Mark IVA DSN 26-Meter Subnet

D. D. Gordon
TDA Engineering Office

The Office of Space Tracking and Data Systems' Networks Consolidation Program (NCP), managed by the Jet Propulsion Laboratory (JPL), includes the implementation of a 26-meter Tracking and Communications Subnet as a part of the Mark IVA Deep Space Network (DSN). The incorporation of this subnet into the DSN will contribute to the NCP goal of consolidating the two NASA ground tracking networks into one tracking network to be operated for NASA by JPL. The ground networks to be consolidated are the Ground Spaceflight Tracking and Data Network operated by the Goddard Space Flight Center, and the DSN operated by JPL.

The 26-meter Tracking and Communication Subnet has been designed to provide the capability to support, at each Deep Space Communication Complex, the tracking and data communication requirements of the earth-orbital missions that cannot be supported by the Tracking and Data Relay Satellite System when it becomes operational.

Previous articles in the TDA Progress Report have traced the history and progress of the NCP's planning and budgeting activities. This article deals with the implementation activities associated with the 26-meter Tracking and Communications Subnet and its planned capabilities as an element of the consolidated DSN.

I. Introduction

Transfer of an operational 26-meter subnet from the Goddard Space Flight Center (GSFC) to JPL as an element of the Mark IVA DSN is scheduled to take place on February 1, 1985. This transfer contributes to the accomplishment of the NCP's objective to consolidate the capabilities of the two NASA ground tracking networks. Previous articles in the *TDA Progress Report* (Refs. 1, 2, and 3) have traced the history of this consolidation effort. The Mark IVA DSN 26-meter Subnet will be composed of a 26-meter, S-band, transmit and receive station located at each of the Deep Space Communication Complexes (DSCCs). The three stations in the Subnet are designed to provide spacecraft support consistent with the 26-meter link capabilities at a typical Ground Spaceflight Tracking and Data Network (GSTDN) station. Implementation of these stations will maximize the use of existing GSTDN hardware and software and will be configured to provide the minimum capabilities to support the needs of the 26-meter subnet mission set.

The NCP schedule requiring an operational 26-meter subnet was based on the planned operational date of the Tracking and Data Relay Satellite System (TDRSS) and the related phaseout of most of the GSTDN stations. However, the closure of GSTDN stations has been deferred, consistent with the recent postponement of the TDRSS operational date. Therefore, the 26-meter subnet will serve in conjunction with the extended GSTDN to provide support to the TDRSS compatible missions, as well as the initially planned 26-meter Subnet mission set.

II. Mission Set

Definition of the missions requiring committed support by the 26-meter Subnet of the DSN has evolved to include a set of missions that can be divided into four classifications.

A. Extended Missions

Existing missions currently supported by the GSTDN that are not TDRSS compatible, but require support beyond the planned phasedown of the GSTDN.

(1) Nimbus 7.

(2) Dynamics Explorer (DE) 1.

(3) International Sun-Earth Explorer (ISEE) 1 and 2.

B. TDRSS Compatible Missions

Missions designed for support by the TDRSS that may require support prior to the TDRSS operational date.

(1) Landsat 4 and 5.

(2) Earth Radiation Budget Satellite (ERBS).

(3) Solar Maximum Mission (SMM).

(4) Solar Mesosphere Explorer (SME).

(5) Space Telescope (ST).

C. Special Support Missions

Missions that require a capability for emergency support or support of special spacecraft events.

(1) Space Transportation System (STS).

(2) Tracking and Data Relay Satellite System (TDRSS).

(3) International Cometary Explorer (ICE) (Encounter).

(4) Active Magnetospheric Particle Tracer Explorers (AMPTE).

(5) Geostationary Operational Environmental Satellite (GOES) G and H.

D. Reimbursable Missions

Missions that have contracted with NASA for support by the DSN on the basis of cost reimbursement.

(1) Broadcasting Satellite (BS) 2B.

(2) German Direct TV Broadcast Satellite (TV-SAT).

(3) French Direct TV Broadcast Satellite (TDF) 1.

III. Configuration

A representation of the 26-meter Subnet is included in Fig. 1, Mark IVA DSN 1985 configuration, where the 26-meter stations are identified as DSS 16, 46, and 66 at the Goldstone, Canberra, and Madrid complexes, respectively. As illustrated in Fig. 1, each station is essentially a stand alone element within a complex. Initially the 26-meter control room functions will not be integrated into the Mark IVA DSN Signal Processing Centers (SPCs). However, operational control will be exercised from the JPL Network Operations Control Center. The control rooms will have direct NASCOM communications with GSFC. Additionally, Fig. 1 indicates a cross-support capability within each complex that will allow command and telemetry signals at baseband to be routed between the 26-meter control room and the SPC.

The physical location and configuration of the 26-meter control room will be different at each complex, although the equipment will be essentially identical. At the Canberra Deep Space Communications Complex, the control room will be located in the pedestal building of the 64-meter antenna. At the Madrid Deep Space Communications Complex, the control room will be located in Room 900, adjacent to the Mark IVA SPC. The existing GSTDN 26-meter link at Goldstone, California will undergo minor modifications, but will not be physically relocated and will become the 26-meter Subnet station at the Goldstone Deep Space Communications Complex (GDSCC).

IV. System Characteristics

The basic equipment complement and interface design are illustrated in Fig. 2, 26-meter Subnet station design. The equipment consists of existing GSTDN hardware with the exception of two new devices, the Programmable Data Formatter (PDF) and the Shuttle Forward Link.

A. Telemetry System

Each 26-meter station will have the capability for processing up to three spacecraft telemetry channels simultaneously depending upon communication circuit limitations. The telemetry system includes a new throughput processor, the PDF. The PDF is a Digital Equipment Corporation LSI-11 based system that will accept the input data streams and block them asynchronously for transmission off-site.

The received spacecraft signal is routed to the various telemetry subsystem assemblies consisting of tunable filters, discriminators, bit synchronizers, frame synchronizers, PSK demodulators, and project unique assemblies, as appropriate. The data is then routed to the PDF where it is block formatted for transmission. In addition to the telemetry blocking function the PDF also performs multiplexing of the blocked serial streams from the Spacecraft Command Encoder and Tracking Data Processor System. This data is then transferred to wideband NASCOM circuits. The PDF is capable of transferring data to a maximum of three 56-kb/s circuits or one 224-kb/s circuit.

A second PDF will be used by the station for monitoring data quality. This unit will sample an output channel of the first PDF, deblock the data stream, and route it to a frame synchronizer. The frame synchronizer will be used to verify the ability to lock-on the data stream.

(1) Key characteristics:

(a) Process data rates up to 800 kb/s.

(b) Process and/or record three data streams simultaneously (e.g. NIMBUS: 4-kb PCM and two 800-kb real time recordings; or, ISEE 1 and 2: two real-time PCMs and one real-time recording).

(c) Demodulation of NRZ-L or Bi-phase-L data on a subcarrier or carrier.

(d) Demodulate subcarriers up to 1.024 MHz.

(e) On-site wideband analog recording of detected and demodulated data.

(2) RF characteristics:

(a) Frequency range: 2200 to 2300 MHz.

(b) Bandwidth (baseband): 10 MHz.

(c) Antenna gain: 52 dbi.

(d) System temperature: 100K (33K Paramp, antenna at zenith).

(e) Polarization: RCP/LCP/linear.

(f) Cross-support interfaces include telemetry baseband signals from 26-meter control room to SPC, or SPC to 26-meter control room.

B. Command System

Two Spacecraft Command Encoders (SCEs) will be installed at each 26-meter station. The SCE is a Honeywell 316 based controller capable of processing NASCOM command blocks and controlling and testing the output functions for spacecraft commanding. New command software will be utilized to provide a throughput data format. The SCE input channel will be directly connected to an incoming NASCOM circuit. The SCE can perform its own polynomial error detection so that polynomial errors in an arriving block will cause that block to be rejected. At the option of a Project Operations Control Center (POCC), each valid block received can be returned for confirmation of valid SCE reception (command echo). The output (echo) channel will access the wideband link through the Telemetry System PDF, which will perform all necessary output multiplexing functions to the NASCOM circuit.

Uplink support for the Space Transportation System (STS) involves additional unique hardware consisting of a Comm Tech Console, the Delta Modulation System (DMS), and the Shuttle Command Voice Multiplexer (SCVM), as well as the SCE. The DMS receives analog voice from the Comm Tech Console and converts it to digital voice. The SCVM multiplexes digital voice from the DMS with command data from the SCE and applies it to the uplink carrier. The SCVM allows selection of uplink at either the high data rate (72 kb/s) or the low data rate (32 kb/s). The command rate of 128 bits/s is the same for either uplink data rate.

The Shuttle Forward Link will be installed prior to TDRSS becoming operational when the Shuttle requirement for support by the 26-meter Subnet is reduced to an emergency mode only. This device provides for transfer of uplink data (voice and command) in a throughput mode from the Johnson Spaceflight Center (JSC) to the Space Shuttle Orbiter (SSO).

A dedicated Command and Telemetry Processor (CTP), provided by the GOES Project, will be used in place of the SCE for launch and early orbit support of the GOES-series of spacecraft. As a back-up, the SCE will provide non-synchronous command capability.

(1) Key characteristics:

(a) PCM data rates 125 to 2000 b/s for NRZ-L, NRZ-L/Bi-phase-L, and NRZ-M.

(b) Subcarrier demodulation

PSK: 8 to 16 kHz

PSK Summed: 8 to 16 kHz

PSK Summed/FM: 2-kHz PSK/70-kHz FM

PSK AM/FM: 3- to 4-kHz PSK/70-kHz FM

FSK AM: 5 to 9 kHz.

(c) S-band uplink carrier with phase modulation index of 0.3 to 1.5 radians, peak.

(d) Local monitor and control, including system status and keyboard entry for emergency commanding with voice communications to DSN operations and GSFC POCCs.

(e) Baseband cross-support interfaces include SCE commands to the 34-meter exciter or SPC commands to the 26-meter exciter.

(f) Redundant transmitters at each station.

(2) RF characteristics:

(a) Uplink frequency range: 2025 to 2120 MHz.

(b) Transmitter step tuning: 20 MHz bandwidth with 5-MHz overlap between steps.

(c) Transmitter power: continuously variable, 1 to 10 kw.

(d) Antenna gain: 51.5 dbi.

(e) Polarization: RCP/LCP.

C. Tracking System

One Tracking Data Processor System (TDPS) and STDN Ranging Equipment (SRE) will be installed at each 26-meter station.

The TDPS is a Modcomp minicomputer used to predict spacecraft position and provide pointing information to the antenna-servo system. It can process two sets of spacecraft state vectors simultaneously. The TDPS logs tracking data during a pass and simultaneously formats and transmits an edited version of these data off-site. Tracking data sampling rates are selectable at 0.1, 1, 10, and 60 second intervals.

The SRE measures the range to the spacecraft in nanoseconds, unambiguously, to 6.4 seconds round-trip light time, and S-band doppler to ±220 kHz.

Tracking and ranging data will be transmitted as low-speed data (LSD) via Teletype (TTY) lines, or as high-speed data (HSD) on wideband lines. Acquisition data will be received on TTY lines.

(1) Key characteristics:

(a) 26-meter X-Y antenna with rim mounted acquisition aid antenna.

(b) Antenna control (including autotrack) provided through tracking subsystem (TDPS/SRE/ACC).

(c) Carrier tracking via phase lock loop equipped receivers.

(d) Doppler and range measurements provided simultaneously.

(e) Data formatted and transmitted by tracking subsystem.

V. Network Operations Control Center (NOCC) Support

The JPL NOCC will have operations control responsibility for the 26-meter Subnet stations, as it does for other elements of the DSN, for the long term. However, until the TDRSS becomes operational and the GSTDN phase down occurs, GSFC will participate in the control of station operations. During this period of time the JPL NOCC will exercise operations control for support of the AMPTE mission and the Extended Missions by the 26-meter stations, but will turn over control of the stations to the GSFC NOCC for support of the TDRSS Compatible Missions (refer to Section II). Development of the sequence of events (SOEs) for these spacecraft passes will be consistent with this division of control responsibilities.

During this same period the GSFC will be responsible for scheduling the 26-meter stations. DSN requirements for support will be provided to the GSFC scheduling system via the JPL NOCC. The GSFC-generated schedules will then be supplied to the JPL NOCC for integration into the overall DSN schedules.

The GSFC will also participate in the development of antenna pointing predicts for the 26-meter stations when GSFC has orbit determination (OD) responsibility for the spacecraft requiring support. The Network Support Subsystem (NSS) in the JPL NOCC receives spacecraft position data either in the form of a P-file from the JPL Navigation Subsystem (NAV), or as an Inter Center Vector (ICV) from the GSFC Operations Support Computing Facility (OSCF), to use in the development of Improved Inter Range Vectors (I^2RVs). The I^2RVs are forwarded via TTY to the TDPS at the station for the generation of antenna pointing predicts. In some cases the OSCF at GSFC will generate the I^2RVs and transmit them directly to the TDPS at the station.

VI. Implementation Activities

Implementation of the 26-meter Subnet is a phased activity with the following planned completion dates:

DSS 16: December 1, 1984

DSS 46: October 1, 1984

DSS 66: February 1, 1985

Maintenance, operations and scheduling of the subnet stations will be the full responsibility of GSFC until they are transferred to JPL on February 1, 1985.

The 26-meter Subnet implementation has been divided into two tasks, the Facilities Development Task, for which JPL has management and implementation responsibility, and the Equipment Reconfiguration Task, for which GSFC has management and implementation responsibility.

(1) Facilities Development Task.

(a) Relocate the decommitted DSS 44 26-meter antenna in Australia and the GSTDN 26-meter antenna in Spain, including dismantling, moving, reassembling, and aligning the antenna structural and mechanical subsystems.

(b) Provide support facilities at each complex as required for the 26-meter antenna and its associated electronics (e.g. power, HVAC, roads, cableways, and buildings).

(2) Equipment Reconfiguration Task.

(a) Acquire, relocate, and install the electronics equipment required to implement an operational 26-meter station at each DSN complex.

(b) Provide documentation for the electronics equipment that is adequate for day-to-day maintenance and operations support.

(c) Develop, conduct, and document mission support tests and demonstrations for each station.

A. DSS 16, Goldstone, California

The 26-meter link at the existing Goldstone GSTDN station (GDS), with minimal modifications, will become the 26-meter Subnet station at the GDSCC. The modifications include installation of a PDF and an optical fiber cross-support link between DSS 16 and SPC 10.

(1) PDF installation:

(a) Equipment delivery, October 1, 1984.

(b) Installation and engineering tests complete, December 1, 1984.

(2) Cross-support link: completed.

B. DSS 46, Canberra, Australia

Implementation of DSS 46 is essentially completed with the remainder of the task to be accomplished by station maintenance personnel. DSS 46 is currently supporting the AMPTE Project using the 26-meter antenna and the RF front end in a cross-support mode with DSS 42. The station is scheduled to assume support responsibility for the Extended Missions, the TDRSS Compatible Missions and the STS (refer to section II, Mission Set) on October 1, 1984.

(1) Antenna relocation: completed.

(2) Facilities development: completed.

(3) Electronic reconfiguration and installation: completed.

(4) Maintenance and operations documentation: in process, completion due December 1, 1984.

(5) Mission support tests: in process, completion due December 1, 1984.

C. DSS 66, Madrid, Spain

(1) Antenna relocation: in process for November 1, 1984 completion.

(2) Facilities development: in process for November 15, 1984 completion.

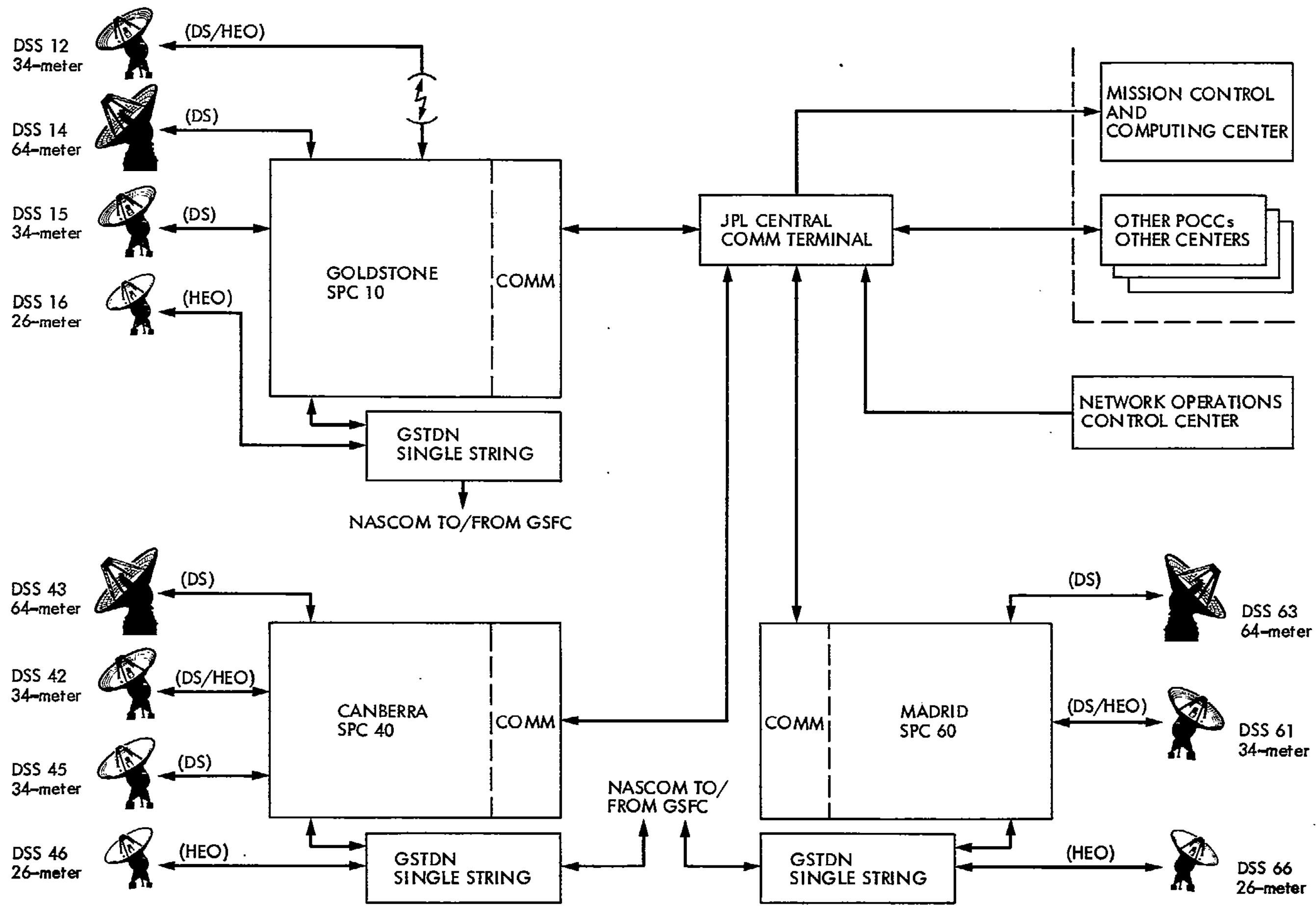
(3) Electronic reconfiguration and installation: in process for December 20, 1984 completion.

(4) Maintenance and operations documentation: in process for February 1, 1985 completion.

(5) Mission support tests: completion due February 1, 1985.

References

1. Yeater, M. L., Herrman, D. T., and Sanner, G. E., "Networks Consolidation Program," *TDA Progress Report 42-59*, July and August 1980, pp. 107-120 Jet Propulsion Laboratory, Pasadena, California, Oct. 15, 1980.
2. Yeater, M. L. and Herrman, D. T., "Networks Consolidation Program," *TDA Progress Report 42-65*, July and August 1981, pp. 19-24, Jet Propulsion Laboratory, Pasadena, California, Oct. 15, 1981.
3. Yeater, M. L., Herrman, D. T., and Luers, E. B., "Networks Consolidation Program," *TDA Progress Report 42-69*, March and April 1982, pp. 10-13, Jet Propulsion Laboratory, Pasadena, California, June 15, 1982.



COMM - GROUND COMMUNICATIONS
DS - DEEP SPACE
DSS - DEEP SPACE STATION
GSTDN - GROUND SPACEFLIGHT TRACKING AND DATA NETWORK

HEO - HIGH EARTH ORBITER
POCC - PROJECT OPERATIONS CONTROL CENTER
SPC - SIGNAL PROCESSING CENTER

Fig. 1. Mark IVA DSN 1985 configuration

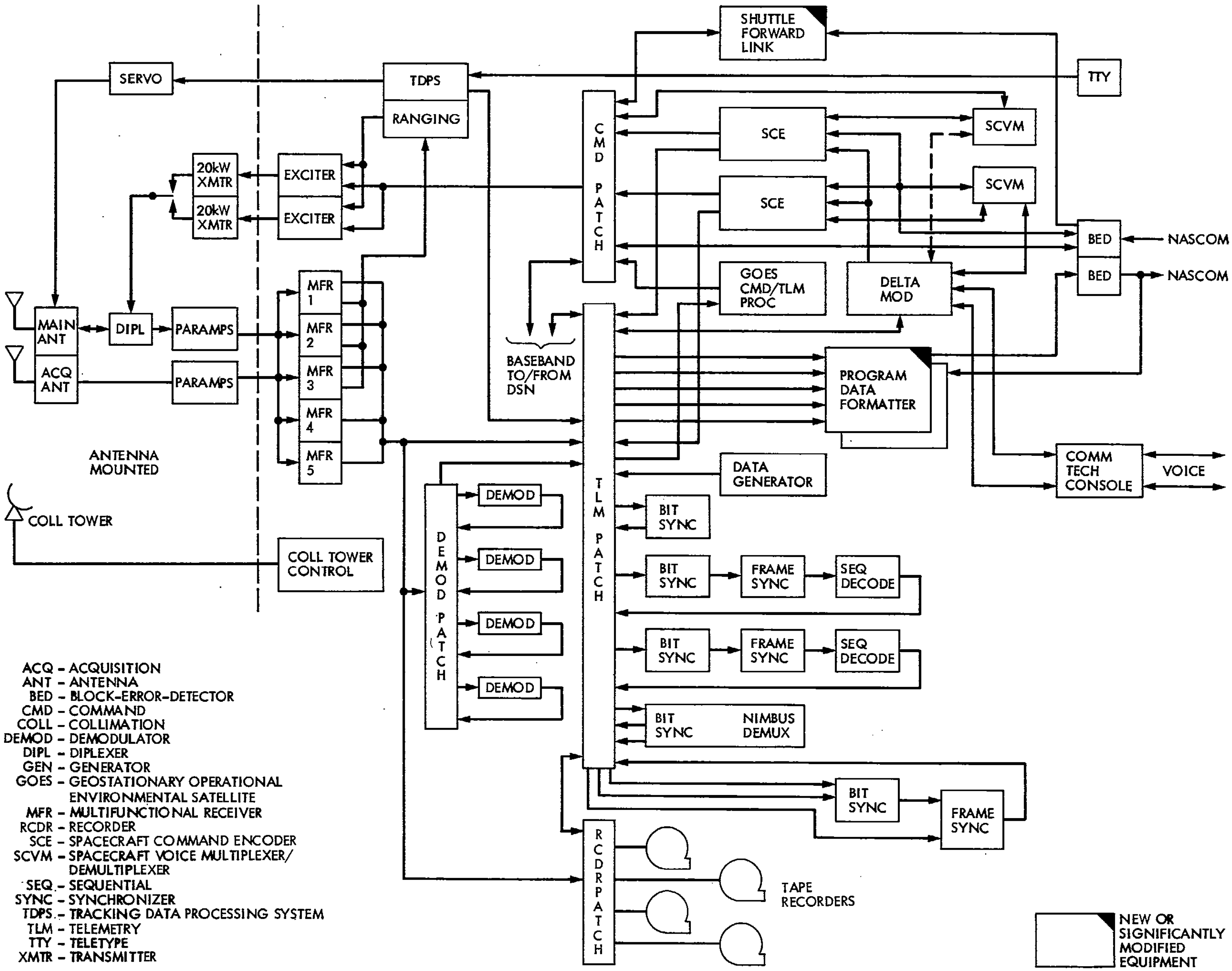


Fig. 2. 26-meter subnet station design