨	RECALL QUEUE
⑩	CCI--DRUM I/O QUELLE
⑪	CCO QUEUE

PROGRAMS

CCI	CPCC INPUT HANDLER PROGRAM
CCO	CPCC OUTPUT HANDLER PROGRAM
CDR	DRUM HANDLER
CFH	DPS--7044 ADAPTER HANDLER
CLH	LOW-SPEED HANDLER (TTY AND GSFC)
CRD	1004 CARD HANDLER
CTH	TAPE HANDLER
CXU	COMEX UTILITY PROGRAM
DPI	DPS INPUT PROGRAM
DPO	DPS OUTPUT PROGRAM
GHI	GSFC HIGH-SPEED INPUT PROGRAM
GHO	GSFC HIGH-SPEED OUTPUT PROGRAM
JRL	JOURNAL PROGRAM
LOG	TAPE LOGGING PROGRAM
LSI	LOW-SPEED INPUT PROGRAM
LSO	LOW-SPEED OUTPUT PROGRAM
REC	RECALL PROGRAM
RTI	INTERRUPT ANALYSIS SCHEDULER
TSR	TAPE SEARCH PROGRAM
VAL	VALIDATION PROGRAM

Fig. 117. Communications processor data flow diagram

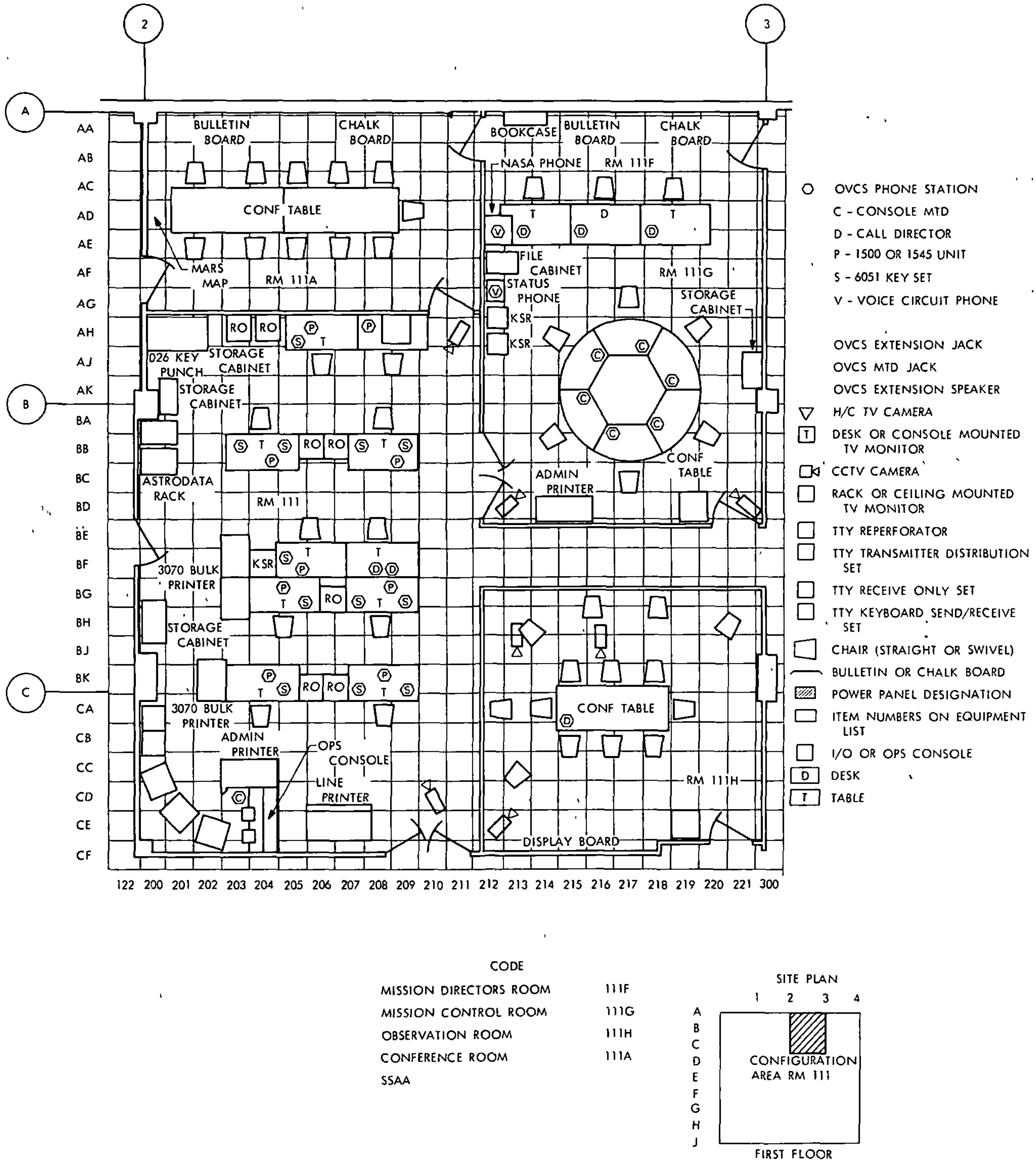


Fig. 118. Mission support area

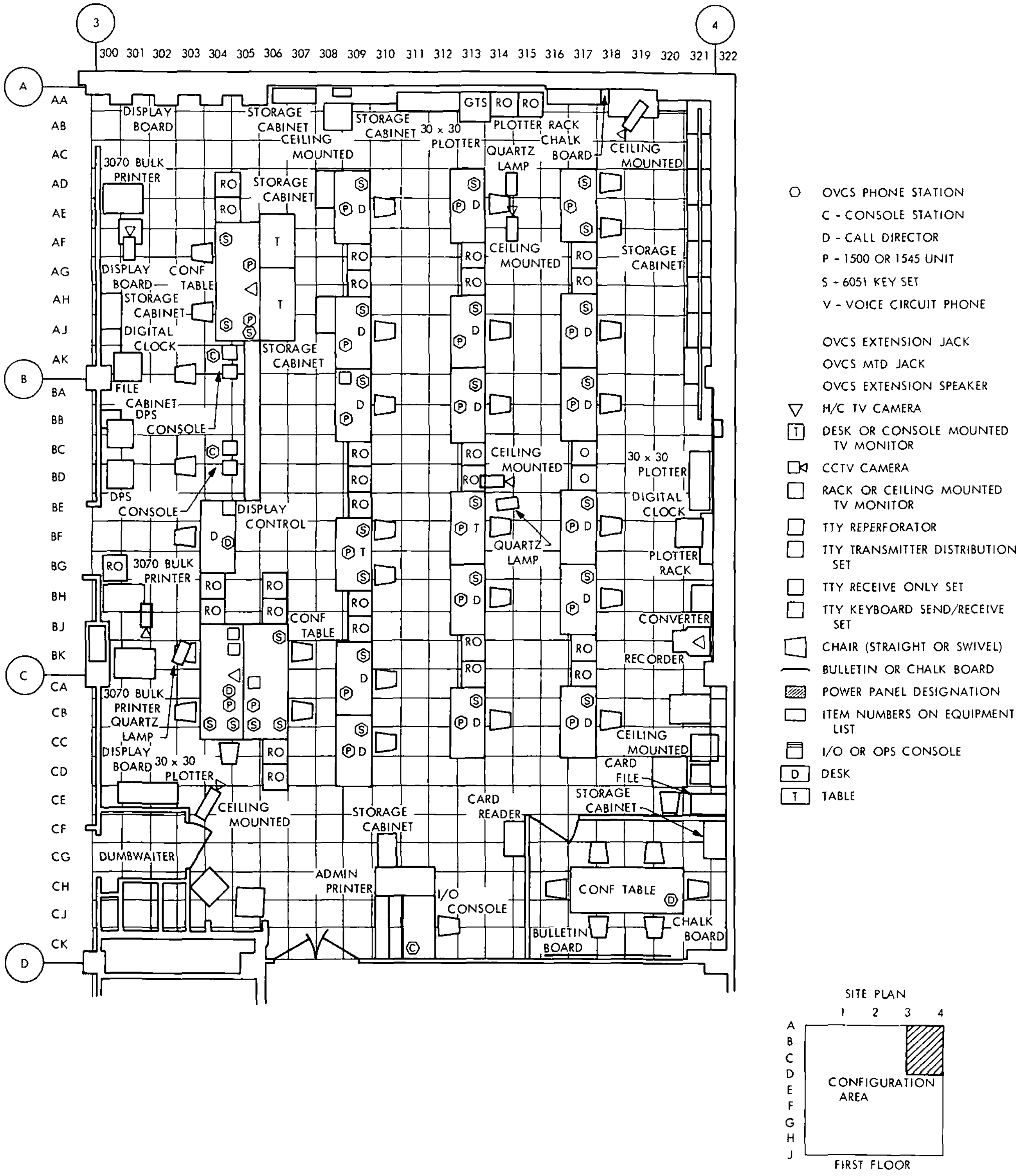


Fig. 119. Spacecraft performance analysis area

Fig. 120. Photograph of spacecraft performance analysis area

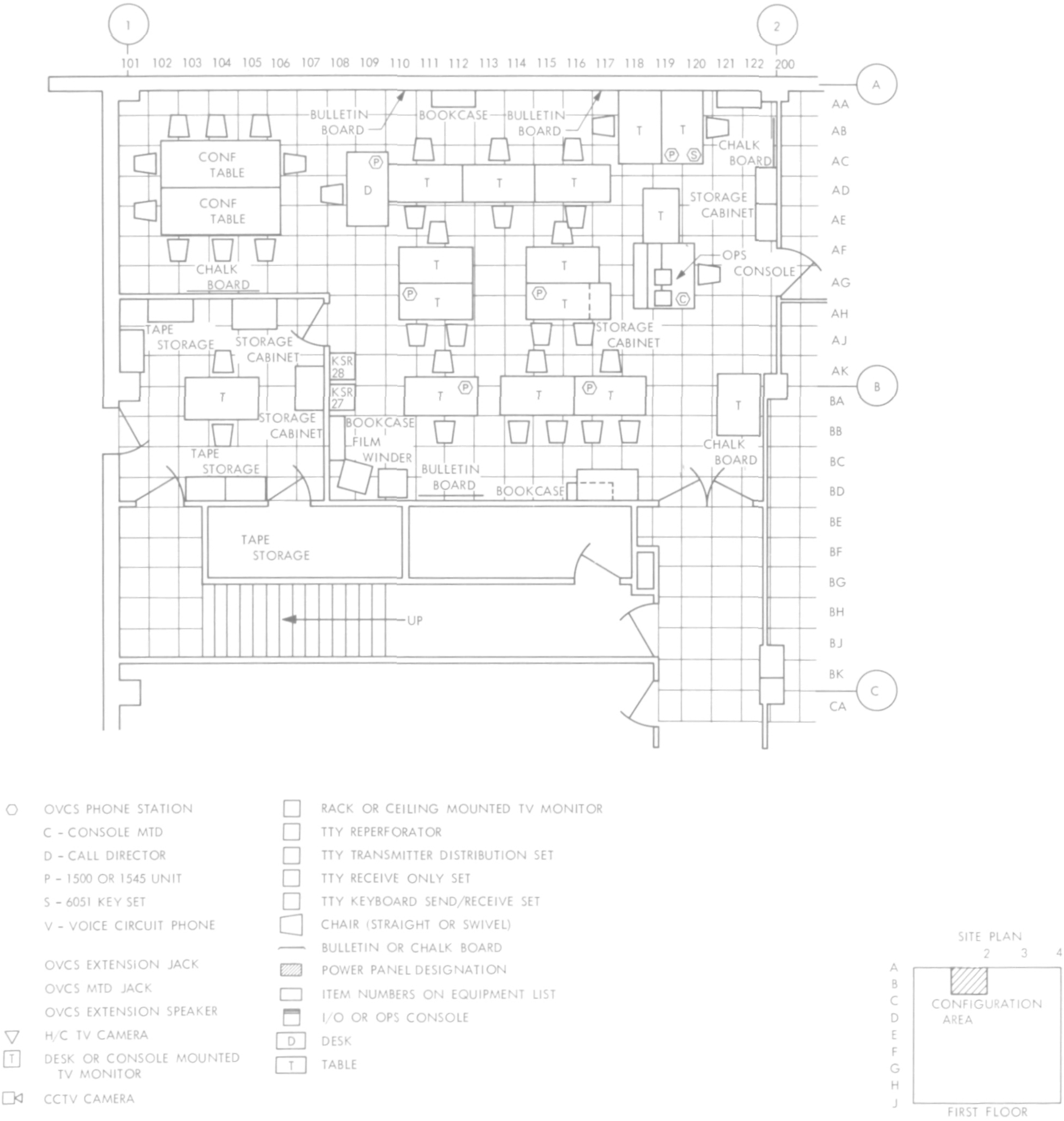


Fig. 121. Principal investigator's area

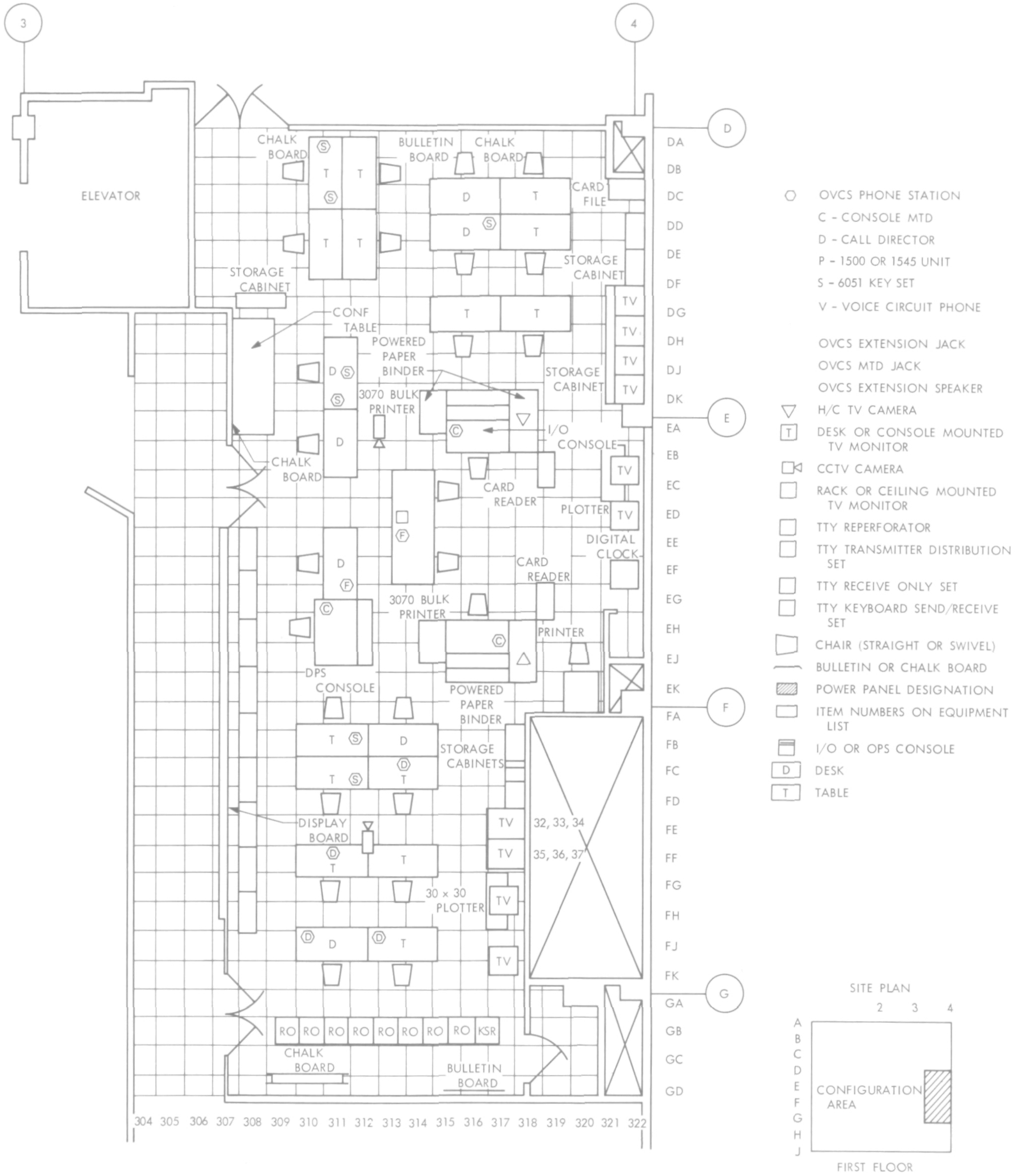
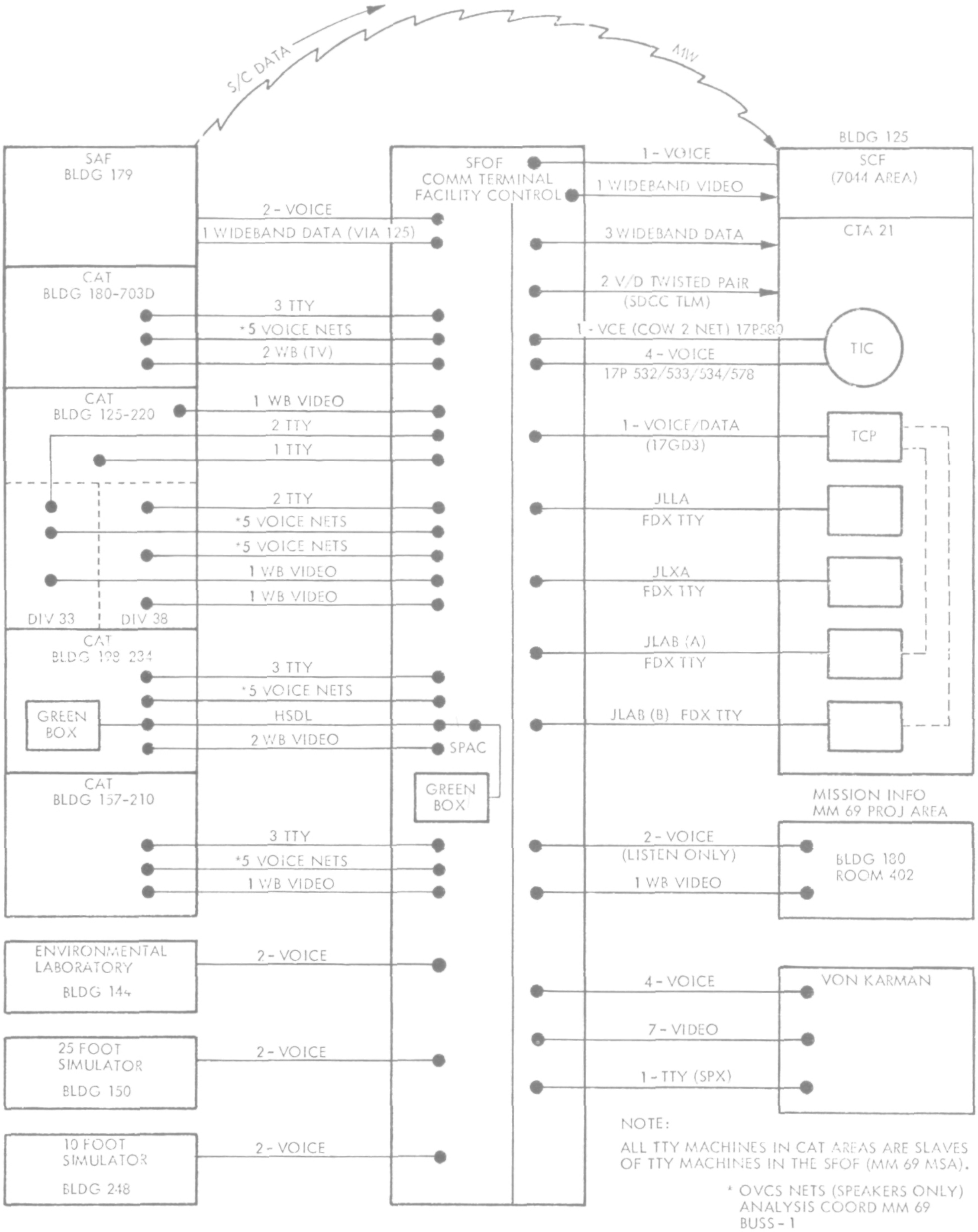


Fig. 122. Flight-path analysis area

Fig. 123. User area I/O station



NOTE:

ALL TTY MACHINES IN CAT AREAS ARE SLAVES OF TTY MACHINES IN THE SFOF (MM 69 MSA).

* OVCS NETS (SPEAKERS ONLY)
ANALYSIS COORD MM 69
BUSS - 1
BUSS - 2
SPAC/ETR
STATUS

Fig. 124. CAT area communication circuit configuration

IV. TDS PRE-FLIGHT TESTING

A. Test Plan

1. Approach. The test program for the Mariner Mars 1969 Project was developed under a Mission Operations Master Test Plan prepared jointly by the Spacecraft System, MOS, and TDS.

Compatibility tests were designed to demonstrate and verify compatibility between the Spacecraft System and Mission Operations. Software tests were designed to demonstrate correct functioning and operational readiness of the software system. Training tests were designed to train TDS and MOS personnel in correct operation of the software and data system. The training provided to TDS personnel by lectures and practice has already been described. Training practice provided to MOS personnel under the Mission Operations Training Plan provided training and testing of TDS personnel and configurations in addition to that provided by the DSN Test Plan.

Five subcategories of system tests were identified. Integration and verification tests under the DSN Test Plan verified the TDS system configurations and the capability of the data system to operate compatibly and meet performance criteria.

Under the Space Flight Operations Test Plan, three classes of tests verified readiness for mission operations. The MOS tests demonstrated the capability of all operating groups to execute mission operations in accordance with the Space Flight Operations Plan during standard and selected nonstandard operations. Participating tests were those in which the mission operations personnel participated in selected operations conducted by the spacecraft system at Cape Kennedy before launch. The purpose of such tests was to familiarize the MOS technical analysis group with actual flight spacecraft telemetry and command data systems and to support spacecraft system operations as requested. Operational readiness tests demonstrated the overall readiness of all elements of the MOS and TDS to support Space Flight Operations and to refine into final form the operational procedures to be used during Space Flight Operations.

TDS testing was conducted primarily under the Compatibility Test Plan and DSN Test Plan. The latter plan included software acceptance test by the DSN. Although the TDS commenced support of Mission Operations Tests some months prior to launch, the support of these tests was used for additional training and testing of the TDS, and supplementary operational verification tests were scheduled to gain more experience with, and correct, operational procedures.

2. Compatibility test plan. The approach to compatibility testing on the Mariner Mars 1969 Project was to demonstrate first a compatible RF interface between spacecraft and a DSS telecommunications systems. Next, the compatibility of the spacecraft and DSN Telemetry and Command Data Systems was demonstrated by the proper processing of data. The operational interface was next verified by conducting typical flight sequences with representative operational procedures. These tests constituted the design compatibility test (Fig. 125). These tests were conducted at JPL between the spacecraft located in the SAF or Environmental Test Facility and CTA-21. The second phase of compatibility testing verified the design compatibility established at JPL by RF verification tests conducted at Cape Kennedy between the spacecraft in Bldg AO and DSS 71.

The number of possible data rates and formats presents a formidable number of telemetry software states. Table 28 indicates the states which must be assumed by the ground system, depending upon the spacecraft system state. The compatibility tests demonstrate the ability to handle data in each state.

3. DSN test plan. The objectives of the DSN Test Plan were to demonstrate the integrity and internal compatibility of the DSN Data System, correct functioning of the DSIF, GCF, and SFOF configurations committed to support the project, and DSN operational readiness to support the mission. The flow plan for the tests for fulfilling these objectives is shown in Fig. 126. The plan consists of basically four types of tests (1) subsystem and system integration, (2) operational verification, and (3) configuration verification. The integration test was designed to demonstrate that the engineering features of the subsystem/system were met. The tests started at the facility level with testing of the mission-dependent hardware and software. The system level integration test followed. Upon completion of these tests, the facilities were transferred from the developing to the operational organization, and operational verification tests (OVT) demonstrated the adequacy of operational procedures to conduct mission operations. The configuration verification tests (CVT) were completed at each facility as close to the actual launch in February 1969 as possible. The DSN Test Program was essentially complete in November 1968, after which mission operations testing was conducted. The CVT verified the correct functioning of the committed configurations as tested at the end of the DSN Test Program.

4. Space flight operations test plan. The TDS supported tests conducted by the MOS to demonstrate the capability to execute space flight operations in accordance with the Space Flight Operations Plan. Such tests were under the direction of the SFOD and carried out under the Space Flight Operations Test Plan (SFOTP). As shown in Table 29, all such tests were supported by the DSN PE and OD, representing the DSN Operations Team. All tests were conducted in the SFOF with support as required from DSIF stations, AFETR, MSFN, and CTA-21. Although outside the DSN Test Plan, these tests afforded valuable training and test experience to the TDS. Table 30 shows the extent of the resources required.

B. Near-Earth Phase Testing

1. Telemetry. Several subsystem integration tests were performed to demonstrate ETR telemetry capability. A Telemetrics bit synchronizer was tested at JPL as a PCM/PM demodulator. Tests verified that the device could demodulate the 24-kHz subcarrier on the 33 1/3 bits/s

engineering telemetry channel. A test was performed at ETR station TEL-4 to determine system threshold using the AFETR S-Band System, the Telemetrics bit synchronizer, and the time division multiplex decommutation system configured to simulate AFETR S-Band support. The threshold signal-to-noise ratio was measured to be 11 dB at an error rate of not greater than 5×10^{-3}. For a receiver IF Band with the 100 kHz, a video bandwidth of 25 kHz, and a loop bandwidth of 500 Hz, the system threshold was -108.7 dBm for an error rate less than 5×10^{-3}. A JPL/ETR demodulator was similarly tested; at the same error rate and bandwidth, the signal-to-noise ratio of 1 dB was measured. A system test at TEL-4 with the same parameters as before resulted in a threshold of -117 dBm. The same test conducted at DSS 71 using the TCP showed a threshold of -131 dBm.

System integration tests demonstrated an acceptable electrical interface between the AFETR and DSN. A tape containing spacecraft data plus 24 kHz subcarrier was replayed and demodulated at TEL-4 and the 33 1/3 bits/s telemetry data transmitted to DSS 71. At DSS 71, the data were processed in the TCP. In the second phase of the tests, the demonstration was repeated with down-range stations of ETR relaying the data to TEL-4 where they were demodulated and routed to DSS71. These tests were conducted in September and October of 1968. In an additional test in November, data were successfully transmitted from DSS 71 to the SFOF in Pasadena.

2. Radio metric data. During the six months preceding the launch, the RTCS of ETR received and processed S-band radiometric data from the MSFN Ascension Station. Live data generated during the tracking of TETR-B, Pioneer D, and Apollo IX were processed as well as simulated radio metric data from Mariner 1969. These tests verified that ACN data format in any of the various modes were directly acceptable by the RTCS computer, that RTCS could process and obtain orbital elements from ACN radio metric data when the station was tracking in one-way, two-way, or three-way modes, and the quality of the orbital solution obtained from ACN data was good enough to provide updated acquisition data. The ACN two-way data, if at least of 1-h duration, were the only near-earth data good enough to provide an early assessment of the spacecraft orbit, although not of the quality provided by DSN data due to the absence of a partial doppler count. When initial test cases of mapping to Mars by the RTCS and SFOF indicated discrepancies in excess of 10,000 km, the format of the orbital elements message forwarded to the SFOF in near-real time was changed from three significant places to seven after the decimal point. Subsequent agreement was within 1,000 km.

3. Operational verification and readiness tests. Table 31 shows the operational verification tests conducted as part of near-earth phase testing. The earlier tests were conducted entirely by the near-earth TDS; later tests were conducted with the DSN and project elements in the SFOF.

Because the extensive testing performed in preparation for the Mariner VI mission contributed to the state of operational readiness for Mariner VII, only one Operational Readiness Test (ORT) was conducted prior to launch. The test was considered successful, with only minor problems encountered (as listed in Table 31 for Launch/Maneuver G ORT).

C. Deep Space Phase Testing

1. Compatibility tests. Spacecraft/DSS compatibility tests were conducted in July of 1968 between the Proof Test Model (PTM) spacecraft in the SAF and the DSN CTA-21. Figure 127 shows the test configuration. CTA-21 is located several hundred yards from the SAF and is connected to the spacecraft test complex by a microwave link and approximately 305 m of co-axial cable. The scope of the testing conducted is shown in Table 32.

All parameters were measured and verified. Therefore, only minor problems and one major one are discussed below. The spacecraft modulation indices were out of tolerance but were later corrected. Some TCP software problems were encountered and were removed.

The spacecraft/DSN real-time telemetry system test was conducted in November of 1968. As indicated in the Test Plan, this test utilized the data-processing system of the SFOF. The version of the 7044 computer program used for real-time data processing operated well, but showed the need for updating which was then in process. Correct operation of the system was demonstrated; however, it was also demonstrated that more highly refined operational procedures and practice in using them were required.

The preliminary compatibility test in July 1968 indicated that the spacecraft radio frequency system could not track S-band signals varying in frequency at the rate specified for 20-Hz loop. Further investigation disclosed a feedback problem when uplink signal levels were greater than -120 dBm. The effects were more pronounced with the ranging channel on; however, some receivers exhibited the effects to a smaller extent even when ranging was off. The observable effects were a change in filter bandwidth, a momentary anomalous DPE output during receiver lockup, an apparent change in command modulation level when the ranging channel was switched on or off, and a false lock effect. As the false lock condition was not correctable prior to launch, the DSIF operational procedures were modified to handle the situation. Tests and analysis were undertaken to determine proper acquisition procedures.

The probability of false lock at strong signal strength was calculated for varying offsets of the uplink signal from the receiver best-lock frequency (Table 33). Tests indicated that the spacecraft tracking loop performed like a 13-Hz tracking loop instead of 20 Hz, verified the probability of false lock was low at any signal strength if the uplink signal were within 10 kHz of the best-lock frequency; different AGC calibration curves were required with the ranging video amplifier on. Operational factors taken into consideration in the development of procedures were that an exact knowledge of the best-lock frequency was fundamental in dealing with the problem, and that if the radio frequency system had gone into a false lock, time must be allowed for the VCO to return to the best-lock frequency before another acquisition attempt (~10 min).

The DSS procedures for uplink initial acquisition were modified. DSS 51 was provided with modified VCO search patterns and uplink power profile. The DSN system data analysis activity maintained close liaison with the project telecommunications analyst in order to select the most accurate temperature data and estimate the spacecraft receiver best-lock frequency. These data were then used to provide accurate predicts to the station.

2. Subsystem integration tests. The DSN integration tests included all internal DSN testing to demonstrate hardware/software design compatibility prior to system level testing. These tests were prerequisites for DSN system integration tests, operational verification tests, configuration verification tests, and Project operational testing. Station mission-dependent hardware and software was integrated into the facility by testing at each of the supporting stations, DSS 12, 41, 51, 62, and 71 and at the MSFN Ascension Island station. The testing to be conducted at the stations was accomplished first at CTA-21 in September 1968. Testing at other stations was accomplished in October and November. Completion of integration tests at DSS 14 was delayed until February 1, 1969 because of the support given to the Apollo Project in December 1968. Testing was accomplished successfully with only minor problems. The TCP program on which the functioning of the MMTS depended functioned correctly except for several features for which the correction was accommodated in the operational procedures. The program severely taxed one component in the magnetic tape unit of the TCP so that operators had to pay particular attention to the maintenance of the unit. Several typewriter outputs were eliminated to relieve some timing problems. The mission-dependent command equipment (RWV) was integrated without incident.

In the SFOF, integration tests resulted in acceptance by the cognizant users of the 7044 and 7094 computers software systems. The delivered versions of the programs were placed on the Operational Program Data Base and placed under change control. Subsequent modifications were thoroughly tested prior to use during MOS testing where additional experience was obtained with them prior to support of launch and flight operations.

The Simulation Data Conversion Center and its software was brought to state of readiness. The Center generated magnetic tapes of simulated spacecraft data for Project testing.

The monitor system integration test was conducted in November 1968 and demonstrated operation in support of mission operations without interference to other activities. Integration of GCF equipment was accomplished in October 1968. The only equipment unique to Mariner 1969 were special high-speed data circuits from CTA-21 to SAF and program boards for the high-speed data quality monitor units at the DSS. The ADSS error rate determination tests were conducted with DSS 41, 51, 62, and 71. The circuit quality standards of 14 errors or less for each 10-min sample interval were met.

3. Level I combined system integration tests. The combined system integration tests verified the compatibility of the DSN telemetry, command, tracking, simulation, and monitor systems. Tests were conducted with the SFOF, GCF, and one station per test. The configurations being tested, therefore, are those shown for each of the DSN systems in Section III-D. The tests were generally successful; however, anomalies were noted for correction as shown in Table 34. Where an excessive number of anomalies occurred, the test was repeated.

4. Level II combined system integration tests. The combined system integration tests were designed to verify the compatibility of the DSN technical systems through each DSS, GCF, and SFOF. Tests were conducted with the SFOF, GCF, and three tracking stations participating concurrently. Participating stations were DSS 12, 41, 51, and 62.

The first test involved DSS 12, 51, and 62. The HSD from the SDCC was routed to two DSS simultaneously. Problems detected were as follows:

(1) Time tag errors were as great as 5 s.

(2) DGI problems at DSS 51; trouble shooting isolated a hardware problem; after changing a module, satisfactory dual mode operation was achieved.

(3) DSS 62 DGI did not retain lock. Corrected by separate test.

(4) Incorrect spacecraft identification by DSS 12 TCP; problem corrected in communication buffer.

(5) An ADSS synchronizer failed.

The second test was conducted with DSS 41, 51, and 62. Problems detected in this test were as follows:

(1) Difficulty at DSS 41 in initializing the DGI.

(2) Procedural error between the SDCC and the OD.

(3) Science digital play back data not properly processed by the 7044 computer.

(4) The HSD line from DSS 51 substandard; removal of regenerators at Ascension Island unknown to JPL.

(5) DIS monitor program at the station did not operate properly.

All DGI were exercised successfully; the stations demonstrated satisfactory DGI and TCP operator proficiency.

5. Ancillary tests. Data system delay measurements were made during testing. Table 35 shows the delay in seconds of the telemetry data due to processing and buffering time in

the TCP, CP, and/or 7044 computer. Data in the table are obtained from tests conducted by DSS 41; the data, however, are representative.

The results of system testing were studied to obtain an indication of data system reliability. Table 36 shows a total of 46 problems reported during tests with DSS 12, 41, 71, and CTA-21. Half of the problems have been classified as procedural; thirteen, or 28%, of the problems were due to hardware.

The average failure/problem rate was estimated at 101.7/100 h of operation, or about 1 failure/h, considering all causes. The failures for hardware subsystems only are shown in Table 37. Based on a limited amount of data, the 7044/7094 computer system has an estimated MTBF of 22.6 h with 90% confidence. Support of MOS testing did indeed result initially in about 1 problem/day in the computer system, a rate which diminished as the time for launch approached.

Three operational verification tests were conducted to validate the DSN operational interfaces. The tests were valuable for clarification of interface procedures, particularly between JPL and ETR operational control, between the OD and the Monitor Director, and between the DSN SDA and the Track Chief in SPAC.

The DSS conducted numerous additional OVT to exercise the net controllers in the SFOF and the station personnel in the use of operational procedures. Of particular concern was the proper transmission of commands, especially under non-standard conditions. A revised command OVT was devised to train the DSS operators and station net controllers. Table 38 summarizes the OVT accomplished. The 45 command OVT accomplished after launch of spacecraft F were conducted in anticipation of heavy command activities during encounter.

6. CTA-21 support. CTA-21 provided support to the compatibility tests described. The facility was, however, heavily used for other activities. Table 39 shows the DSN man-hours expended for various types of support. Man hours are portrayed rather than station hours because they show better the allocation of resources and because some activities were concurrent. With the exception of tests during the first week of June and July, the preponderance of man hours during the early weeks of operation were applied to the maintenance and installation of DSN equipment and developmental testing of the multiple mission telemetry and high-rate telemetry systems. Throughout the entire period, the spacecraft system received support of its system test activities in SAF and the radio and telemetry subsystem development. Such support continued when the spacecraft were moved to the Environmental Test Chamber. Monitoring of environmental tests also provided an opportunity to collect compatibility test data. During November and December of 1968 and January and February of 1969, CTA-21 supported MOS tests. Throughout the support, TCP software under development was checked out in CTA-21. The DSN used the station for training and operations. It was here that the overseas operators were trained and operational procedures were checked out. During the period, a minor amount of support was provided to other projects.

Table 28. Spacecraft data system – TCP software – 7044 mission-dependent telemetry software states

When The Spacecraft is Transmitting							Then The Spacecraft		And the DSN Telemetry Software must be in State No	Which Implies					
Engineering Telemetry			And	Science Telemetry						That the TCP		And the 7044		And the Highrate	
at the Rate of	in the Format	Whose Frame Length is		at the Rate of	in the Format	Whose Frame Length is	Telemetry Mode is	And Data System is said to be in State No		Software is in State No.	Which is Defined As	Mission Dependent Telemetry Software is in State No	Which is Defined As	Software At DSS14 (only) is in State No	Which is Defined As
8 1/3 bps	RTE	28000 bits		None	--	--	Cruise	1	1	A	Engineering 8 1/3 (1/2 TCP)	a	RTE	0	Not operative
8 1/3 bps	CC&S	Variable		None	--	--	Cruise	2	2			b	CC&S Dump		
33 1/3 bps	RTE	28000 bits		None	--	--	Cruise	3	3	B	Engineering 33 1/3 (1/2 TCP)	a	RTE		
33 1/3 bps	CC&S	Variable		None	--	--	Cruise	4	4			b	CC&S Dump		
8 1/3 bps	RTE	28000 bits		66 2/3 bps	RTS	280 bits	Encounter 1	5	5	C	Engineering 8 1/3 and Science 66 2/3	c	RTE/Science		
8 1/3 bps	CC&S	Variable		66 2/3 bps	RTS	280 bits	Encounter 1	6	6			d	CC&S Dump/Science		
33 1/3 bps	RTE	28000 bits		66 2/3 bps	RTS	280 bits	Encounter 1	7	7	D	Engineering 33 1/3 and Science 66 2/3	c	RTE/Science		
33 1/3 bps	CC&S	Variable		66 2/3 bps	RTS	280 bits	Encounter 1	8	8			d	CC&S Dump/Science		
8 1/3 bps	RTE	28000 bits		16.2K bps	Combined Science	972 bits	Encounter 2	9	9	A	At DSS14 Only Engineering 8 1/3 (1/2 TCP)	a	RTE	1	16 2 K bps Science
8 1/3 bps	CC&S	Variable		16.2K bps	Combined Science	972 bits	Encounter 2	10	10			b	CC&S Dump		
33 1/3 bps	RTE	28000 bits		16 2K bps	Combined Science	972 bits	Encounter 2	11	11	B	At DSS14 Only Engineering 33 1/3 (1/2 TCP)	a	RTE		
33 1/3 bps	CC&S	Variable		16 2K bps	Combined Science	972 bits	Encounter 2	12	12			b	CC&S Dump		
8 1/3 bps	RTE	28000 bits		270 bps	Combined Science	972 bits	Playback 1	13	13	E	Engineering 8 1/3 and Science 270-972 frame	c	RTE/Science	0	Not operative
8 1/3 bps	CC&S	Variable		270 bps	Combined Science	972 bits	Playback 1	14	14			d	CC&S Dump/Science		
8 1/3 bps	RTE	28000 bits		270 bps	TV Science	6804 bits	Playback 1	15	15	F	Engineering 8 1/3 and Science 270-6804 frame	c	RTE/Science		
8 1/3 bps	CC&S	Variable		270 bps	TV Science	6804 bits	Playback 1	16	16			d	CC&S Dump/Science		
33 1/3 bps	RTE	28000 bits		270 bps	Combined Science	972 bits	Playback 1	17	17	G	Engineering 33 1/3 and Science 270-972 frame	c	RTE/Science		
33 1/3 bps	CC&S	Variable		270 bps	Combined Science	972 bits	Playback 1	18	18			d	CC&S Dump/Science		
33 1/3 bps	RTE	28000 bits		270 bps	TV Science	6804 bits	Playback 1	19	19	H	Engineering 33 1/3 and Science 270-6804 frame	c	RTE/Science		
33 1/3 bps	CC&S	Variable		270 bps	TV Science	6804 bits	Playback 1	20	20			d	CC&S Dump/Science		
8 1/3 bps	RTE	28000 bits		16 2K bps	TV Science	6804 bits	Playback 2	21	9	A	At DSS14 Only Engineering 8 1/3 and Science 16 2	a	RTE	1	16 2K bps Science
8 1/3 bps	CC&S	Variable		16.2K bps	TV Science	6804 bits	Playback 2	22	10			b	CC&S Dump		
33 1/3 bps	RTE	28000 bits		16 2K bps	TV Science	6804 bits	Playback 2	23	11	B	At DSS14 Only Engineering 8 1/3 and Science 16 2	a	RTE		
33 1/3 bps	CC&S	Variable		16.2K bps	TV Science	6804 bits	Playback 2	24	12			b	CC&S Dump		
									21	I	Science 66 2/3 (1/2 TCP)	e	Science Only	0	Not operative
									22	J	Science 270-972 frame (1/2 TCP)				
									23	K	Science 270-6804 frame (1/2 TCP)				

NOTE. There are no different spacecraft data system states corresponding to these back up DSN telemetry software states See Table 5-2 for relationships

LEGEND RTE = Real time engineering CC&S = Central Computer & Sequencer
RTS = Real time science

Table 29. Test participation

	Mission Director	Mission Control Group	SPAC	FPAC	SSAC	DSN PE & OD	DPPE & DSPE	DSIF PE (Track Chief)	COMM PE (COMM Man)	DSS 12	DSS 14	DSS 41	DSS 51	DSS 62	DSS 71	AFETR	MSFN ACN	SCF	CTA-21	Multi-shifts Required	SAF
SYSTEM TRAINING TESTS																					
Launch G		X	X	X		X	X	X	X				X	X	X	X	X	X			
Command		X	X			X	X	X	X	X	X	X	X	X			X				
OPERATIONAL DEMONSTRATION TESTS																					
Maneuver F		X	X	X		X	X	X	X	X		X	X								
Launch G/Cruise F		X	X	X		X	X	X				X	X	X	X	X	X	X	X		
Maneuver G/Cruise F		X	X	X		X	X	X				X									
Launch-Maneuver Cruise F	X	X	X	X		X	X	X	X	X		X	X		X	X	X	X	X	X	X
OPERATIONAL READINESS TESTS																					
ORT F	X	X	X	X		X	X	X	X	X		X	X		X	X	X	X		X	
ORT G	X	X	X	X		X	X	X	X				X	X	X	X	X	X			
MA VI ENCOUNTER TRAINING TEST																					
Test #1		X	X	X	X	X	X	X	X										X		X
Test #2		X	X	X	X	X	X	X	X										X		X
MA VI ENCOUNTER OPERATIONAL TEST	X	X	X	X	X	X	X	X	X										X	X	X
MA VII ENCOUNTER TRAINING TEST		X	X	X	X	X	X	X	X										X		X
MA VII ENCOUNTER OPERATIONAL TEST	X	X	X	X	X	X	X	X	X	X	X	X		X					X	X	X
NON-STANDARD ENCOUNTER TESTS	X	X	X	X	X	X	X	X	X										X		X
ENCOUNTER ORT	X	X	X	X	X	X	X	X	X	X	X	X		X					X	X	X

Table 30. Resources

		DSN Systems				SFOF																						DSS								ETR		GCF				
						DPS				SDCC			ICS			Areas							Services and Support																			
	Test Duration (hrs)	Tracking Data System	TLM Data System	CMD Data System	Monitor Data System	DCOS	Mode III	Mode II	Dual Mode II	6050	TTY	HSD	OVCS	CCTV	CP	MMSA	SSAA	PIA	FPAA	COMM	DSIF Net Control	OPS	Repro	DAFLO	Display	Simulated Time	1219 System	TV-1 System	DSS 12	DSS 14	DSS 41	DSS 51	DSS 62	DSS 71	CTA 21	MSFN ACN	SCF	Range Total	TTY to/from CTA 21	HSD from CTA 21	HSD to/from DSS	Voice to/from DSS	SAF
SYSTEM TRAINING TESTS																																											
Launch G	9	X	X	X				X		X	X	X	X	X	X	X			X	X	X	X	X	X	X	X						X	X	X		X	X	X			X	X	
Command	6							X					X	X	X	X				X	X	X			X				X	X	X	X	X	X		X					X	X	
OPERATIONAL DEMONSTRATION TESTS																																											
Maneuver F	18	X	X	X					X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X			X		X	X									X	X	
Launch G/Cruise F	9	X	X	X					X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X					X	X	X	X		X	X	X			X	X	
Maneuver G/Cruise F	11	X	X	X					X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X					X										X	X	
Launch-Maneuver Cruise F	76	X	X	X					X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X					X	X		X	X	X	X	X	X	X	X	X	X
OPERATIONAL READINESS TESTS																																											
ORT F	19	X	X	X					X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X			X		X	X		X		X	X	X			X	X	
ORT G	8	X	X	X					X	X	X	X	X	X	X	X			X	X	X	X	X	X	X	X																	
MARINER VI ENCOUNTER TRAINING TESTS																																											
Test 1	6	X	X	X	X	X		X					X	X	X	X	X	X	X	X	X	X		X	X	X	X								X				X	X			X
Test 2	20	X	X	X	X	X		X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X								X				X	X			X
MARINER VI ENCOUNTER OPERATIONAL TEST	58	X	X	X	X	X	X	X			X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X							X				X	X			X
MARINER VII ENCOUNTER TRAINING TEST	10	X	X	X	X	X		X					X	X	X	X	X	X	X	X	X	X		X	X	X	X	X							X				X	X			X
MARINER VII ENCOUNTER OPERATIONAL TEST	60	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X	X	X		X		X				X	X	X	X	X
NON-STANDARD ENCOUNTER TESTS	24	X	X	X	X	X		X					X	X	X	X	X	X	X	X	X	X		X	X	X	X	X															
ENCOUNTER ORT	24	X	X	X	X	X		X					X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X		X		X				X	X	X	X	X

Table 31. Near-earth operational verification tests

Test title	Date	Participants	Deficiencies
Launch G Training Test	December 18, 1968	DSN, MSFN, and JPL/ETR	1. Grand Turk radar metric data at wrong rate 2. DSS data handling subsystem punch test data late and improperly addressed 3. DSN frequency constants for the RTCS received late 4. DSS 51 radio metric data received with wrong format. 5. CP feedback of tracking and telemetry data as late as 1 h
Launch F Near-Earth Phase	January 9, 1969	JPL/ETR, ETR, MSFN	1. Establishment of communications circuits late 2. Completion of ETR telemetry check 70 min late 3. RTCS outputting of messages delayed due to simulation problems
Launch G/Cruise F Operational Demonstration	January 21/22, 1969	All Near-Earth TDS Systems	1. Spacecraft telemetry circuits from TEL-4 to Bldg AO and DSS 71 established 55 min late due to prior launch commitment 2. Start of telemetry checks delayed 30 min 3. Telemetry checkout of Twin Falls instrumentation ship completed at T -19 min (251 min late) 4. Mariner 1969 test tapes supplied to ETR were faulty 5. Centaur guidance data unusable 6. TDH punch test data not received from DSN 7. DSN frequency constants not received during the minus count 8. First-motion pulse not received from ETR; plus count did not start at T -0 9. DSS 51 radiometric data contained bad angle indications; RTCS not able to process data 10. TRCS not able to process MSFN Ascension radiometric data; apparently invalid simulation data 11. RTCS mapping to planetary encounter in error by 70,000 km (use of incorrect constants) 12. Spacecraft telemetry data started at T +4 min because of patching errors at TEL-4

Table 31 (contd)

Test title	Date	Participants	Deficiencies
Launch/Maneuver/ Cruise F Operational Readiness Tests	February 10/11, 1969	All systems of Near-Earth TDS	1. Erroneous reporting on receipt of predicts at DSS 51 2. Grand Turk radar metric data lost due to patching problem at ETR
Launch F Near-Earth Phase	February 17, 1969	JPL/ETR, ETR, MSFN, and FPAC	None
Launch/Maneuver F Operational Readiness Tests	February 19, 1969	All system of Near-Earth TDS	Incorrect setup of bit synchronizer at TEL-4
Launch/Maneuver G Operational Readiness Test	March 18, 1969	All systems of Near-Earth TDS	1. Teletype data circuits between RTCS and Bldg AO were brought up 1 h late; delay was caused by a prior AFETR test 2. Completion of telemetry checks with RIS Twin Falls was ~ 40 min late 3. AFETR was requested to start telemetry test tapes at T -3, rather than scheduled T -7, because of updated test tape data received during countdown 4. During plus count, data output from Twin Falls data demodulator was intermittent due to a low-voltage level input to demodulator; normal operation was observed when voltage was adjusted to proper level (6 V) 5. First set of DSN predicts from RTCS was received ~13 min late

Table 32. Compatibility tests

Test title
Downlink 1-Way Threshold
Uplink Threshold
Downlink 2-Way Threshold
Spacecraft Receiver Pull-In Range
Spacecraft Receiver Tuning Rate
Residual Phase Jitter
Downlink Spectrum Analysis
Uplink Spectrum Analysis
Receiver Best-Lock Frequency
Downlink Carrier Suppression
Uplink Carrier Suppression
Ranging Carrier Suppression
Auxiliary Oscillator Frequency Stability
Bit Error Tests
Subcarrier Acquisition Time
Bit Sync Acquisition Time
Frame Sync Acquisition Time
Two-Channel Operation
High-Rate Telemetry Performance Test
Subcarrier Phase Jitter
Command Polarity Check
Command Performance at Threshold
Flight Command System Sync Acquisition
Command with Ranging
Command with Static Phase Error Offset
Ranging Polarity
Ranging Threshold
Ranging Acquisition
Ranging Spectrum
Ranging Delay

Table 33. Probability distribution for false lock at signals stronger than -100 dbm

Fs-Fo, kHz	Ranging	Probability, P
0 to ± 10	ON	.01
0 to ± 10	OFF	.01
+ 10 to + 400	ON	.90
- 10 to - 400	ON	.90
+ 10 to + 40	OFF	.50
- 10 to - 40	OFF	.50
+ 40 to + 400	OFF	.01
- 40 to - 400	OFF	.01

Table 34. Anomalies during level I combined system integration tests

Test	Anomalies	Remarks
CTA-21 test 1	1. Test delayed by SFOF power failures 2. Incorrect TCP output due to software version used 3. 7044/CP interface problem interrupted transmission of coded commands 4. TCP limited in ability to output headers 5. Correct procedure for end of message notification on command messages not available 6. No monitor system support after power failure 7. SDCC sent wrong type of data to CTA-21 8. Plotters connected to wrong computer string 9. Inadequate familiarity with procedures 10. Inadequate data package script 11. Cross talk on voice nets 12. Insufficient status reporting	Anomalies necessitated repeating the test
CTA-21 test 2	1. Command sent via teletype arrived garbled at CTA-21 2. Incorrect teletype printer output in user area 3. Some command messages incorrectly addressed 4. Metric data from CTA-21 to the SFOF occasionally interrupted 5. The 7044 computer underwent a cold start 6. Delay in locating lines from SDCC to CTA-21 7. Difficulties with plotters	Telemetry, radiometric, and command data successfully transferred throughout all elements of the system. Capability of the SDCC to enter reliable spacecraft data at SFOF or tracking station was verified. Command transfer and Mode II operation with concurrent inbound and outbound traffic demonstrated
DSS 12 test 1	1. SDCC communication requirements not scheduled 2. TCP could not lock up on science data 3. Command sequence delayed for lack of priority indication 4. Plotters and alarm printers not operating properly 5. A correct input message to the 7044 computer was incorrectly rejected	Command procedure exercise was successful
DSS 12 test 2	1. Inadequate 7094 user program operator support 2. Communication lines not scheduled as early as needed 3. Failure in ADSS synchronizer 4. Data processing system mixed commands and predicts to DSS 12 on the same line 5. Procedural error by DACON 6. A hung-up header in the TCP required a cold start 7. Defective system tape caused the 7044 computer to hand up when commands were transmitted 8. RWV malfunction	Both halves of the TCP were operational. The 7044 software successfully processed four streams of telemetry data (two outbound from SDCC and two inbound from DSS 12) as well as tracking data. Mode II operation demonstrated with transmission of commands and predicts
DSS 41 test 1	1. Procedural error by GCF 2. 7044 software did not process two streams of science telemetry data simultaneously 3. DSS 41 sent the wrong tracking data preambles 4. Wrong PN number entered into the 7044 computer 5. Station recorder did not play back simulated data reliably 6. Two-hour high-speed data line outage	Dual TCP output demonstrated. Command procedures successful in all three modes by two DSS 41 shifts. Successful transmission of predicts in Mode II

Table 34. (contd)

Test	Anomalies	Remarks
DSS 41 test 1 (contd)	7. TCP output not available at DSS 41; TTY printers not available 8. Monitor program not operational	
DSS 41 test 2	1. Slow response by DACON due to staffing shortage 2. Administrative printer in the 7044 computer overloaded 3. Improper voice labeling on simulation tapes 4. Plotters did not operate properly 5. CP unable to operate in dual mode due to software problem	Demonstration of correct operation repeated. Data system delay measurements made for 8 1/3 and 33 1/3 bits/s. DGI not operational
DSS 51 test 1	1. Test terminated due to numerous outages of high-speed data and voice lines	
DSS 51 test 2	1. Communication line outages 2. Incomplete familiarity with operational procedures 3. The 7044 computer went into recovery every few minutes during playback of digital data 4. Station modulation problem 5. Limited source of engineering data to the telemetry simulator 6. DGI software not operational 7. TCP software problems	Test to be repeated to obtain more practice
DSS 51 test 3	1. Command log tape snapped by tape drive 2. DGI problems 3. ADS synchronizer failed 4. Noise on line between SDA and TCP patch panel	Regular test sequence of events shelved in favor of intensive DGI testing
DSS 62 test 1	1. The 7094 user program not operated; flight support personnel not available 2. Predicts not displayed in track area prior to transmission 3. Simulation tape gave problems to station personnel	Dual TCP output and command handling successfully demonstrated. Data system delay measurements obtained
DSS 62 test 2	1. Poorly recorded science data on simulation tape	All objectives satisfied
DSS 71 test 1	1. No DACON support; data chief not fully briefed 2. Faulty ADSS synchronizer 3. High-speed data channel information given to data chief late 4. The 7044 data output fell behind when processing data from two stations 5. Error on COMGEN command tape prevented transmission of command messages to station 6. Simulation data packages not received at station 7. The 7044 software problem prevented output of science teletype formats 8. User area display devices not functioned properly 9. High-speed data line problems	Dual TCP operation accomplished with TEL 4 and DSS 71 simulator data. Command procedure checkout successful

Table 34. (contd)

Test	Anomalies	Remarks
Ascension test 1	1. Comm line activation delayed 2. The 7044 computer did not time-tag data to 1-s accuracy 3. Improper header on data by ACN prevented transmission of metric data 4. Excessive voice traffic during command exercises 5. Excessive time for coded command verification 6. Teletype message from JPL did not reach ACN 7. Transmission of acquisition messages delayed	End-to-end data flow test and command exercise successful with exception of 7044 computer timing problem
Ascension test 2	1. Procedural error on end of message notification	End-to-end data flow and command exercise successful

Table 35. Mariner Mars 1969 inherent telemetry data system delays

Data Rate (bps)	HSDL				TTY				TTY - CP Bypassed			
	Design		Actual		Design		Actual		Design		Actual	
	Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.	Range	Ave.
8-1/3**	21.5-30.0	25.7	35.0-46 0	36.8	11.2-27.2	19.2	21.0-30-0	25.3	10.4-26.4	18.4	4.0-8 0	5 3
8-1/3	21.5-30.0	25.7	25.0-53 0	39.9	11.2-27.2	19.2	18.0-26.0	21.6	10.4-26.4	18.4	4 0-15.0	6 3
33-1/3	6.3-14.8	10.5	16.3-33.0	24.0	10.6-106.6	58.6	14.0-28.0	20.0	10.4-26.4	18.4	2 0-16.0	7 0

*Time in seconds

**The 7044 was also simultaneously processing two telemetry streams and one tracking data stream from the SDCC.

Table 36. Statistical analysis of seven Mariner Mars 1969 system integration tests

Source of Problem	DSN Facilities			Total Problems		Total Testing Hours	Estimated Failure/Problem Rate per 100 Hr. Operation	
	SFOF	GCF	DSIF	Number	%		Average	90% Conf. Limits*
Hardware	8	2	3	13	28	45.25	28.7	17-43
Software	5	2	1	8	18	45.25	17.7	9-29
Procedure/Human	20	3	—	23	50	45.25	50.8	34-70
Undetermined	—	2	—	2	4	45.25	4.4	0.8-10.4
Total	33	9	4	46	100	45.25	101.7	78-127

*Assuming Poisson distribution.

Table 37. Statistical analysis of hardware problems and estimated failure rates

Hardware/ Subsystem	No. Used Per Test (n)	Total Operating Hours (n x 45.25) x D.C. *	No. of Problems Reported in Seven Tests	Estimated Failure/ Problem Rate per 100 Hr. Operation	
				Ave.	90% Conf. Limit**
SFOF:					
7044/94	1	45.25	2	4.4	0.8 - 10.4
Milgo Plotter	3	102.81	2	1.9	0.3 - 4.5
TTY	~25	452.50	2	0.44	0.1 - 1.0
Power System	1	45.25	2	4.4	0.8 - 10.4
GCF:					
HSDL/ADSS	1	45.25	2	4.4	0.8 - 10.4
DSIF:					
FR 1200	1	45.25	1	2.2	0.1 - 6.6
TCP	1	45.25	2	4.4	0.8 - 10.4

*Assuming the duty cycle (D. C.) for Milgo Plotter is 75%, for TTY 40%, and for the rest of the equipment is 100%.

**Assuming Poisson distribution.

Table 38. Summary of OVT accomplished

Station	Before F Launch	Between F and G	After G Launch	Total
CTA 21	7	0	2	9
DSS 11	0	0	6	6
DSS 12	11	0	10	21
DSS 14	1	1	10	12
DSS 41	8	0	6	14
DSS 42	0	2	8	10
DSS 51	8	0	6	14
DSS 62	8	1	9	18
DSS 71	1	0	0	1
ACN	4	0	0	4
Totals	48	4	57	109*

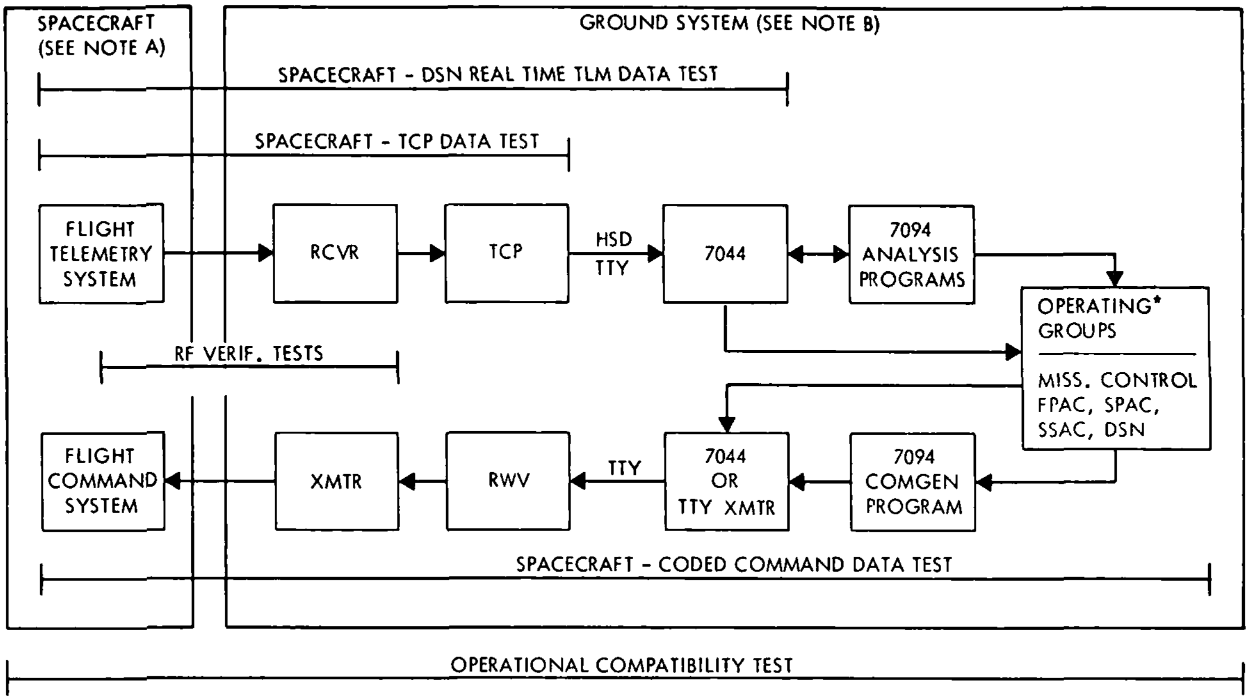
*Includes 45 Command OVTs, all of which were performed after launch of S/C F.

Table 39. CTA-21 support

	WEEK OF																		
ACTIVITY	10/21	10/28	11/4	11/11	11/18	11/25	12/2	12/9	12/16	12/23	12/30	1/6	1/13	1/20	1/27	2/3	2/10	2/17	2/24
<u>MM69 S/C AND MOS</u>																			
ENVIRONMENTAL TEST MONITORING	30	128	140	100	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
SAF SUPPORT	40	96	60	40	--	96	--	--	--	--	--	--	--	--	--	--	--	--	--
DEVELOPMENT	--	--	--	--	64	--	88	128	128	80	--	--	80	80	80	80	120	40	30
OTHER	--	--	--	84	144	--	--	--	20	--	--	--	--	--	--	8	--	--	--
MOS	--	32	--	32	40	--	--	8	--	--	120	56	--	12	42	72	152	42	--
PROGRAM TEST	--	--	--	--	--	--	--	20	--	30	--	12	--	32	--	--	--	--	--
MM 69 SUBTOTAL	70	256	200	256	248	96	88	156	148	110	120	68	80	124	122	160	272	82	30
<u>DSN</u>																			
MMT	64	16	60	--	--	192	80	80	80	40	--	80	64	32	50	--	--	90	80
HRT	--	12	--	--	--	--	64	--	--	--	--	--	--	--	--	--	--	--	--
RANGING	--	--	--	12	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
INTEGRATION	50	--	--	--	--	--	--	40	80	20	40	120	--	--	--	--	--	--	--
TRAINING AND OPERATIONS	210	12	40	325	--	--	40	24	58	24	40	24	62	64	80	60	80	90	90
MAINTENANCE AND INSTALLATION	60	40	160	111	23	9	68	46	38	64	30	27	35	28	32	14½	26	43	62
MISCELLANEOUS	32	152	152	28	185	--	--	50	--	50	50	30	80	64	32	88	--	--	70
DSN SUBTOTAL	416	232	412	476	208	201	252	240	256	198	160	281	241	188	194	162	106	223	302
COMPATIBILITY TEST	--	--	--	--	120	--	--	--	--	--	--	--	--	--	--	--	--	--	--
PIONEER	90	40	8	--	--	--	64	--	--	--	40	16	--	--	--	--	--	120	--
MM 71	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	80
TOTAL	576	528	620	732	576	297	404	396	404	308	320	365	321	312	316	322	378	425	412

Table 39 (contd)

	WEEK OF																						
ACTIVITY	5/6	5/13	5/20	5/27	6/3	6/10	6/17	6/24	7/1	7/8	7/15	7/22	8/5	8/12	8/19	8/26	9/2	9/9	9/16	9/23	9/30	10/7	10/14
MM 69 S/C AND MOS																							
ENVIRONMENTAL TEST MONITORING	--	--	--	--	260	--	--	--	--	--	--	--	--	--	46	200	16	120	96	66	72	85	24
SAF SUPPORT	--	24	--	--	--	--	--	--	240	160	--	20	--	--	--	--	8	48	52	54	36	80	--
DEVELOPMENT	64	78	--	30	16	48	--	--	--	--	--	40	--	--	--	80	--	12	--	--	42	--	88
OTHER	80	98	--	16	--	--	--	--	--	--	48	8	--	--	--	32	--	--	--	--	42	17	--
PROGRAM TEST	--	4	22	16	32	32	64	60	16	--	64	80	64	100	57	72	8	24	38	72	69	276	30
MM 69 SUBTOTAL	144	204	22	62	308	80	64	60	256	160	112	148	64	100	103	384	32	204	186	192	261	458	142
DSN																							
MMT	28	18	8	156	--	148	32	80	--	--	32	90	--	--	--	48	24	76	160	100	56	80	52
HRT	4	6	119	16	16	--	--	--	--	--	--	--	--	6	--	--	4	--	--	2	--	--	--
RANGING	--	--	--	--	--	--	--	36	--	--	--	--	--	--	--	10	20	--	--	18	--	--	--
INTEGRATION	--	--	--	--	--	--	--	--	--	--	--	--	--	--	105	--	--	--	--	--	--	48	--
TRAINING AND OPERATIONS	--	42	10	22	52	82	39	230	16	10	39	40	37	89	60	--	48	93	116	211	73	24	76
MAINTENANCE AND INSTALLATION	51	60	144	60	66	158	170	100	36	20	170	140	427	312	300	120	120	78	107	47	70	35	54
MISCELLANEOUS	2	32	60	16	--	36	225	152	--	--	52	--	--	--	--	14	10	48	16	--	6	75	248
DSN SUBTOTAL	85	158	341	270	134	424	466	598	52	30	293	270	464	407	465	192	226	295	399	378	205	262	420
COMPATIBILITY TEST	--	--	--	--	--	--	--	--	--	280	--	--	--	48	--	120	24	--	79	--	--	--	--
PIONEER	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	24	--	--	--	--	--	16
MM 71	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
TOTAL	229	362	363	332	442	504	530	658	308	470	405	418	528	555	568	696	306	499	664	560	466	726	578



NOTE A – SPACECRAFT DESIGN DOCUMENTED IN MM'69 SPACECRAFT DESIGN BOOK

NOTE B – DATA SYSTEM DESIGN DOCUMENTED IN DSN OPERATIONS PLAN VOL. III. SOFTWARE SYSTEM DESIGN DOCUMENTED IN MM'69 SOFTWARE DESIGN BOOK, DATA SYSTEM INTEGRATION TESTING IS DOCUMENTED IN DSN TEST PLAN, VOL. I.

* – FUNCTIONS OF OPERATING GROUPS DOCUMENTED IN SPACE FLIGHT OPERATIONS PLAN.

Fig. 125. Compatibility tests

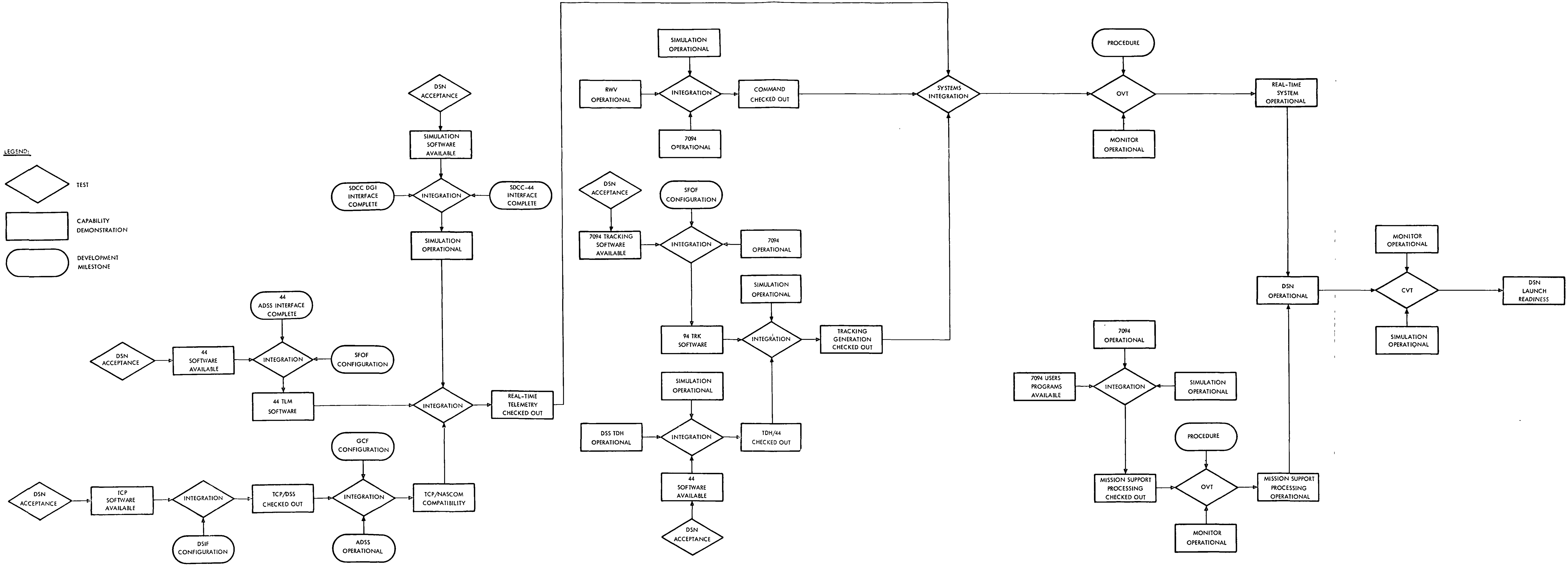


Fig. 126. DSN test flow plan for Mariner Mars 1969

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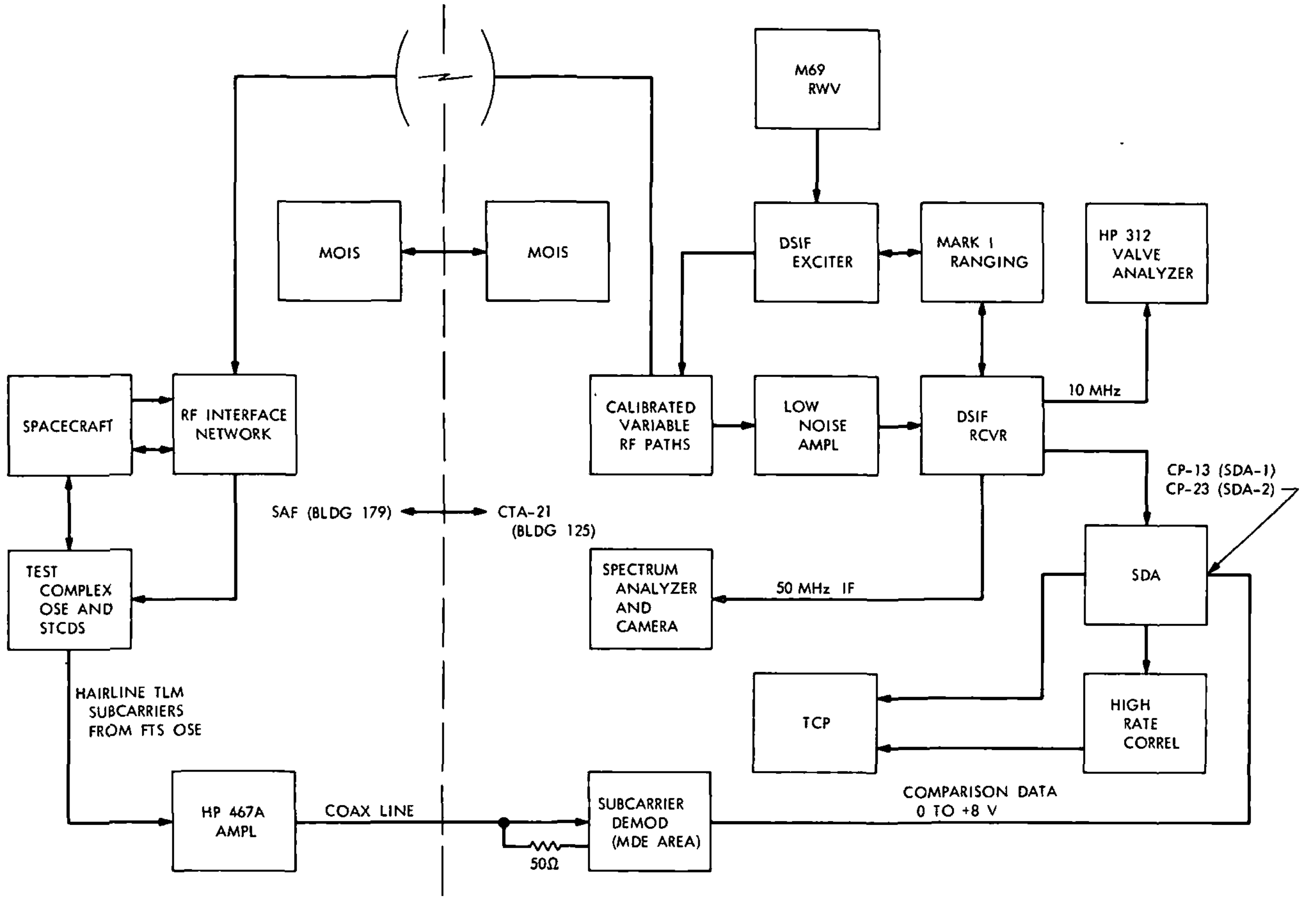


Fig. 127. Test configuration

V. FLIGHT SUPPORT

The TDS maintains logs related to the flight support provided to the Mariner Mars 1969 project. These logs list the major events which occur, in chronological order. The format of the log varies between the near-earth phase and the deep space phase. The near-earth phase period is very short and the log, therefore, is presented in narrative form. The deep space phase covers an interval of many months and, therefore, a condensed format was adopted.

A. Near-Earth Phase Flight Support, Mariner VI

1. Countdown summary. The planned countdown for February 24 and 25, 1969 included two built-in holds, one of a 60-min duration at T - 90, and a second of a 10-min duration at T - 10 Liftoff was scheduled for 0114, with a flight azimuth of 108 deg, a yaw index of 19.6, and a flight-path angle of 11.5 deg. The launch window duration was 40 min. The actual countdown time summary is shown in Table 40.

The JPL/ETR Mission Operations Center was manned and operational at 1759, and operational reporting was established with JPL/Pasadena at 1814. The range countdown was started on schedule at T - 335 min at 1829. Initial ETR status at the beginning of the count was GO, with the exception of the Dynatronics receiver (S-band) at Antigua, which was not operationally ready (NOR) with no estimated time operational (ETO). The DSN reported that the maser at DSS 12 was down, also with no ETO. (An ETO of 0300 was established later in the count.) All other DSN systems were considered to be in a GO condition.

At T - 315 min the ETR reported that the klystron for the Antigua 91.18 radar was NOR, with an ETO of 2330. This radar was subsequently declared operational at 2326. The ACN demodulator was reported NOR because of a data conditioner failure at 1946, with no ETO, but was later declared operational at 2028.

The first RF propagation forecast, which was received at T - 250 min, predicted Condition 3 (fair) for the HF data circuits between the RIS Twin Falls and Cape Kennedy, and between Ascension and the Cape. Condition 2 (unusable) was forecast for the HF circuits between Pretoria and Ascension. The forecast conditions were later changed to Conditions 2, 3, and 2, respectively, which remained in effect for launch. A total of seven forecasts were provided during the count.

At T - 227 min an apparent excessive drift of the Centaur "W" gyro was observed during final alignment prior to the GAP test. This was later determined to be the result of the optics torquing circuit loading the gyro torquing signal. After terminating final alignment and opening the optical torquing relay, the drift was well within tolerance.

Checkout of the spacecraft telemetry data circuits from downrange was completed by T - 272 min, and the spacecraft countdown was started on schedule with spacecraft power on at T - 210 min. Proper operation of all spacecraft subsystems was observed throughout the count.

At T - 165 min, the ETR reported that the 3.18 radar at Grand Bahama was NOR because of an azimuth problem, with no ETO. This radar was subsequently declared operational at 2306. At T -118 min, the DSN reported that DSS 12 was RED for commitment to the Project using the maser. The station was considered RED but could support using the paramplifier.

The countdown then progressed normally through the built-in hold at T - 90 min, which began at 2234 and ended at 2344, and continued until T - 80 min, when a hold was required because of the time previously consumed in evaluating the apparent excessive drift problem in the Centaur guidance system. A total of 25 min was consumed during this hold; however, the planned 10-min built-in hold at T - 10 min was cancelled, which resulted in 15 min of the 40-min launch window being used.

During the hold, the impact of the delay in launch time was determined, the later time improved the tracking coverage. The new flight-path angle was obtained by analysis of the firing tables.

The count was resumed at T - 80 min at 0009. At T - 72 min the ETR reported that the TAA-3 S-band antenna system at Grand Turk was NOR, however, the TAA-3 was returned to operation 5 min later. At T - 8 min the MSFN reported that the FPQ-6 radar at Bermuda was considered RED, and that the FPS-16 would be the prime radar for launch. Shortly before launch, the problem was determined to be insufficient gain in the reference channel, and was temporarily alleviated by adjustments to the receiver, the FPQ-6 was considered GREEN and prime for launch at 0129:42.

The count then progressed normally to liftoff, which occurred at 0129:02.013 GMT on February 25, with a flight azimuth of 108 deg, a yaw index of 18 1, and a flight-path angle of 12.8 deg.

2. Flight phase

a. AFETR — C-band tracking. Estimated and actual radar coverage is shown in Fig. 128. All Class I radar metric coverage requirements were met, with the actual coverage equaling or exceeding the estimate at most stations.

Antigua, the RIS Twin Falls, Ascension, and Pretoria reported low C-band received signal strength. This apparently resulted from poor aspect angle, and is the reason for the early loss of signal at Antigua, the dropout at Twin Falls, and the slightly late acquisition of signal at Ascension. The AFETR commitments were on a best-obtainable basis following main engine cutoff (MECO).

b. AFETR — Computed data. The transfer orbit computed using Antigua free-flight data after MECO was considered only a fair fit of the data. An IRV, SOPM, orbital elements, and Mars mapping in the B-plane were provided from this solution. Also, predicts in the DSN format were provided to DSS 51 and the MSFN ACN site.

A transfer orbit using Centaur Guidance telemetry data after MECO was also computed, providing an IRV, SOPM, orbital elements, and Mars mapping

Transfer orbits based on recursive solutions of all the available transfer orbit C-band data were computed but not transmitted. The C-band radars experienced low signal strength shortly after injection, which caused the data to be noisy during this period As a result, the recursive solutions obtained by the RTCS analysts were of insufficient quality to warrant transmission.

An actual spacecraft orbit was computed by the RTCS using a 30-min span of DSS 51 data. This solution was a good fit of the data and indicated an almost nominal orbit and provided an IRV, SOPM, orbital elements, I-matrix, and Mars mapping. A second set of predicts based on this solution were also sent to DSS 51 and the MSFN ACN site.

The RTCS then computed a post-deflection Centaur orbit based on Pretoria data. This solution was from a good fit of the data, and provided an IRV, SOPM, orbital elements, and Mars mapping. The orbital elements and Mars mapping indicated that the post-deflection maneuver occurred in a nominal manner.

The post-deflection Centaur telemetry solution which was to be provided by the RTCS was not accomplished because the guidance telemetry data from Ascension were not of sufficient quality. Instead, a second post-deflection orbit was computed by the RTCS using Ascension C-band data. This solution was considered only fair, but it agreed adequately with the Pretoria solution, and provided an IRV, SOPM, Mars mapping, and I-matrix.

The RTCS also provided near-real-time metric data in the decimal format to Bldg AO, for relay to the SFOF during the near-earth phase These data were provided by Antigua, Ascension, Twin Falls, and Pretoria.

The RTCS orbital computations are summarized in Tables 41 and 42. Mars mapping of the RTCS transfer orbits and spacecraft orbit is provided in Fig. 129.

The TDS Analyst and Launch Phase Analyst, as a part of their responsibility for providing the Mission Director an integrated model of the progress of the near-earth flight, plotted all of the B·T and B·R parameters from the computed Mars mapping messages on a B-plane map.

c. AFETR — VHF telemetry. Estimated and actual VHF telemetry coverage is shown in Fig. 130. All Class I requirements were met, with the actual coverage equaling or exceeding the estimate at most stations.

The data acquired by Ascension were noisy throughout the indicated actual coverage period, and the data acquired by RIS Twin Falls were noisy during approximately the last third of the track.

The real-time transmission of VHF telemetry data was considered good.

The near-real-time reports of launch vehicle inflight events (mark events), along with the nominal times of occurrence, are shown in Table 43.

d. AFETR — S-band telemetry. Estimated and actual S-band telemetry coverage is shown in Fig. 131. Telemetry coverage during the near-earth flight phase was satisfactory.

Preliminary reports from Ascension and Twin Falls indicated that the left-hand circular polarization signal was considerably better than that of the right-hand polarized received signal. Further evaluation from station strip charts may give an indication as to the cause of this phenomenon. However, no loss of recorded data resulted from this unexpected situation, although a brief dropout (~1 to 1 1/2 min) of real-time data from Ascension was experienced.

The S-band signal received by the TAA-8 antenna system at Antigua showed extensive lobing beginning just after separation. This lobing may have been the result of electromagnetic wave compressions caused by the interaction between the spacecraft and the Centaur, as the spacecraft moves through short wavelengths ($\lambda \approx 13.06$ cm) as the two objects separate. More investigation correlating separation velocity, lobing cycle, and spacecraft/tracking station aspect angle is required to support this conclusion. The real-time transmission of S-band telemetry data was satisfactory.

e. GSFC — MSFN tracking and telemetry coverage. Estimated and actual MSFN tracking and telemetry coverage is shown in Fig. 132. The actual MSFN coverage exceeded the estimates.

Bermuda radar acquisition was accomplished earlier than predicted, through the use of data provided by the RTCS to the Launch Trajectory Data System. This method of acquisition, used successfully for the first time, was reported by Bermuda as excellent.

During the minus count, Bermuda reported RF interference on the Centaur 225.7 mHz. Both acquisition aids therefore tracked the Centaur 259.7-mHz link. The interfering signal was later determined to have been generated on-site by an FPS-16 synchro line amplifier which was oscillating at approximately 225.7 mHz. A permanent solution to this problem is being investigated.

ACN experienced low signal strength on the VHF telemetry link which was to be used as an acquisition aid. S-band telemetry and tracking support was better than predicted and the cause of a bias in the doppler data provided by ACN is under review. Good ranging data were provided.

f. Support functions. The GSFC Data Operations Branch provided all required support for computed data. NASCOM provided all of the required communications support with good performance.

3. Mariner VI tracking support operations

a. Frequency calculations. All DSS 71 frequency reports arrived either early or right on schedule. The day-old, best-lock, and all auxiliary oscillator measurements were well within tolerance on the nominal frequency versus temperature curves. DSIF advisors communicated directly to the telecommunications analyst (project telcom) at regular intervals before launch to update the estimated frequencies at DSS 51 rise and time of two-way acquisition. Best estimates of spacecraft frequencies were teletyped periodically to RTCS and were used in JPL predicts. Estimated frequencies were updated continuously after launch, based on actual spacecraft temperature. The temperature just before the time DSS 51 was to try two-way acquisition was lower than the value used to calculate frequencies in the predicts sent to DSS 51 at liftoff. This corresponded to a 10-Hz (at ground VCO level) change in the estimated best-lock frequency. Since the tuning pattern to be used for acquisition would encompass this 10 Hz, to simplify use of predicts, a bias was not given to the station. The stations did acquire on their first sweep at about 18 Hz above the predicts, which means that the total error in the predicted XA for two-way acquisition (allowing for the known 10-Hz error) was, at most, 8 Hz.

The predict at the time of initial one-way acquisition was 1.5 kHz (at S-band) too large, decreasing to 700 Hz at launch + 1 h. This is within the tolerances of the nominal frequency versus temperature curves for the auxiliary oscillator with part of the error due to a temperature difference.

b. Launch phase predicts. An unscheduled 20-min hold occurred at about L - 1:20 which resulted in the removal of the L - 10 min hold. The launch predict strategy adapted smoothly to the real-time situation. Predict set 05Y was generated at 00:54Z (L - 35 min) and transmitted to ACN (MSFN 75) at 00:58Z. Since no change in expected liftoff or predicted frequencies had occurred since set 05Y was generated, set 05Y was transmitted to DSS 51 at 01:29Z (liftoff). At 01:43Z (L + 14 min) DSS 51 reported it had an adequate amount of predict set 05Y for acquisition. At 01:49Z (L + 20 min) it was decided that another predict set was not required to support the two-way acquisition. Set 05Y was therefore the predict set used by ACN for one-way acquisition, and by DSS 51 for one-way and two-way acquisition.

One-way and two-way acquisition at DSS 51 was smooth, quick, and on time. The station operations is summarized in Table 44.

B. Near-Earth Phase Flight Support, Mariner VII

1. Countdown summary. The planned countdown for March 27, 1969 included two built-in holds: one of 60-min duration at T - 90 min, and a second of 10-min duration at T - 10 min. Liftoff was scheduled for 2135, with a flight azimuth of 101.66 deg and a flight path angle of 6.59 deg. The launch window duration was 60 min. The actual countdown time summary is shown in Table 45.

The JPL/ETR Mission Operations Center was manned and operational at 1400, and operational reporting was established with JPL/Pasadena at 1435. Initial DSN status was reported in the GO condition, with the exception of a clock problem with the 7044X computer and a 7094X problem which prevented loading of the system tape. This latter problem had existed since 1130 and consideration was given to establishing the Y string as prime, with the 7044X in mode 3 as backup; however, it was determined that the 7044X programs could not be loaded because of a disc problem, and both the 7044X and the 7094X were returned to operational status at 1500.

The Range Countdown was started on schedule at T - 335 min at 1450 Initial ETR status at the beginning of the count was GO. The RF propagation forecast, which was received at T - 270 min, predicted Condition 3 (fair) for all HF data circuits. At T - 232 min the MSFN reported that all stations and systems were GO, and the spacecraft countdown was started on schedule at T - 210 min, with spacecraft power ON.

All countdown operations proceeded normally until T - 172 min, when the ETR reported that the 3.13 radar at GBI was NOR because of a σ - 5 computer problem which prevented high- or low-speed data output. The radar was later declared operational at T - 102 min. An azimuth/elevation encoder problem with the 91.18 radar at Antigua was reported at T - 136 min. This radar was returned to service at 1914, during the first built-in hold.

The first built-in hold began as planned at T - 90 min, at 1855; however, the count was not resumed until 1955:45, which was 45 s later than scheduled. This time was picked up during the built-in hold at T - 10 min.

At T - 73 min, the 7.18 radar at Grand Turk was reported as NOR because of a transmitter problem. The problem was corrected and the radar returned to service at 2158.

The second built-in hold began at T - 10 min at 2115:45, and the count was resumed on schedule at 2125. During this hold, the RIS Twin Falls radar was declared NOR, then returned to a GO status 2 min later.

After resuming count at T - 10 min, all operations proceeded normally until T - 7 min, when Centaur guidance reported intermittent optical acquisition of the vehicle. The countdown was continued, while guidance tried to resolve the problem, until T - 56 s, when guidance reported that the vehicle could not be optically acquired. The countdown was held at this point to confirm the configuration, and then recycled to T - 10 min to evaluate the anomaly. It was determined that the platform position could be assured well within allowable tolerances by manual torquing commands in conjunction with meter measurements of drift. A launch configuration was confirmed and the count was resumed at T - 10 min at 2212:01. During this hold, the impact of the delay in launch time was determined. The later time improved the tracking coverage from Antigua and Ascension, and the new flight path angle was obtained by analysis of the firing tables.

Terminal count operations then progressed normally to liftoff, which occurred at 2222:01.198 on March 27, with a flight azimuth of 102.79 deg and a flight path angle of 12.5 deg.

2. Flight phase

a. AFETR — C-band tracking. Estimated and actual radar coverage is shown in Fig. 133. All Class I metric coverage requirements were met, with the actual coverage equaling or exceeding the estimate at most stations.

Antigua had an early LOS, the station observed a 15-dB step decrease at T + 759 s, a decrease also observed by Grand Turk The RIS Twin Falls, which had view during this period, was unable to observe the decrease since they were in a range recycle interval. Ascension reported a 124-ft decrease in range at the same time. The 4.65-m (12.18) radar experienced problems with the digital range machine at T + 1817 s and, as a result, had early LOS.

Pretoria tracked to T + 3969 s; the data were very good and were used in the computation of the post-deflection orbit.

b. AFETR — computed data. A transfer orbit was computed using Antigua free-flight data after MECO. This solution was considered a fair fit of the data, and provided an IRV, SOPM, orbital elements, and Mars mapping in the B-plane. Also, predicts in the DSN format were provided to DSS 51, DSS 62, and the MSFN ACN site.

A transfer orbit was then computed using Centaur guidance telemetry data after MECO. This solution indicated a nominal vehicle trajectory and provided an IRV, SOPM, orbital elements, and Mars mapping.

A transfer orbit based on a recursive solution of Ascension data (span — L + 1024 to 1150 s) was computed and transmitted. This solution was a good fit of the data and indicated an almost nominal mission; it provided an IRV, SOPM, orbital element, Mars mapping, and I-matrix.

An actual spacecraft orbit was then computed by the RTCS, using a 40-min span of DSS 51 data. This solution was a very good fit of the data and indicated an almost nominal orbit; it also provided an IRV, SOPM, orbital elements, I-matrix, and Mars mapping. A second set of predicts based on this solution were also sent to DSS 51, DSS 62, and the MSFN ACN site.

The RTCS next computed a post-deflection Centaur orbit based on Pretoria data. The data span used was from L + 3100 to 3550 s. This recursive solution was from a good fit of the data and provided an IRV, SOPM, orbital elements, I-matrix, and Mars mapping. The orbital elements and Mars mapping indicated that the post-deflection maneuver occurred in a nominal manner.

A post-deflection Centaur guidance telemetry solution was to be provided by the RTCS; however, this was not accomplished because valid guidance telemetry data from Ascension were not received due to an overload of the Centaur airborne computer.

The RTCS also provided near-real-time metric data in the decimal format to Bldg AO for relay to the SFOF during the near-earth phase. Data in the decimal format were provided from Antigua, Ascension, Twin Falls, Pretoria, and Grand Turk, in that order. The RTCS orbital computations are summarized in Tables 46 and 47.

Mars mapping of the RTCS transfer orbits and spacecraft orbit is provided in Fig. 134. Mars mapping by other computer sources (SFOF and GD/C), as reported during the near-earth phase, are also included.

The TDS Analyst and Launch Phase Analyst, as a part of their responsibilities for providing the Mission Director with an integrated model of the progress of the near-earth flight, plotted all of the mapping B·T and B·R parameters from the computed Mars mapping messages on a B-plane map.

c. AFETR — VHF telemetry. Estimated and actual VHF telemetry coverage is shown in Fig. 135. All Class I requirements were met, with the actual coverage equaling or exceeding the estimate at most stations.

Noisy signal was received by the RIS Twin Falls, beginning about T + 1090 s. Ascension also observed noisy received signal from the time of its initial acquisition. No explanation as to the cause of the noisy signals is available.

The real-time transmission of VHF telemetry data was considered excellent. The near-real-time reports of launch vehicle inflight events (Mark Events), along with the nominal times of occurrence, are shown in Table 48.

d. AFETR — S-band telemetry. Estimated and actual S-band telemetry coverage is shown in Fig. 136. Telemetry coverage during the near-earth flight phase was satisfactory. The S-band signal strength dropped shortly after launch, but came up to its nominal value at spacecraft separation. The TAA-8 antenna received signal strength record again shows the lobing reported on Mariner VI. The real-time transmission of S-band telemetry data was considered excellent.

e. GSFC — MSFN tracking and telemetry coverage. Estimated and actual MSFN tracking and telemetry coverage is shown in Fig. 137. The actual MSFN coverage exceeded the estimates.

Good S-band tracking support was provided by the MSFN. The data were biased similar to the data received during Mariner VI.

Bermuda acquired with the use of the S-band system, since the FPQ-6 could not slave to the incoming LTDS data. The problem is still under investigation. The system has been used successfully on a DOD launch since this launch.

ACN experienced RFI beginning at 2245Z (L + 23 min). It was of a random nature, at a level approximately 10 dB down from the carrier, and continued through their pass. When queried, DSS 51 replied that they were not experiencing such RFI. Copies of the RFI data have been provided to JPL.

f. GSFC — support functions. The GSFC Data Operations Branch provided all required support in an excellent manner. NASCOM provided all of the required communications support; their performance was considered very good.

3. Mariner VII tracking support operations

a. Frequency calculations. The interface between DSIF advisors and project telcom operated smoothly, as in the Mariner VI launch, to update frequencies up to the time of two-way acquisition.

The predicts provided to DSS 51 for acquisition were 460 Hz too low (at S-band) in one-way acquisition, and the station acquired two-way 17.1 Hz (at VCO level) above the predicts. Some of the 17.1 Hz was because the station was tuning up at the time of acquisition (standard procedure). Both frequencies were predicted to within the tolerances of the preflight temperature versus frequency curves.

b. Launch phase predicts. A 47-min unscheduled hold occurred; when the count resumed at L - 10 min, the injection conditions produced on both computer strings by the trajectory group were in error. Since the predicts were then in jeopardy of not getting out, ACN, DSS 62, and DSS 51 were read biases to apply to predicts already available.

It was not until L + 7 min that valid injection conditions were available. Predict set 11Y was ready for transmission at L + 9.5 min and, at L + 13 min, DSS 51 reported the start of receipt. At L + 21 min DSS 51 reported receipt of enough of set 11Y to use for acquisition. For time scale, DSS 51 acquired one-way at L + 23.5 min, and two-way at L + 36 min.

As a result, DSS 51 acquired one-way and two-way predict set 11Y with no biases. DSS 62 acquired one-way on predict set P06 (a preflight nominal) with a negative 13-min bias. ACN used Goddard-generated predicts to acquire angles, as planned, and used a predict set 01Y with a 47-min bias for frequency information. Soon after acquisition predict, set 11Y was received by ACN and DSS 62 for subsequent tracking.

DSS 51 experienced antenna mechanical problem, which resulted in restricting the initial acquisition to the 45-deg hour angle point. Consistent with the constraint, one-way and two-way acquisition were again smooth and quick. DSS 62 acquired one-way successfully and, perhaps, earlier than anticipated. A summary follows in Table 49.

C. Deep Space Phase Flight Support

The launch for Mariner VI proceeded on GMT day 056 at 012902 and DSS 51 quickly acquired the spacecraft as planned. Trajectory correction for Mariner VI occurred on day 060 at 005005. All command activities were conducted by DSS 41 at Woomera. A large number of coded commands were sent to the spacecraft CC&S computer. After these commands were read out of the spacecraft computer and verified, a DC-14 command was sent to arm the maneuver. Approximately 10 min later, the maneuver start command (DC-27) was sent to the spacecraft. A tracking and telemetry analysis conducted at the SFOF indicated that the maneuver was conducted properly and the spacecraft was in good condition.

Launch of Mariner VII occurred on day 086 at 222201. Injection was as accurate as that of Mariner VI, and DSS 51 again acquired the spacecraft without difficulty. Trajectory correction occurred on day 098 at 202224 as conducted by DSS 41. As on Mariner VI, the commands were stored in the spacecraft computer, read out, and verified, with the maneuver armed by a DC-14 command and initiated by a DC-27 command. This maneuver, unlike the Mariner VI maneuver, started from a roll position based on the star Sirius. The spacecraft was unlocked from Canopus and permitted to roll to Sirius. The use of this option permitted the star tracker to stay in normal operation throughout the turns and motor burn, improved the communications margin, and kept the spacecraft on solar power throughout the maneuver. Again, the maneuver was successful.

Tables 50 and 51 summarize DSN flight support for Mariners VI and VII.

Table 40. Countdown time summary

Event	T-Time	GMT
MOC Manned and Operational	-	1759
Start Range Countdown	T-335	1829
Start Spacecraft Countdown	T-210	1734
Start 60 minute Built-In Hold (BIH)	T-90	2234
End of BIH; Resume Count	T-90	2334
Hold for Centaur Guidance	T-80	2334
Resume Count	T-80	2409
Liftoff	T-0	0129

Table 41. RTCS orbital computations

Orbit	Epoch (seconds)	Time of Computations (minutes)	Data Source	Quality of Solution
Transfer orbit	L+749	L+15	Antigua	Fair
Transfer orbit	L+747	L+27	Centaur guidance telemetry	Fair
Spacecraft orbit	L+749	L+137	DSS 51	Good
Post deflection	L+3691	L+183	Pretoria	Good
Post deflection	L+3088	L+251	Ascension	Fair

Table 42. Orbital parameters from RTCS computations

Parameters		Transfer Orbit (Based on Antigua Data)	Transfer Orbit (Based on Centaur TLM Data)	Spacecraft Orbit (Based on DSS 51 Data)	Centaur Post Deflection Orbit (Based on Pretoria Data)	Centaur Post Deflection Orbit (Based) on Ascension Data)
Epoch time		0141.31.7	0141:29.4	0141:31.7	0230:33.0	0220:30.0
Earth-Fixed Sphericals	Radius	6862.9686	6801.7909	6866.5278	24094.9331	20455.1753
	Latitude	11.7733	13.1743	11.7119	-39.0048	-36.9592
	Longitude	306.1181	304.1404	306.1404	05.6570	01.9830
	Velocity	10.9350	10.9847	10.9351	06.2576	06.6763
	Path angle (gamma)	14.9508	13.7400	14.9081	72.1837	66.4742
	Azimuth angle	133 7861	133.4230	133.8124	124.7447	125.1327
Eccentricity		1.1805	1.1814	1.1817	1.1996	1.2005
Inclination		43.3292	43.3634	43.3391	43.2399	43.3357
C_3		11.1271	11.1788	11.1944	12.2319	12.2167

Table 43. Launch vehicle inflight event times

Mark	Event	Nominal Time	Near-Real-Time Report				
			Tel-4	Bermuda	Antigua	Twin Falls	Ascension
-	Liftoff (2-inch motion)	0.0					
1	Atlas BECO	152.11	147.19				
2	Atlas booster engine jettison	155.21	150.19				
3	Centaur insulation panel jettison	197.11	192.39				
4	Nose fairing jettison	234.11	228.49				
5	Atlas SECO and VECO	252.25	271.29	270.49			
6	Atlas/Centaur separation	254.1	274.24	273.19			
7	Centaur MES	263.75	282.89	283.69			
8	Centaur MECO	699.6			725.59		
9	Centaur/Mariner separation	794.6			821.29	821.24	
10	Begin Centaur reorientation	1064.6			1090.99	1091.54	1091.49
11	Start Centaur blowdown	1549.6				1578.19	

Table 44. Mariner VI acquisition log of events

GMT	Event
01:29:02.013	Launch
(01:45:17)	(ACN one-way lock)
01:52:21	DSS 51 one-way lock
01:52:36	SDA lock
01:52:58	Bit and frame lock
01:55:03	Auto track on the SAA
01:55:13	Auto track on the SCM
02:31:00	Transmitter on, 200 w through the SAA
02:31:14	Receiver out of lock (two-way)
02:31:20	Auto track on the SCM
02:33:18	Arrived at track syn freq (good doppler)
02:45:00	Command mod on
02:50:48	Command loop lock
03:16:00	Ranging mod on
04:06:00	Good ranging data

Table 45. Countdown time summary

Event	T-Time	GMT
MOC manned and operational	T - 365	1420
Start range countdown	T - 335	1450
Start spacecraft countdown	T - 210	1655
Start 60-min built-in hold	T - 90	1855
End BIH; resume count	T - 90	1955
Start 10-min built-in hold	T - 10	2115
End BIH; resume count	T - 10	2125
Hold for Centaur guidance, recycle to T - 10	T - 56 s	2134
Resume count	T - 10	2212
Lift off	T - 0	2222

Table 46. RTCS orbital computations

Orbit	Epoch (seconds)	Time of Computations (minutes)	Data Source	Quality of Solution
Transfer orbit	L+749	L+17	Antigua	Fair
Transfer orbit	L+734	L+26	Centaur Guidance Telemetry	Fair
Transfer orbit	L+1042	L+44	Ascension	Good
Spacecraft orbit	L+1042	L+121	DSS51 (40 min. span)	Very Good
Postdeflection	L+3256	L+163	Pretoria	Good

Table 47. Orbital parameters from RTCS computations

Parameters		Transfer Orbit (Based on Antigua Data)	Transfer Orbit (Based on Centaur Tlm Data)	Transfer Orbit (Based on Ascension Data)	Spacecraft Orbit (Based on DSS 51 Data)	Centaur Post-Deflection Orbit (Based on Pretoria Data)
Epoch Time (GMT, hr, min, sec)		2234:30.7	2234:15.5	2239:23.9	2239:23.9	2316:17.9
Radius		6884.0416	6788.2658	8085.5747	8086.9170	22307.0738
Earth Fixed Sphericals	Latitude	16.9689	18.4282	5.6554	5.6388	-21.2590
	Longitude	311.5455	308.5933	331.3443	331.3506	11.7913
	Velocity	11.1045	11.1781	10.3067	10.3056	6.8036
	Path Angle	15.2554	13.3327	29.3087	29.3087	71.4991
	Azimuth Angle	117.4960	116.4316	122.4423	122.4276	129.3558
Eccentricity		1.2744	1.2748	1.2748	1.2748	1.2939
Inclination		31.0139	30.9947	31.0106	30.9936	31.1056
C^3		16.8612	16.8818	16.8780	16.8735	17.9112

Table 48. Launch vehicle inflight event times

Mark	Event	Nominal Time	Near-Real-Time Report				
			Tel 4	Bermuda	Antigua	Twin Falls	Ascension
-	Liftoff (5.1-cm motion)	0.0					
1	Atlas BECO	152.5	150.5				
2	Atlas booster engine jettison	155.6	153.0				
3	Centaur insulation panel jettison	197.5	195.6				
4	Nose fairing jettison	234.5	232.6				
5	Atlas SECO and VECO	253.1	254.3	254.5			
6	Atlas/Centaur separation	255.0	257.1	257.1			
7	Centaur MES	264.6	268.0	266.6			
8	Centaur MECO	701.5	712.3	712.3	712.3	712.3	
9	Centaur/Mariner separation	796.5		807.3	805.4	807.26	
10	Begin Centaur reorientation	1066.5			1079.2	1079.5	1079.2
11	Start Centaur blowdown	1551.5				1563.0	1562.3

Table 49. Mariner VII acquisition log of events

GMT	Event
22:22:01.198	Launch
(22 36.40)	(ACN one-way lock)
(22 40·29)	(DSS 62 one-way lock)
22 45·02	DSS 51 one-way lock
22 45·23	SDA lock
22 46:52	Bit and frame lock
22:55:10	Autotrack on the SCM
22:57·00	Xmitter on, 200 w through the SAA
22.57:42	Receiver out of lock (two-way)
22·58:48	Autotrack on the SAA
22·59 15	Autotrack on the SCM
22 59 38	Arrived at track syn freq (good doppler)
23 03.00	Command mod on
23·04:30	Command loop lock

Table 50. DSN operations log of Mariner VI

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
Launch	71	055/6	2036	0138	-60	98.73	--	--		DSIF GCF SFOF	Launch Std Dual Mode 2	
Launch	ACN	056	0145	1253	-114	100	--	--		MSFN GCF SFOF	Cooled paramp. HSD only Dual Mode 2	
001	51	056	0152	0927	-115	88.01	86.08	96.8	Initial difficulty with ranging, but still obtained good ranging last two hours of pass.	DSIF GCF SFOF	2-way, ranging Std and handwire Dual Mode 2	Sent two DC-9 commands.
001	12	056	1018	1558	-126	96.75	78.59	98.6		DSIF GCF SFOF	2-way, ranging Std Dual Mode 2	Sent one DC-9 command.
001	41	056/7	1423	0303	-130	99.12	91.72	98.00	TCP SNR anomalous. Fixed prior to maneuver by incorporation of outstanding ECR.	DSIF GCF SFOF	2-way, ranging Std Dual Mode 2	
002	51	056/7	2200	1005	-129	92.26	85.64	95.1		DSIF GCF SFOF	2-way, ranging Std	Sent one DC-9 command.

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
002	12	057	1024	1500	-134.5	89.36		96.8		DSIF	2-way, ranging	
										GCF	Std	
										SFOF		
002	41	057/8	1431	0012	-136.4	87.17	91.31	99.40	DSIF: Wrong syn freq; lost four minutes TDH.	DSIF	2-way, ranging	
									GCF: CP drum problems.	GCF	Std	
									SFOF: 7044/CP interface problem; lost 30 minutes data.	SFOF	Mode 2	
003	51	057/8	2205	1008	-133.0	98.41	95.28	94.4	DSIF: Ranging receiver problem.	DSIF	2-way, ranging	Sent one DC-9 command.
										GCF	Hardwire	
										SFOF	Mode 2	
003	12	058	1022	1618	-138.3	97.27	42.44	97.6	DSIF: Faulty klystron power adjustment caused signal fluctuation.	DSIF	2-way, ranging	Made best lock frequency measurements.
										GCF	Std	
										SFOF	Mode 2	
003	41	058/9	1430	0309	-139.5	98.34	73.29	96.30	DSIF: Faulty TDH TD replaced, lost five minutes data on TCP log tape while troubleshooting SNR problem.	DSIF	2-way, ranging	
										GCF	Std	
										SFOF	Mode 2	
004	51	058/9	2204	1022	-138.7	97.58	93.61	94.0	DSIF: TCP and log tape problem.	DSIF	2-way, ranging	Sent one DC-9 command.
									SFOF: 6-1/2 hr. of data were not logged on 7044. Did not play back TCP tape.	GCF	Std	
										SFOF	Mode 2	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%) Telemetry HSD	DSN Real-Time Performance (%) Tracking TTY TRK	DSN Real-Time Performance (%) Tracking Total Available	Failures and Anomalies	Configuration		Significant Events
004	12	059	1018	1616	-140.2	99.29	93.09	Not Evaluated	DSIF: Poor ranging data. SFOF: 4-1/2 hours data not logged on 7044. TCP tape replayed later to fill in.	DSIF GCF SFOF	2-way, ranging Std Mode 2	
004	41	059/60	1429	0307	-142.0	90.73	89.06	99.40	GCF: Trouble with voice and HSDL prior to DC-2.	DSIF GCF SFOF	2-way Std and hard-wires Dual Mode 2	Sent 20 coded commands for maneuver. Sent DC-2, 9, 14, and 27 for maneuver execution. Sent DC-9 and 38 and three coded commands after maneuver.
005	51	059/60	2200	1001	-140	99.26	98.11	95.0		DSIF GCF SFOF	3-way Std and hard-wires Dual Mode 2	Backup for DSS 41 for maneuver commands and telemetry. Back-feed to AO discontinued.
005	12	060	1015	1615	-142.5	93.19	78.95	97.9		DSIF GCF SFOF	2-way, ranging Std Mode 2	Made best lock frequency measurements. Retransmitted Pass 004 TCP log tape during post-cals.
005	41	060/1	1426	0300	-144.7	98.46	97.35	98.60		DSIF GCF SFOF	2-way, ranging Std Mode 2	Sent one DC-9 command.

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
006	51	060/1	2159	1000	-143.0	96.99	81.02	95.2		DSIF GCF SFOF	2-way, ranging Std Mode 2	
006	12	061	1010	1610	-144.1	98.91	96.69	97.1		DSIF GCF SFOF	2-way, ranging Std Mode 2	Made best lock frequency measurements.
006	41	061/2	1424	0257	-145.3	97.67	98.28	95.20		DSIF GCF SFOF	2-way, ranging Std Mode 2	Sent one DC-9 command.
007	51	061/2	2156	0955	-143.7	98.41	92.41	97.4	DSIF: Broken transmitter coolant line.	DSIF GCF SFOF	2-way, ranging Std Mode 2	
007	12	062	1030	1600	-144.6	98.95	86.36	98.5		DSIF GCF SFOF	2-way, ranging Std Mode 2	Made best lock frequency measurements.
007	41	062/3	1500	0052	-145.8	99.81	95.45	99.16		DSIF GCF SFOF	2-way, ranging Std Mode 2	Sent one DC-9 command.
008	51	062/3	2153	0930	-144.0	91.63	97.57	95.6		DSIF GCF SFOF	2-way, ranging Std Mode 2	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
008	12	063	1029	1600	-146.3	99.84	93.37	95.0		DSIF GCF SFOF	2-way, ranging Std Mode 2	
008	41	063/4	1500	0103	-147.0	100	96.18	96.18		DSIF GCF SFOF	2-way, ranging Std Mode 2	Sent DC-9, 13, and 33 for second maneuver prep.
009	51	063/4	2202	0930	-146.3	98.99	93.52	95.4		DSIF GCF SFOF	2-way, ranging Std Mode 2	
009	12	064	1029	1600	-147.2	97.38	92.45	98.7		DSIF GCF SFOF	2-way, ranging Std Mode 2	
009	14	064	1105	1138	-139.5	0	0	0	DSIF: Bearing problem; pass terminated. SFOF: 7044 wouldn't process DSS 14 ID data; since fixed.	DSIF GCF SFOF	R&D Std Mode 2	
009	41	064/5	1500	0100	-148.3	94.22	97.51	98.47		DSIF GCF SFOF	2-way, ranging Std Mode 2	Sent one DC-9 command.
010	51	064/5	2215	0400	-146.3	98.21	95.98	Not Evaluated	DSIF: Pass shortened to allow antenna repair.	DSIF GCF SFOF	2-way Std Mode 2	Reached ranging threshold at DSS 51.

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
010	12	065	1029	1600	-148.0	97.35	88.25	96.3		DSIF GCF SFOF	2-way Std Mode 2	Numerous two-way transfers with DSS 14, hence not much TDH. Reached ranging threshold.
010	14	065	1057	1300	-140.5	N/A	86.05	95.5		DSIF GCF SFOF	R&D Std Mode 2	Obtained good interplanetary ranging.
010	41	065/6	1500	0101	-148.3	97.81	96.52	98.36		DSIF GCF SFOF	2-way, ranging Std Mode 2	Sent DC-45 to remove scan cover. Sent one DC-9.
011	51	065/6	2320	0930	-144.0	92.53	95.28	96.0		DSIF GCF SFOF	2-way Std Mode 2	Reached ranging threshold.
011	41	066/7	1455	0101	-148.3	98.34	90.26	98.06		DSIF GCF SFOF	2-way Std Mode 2	Made best lock frequency measurements. Reached ranging threshold.
012	51	066/7	2203	0930	-147.3	92.75	95.79	95.1		DSIF GCF SFOF	2-way Std Mode 2	
012	41	067/8	1419	0201	-148.8	93.56	91.88	98.09		DSIF GCF SFOF	2-way Std Mode 2	Made best lock frequency measurements.

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Year (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
013	51	067/8	2202	0930	-147.1	96.39	96.25	97.1		DSIF GCF SFOF	2-way Std Mode 2	
013	41	068/9	1418	0200	-149.0	90.06	86.77	98.44		DSIF GCF SFOF	2-way Std Mode 2	Made best lock frequency measurements.
014	51	068/9	2132	0930	-147.4	94.32	93.76	95.0		DSIF GCF SFOF	2-way Std Mode 2	
014	41	069/70	1513	0232	-149.4	92.85	98.61	Not Evaluated		DSIF GCF SFOF	2-way Std Mode 2	
015	12	070	0937	1530	-148.9	69.68	96.41	98.8		DSIF GCF SFOF	2-way Std and 96 kHz microwave Mode 2	Ran piggyback encounter engineering data flow test.
016	51	070/71	2128	0800	-148.5	87.56	91.80	Not Evaluated	DSIF: Unable to replay data from Pass 014 TCP log tape.	DSIF GCF SFOF	2-way Std Mode 2	
016	62	071	0323	0736	-150.0	99.53	89.02	97.9		DSIF GCF SFOF	2 and 3-way Std	First MM69 track by DSS 62, excellent performance.
016	41	071	1350	0000	-150.0	97.83	96.24	97.9		DSIF GCF SFOF	2-way Std Mode 2	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Year (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
016	42	071	1300	1735	-150.0	N/A	97.72	No data package		DSIF GCF SFOF	3-way Std Mode 2	First MM69 track by DSS 42; excellent performance.
017	51	071/2	2250	0900	--	97.36	92.47	94.9	DSIF: FR-1400 recording problem noted when attempting to replay Pass 014.	DSIF GCF SFOF	2-way Std Mode 2	
017	41	072	1345	0000	-149.4	96.46	96.10	Not Evaluated	DSIF: Maser down, tracked on paramp entire pass.	DSIF GCF SFOF	2-way Std Mode 2	
018	51	072/3	2300	0900	-149.0	83.11	87.87	95.3		DSIF GCF SFOF	2-way Std Mode 2	
018	41	073	1356	0000	-150.5	93.79	96.17	99.6	DSIF: Entire track on paramp.	DSIF GCF SFOF	2-way Std Mode 2	
019	51	073/4	2256	0900	-149.3	98.19	94.56	96.7		DSIF GCF SFOF	2-way Std Mode 2	
019	41	074	1355	0000	-150.8	99.78	99.00	99.5		DSIF GCF SFOF	2-way Std Mode 2	
020	51	074/5	2245	0900	-149.2	99.51	96.10	95.5	DSIF: No TCP log tape playback possible; TFR 109436.	DSIF GCF SFOF	2-way Std Mode 2	
020	41	075	1356	0000	-150.5	99.30	98.17	99.7		DSIF GCF SFOF	2-way Std Mode 2	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
021	62	076	0329	0630	-150.0	98.0	86.34	98.2		DSIF GCF SFOF	MCD/219 HSDL, TTY DPS/M3	
021	41	076/077	1327	0200	-150.6	98.49	97.87	99.2		DSIF GCF SFOF	MCD/223/219 STD STD = HSDL, TTY DPS/M3	
022	12	077	0909	1512	-149.6	99.48	94.79	98.5		DSIF GCF SFOF	MCD/224 STD DPS/M3	
022	14	077	1008	1446	-143.2		92.91	96.4	Inspection of raw telemetry shows no outage over 5 minutes.	DSIF GCF SFOF	 TTY DPS/M3	
022	41	077	1426	2400	-151.3	95.22	98.08	99.5	TTY and HSD lines down, 21 minutes lost.	DSIF GCF SFOF	MCD/224/219 STD DPS/M3	
023	51	078	0038	0853	-149.8	96.24	94.35	95.7	No excessive outages.	DSIF GCF SFOF	MCD/219/224 STD DPS/M3	
023	41	078	1356	2300	-150.8	99.1	96.51	99.2	No excessive outages.	DSIF GCF SFOF	MCD/223/219/224 STD DPS/M3	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%) Telemetry HSD	DSN Real-Time Performance (%) Tracking TTY TRK	DSN Real-Time Performance (%) Tracking Total Available	Failures and Anomalies	Configuration		Significant Events
024	51	078/079	2211	0700	-149.0	99.31	92.92	93.1	No excessive outages.	DSIF	MCD/224/219	
									Update in process.	GCF	STD	
										SFOF	DPS/M3	
024	41	079	1355	2300	-150.2	97.84	97.06	97.7	No excessive outages.	DSIF	MCD/223/219/224	
										GCF	STD	
										SFOF	DPS/M3	
024	42	079/080	2051	0100	-151.0	94.97	95.6	99.4	7 minute outage, TTY available.	DSIF		
										GCF	STD	
										SFOF	DPS/M3	
025	62	080	0300	0630	-149.3	92.29	91.55	99.0	11 total minutes, TTY available.	DSIF	MCD/223/219	
										GCF	STD	
										SFOF	DPS/M3	
025	41	080	1328	2300	-150.4	97.65	94.07	99.6	5 minutes outage, TTY available.	DSIF	MCD/223/219/224	
										GCF	STD	
										SFOF	DPS/M3	
026	51	080/081	2204	0700	-148.8	84.94	17.33	97.6	0421 - 0442 TTY available.	DSIF	MCD/224/219	
									All other outages assumed recoverable.	GCF	STD	
										SFOF	DPS/M3	
026	41	081	1357	2300	-150.3	99.38	96.51	99.4	No excessive outages.	DSIF	MCD/223/219/224	
										GCF	STD	
										SFOF	DPS/M3	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
027	51	081/082	2155	0700	-148.9	94.2	91.94	97.7	Total of 14 minutes outage, 5 minutes TTY available. Outage due to line probs.	DSIF GCF SFOF	MCD/224/219 STD DPS/M3	
027	41	082	1357	2400	-150.1	99.09	98.68	99.8	No excessive outages.	DSIF GCF SFOF	MCD/223/219/221/219 STD DPS/M3	
028	14	083	0938	1434	-141.7	99.0	92.93	97.2	No excessive outages.	DSIF GCF SFOF	STD DPS/M3	
028	41	083	1257	2400	-150.3	46.57	97.14	100.0	312 minutes outage, TTY available Maser down, paramp.	DSIF GCF SFOF	MCD/224/219 STD DPS/M3	
029	51	083/084	2330	0800	-148.8	96.1	94.52	96.5	No excessive outages.	DSIF GCF SFOF	MCD/224/219 STD DPS/M3	
029	41	084/085	1257	0131	-150.2	77.8	96.69	98.2	No excessive outages.	DSIF GCF SFOF	MCD/219/224 STD DPS/M3	
030	51	084/085	2257	0800	-149.0	98.79	96.86	97.6	No excessive outages	DSIF GCF SFOF	MCD/219 STD DPS/M3	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
030	41	085	1257	2400	-149.9	99.72	98.34	99.7	No excessive outages.	DSIF GCF SFOF	MCD/223/219 STD SPD/M3	
031	12	086	0940	1430	-153.3	96.86	93.15	96.0	TFR No. 0100 - 140760: No available data from 1102Z to 1110Z. SDA 2 synth. power fuse failure.	DSIF GCF SFOF	MCD/223/219/224 STD DPS/M3	
031	41	086	1257	2400	-150.0	94.86	96.7	98.5	11 minutes outage; TTY available. Record only from 1930Z to 2400Z.	DSIF GCF SFOF	MCD/224/219 STD DPS/M3	
032	62	087	0230	0657	-150.2	97.56	Not Available	98.0	5 minutes outage; TTY available.	DSIF GCF SFOF	MCD/223/219 STD DPS/M2	
032	12	087	1200	1430	-153.6	99.42	93.33	100.0	No excessive outages.	DSIF GCF SFOF	MCD/219 STD DPS/M3	
033	51	087/088	2014	0800	-148.2	96.28	89.14	96.7	14.0 minutes outage from 2250Z to 2304Z. TTY data garbled. Data is assumed to be recoverable. NOTE: Station manager assumed transmitter on from 2036Z to 2150Z.	DSIF GCF SFOF	MCD/219 STD DPS/M3	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
033	12	088	1200	1426	-147.1	97.73	95.24	98.3	No excessive outages.	DSIF GCF SFOF	MCD/219 STD DPS/M3	
034	51	088/089	2024	0800	-148.4	90.61	84.03	95.5	12.5 minutes not available via TTY due to line problems. Data assumed to be recoverable. All data lost during power failure at Madrid assumed to be recoverable.	DSIF GCF SFOF	MCD/219 STD DPS/M3	Power failure at Madrid at 0709Z. HSD up at 0718Z. TTY up at 0742Z. No data to SFOF after 0740Z.
034	12	089	1200	1422	-148.2	99.24	94.41	98.4	No excessive outages.	DSIF GCF SFOF	MCD/219 STD DPS/M3	
035	51	089/090	2002	0757	-148.2	98.01	94.85	95.4	6 minutes data available.	DSIF GCF SFOF	MCD/219 STD DPS/M3	
035	12	090	1200	1418	-149.0	99.45	90.78	100.0	No excessive outages.	DSIF GCF SFOF	MCD/219 STD DPS/M3	
035	41	090/091	2201	0049	-147.8	99.62	92.31	97.8	No excessive outages.	DSIF GCF SFOF	MCD/223/219/224 STD DPS/M3	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
036	51	90/91	1956	0754	-148.1	97.48	84.98	92.2	No excessive outages. TFR 10948 TCD problems from 1956Z to 2355Z. TFR 109482: Transmitter coolant line problems at 0130Z. Update in process.	DSIF GCF SFOF	MCD/223/224/219 STD DPS/M3	
036	12	091	1005	1300	-147.2	99.59	96.0	100.0	No excessive outages.	DSIF GCF SFOF	MCD/219 STD DPS/M3	
037	51	091/092	1951	0747	-147.8	97.17	92.33	99.2	Total of 12 minutes outages, all available.	DSIF GCF SFOF	MCD/219 STD DPS/M3	
037	12	092	1030	1230	-148.2	99.35	93.33	99.1	No excessive outages.	DSIF GCF SFOF	MCD/219 STD DPS/M3	
038	51	92/93	1953	0744	-147.8	95.97	89.69	96.7	No excessive outages.	DSIF GCF SFOF	MCD/223/219 STD DPS/M3	
038	14	093	1009	1248	-143.0	99.22	91.82	97.1	No excessive outages. NOTE: Antenna to brake at 1245Z. Low film height, Pad-1, end of track early.	DSIF GCF SFOF	MCD/223/220/219 STD DPS/M3	
039	51	093/094	2046	0737	-147.8	98.3	89.14	95.3	DSS tracked S/C 72 from 0259Z to 0350Z.	DSIF GCF SFOF	MCD/223/219/223 STD DPS/M3	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
039	12	094	0900	1100	-148.5	98.65		100.0	No excessive outages.	DSIF GCF SFOF	 STD DPS/M3	
040	51	94/95	1934	0732	-147.3	90.24		71.3	No explanation for 26 minutes outage from 2015Z to 2041Z. Antenna problems at 2042Z. TTY data garbled, assumed to be recoverable.	DSIF GCF SFOF	MCD/223/219 STD DPS/M3	
040	12	095	0900	1100	-148.0	95.95		100.0	From 0911Z to 0914Z data appears to be wrong data (times also).	DSIF GCF SFOF	MCD/220 STD DPS/M3	
041	51	95/96	1929	0727	-147.9	99.37		99.6	No excessive outages.	DSIF GCF SFOF	MCD/219 STD DPS/M3	
041	12	096	1018	1230	-148.3	98.34		97.5	No excessive outages.	DSIF GCF SFOF	MCD/220 STD DPS/M3	
042	51	096/097	1927	0722	-147.8	96.99		96.6	11 minutes outage, TTY available.	DSIF GCF SFOF	MCD/223/219 STD DPS/M3	
042	12	097	0800	1100	-148.0	99.35		98.2	No excessive outages.	DSIF GCF SFOF	MCD/220 STD DPS/M3	

Table 50 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
043	51	97/98	1951	0500	-147.4	90.8		97.2	Outages, TTY available.	DSIF GCF SFOF	MCD/223/219 STD DPS/M3	
043	12	098	1105	1330	-147.8	99.36		98.4	No excessive outages.	DSIF GCF SFOF	MCD/220 STD DPS/M3	

Table 51. DSN Operations Log for Mariner VII

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%) Telemetry	DSN Real-Time Performance (%) Tracking		Failures and Anomalies	Configuration		Significant Events
						HSD	TTY TRK	Total Available				
Launch	71	086	1822	2245		88.23			No data available.	DSIF GCF SFOF	 HSDL MODE 2	
Launch	72	086	224539	225704		98.17			No data available.	DSIF GCF SFOF	 HSDL MODE 2	
001	51	86/87	2245	0600	-84.0	98.5	85.4	95.7	No excessive outages.	DSIF GCF SFOF	MCD/95/91/93 STD DPS/M2	
001	72	087	0534	0837		98.46		N/AV.	No excessive outages.	DSIF GCF SFOF	 HSDL DPS/M2	
001	12	087	0540	1146	-113.7	100.0	62.1	99.4	No outages.	DSIF GCF SFOF	MCD/224/219/224 STD DPS/M3/2	
001	62	86/87	2240	0200			72.2		No data available. (backup station)	DSIF GCF SFOF	MCD/91/224 DPS/M3	
001	41	087	1058	2340	-115.7	99.28	94.7	95.0	No excessive outages. From 2306Z to 2307Z, antenna drove off in dec. chn., S/C tracked with dec. brake on for rest of pass.	DSIF GCF SFOF	MCD/224/219/224 STD DPS/M3	

Table 51 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
002	62	87/88	2256	0623	-117.9	99.64	85.54	98.3	No excessive outages.	DSIF GCF SFOF	MCD/224/219/224 STD DPS/M3	
002	12	088	0551	1143	-117.5	99.48	96.30	98.1	No excessive outages.	DSIF GCF SFOF	MCD/219/224 STD DPS/M3	
002	41	088	1100	2342	-121.8	95.44	96.33	98.4	TTY outages from 2229Z to 2302Z, TTY available.	DSIF GCF SFOF	MCD/224/219/224 STD DPS/M3	
003	62	88/89	2258	0620	-120.2	97.78	86.68	98.7	No excessive outages.	DSIF GCF SFOF	MCD/224/219/224 STD DPS/M3	
003	12	089	0549	1150	-123.4	99.81	95.3	97.3	No excessive outages.	DSIF GCF SFOF	MCD/224/220 STD DPS/M3	
003	41	089	1100	2340	-125.7	98.87	98.6	98.9	5.5 minutes outage, TTY available.	DSIF GCF SFOF	MCD/224/219/224 STD DPS/M3	
004	62	89/90	2253	0619	-125.4	99.71	91.3	97.0	No excessive outages.	DSIF GCF SFOF	MCD/224/219/224 STD DPS/M3	
004	12	090	0546	1130	-126.7	100.0	94.4	97.9	No excessive outages.	DSIF GCF SFOF	MCD/224/219 STD DPS/M3	

Table 51 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
004	41	090	1057	2200	-127.5	99.52	98.2	87.8	No excessive outages. Recall, Total available = 99.3.	DSIF GCF SFOF	MCD/224/219 STD DPS/M3	
005	62	90/91	2300	0618	-128.3	98.48	93.8	97.9	No excessive outages.	DSIF GCF SFOF	MCD/224/219/224 STD DPS/M3	
005	12	091	0600	0935	-127.8	98.87	93.7	96.3	No excessive outages.	DSIF GCF SFOF	MCD/224/219 STD DPS/M3	
005	14	091	0858	1200	-121.0	99.53	0	95.1	No excessive outages Low TDH figure because of aided track.	DSIF GCF SFOF	MCD/224/219/224 STD DPS/M3	
005	41	091	1053	2334	-129.9	98.28	94.2	98.8	No excessive outages.	DSIF GCF SFOF	MCD/224/219/221/222/219/221/220 STD DPS/M3	
006	62	91/92	2257	0613	-131.3	94.85	96.8	96.9	Approx. 17 minutes of outages, all TTY available. From 231546Z to 231600Z receivers out of lock, wrong receiver 400p bandwidth.	DSIF GCF SFOF	MCD/224/220/219/220 STD DPS/M3	

Table 51 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
006	12	092	0800	1000	-131.7	99.27	94.2	99.1	No excessive outages.	DSIF GCF SFOF	MCD/223/219 STD DPS/M3	
006	41	092	1048	2330	-131.6	96.55	96.2	99.4	17 minutes outage, TTY available. Anomalies TFR 125560 Faulty module, 2 minutes data lost. TFR 125561, Transmitter failed at 222830Z, reset at 222845Z.	DSIF GCF SFOF	MCD/223/219/220/219/223/219/221/220/223/224 STD DPS/M3	
007	62	92/93	2254	0608	-133.2	99.28	96.5	98.1	No excessive outages	DSIF GCF SFOF	MCD/223/219/220 STD DPS/M3	
007	14	093	0619	1000	-125.4	97.94	0	96.8	No excessive outages. Low TDH figure due to aided track.	DSIF GCF SFOF	MCD/220 STD DPS/M3	
007	41	093	1049	2324	-132.9	98.91	97.8	96.7	No excessive outages.	DSIF GCF SFOF	MCD/223/220/219/221/220/224 STD DPS/M3	
008	62	93/94	2252	0604	-133.9	98.12	85.4	95.8	No excessive outages.	DSIF GCF SFOF	MCD/224/219/220 STD DPS/M3	

Table 51 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
008	51	094	0304	0346	Not available	Not available	97.3	Not available	Time period available in TTY data.	DSIF		
										GCF	TTY	
										SFOF	DPS/M3	
008	12	094	1130	1330	-134.3	Not available	99.2	Not available	Time period available in TTY data.	DSIF		
										GCF	TTY	
										SFOF	DPS/M3	
008	41	094	1055	2300	-133.9	98.29	98.6	99.8	No excessive outages.	DSIF	MCD/223/ 219/220/ 219/221/ 220/223	
										GCF	STD	
										SFOF	DPS/M3	
009	62	94/95	2300	0600	-134.6	99.65	95.7	97.8	No excessive outages.	DSIF	MCD/223/ 219/220	
										GCF	STD	
										SFOF	DPS/M3	
009	12	095	1130	1330	-135.2	Not available	98.3	Not available	Time period available in TTY data.	DSIF		
										GCF	TTY	
										SFOF	DPS/M3	
009	41	095	1055	2311	-135.0	99.86	97.8	99.0	No excessive outages.	DSIF	MCD/223/ 219/220/ 221/220	
										GCF	STD	
										SFOF	DPS/M3	
010	62	95/96	2300	0556	-134.8	99.85	96.4	98.3	No excessive outages.	DSIF	MCD/224/ 219/220	
										GCF	STD	
										SFOF	DPS/M3	

Table 51 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
010	12	096	0800	1010	-135.5	99.89	93.9	97.4	No excessive outages.	DSIF GCF SFOF	MCD/223/220/222 STD DPS/M3	
010	41	096	1054	2310	-135.4	97.31	98.5	99.6	4 minutes outage, TTY available.	DSIF GCF SFOF	MCD/223/219/220/219/220 STD DPS/M3	
011	62	96/97	2300	0552	-136.7	97.2	96.1	97.5	11 minutes outage, TTY available.	DSIF GCF SFOF	MCD/224/219/220 STD DPS/M3	
011	14	097	1000	1327	-128.2	99.63	0	95.0	No excessive outages. Low TDH figure because of aided track.	DSIF GCF SFOF	MCD/223/219/224 STD DPS/M3	
011	41	097	1032	2230	-136.6	97.16	96.4	99.3	8 minutes outage, TTY available. NOTE: Tracked with brake on in dec. entire pass.	DSIF GCF SFOF	MCD/223/219/220/222/221/220 STD DPS/M3	
012	62	97/98	2242	0551	-137.2	96.47	89.1	94.8	No excessive outages.	DSIF GCF SFOF	MCD/223/219/220/224 STD DPS/M3	
012	12	098	0530	1100	-136.4	98.91	93.6	98.3	No excessive outages.	DSIF GCF SFOF	MCD/220/223 STD DPS/M3	

Table 51 (contd)

Pass No.	Station (DSS)	Day of Year (GMT)	Acquisition (GMT)	End of Track (GMT)	Average Received Signal Level (dbm)	DSN Real-Time Performance (%)			Failures and Anomalies	Configuration		Significant Events
						Telemetry	Tracking					
						HSD	TTY TRK	Total Available				
012	41	098	1029	2306	-135.7	99.29	96.7	99.4	No excessive outages. NOTE: Transmitter failed at 0828Z, operator error, TFR 125576.	DSIF GCF SFOF	MCD/224/219/220/221/220 STD DPS/M3	
013	51	098	1800	2200	-135.1	99.08	98.0	100.0	Time period available in TTY data.	DSIF GCF SFOF	 TTY DPS/M3	

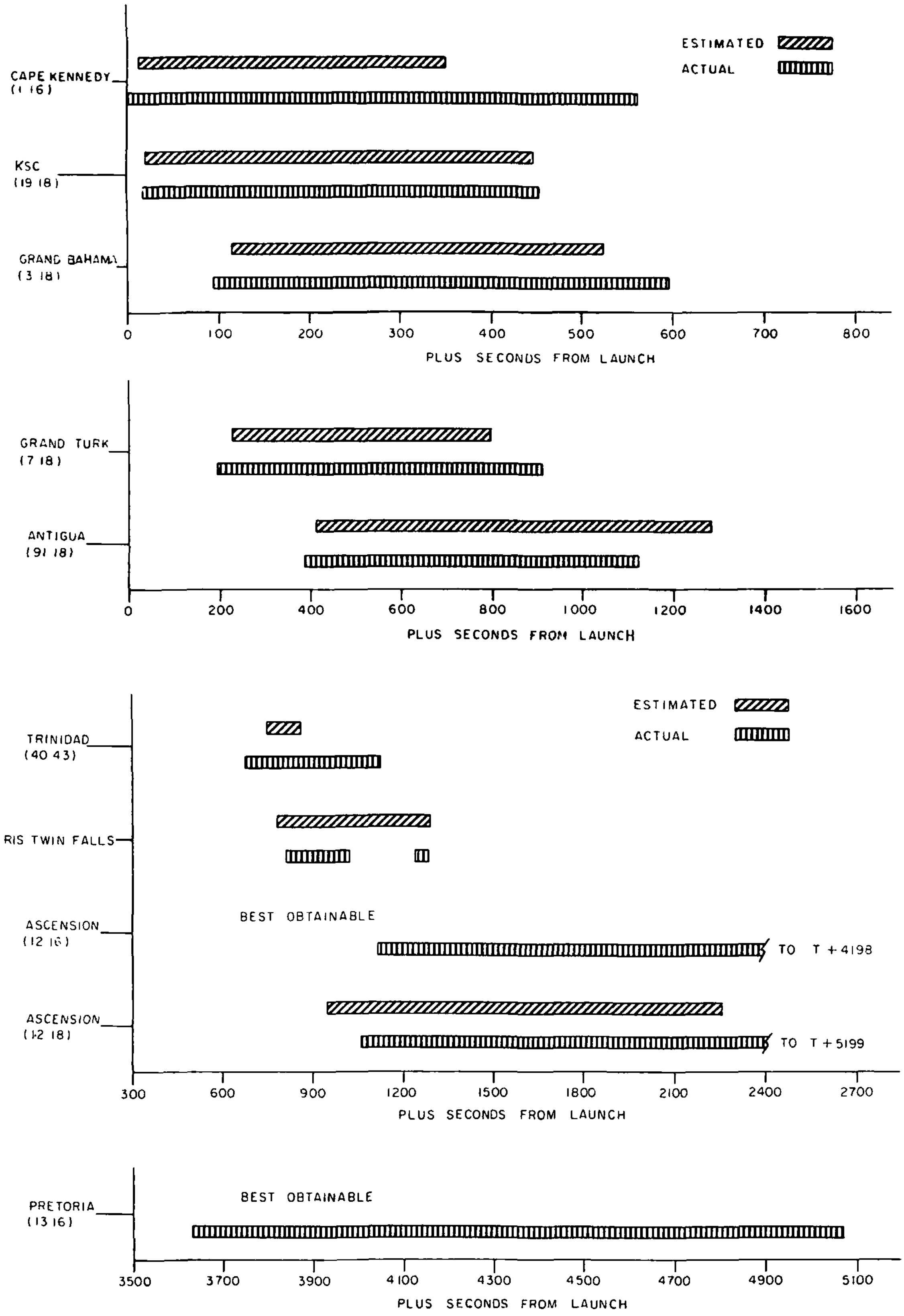
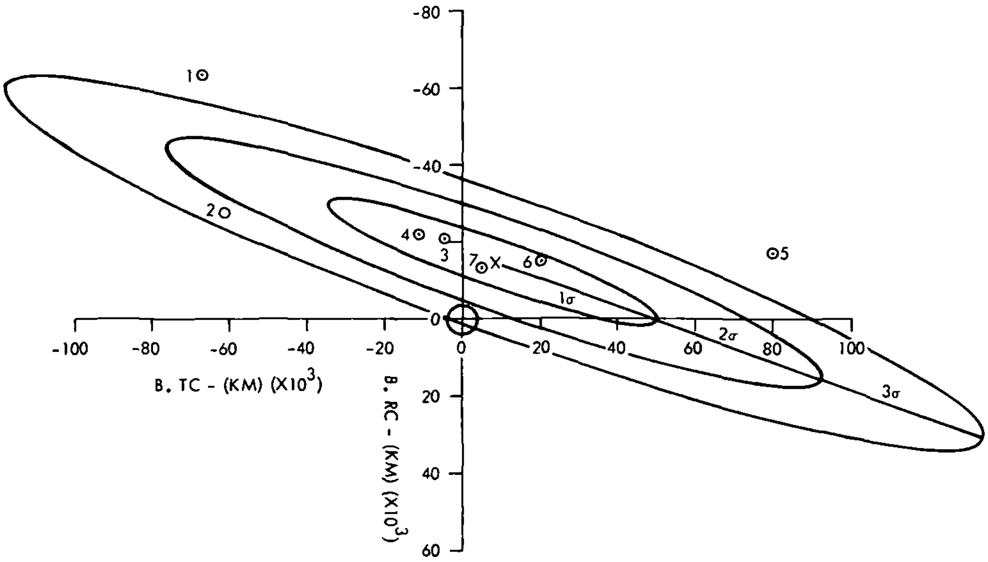


Fig. 128. AFETR radar coverage



NOTE THE ELLIPSES ABOVE ARE THE ONE, TWO, AND THREE SIGMA DISPERSION ELLIPSES OFTHE VEHICLE AT INJECTION MAPPED TO THE B-PLANE.

THE "X" IN THE CENTER OF THE ONE SIGMA ELLIPSE IS THE TARGETED AIMING POINT.

LEGEND

1. RTCS - ANTIGUA C - BAND
2. RTCS - ANTIGUA CENTAUR GUIDANCE TLM
3. BD/C - CENTAUR GUIDANCE TLM
4. RTCS - DSS 51 S - BAND (30 MIN DATA)
5. SFOF - DSS 51 S - BAND (30 MIN DATA)
6. SFOF - DSS 51 S - BAND (2 HR DATA)
7. SFOF - DSS 51 S - BAND (5 HR DATA)

Fig. 129. B-plane map

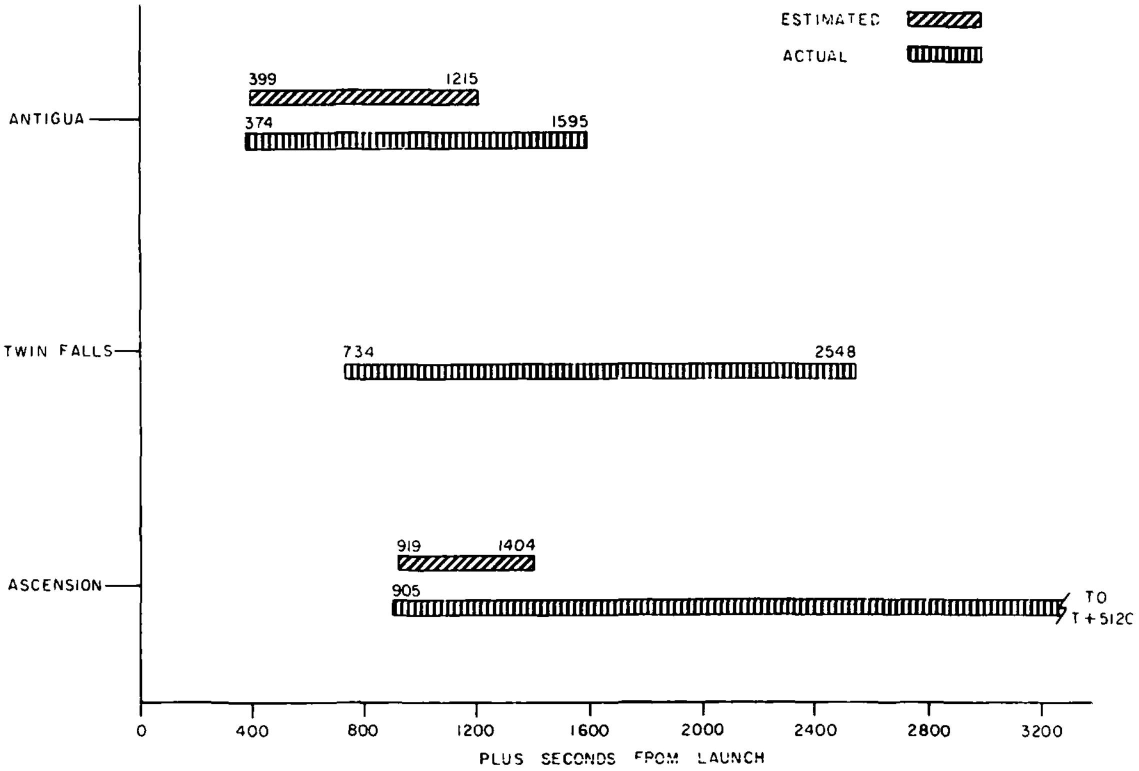


Fig. 130. AFETR VHF telemetry coverage

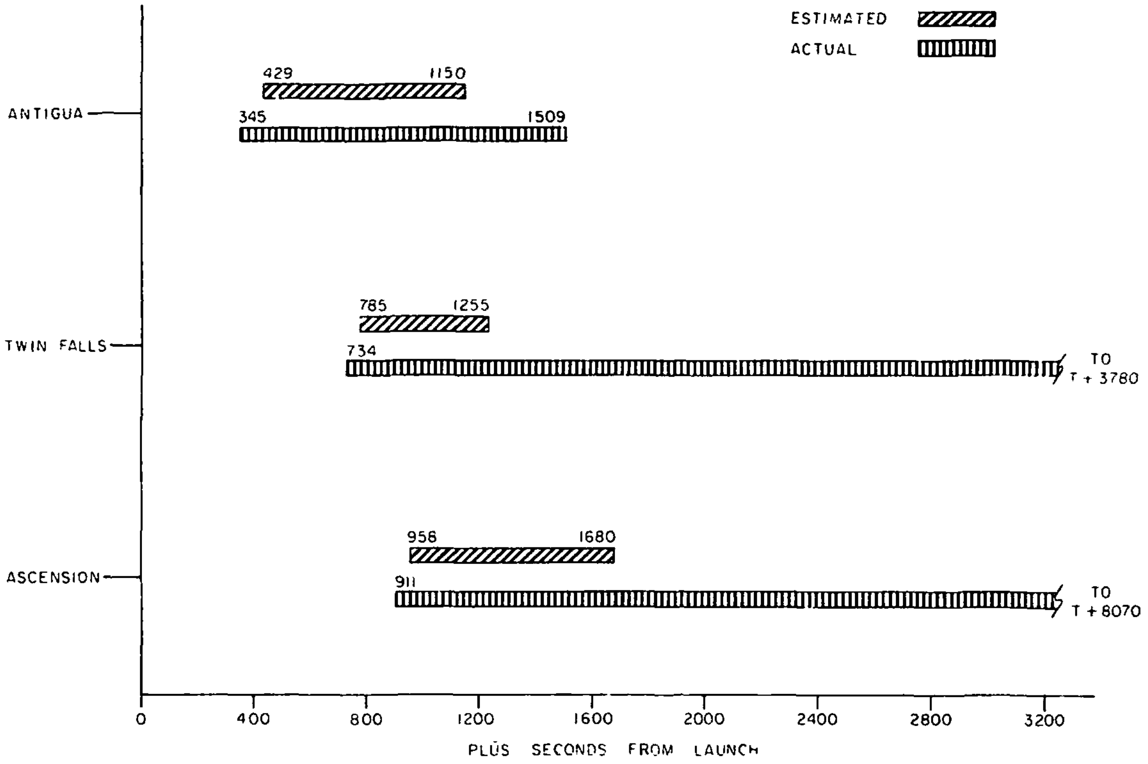


Fig. 131. AFETR spacecraft S-band telemetry coverage

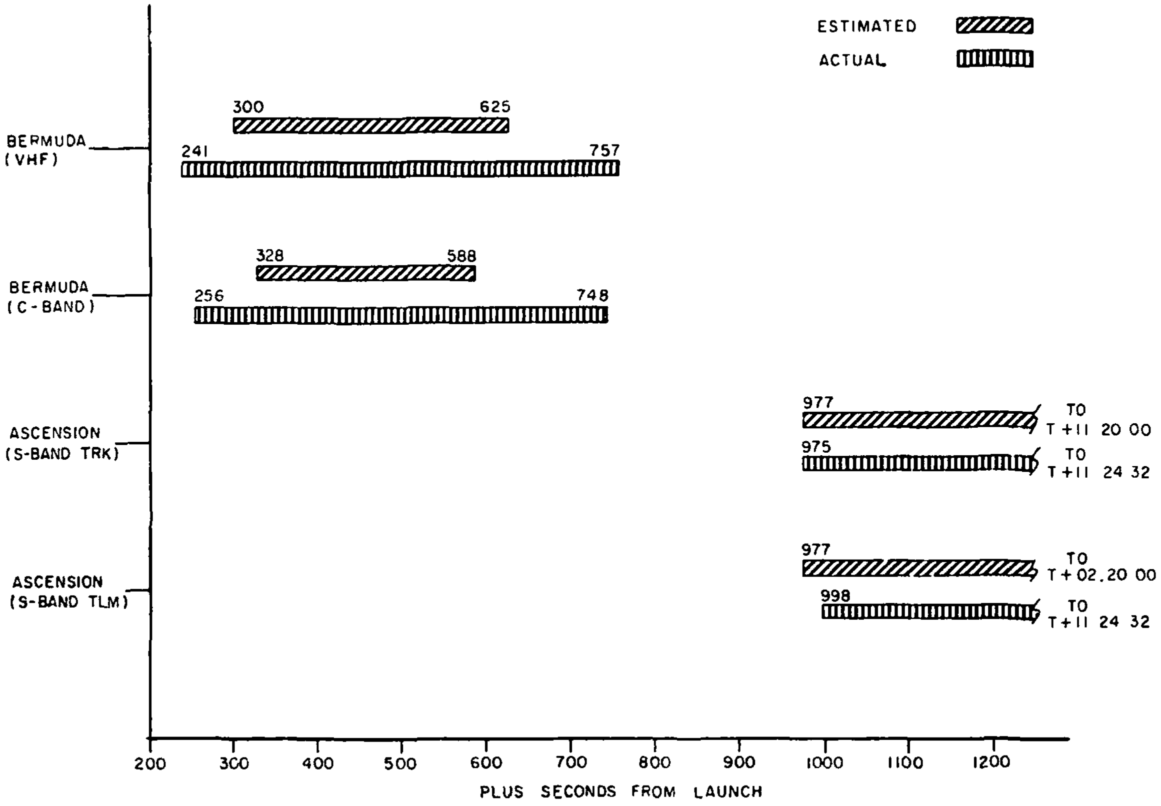


Fig. 132. MSFN coverage for telemetry and radar/radio metric data

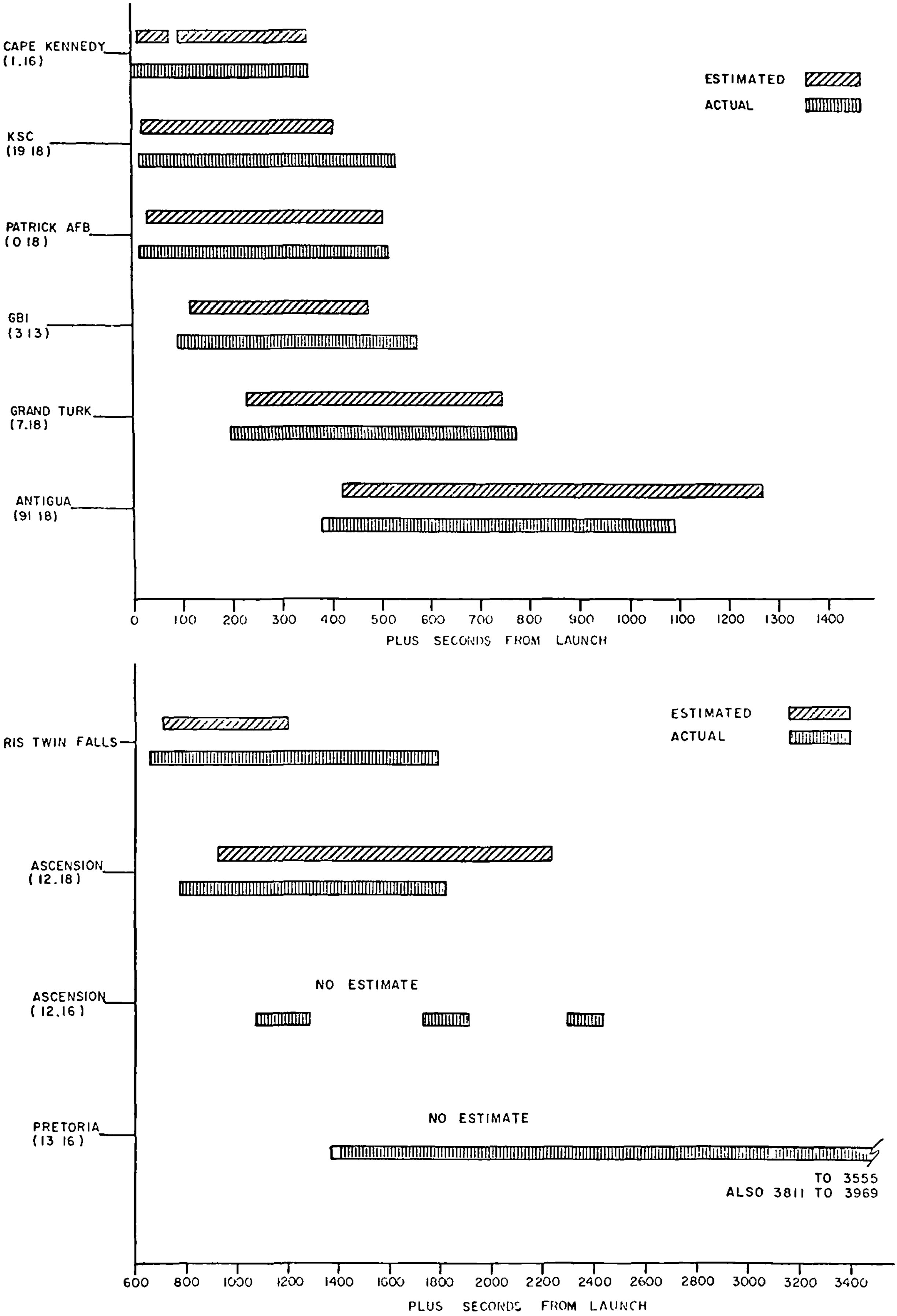


Fig. 133. AFETR radar coverage

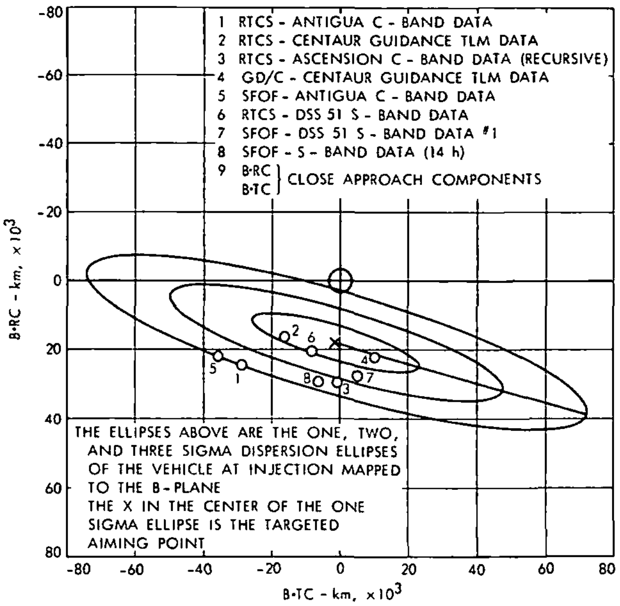


Fig. 134. B-plane map

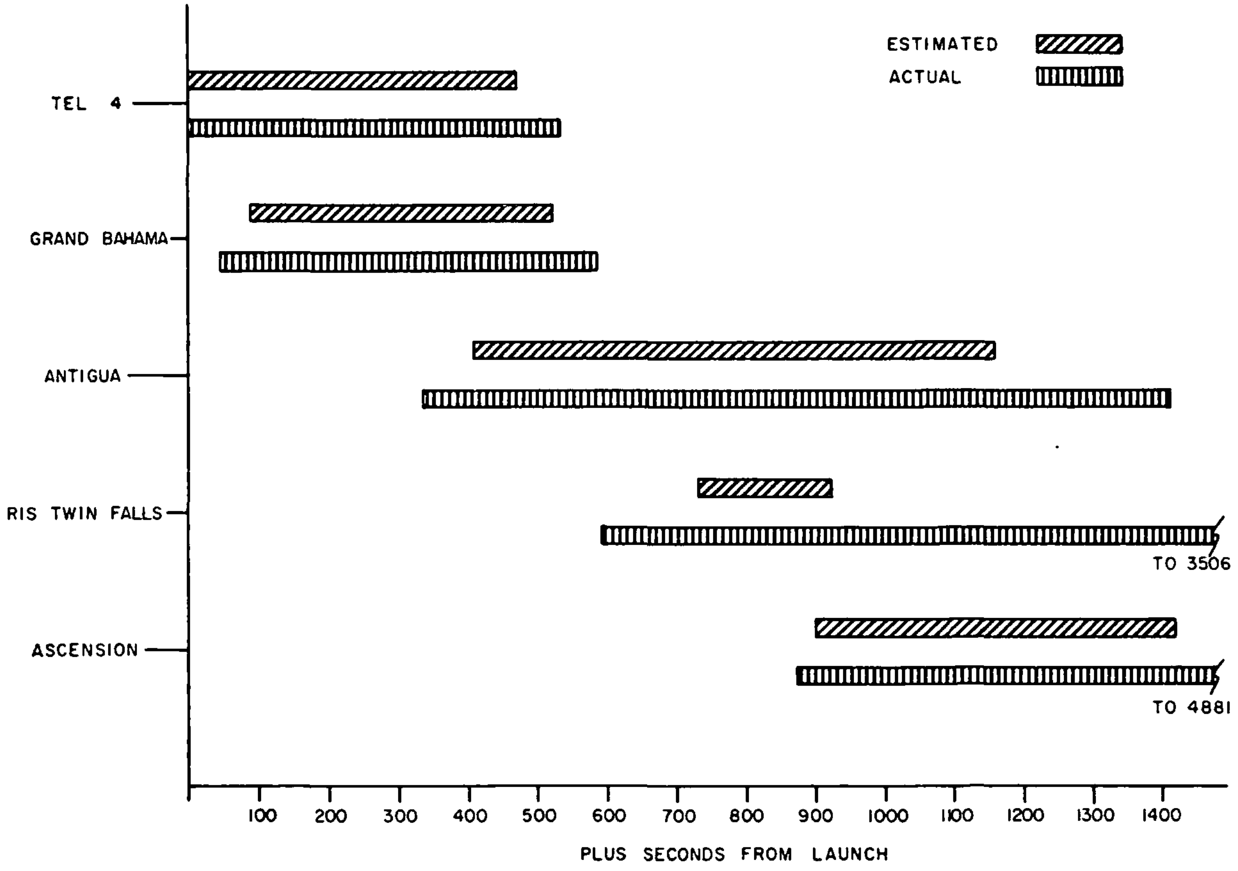


Fig. 135. AFETR VHF telemetry coverage

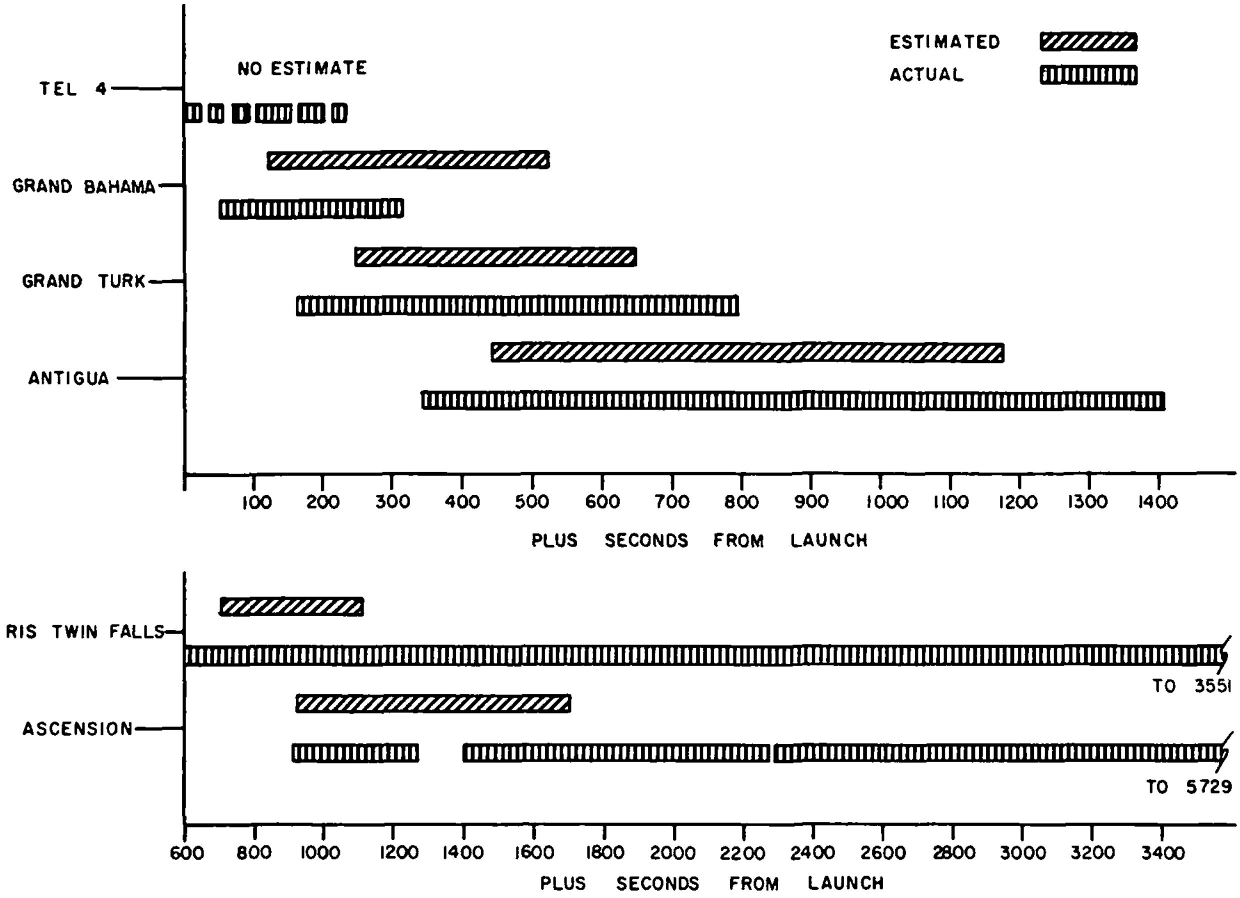


Fig. 136. AFETR S-band telemetry coverage

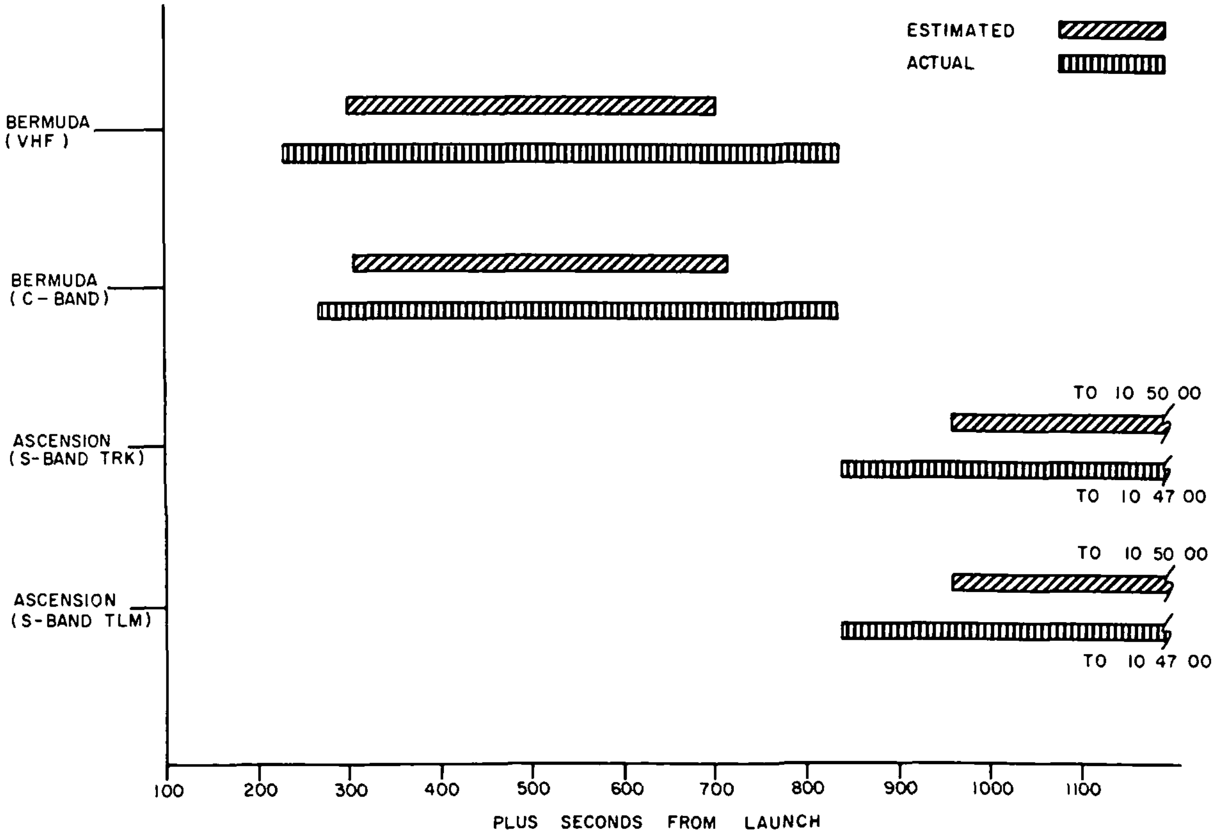


Fig. 137. MSFN tracking and telemetry coverage

VI. PERFORMANCE EVALUATION

The TDS system performance was monitored daily by the NAT. The results of the analysis are provided to the OCT to allow corrective action to be initiated when performance falls below predicted or committed levels. Results of the analysis indicate that the performance of the TDS has been excellent.

A. Tracking System Performance

The NAT metric data group has provided, since launch, an analysis of the tracking system performance. Results of Mariners VI and VII deep space phase for GMT days 56 through 100 are shown in Figs. 138 through 142 for two-way doppler data only. The figures include only the usable two-way data, which were flagged with a good data condition code, transmitted by the DSS and actually processed by the TDP and contained on the MDR. The percentage shown on the figures is the ratio between the usable data transmitted versus the usable data received. Recall was initiated when less than 95% of the available data were processed or when a data outage of at least 15 min occurred.

1. SDA/NAT performance. The tracking system portion of the NAT area was manned and operated by the SDA group during the Mariner 1969 mission. The tracking data system was therefore monitored in real time 25 h/day during all mission phases. Previous missions had 24-h coverage only during critical phases.

Continuous coverage of the tracking system was considered a principal reason for the high return and consistent quality of tracking data during the Mariner 1969 mission.

2. Tracking data processor performance. The tracking data processor program (TDP), under the responsibility of the SDA group, successfully prepared tracking data for project orbit determination and created the MDF in TDP tape form.

A design goal of SDA was to make the tracking data MDF a self-contained record containing peripheral data necessary to use the tracking data, such as spacecraft frequencies, range delays, and labeling suspect data. Much of the new information to be contained on the TDP tape was to be transferred to the orbit-determination process automatically via the orbit data generator program (ODG). Unfortunately, it was discovered after launch that the changes to the ODG did not properly handle the transfer of this information. For this, and other real-time operational reasons that developed, a large part of the desired information was not placed on TDP tapes created during the course of the mission. The missing information was added by recreating MDF from duplicated tapes.

It should be pointed out that the information was not placed on the TDP tapes before the Mariner 1969 mission and is more for historical rather than real-time use of the MDF.

The detailed aspects of TDP operation, particularly with regard to reconciling the real-time and historical requirements, is an area requiring further work for future missions.

B. Telemetry System Performance

1. Near-earth phase. The performance of the telemetry system during the near-earth phase is not evaluated quantitatively in the same sense as the deep space phase. The response time applicable to operational feedback is much shorter because the coverage interval is ~30 min. In addition, the number of input sources during this phase requires that quick decisions be made to optimize data return. Therefore, the analysis function for this phase was placed at the Tel-4 terminal at Cape Kennedy.

No attempt was made to provide an assessment of overall performance, but rather to optimize the response of the system to provide maximum data to the user. A qualitative statement can be made, however. All committed coverage was provided, and for both launches, the users were supplied with a continuous source of real-time telemetry data.

2. Deep space phase. The NAT telemetry group has, since shortly after launch, provided analysis of Telemetry System performance. During the early phases of the mission, some of the data were not available because the NAT was not fully staffed. Results of the analysis are shown in Figs. 143 and 144.

C. Command System Performance

The TDS successfully transmitted all commands from DSN stations to both Mariners VI and VII. The results of the command activities are shown in Table 52.

Presented in Table 53 is a summary of TFR received for the Mariner RWV equipment which have most frequently failed during each of these three years. It is noted that, of the equipment accruing ten or more failures per year, the Model 420 perforator assembly and various 12000 series Astrodata PC boards are reported consistently, but with random component failures.

D. DSN monitor System Operations

1. Data validation programs. The telemetry engineering program for validation of TCP tape data was completed in early March 1969 and validation of Mariner VI critical phase data was started and completed before Mariner VII launch. Critical phase validation for Mariner VII data was completed by mid-April.

Tracking data validation programs included the addition of ranging data accountability, a major new development. Incorporation of this feature allowed complete validation of all available tracking data types.

2. DSIF monitor station. Inconsistencies and anomalies noted with the DSIF monitor

station during the Mariner Mars 1969 mission are as follows:

(1) When comparing a station's downlink signal level using the station voice report, the DSN monitor digital television display and the processed IBM 7044 formatted data, there seemed to be a discrepancy of approximately 3 dB between readings. The discrepancies are probably due to the manner in which the data were monitored. The AGC voltage is transferred from the station S-band receiver in a one-to-one ratio and computed in the DIS for DSN monitor television display. The AGC voltage used for monitoring by the IBM 7044 computer is transferred from the station S-band receiver in a one-to-one half ratio through an isolation amplifier and doubled in the IBM 7044 computer for monitoring. It is suggested that this procedure be re-evaluated to produce readings that would allow a 0.5-dB tolerance when comparing AGC signal levels.

(2) The monitoring of the station's TCP SNR proved correct when the DSN monitor digital television display was used. However, when the SNR level exceeded 30 dB, the IBM 7044 computer would not accept this level and would print out 0 dB for the SNR. The DSN monitor digital television display would indicate the correct SNR.

(3) The MCD sets (300 different sets) proved impractical if the stations were configured other than in a standard mode. If the station was unable to determine the correct MCD set to be used, alarms in the Monitor System resulted, causing undue consternation to some users at the SFOF. It is suggested that the amount of MCD sets be greatly reduced to allow ready changes by the station when switching configurations.

E. Simulation Performance

DSIF participation in operational testing activities before launch and during flight was much more extensive than anticipated or ever accomplished on previous missions. Not only did the DSIF benefit from the testing, but it played a major part in the troubleshooting of the inflight spacecraft radio problems as well. The DSN Simulation System for Mariner Mars 1969 added much to the realism and usefulness of prelaunch and encounter testing.

1. Telemetry simulation. Since it was known that tapes from SAF contained erroneous data for some channels (Pasadena environment is not space environment), a preprocessing Phase 1A edit run was developed. This edit run copied SAF tapes, but allowed biases to be applied to selected channels to bring them to their correct values. Using these edited tapes, the Phase 1A program was used for most of the simulation tests requiring realistic spacecraft data.

The first use of this type of simulation revealed numerous data discrepancies, some due to human error and some to lack of information about the spacecraft. With increased usage of the program, these discrepancies were reduced and the data was significantly improved. However, this required about 80% of the data recorded in SAF to be changed by the edit run, and the results depended upon the ability of the engineers to determine spacecraft characteristics and to simulate the telemetry.

A simulation run from the Phase 1A program had a major disadvantage: the telemetry reflected a preplanned canned mission profile. Spacecraft commands could not be inserted, deleted, nor slipped in time from the pre-test planned sequence, unless the reaction to the command was simple, or the real-time operator action to an expected command was carefully preplanned. Anomalies were restricted to relatively simple ones which required little change in data and for which corrective responses could be accomplished.

In one simulation, the planned anomaly was to keep the gyros on after the end of a successful midcourse. The simulation team was prepared for the obvious corrective response, DC-40 Gyros OFF. Instead, SPAC issued a sequence of a half-dozen commands to investigate the reason for the anomaly. Fortunately, the test ended here, because the Phase 1A program could not respond to this type of activity.

In March 1968, the Phase II program was revived under the auspices of the DSN, without any commitment from Mariner Mars 1969 Project that they would need or use the program. The Phase II effort was considered to be a R&D effort to investigate simulation techniques. The program was to accomplish the same objectives as Phase 1A, except that the telemetry was to follow mission sequences automatically by means of mathematical models of the spacecraft with full automatic response to all ground commands and external events (earth shadow, etc.).

The Phase II program, declared operational in January 1969, was used to simulate engineering telemetry for most of the following tests, including the ORT for Mariners VI and VII. The data quality was improved as feedback was obtained from SPAC, and the data generated by Phase II for the ORT was the most realistic of any data source used during the Mariner Mars 1969 tests.

After the successful launch and midcourse of Mariner VI, the Phase II program was begun and run so as to duplicate the flight data as closely as possible. Point-by-point and channel-by-channel comparisons have been made between the simulated data and the flight data. This showed that some subsystem models were very good in their simulation (power distribution, CC&S computer), while others will need improvement for future simulation (solar panels, launch transients in attitude control).

2. Telemetry output modes. The various uses of the 6050 telemetry simulation program can be classified by considering the types of output available from the computer.

a. Spacecraft simulation. The simulated spacecraft output is two telemetry bit streams (zeros and ones) simulating the engineering and the science commutators. All spacecraft formats and bit rates are available, except for the high-rate (16.2 kbits/s) which was never generated by SDCC.

The direct commutator output mode was used primarily to record analog tapes. These tapes were used to supply spacecraft data for DSIF station checkout and testing, and to serve as a source of telemetry from the ETR and MSFN stations (since these stations could not use the DSIF input mode described later). Analog tapes, played through CTA-21, were also used to simulate a second spacecraft while the 6050 was simulating the primary spacecraft.

The recording of these analog tapes was more difficult than expected and took more time than anticipated. There were problems with incompatibilities between different models of recording and playback tape decks, with choosing appropriate tape speeds and speed-lock signals, with signal levels and modulation characteristics, and with ensuring correct data content. It is recommended that future simulation configuration exclude analog tape operations. A total of 117 analog tapes were made, including 12 made directly from spacecraft in SAF.

b. Combined SFOF/DSIF input. Another output mode was developed under the pressure of operational requirements. The SDCC computer would be initialized in the SFOF input mode, including output of teletype and all HSD blocks. The HSD blocks would also be sent to a DSIF. Here, special initialization of the DGI would make the DGI skip all HSD block types except the engineering telemetry.

By operating in this mode, SDCC personnel could simulate, for example, the later part of a pass at DSS 41, while the data were also going to DSS 12 to begin their pass. After LOS at DSS 41, the SFOF input would be terminated and the test would continue in the DSIF input mode.

Since this mode of initialization could act as SFOF input, or DSIF input, or both, it became the standard mode of operation. It should be planned for in any future simulation system design.

3. Tracking simulation. A 6050 simulated tracking data generator program that produces multiple-station, on-line, teletype tracking messages, is controlled from a special console in SDCC. However, this program could be used only occasionally because the 6050 was necessary for the telemetry simulation program. Instead, simulated tracking data was supplied by prepunched teletype paper tapes prepared by one of two 7094 processes.

a. SIM 94. SIM 94 is a 7094 Tracking Data Simulation Program that was developed as a mission-independent program in 1967. This program has been used for other projects, and was the major source of tracking data for Mariner Mars 1969 with the addition of ranging and doppler resolver data.

The input to SIM 94 is a station ephemeris tape developed by PREDIX, and simulation control cards that select output options such as one-, two-, or three-way lock, ranging on/off, sample rates, and can add simulation noise and bias. The SIM 94 output, after media conversion, was punched teletype tapes and equivalent punched cards. The punched card output was used typically, to quickly load two-, or three-days worth of tracking data onto the 7044-7094 disk to provide a backlog of data for a midcourse test.

The simulation scheme was, for each station, to punch several parallel tapes containing, for example, one-, two-, and three-way data, with and without ranging. These tapes would be played on especially timed, parallel tape readers (TD) in SDCC, and real-time choices of data types (e.g., ranging on/off) could be made by selecting the TD to be patched into the CP. However, there are only eight tape readers in SDCC, and these had to be allocated for two or three stations at once, therefore, it was not possible to have available all possible data types for all stations. This did not cause too much inconvenience, since the FPAC Director was always informed of what types he could request before the start of a test. However, anomalous conditions could occur, such as good ranging data in the tracking data after the ranging transponder in the spacecraft had been turned off.

The DSIF stations did not have parallel tape readers, especially timed to correctly pace out the usual 60-s sampled data. Therefore, most tracking simulations were run with the tracking data going directly from SDCC through the Comm Processor to the 7044-7094 (i.e., short loop) even if the DSIF was in the loop for telemetry data.

b. Tracking simulation from the ODP. The tracking data generated by SIM 94 was barely adequate for simulations of cruise or midcourse tests and it gave very poor results whenever the spacecraft was near a planet (i.e., launch and encounter). It was first thought that SIM 94 was causing the errors, since it was still being debugged, but the cause was finally proven to be PREDIX. PREDIX was programmed to be adequate for its primary function — directing a DSIF onto a spacecraft — but it was not accurate enough to drive the tracking programs.

After this was discovered (at about the start of encounter testing), the simulated tracking data were prepared by a scheme used during Surveyor testing, based upon an output directly from the SPACE and ODP programs. This method produced data with the required accuracy, but it was more cumbersome and time consuming for simulation personnel, since many simulation features available in SIM 94 were lacking.

c. ETR tracking simulation. JPL does not have any powered flight tracking simulation generation programs. The simulated tracking data for launch tests were always generated by ETR from their programs. Punched teletype tapes would be mailed to JPL if the test was to be in-house, or would be played from the Cape if they were included in the test.

d. Canned tracking data limitations. Tracking simulation was derived from pre-planned canned tapes, and could not respond to all real time changes. Data types not preplanned could not be supplied. Any change in midcourse magnitudes or in midcourse execution time would not be reflected in the tracking data. The spacecraft/DSIF state reflected in the telemetry data did not always agree with the state reflected in the tracking data. It will require a real-time tracking generator program in the same computer system as the simulated telemetry generator to solve these deficiencies.

4. Simulator equipment failures. Mariner Mars 1969 simulator equipment failure summary is shown in Table 54. The main anomaly was in the Model 6122 DC amplifier. It is suggested that this amplifier be given a closer review before use in subsequent missions.

F. GCF Operations Support

1. HSD failure. The standard Mariner Mars 1969 DSS/SFOF communications complement (i.e., 1 voice, 1 HSDL, 4 TTY) was employed for the maneuver of Mariner VI. However, successive indications of bits-in-error displayed on the GCF HSD digital TV (DTV), monitor and display, on the prime (DSS 41) HSD were observed by communications operations personnel immediately before initiation of the time-critical maneuver sequence, the line itself failed moments later. An alternate circuit path was obtained and operationally certified by operating personnel on short order, only minutes remained before initiation of the maneuver command sequence.

2. Dual HSD link study. As a result of this untimely HSD failure, a study was initiated by GCF operations to determine a method of averting the effect of a similar failure — a recurrence was not improbable — during the impending maneuver of Mariner VII. Discussion of the problem did not center about the quality of communications to DSS 41, the overall reliability of circuits to this DSS was within established tolerances before and after the HSD failure. The objective of this study was therefore to devise a method providing immediate availability (within the framework of existing resources) of dual HSD from the DSS to the SFOF, should the prime data link fail at a critical time.

Negotiation with NASCOM representatives secured the availability of a second HSD from DSS 41 to the SFOF for use during the maneuver of Mariner VII. Additionally, both HSD available to the DSN were geographically diverse-routed, negating the possibility of failure or quality degradation of both lines as a result of natural causes.

The audio patch configuration within the Comm Control Group at the DSS itself was modified accordingly in order to interface the singular transmitting source with the dual NASCOM HSD. Modification of the manual patch configuration required entry of data set audio output into a four-wire audio bridge, the DSS transmit side of each HSD was patched to an output "port" of the bridge. No hard-wired changes were required to accomplish this configuration.

Inasmuch as the incoming dual streams of HSD electrically appeared to be transmitted from different sources, no modification of either patching or equipment configuration was required within the SFOF Comm Terminal Subsystem and the DPS.

A later review of this dual HSD capability, which supported DSS 41 coverage of the Mariner VII maneuver in an excellent manner, led to a slight change of GCF HSD equipment operation at the DSS and the philosophy behind authorizing the use of this redundant capability.

Availability of redundant streams of HSD proved popular with Project mission operations personnel. During the pre-encounter cruise phase, the greater majority of programmed CC&S readouts were preceded with a real-time request of the DSN to provide dual HSD coverage to the in-view DSS. This development did not appeal to GCF operations. The original intent of the GCF was provision of HSD redundancy during mission-critical events only in an attempt to avoid significant real-time HSD loss in the event of DSS GCF equipment or HSD outages. Secondly, NASCOM was not committed to provide dual operational HSD to overseas DSS; the exception of course was that agreement reached with this agency before the maneuver of Mariner VII. It must be recognized that this agreement extended beyond the scope of the SIRD and NSP as the requirement for dual HSD to each Mariner Mars 1969 DSS was never identified therein.

G. Discrepancy Report Summary

1. DSN discrepancy report system. A review of the discrepancy report (DR) Level A System was initiated in October 1968 and a number of modifications and updates were implemented into the system in order to assure satisfactory system performance in support of the Mariner Mars 1969 Project.

In mid-January 1969, the DSN DR Group provided DR presentations to DSN and Project operations personnel, with particular emphasis on proper use of the DR system in reporting and documenting DSN operational discrepancies. The newly developed procedure, DR Report Initiation (JPL 840 Series Document 842-31, DSN SOP 20-211) was used as a guideline for discussion.

DSN DR presentations were also given at both Mariner Mission F and G Prelaunch Readiness Reviews. Mariner Mars 1969 DR discrepancy data were presented which related the total number of DR written to the total number of DR outstanding. Those DR remaining open which were classified critical were presented for consideration and comment by members of the Readiness Review Board.

On March 28, 1969 and April 29, 1969, the DSN DR Group issued DSN DR Mariner Mars 1969 launch through midcourse reports for Mission F and G, respectively. A special RWV failure-by-station summary was also provided to the Mariner Mars 1969/DSN PE by the DR group on June 10, 1969.

2. DR facility data summary

a. Review. A review of all Mariner Mars 1969 DR, Level A, data submitted between

October 1, 1968, and August 31, 1969 indicates the following: a total of two 142 Mariner Mars 1969 DR were collected and processed by the DR group during the indicated period. Forty-eight percent of the reports submitted were initiated against the GCF, 42% against the SFOF, and 10% against the DSIF.

b. DSIF. Of the 212 DSIF discrepancy reports submitted, approximately 61% were classified as hardware and 28 % as procedural. The remaining 11% were in the software and undetermined categories.

c. GCF. Out of a total of 1027 GCF DR reports, the most significant number (42%) was against the SFOF CP. Approximately 24% were written against the teletype system, 17% against the SFOF intercommunication system (ICS), and 14% against the HSD system. The remaining GCF DR were distributed as follows

Area	Number of DR
Voice	112
CP (GSFC)	39
CP (Madrid)	19
CP (Canberra)	3
Miscellaneous	43
Total	216

d. SFOF. Out of 903 SFOF DR, which constituted 42% of the total number of DR received, 80% were initiated against the DPS. The support system accounted for the remaining 20%. The distribution of DR was as follows:

SFOF DR dispersion	Number of DR
IBM X and Y strings	235
Milgo, 30 × 30 plotters	165
Stromberg Carlson 3070 printers	118
Motorola 3000 printer	82
4020 processors	21
Burroughs, B122 card reader	26
Consoles	16
Procedures	36
Miscellaneous	29
DPS total	728
Support (FSG)	175
SFOF total	903

The X string computers accounted for 144, or approximately 61% of the total X and Y computer string anomalies. The Milgo 30 × 30 plotter DR constituted approximately 22% of the total DPS discrepancies.

3. Comparative summaries

a. Comparative totals. Figure 145 provides a comparison of the total number of DR (all facilities, all projects) to the total number of Mariner Mars 1969 DR (all facilities).

b. Comparative support, DSIF. Figure 146 presents a comparison of the total number of Mariner Mars 1969 DR to the total hours of DSIF support provided Mariner Mars 1969 project. It is interesting to note the inverse relationship between the number of DR compared to DSIF loading.

c. Comparative support, DSS. The total DSIF Mariner Mars 1969 support by hours is compared to the total number of Mariner Mars 1969 DR by site in Fig. 147. Using these data, the number of hours of operation per DR (h/DR) for each station was computed as follows:

DSS	Hours of operation per DR
11	11.5
12	35.5
14	49.8
41	52.6
42	32.5
51	28.5
62	39.6

Station efficiency ratings (h/DR) can be derived from these results. However, it should be remembered that the efficiency ratings so derived are only apparent inasmuch as they are a function of the number of DR submitted, over the known hours of support.

4. Pioneer data compared. As a point of reference, the number of h/DR was calculated using Pioneer DR data (Table 55) for the same stations as those supporting Mariner Mars 1969, over the same period of time.

The differential in h/DR for Pioneer as compared to Mariner was found to be quite noticeable (Table 56).

An attempt was made to explain the difference in the following manner: On the assumption that a large number of Mariner procedural and software problems may have contributed to the lower efficiency ratings, those DR were extracted from the Mariner data. The resulting number of hours of operation per DR (efficiency), for all sites, was still higher for Pioneer than for Mariner (Table 56B).

The use of h/DR as a single measure of efficiency is questionably sufficient. The large disparity in h/DR between two projects using basically the same support system suggests the need for further analysis.

H. Recommendations

1. Spacecraft CC&S memory readout. The CC&S dump should be coded for error correction. If possible, this should be accomplished in the spacecraft. The second choice would be an error code inserted at the TCP.

2. DSN scheduling. Scheduling should be handled by project ID rather than spacecraft ID. A policy should be established with the MOS to provide the coverage plan before countdown. A major expenditure of energy was required on the part of all involved in scheduling when a spacecraft anomaly or strategy change required changing spacecraft numbers. This was true even when the committed resources were unchanged. Energy lost in these efforts could be better expended in other areas. This change should not affect the weekly forecast, and this information should be forwarded from the DSIF to the DSS in the weekly forecast TWX.

3. Simulation. Simulation for Mariner Mars 1969 was excellent, but far too limited. As a minimum extension, the capability to generate worst case CC&S dumps (minimum transitions in the PCM stream) and the capability to generate coded high-rate data that contains recognizable TV patterns are required.

4. CAT areas. CAT areas should be recognized as a DSN responsibility and implementation should be handled in the same manner as the Mission Operations and Mission Support area implementation. Support requirements should be included in the SIRD and thus become a properly funded and planned activity.

5. User area display devices. The current inventory of DPS display devices consisting of TTY machines, Milgo plotters, and 3070 bulk printers, should not be used on other projects. The devices proved to be unreliable and required excessive maintenance, excessive downtime, and had many other undesirable features. They should be replaced with state-of-the-art display devices.

6. Operational support systems. The DSN must immediately provide manpower and funding to update archaic operational support systems. Efforts in these areas were heroic, but improper use of manpower jeopardized the DSN's ability to provide strong technical support. The systems that require a well-supported systems study and procurement of equipment and software include DSN Sequence of Events, Scheduling, and Discrepancy Reporting Systems.

7. Telecommunications performance estimates. The DSN must develop a mission-independent capability for telecommunication performance estimates. Historically, the Project has been responsible for providing performance estimates, however, their activities, although useful, are normally concentrated only on critical events. The DSN requires telecommunications performance estimates during 24 h/day operations and for planning support. The DSN should develop a software to perform the analysis.

8. Training. The DSN should study a training approach to fit a geographically diverse, multi-shift operational team. A studio should be maintained to allow video taping of subjects such as mission plan, systems, description, and project roster. Video tape equipment is needed at overseas sites, NASCOM facilities, and the SFOF.

Table 52. TDS command performance[a]

Spacecraft number	Number of commands transmitted	Number of operator errors	Number of equipment failures
6	46	0	0
7	57	0	0

[a] These values reflect data taken through GMT Day 104.

Table 53. Mariner RWV equipment frequency of failures summary

Year	Model	Equipment	Manufacturer	TFR
1969	420	Perforator	Tally	13
	12000	Assembly PCB	Astrodata	12
	12029	Assembly PCB	Astrodata	07
	RM561A	Oscilloscope	Tektronix	06
1968	12011	Assembly PCB	Astrodata	18
	12026	Assembly PCB	Astrodata	14
	420	Perforator	Tally	11
	12000	Assembly PCB	Astrodata	08
	12078	Assembly PCB	Astrodata	08
1967	12006	Assembly PCB	Astrodata	11
	420	Perforator	Tally	10
	420PF	Perforator	Tally	06
	424	Reader	Tally	06
	TMR21B	Time Meter	Defense Electronics	06

Table 54. Mariner Mars 1969 simulator equipment failure summary

Model	Equipment	Manufacturer	TFR
6122	Amplifier DC	Dynamics	12
3310	Supply Power	TRW Systems	02
542357	Assembly PCB	Texas Instruments	02
7816R	Oscillator Generator	Dynamics	01

Table 55. Pioneer data

DSS	11	12	14	41[a]	42	51	62
Total hours support	499	2793	2169	1340	2538	1457	1599
Pioneer DR	3	24	38	–	25	9	16
No. of H/DR	166.3	116.4	57	∞	101.5	161.9	99.9

[a] DSS 41 submitted no DR although they provided some 1340 h of support. Yet in the case of Mariner during the same period, DSS 41 showed a total of 42 DR against 2209 h of support. In the first case, we have an efficiency rating of 52.6 h/DR and in the latter, an efficiency rating of infinity.

Table 56. Comparison of Mariner and Pioneer DR

A		B	
DSS	Mariner Mars 1969, h/DR	Pioneer, h/DR	Mariner Mars 1969, h/DR H/W Only
11	11.5	166.3	12.5
12	35.5	116.4	55.1
14	49.8	57.0	83.0
41	52.6	∞	84.9
42	32.5	101.5	37.1
51	28.5	161.9	50.1
62	39.6	99.9	64 0

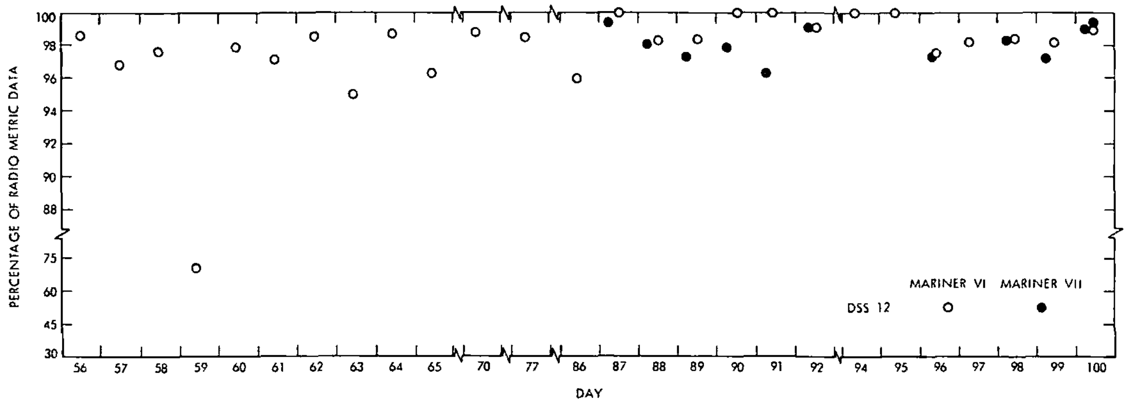


Fig. 138. Radio metric data recovery percentages for Mariners VI and VII (DSS 12)

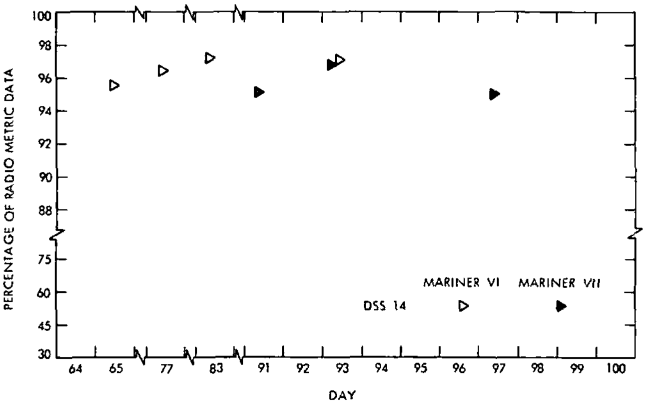


Fig. 139. Radio metric data recovery percentages for Mariners VI and VII (DSS 14)

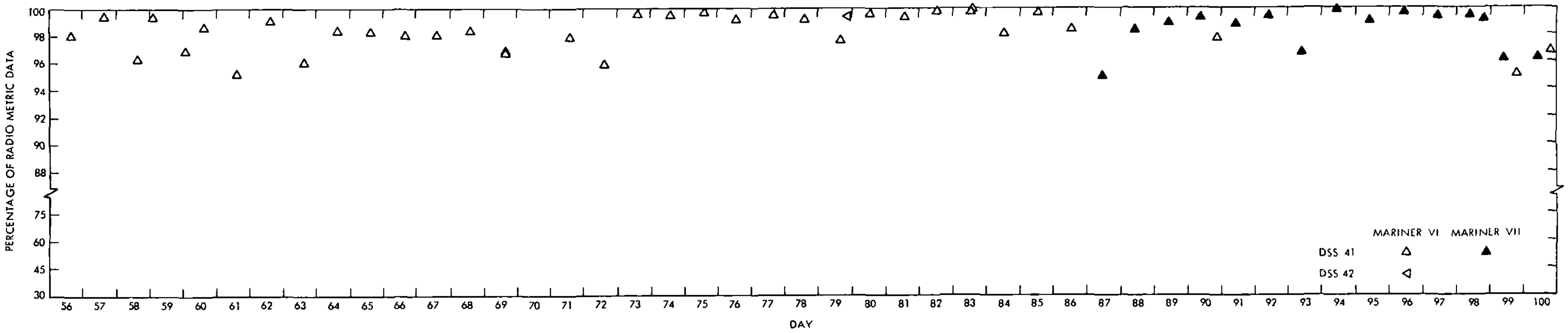


Fig. 140. Radio metric data recovery percentages for Mariners VI and VII (DSS 41), and Mariner VI (DSS 42)

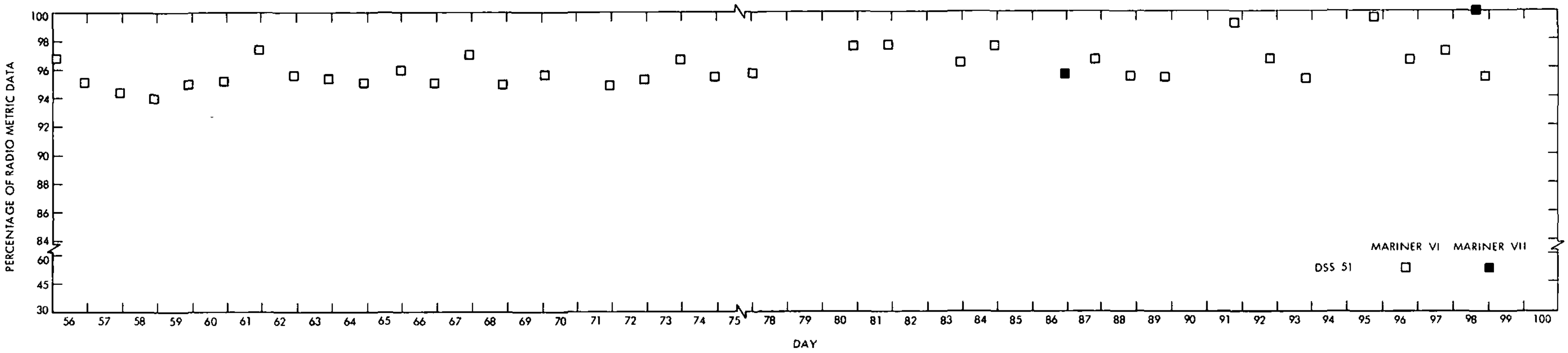


Fig. 141. Radio metric data recovery percentages for Mariners VI and VII (DSS 51)

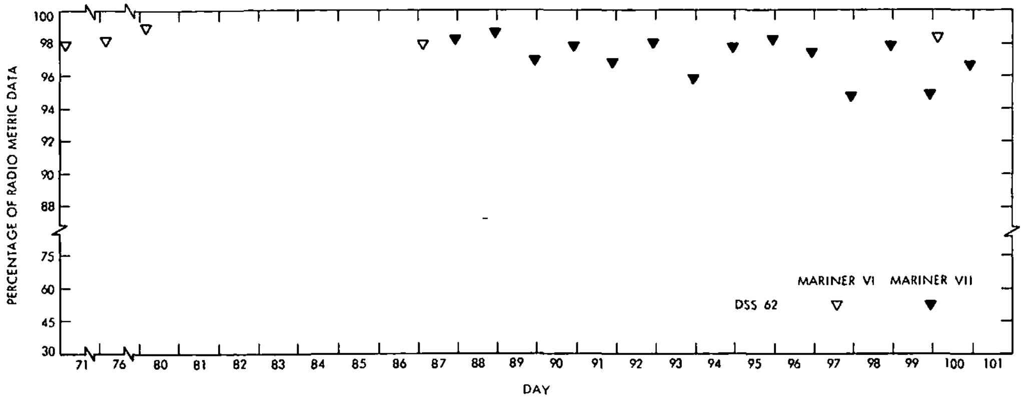


Fig. 142. Radio metric data recovery percentages for Mariners VI and VII (DSS 62)

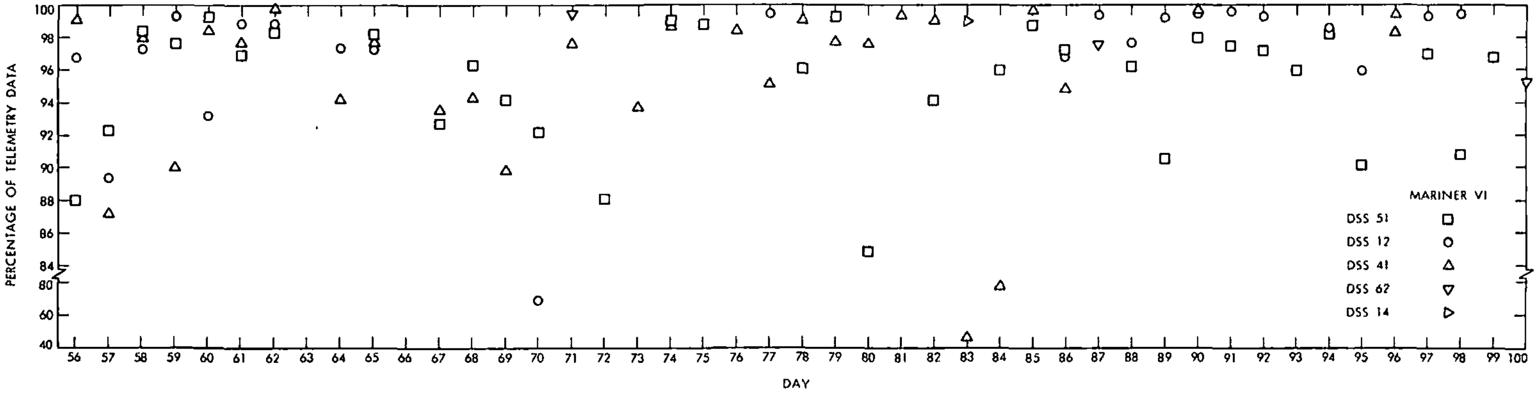


Fig. 143. Mariner VI telemetry percentages

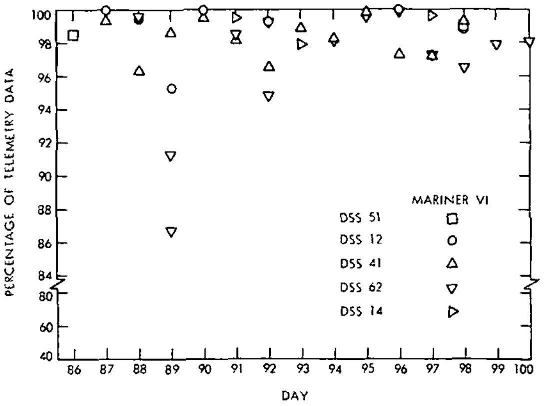


Fig. 144. Mariner VII telemetry percentages

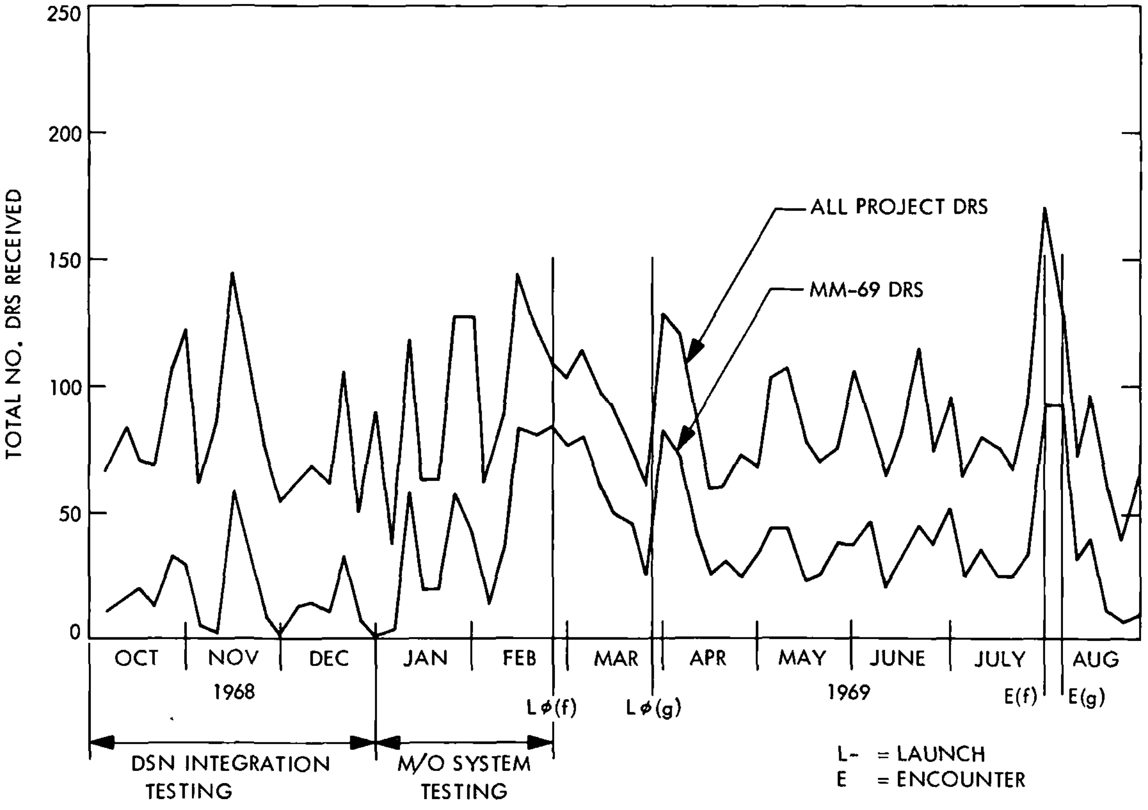
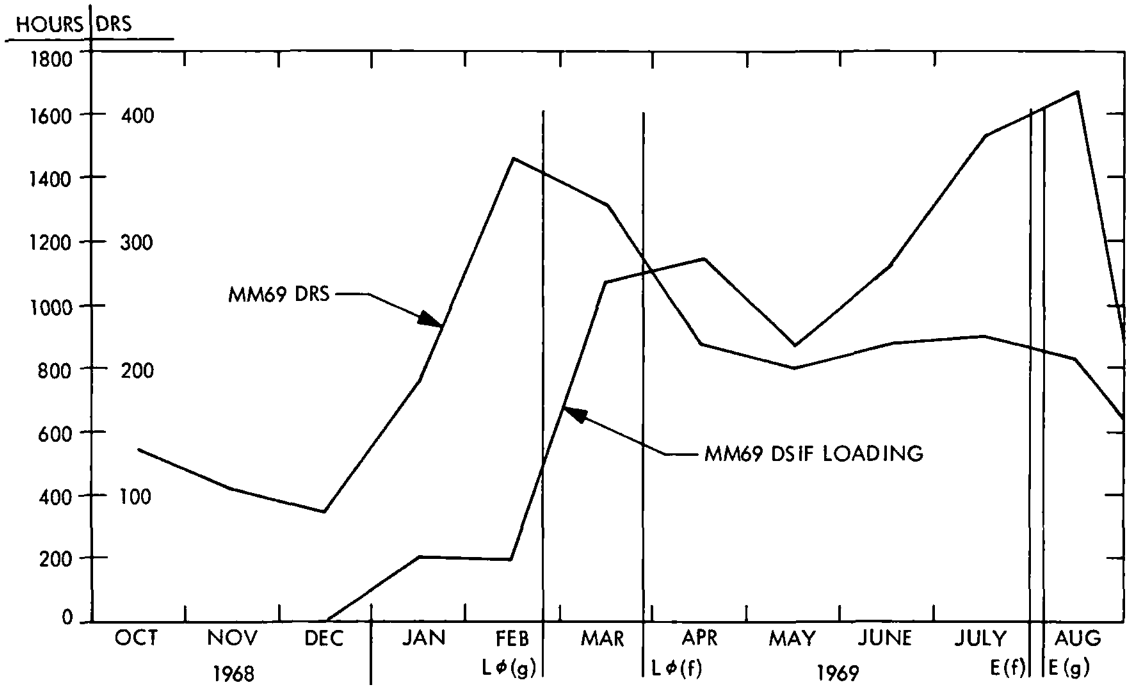


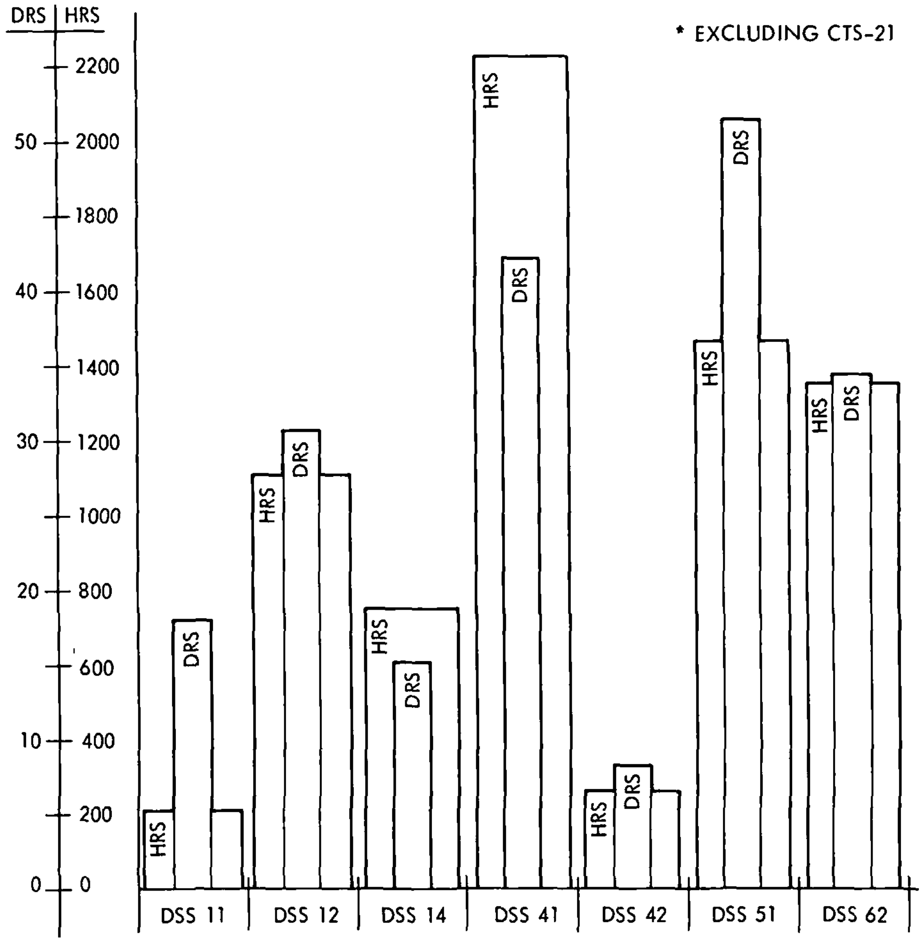
Fig. 145. Total DR activity vs Mariner Mars 1969 DR activity



	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUNE	JULY	AUG
NO. OF MM69 DRS	132	102	82	189	362	327	219	199	216	222	204
MM69 DSIF LOADING, (hrs)	—	—	—	200	194	1031	1068	858	1104	1520	1655

NOTE: DSIF LOADING DATA WERE
OBTAINED FROM A SOURCE
OTHER THAN DR

Fig. 146. Mariner Mars 1969 DR volume vs DSIF loading



	DSS 11	DSS 12	DSS 14	DSS 41	DSS 42	DSS 51	DSS 62
HRS	207	1102	747	2209	260	1454	1345
DRS	18	31	15	42	08	51	31
HRS PER DR	11.5	35.5	49.8	52.6	32.5	28.5	39.6

Fig. 147. Station support hours vs Mariner Mars 1969 DR total, by site

GLOSSARY

A/C	attitide control
AFETR	Air Force Eastern Test Range
AGC	automatic gain control
ANT	Station 91, Antigua Island
ASC	Ascension Island, MSFN/USB site
ATR	analog tape recorder
az	azimuth
BDA	Bermuda Island station, MSFN
CAT	complementary analysis team
CC&S	central computer and sequencer
comm	communications
COMSAT	communications satellite
CP	communications processor
CVT	configuration verification test
DACON	data controller
DAS	data automation subsystem
DIS	digital instrumentation system
DOD	Department of Defense
DPS	data processing system
DR	discrepancy report
DSIF	Deep Space Instrumentation Facility
DSN	Deep Space Network
DSS	Deep Space Station
DSS 11	Pioneer Deep Space Station, Goldstone, California
DSS 12	Echo Deep Space Station, Goldstone, California
DSS 13	Venus Deep Space Station, Goldstone, California
DSS 14	Mars Deep Space Station, Goldstone, California
DSS 41	Woomera Deep Space Station, Island Lagoon, Australia
DSS 42	Tidbinbilla Deep Space Station, Canberra, Australia
DSS 51	Johannesburg Deep Space Station, Johannesburg, South Africa
DSS 61	Robledo Deep Space Station, Madrid, Spain
DSS 62	Cebreros Deep Space Station, Madrid, Spain
DSS 72	Ascension Deep Space Station, Ascension Island
DTR	digital tape recorder
DTV	digital TV
EDED	error-detector-encoder-decoder
EI	engineering instructions
EOPS	AFETR Operations
ETO	estimated time operational
ETR	Eastern Test Range
FM	frequency modulation
GBI	Grand Bahama Island
GCF	Ground Communications Facility
GRTS	Goddard real-time system
GSFC	Goddard Space Flight Center
HA-DEC	hour angle-declination
HRC	high-rate correlator
HSD	high-speed data
IBM	International Business Machines
ICS	Intercommunication system
IF	intermediate frequency
I/O	input/output
IRV	inter-range vector
JPL	Jet Propulsion Laboratory
L	time of launch
LOS	loss of signal
LV	launch vehicle
M	time of maneuver
MECO	main engine cutoff
MMTS	multiple-mission telemetry system
MODEM	modulator-demodulator
MOS	mission operations system
MSFN	Manned Space Flight Network
NASCOM	NASA communications system
NAT	network analyst team
NOP	network operations plan
NOR	not operationally ready
NSP	NASA support plan

OCC	Operations Control Chief
OCT	Operations Control Team
OD	Operations Director
ODG	orbit data generator
ORT	operational readiness test
OSE	operational support equipment
OVT	operational verification tests
PAM	pulse-amplitude modulation
PCM	pulse code modulated
PE	project engineer
PTM	proof test model
RTCS	real-time computing system
RWV	read, write, verify
SAA	S-band acquisition aid
SAF	Spacecraft Assembly Facility
S/C	spacecraft
SDA	subcarrier demodulator assembly
SDCC	system data conversion center
SFOF	Space Flight Operations Facility
SFOD	Space Flight Operations Director
SFOTP	space flight operations test plan
SIRD	support instrumentation requirements document
SMC	station and monitor console
SPAC	spacecraft performance analysis and command
syn	synchronization
T	interruptible time count referenced to an event
TAER	time, azimuth, elevation, range
TCP	telemetry and command processor
TDA	tracking and data acquisition
TR	tape readers
TDP	tracking data processor
TDS	tracking and data system
TEL-2, -4	AFETR stations
TLM	telemetry
TSS	teletype switching machine
TTY	teletype
TV	television
TWT	traveling wave tube
UHF	ultrahigh frequency
USB	unified S-band
VCO	voltage-controlled oscillator
VECO	vernier engine cutoff

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