DSN Tracking System—Mark III-75

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This article provides a description of the DSN Tracking System—Mark III-75 currently in use for multimission support. Tracking functions performed by the Deep Space Stations, Ground Communications Facility, and Network Operations Control Center are given. Changes that were made to the subsystems of the DSN Tracking System—Mark III-73 to implement the DSN Tracking System—Mark III-75 are briefly described.

I. Introduction

This article provides a description of the functional capabilities of the DSN Tracking System—Mark III-75 currently in use for multimission support in the generation of radio metric data. The DSN Tracking System—Mark III-75 performs the main functions of radio metric data generation, transmission of data to the Projects and the validation of the tracking system performance. A summary of the functions and data flow is presented in Figure 1.

II. Key Characteristics

The key characteristics of the DSN Tracking System—Mark III-75 are as follows:

(1) Generation of predictions by DSN Tracking Operations

(2) Real-time reporting of DSN Tracking System status to DSN Operations Control

(3) S-X band doppler and range data generation

(4) Data time tagged to the 10 microsecond level relative to the DSN master clock

(5) Precision control of Block IV receiver and exciter frequencies

(6) Calibration data for the RF transmission media

(7) Use of high-speed data lines for radio metric data and prediction data transmission.

III. Functional Description

Each 26-meter Deep Space Station (DSS) has the capability of generating one-way, two-way, or three-way doppler and angles from a single spacecraft S-band carrier. Planetary ranging and Differenced Range Versus Integrated Doppler (DRVID) capability can be provided in one 26-meter subnet. Each 64-meter station has the capability of generating one-way, two-way, or three-way doppler simultaneously from two spacecraft carriers within the same beam width, and of obtaining angles,

planetary distance S-X band range, and S-X band DRVID from a single spacecraft. Table 1 summarizes the planned capability for doppler, range, and DRVID.

A. Data Generation Functions

Functions performed in the generation of radio metric data are:

(1) Tracking predictions generation (Network Operations Control Center (NOCC))

(2) Tracking predictions transmission (Ground Communications Facility (GCF))

(3) Data mode and system configuration selection (Deep Space Station (DSS))

(4) Antenna pointing control (DSS)

(5) Receiver and exciter frequency control (DSS)

(6) Doppler extraction and counting (DSS)

(7) Range and DRVID extraction and measurement (DSS)

(8) Angle readout (DSS)

(9) Interlace partial status, data mode, and system configuration (DSS)

(10) Tracking data handling (DSS)

(11) Original Data Record (ODR) generation (DSS)

(12) Ground weather data and ionosphere data, measurements (DSS)

(13) Open-loop reception and data recording (DSS)

B. Data Transmission Functions

Functions performed in the transmission of radio metric data are:

(1) Radio metric, ground weather and ionosphere data formatting (DSS)

(2) Radio metric, ground weather and ionosphere data error encoding and transmission (GCF)

(3) Tracking prediction data formatting (NOCC)

(4) Tracking prediction data error encoding and transmission (GCF)

(5) Network Data Log generation (GCF)

(6) Ground Communications error detection (GCF)

C. Tracking System Validation Functions

Functions performed to accomplish DSN Tracking System validation are:

(1) Transmission of outage alarms to DSN Operations Control (NOCC)

(2) Verification of Tracking System configuration and data mode (NOCC, DSS)

(3) Comparison of radio metric data with predictions (NOCC, DSS)

(4) Transmission of System alarms and status to DSN Operations Control (NOCC)

(5) Display of Tracking System performance and status (NOCC, DSS)

Deep Space Station, Ground Communications and Network Operations control functions are shown in Figures 2, 3 and 4 respectively.

D. Functional Operation

A brief description of the functional operation of the DSN Tracking System is presented in the remainder of this section. Simplified block diagrams of the 26-m and 64-m stations for Mark III-75 are shown in Figures 5 and 6 respectively.

A spacecraft ephemeris is received from the project, together with standards and limits consisting of spacecraft frequencies, tuning rates, tuning range, data types and rates. DSN tracking predicions are generated from the spacecraft ephemeris (ϕ factors) by the Network Operations Control Center Tracking Subsystem. After validation, the predictions are transmitted from the NOCC to the stations via high-speed data line for use in acquiring the spacecraft carriers. The predictions are also used in Tracking System performance validation.

Data mode and system configuration messages are generated for transmission to the stations by high-speed data line or voice, and are used to select the proper data mode and system configuration.

Radio metric data, consisting of angles, range, DRVID, and doppler, together with associated data (i.e., time, frequencies, system configuration, data mode, and status) are measured and sampled by the DSS Tracking Subsystem and are formatted for transmission via high-speed data line. Supplementary data consisting of ground weather data and ionosphere data are also formatted by the DSS Tracking Subsystem for transmission via high-speed data line. An Original Data Record is generated for post-pass recall, if necessary.

The radio metric data are received by the Central Communications Terminal (CCT) and are routed to the Mission Control and Computing Center. A log tape

containing all data received either in real time or by recall is generated by the Central Communications Terminal. Data to fill in gaps in the project data records can be supplied from the Deep Space Station Original Data Record.

The Tracking System performance is validated by the Network Control Tracking Real-Time Monitor processor in response to controls and standards and limits supplied from personnel in the Network Operations Control Area (NOCA). Tracking System alarms, status, and performance data are transmitted from the Network Control Tracking real-time monitor to the Network Control Display Subsystem for display in the NOCA. The Tracking System alarms and status are also transmitted to the Operations Control System for display. A Tracking System Performance Record containing status, alarms, performance data, and radio metric data is maintained for nonreal-time analysis. The Network Control Test and Training Subsystem is used to provide test data to the Tracking System in order to check out the Network Control Tracking Subsystem and to train Network personnel.

IV. Subsystem Modifications

This section describes the modifications, by subsystem, that were made to the DSN Tracking System—Mark III-73 to produce the Mark III-75 version.

A. 64-m Deep Space Station Modifications

(1) Antenna Mechanical and Microwave Subsystem. Equipment was added to the antenna mechanical and microwave subsystems to provide the capability of simultaneously acquiring S and X band carriers at 64-m Deep Space Stations.

(2) Receiver-Exciter Subsystem. One Block IV S-band exciter and two Block IV receivers capable of operating at S or X band frequencies were added at the 64-m Deep Space Stations. The Block IV Receiver-Exciter Subsystem was modified to produce biased doppler at 1 MHz rather than 5 MHz, thus improving the doppler resolution for radio science experiments. A second Ranging Demodulation Assembly was added to the Receiver-Exciter Subsystem. These new assemblies produced the capability to generate S and X band doppler and range data simultaneously.

(3) Transmitter Subsystem. A high power amplifier assembly was added at DSS 43 in Australia and 63 in Spain that is capable of transmitting 100 kW at S-band frequencies.

(4) Tracking Subsystem(s). The software for the antenna pointing subsystem was modified to provide precision tracking of the S or X band carriers using conical scan techniques. The Tracking Data Handling Subsystems were modified to provide simultaneous S and X band Doppler counting.

(5) Monitor and Control Subsystem(s). The software for the Digital Instrumentation Subsystem was modified to provide an improved drive tape interface to the Antenna Pointing Subsystem, the one megahertz biased doppler and improved S and X band doppler validation.

(6) Technical Facilities Subsystem. A Meteorological Monitor Assembly was added. This assembly measures and records ground temperature, pressure, relative humidity and ionosphere data. The ionosphere data are measured from tracking the polarization angle of a linearly polarized stationary satellite. These data are recorded on magnetic tape and are transmitted via high speed data lines on a post-pass basis using the Original Data Record recall software.

B. 26-m Deep Space Stations

(1) Receiver-Exciter Subsystem. A Ranging Demodulator Assembly was added at Goldstone (DSS 11). Switching was provided at DSS 42 in Australia and 61 in Spain to switch the Ranging Demodulator Assemblies from the 64-meter stations to the 26-m stations.

(2) Tracking Subsystem(s). The Antenna Pointing Subsystem software developed for the 64-m stations was also tested and transferred to operations at the 26-m stations. A Planetary Ranging Assembly was added at Goldstone (DSS-11) for ranging data generation. Switching was provided at DSS 42 in Australia and 61 in Spain to switch the Planetary Ranging Assembly from the 64-meter stations to the 26-meter stations.

(3) Monitor and Control Subsystem(s). The software implemented for the 64-meter stations was tested and transferred to operations at the 26-m stations.

C. Network Operations Control Center

The Tracking System prediction and validation functions were transferred from Mission Support Computers to DSN dedicated computers.

(1) Real Time Monitor Assembly. The real time monitor assembly was developed on a dedicated minicomputer (ModComp II). This assembly validates

tracking system performance for 6 radio metric data streams simultaneously. A System Performance Record is generated for non-real time analysis.

(2) Display Assembly. The display assembly provides cathode ray tube and hard copy displays of performance data for up to 6 radio metric streams simultaneously.

(3) Prediction Assembly. The prediction assembly generates predicted frequencies and angles that are used by the Deep Space Stations for the acquisition and tracking of spacecraft carriers. The prediction assembly operates in a Sigma-5 computer. The predictions are transmitted to the stations via high speed data lines. In addition, the predictions are used to validate the Tracking System performance by comparing observed radio metric data with predicted data.

V. Summary

The DSN Tracking System—Mark III-75 has been tested in the Network during 1975 and all capabilities except meteorological data have been used for mission support. Complete transfer to operations of the DSN Tracking System—Mark III-75 will occur in the second quarter of CY-1976.

Table 1. Planned DSS Radio Metric Data Capability

Data type	26-m DSS	64-m DSS
Doppler	1 S-band	2 S-band or 1 S-X band
Range	1 S-band*	1 S-band or 1 S-X band
DRVID	1 S-band*	1 S-band or 1 S-X band
Angles	Autotrack or computer aided	Computer aided with conical scan

*Planetary ranging at DSS 11 and planetary ranging switching capability between DSS 42/43 and DSS 61/63.

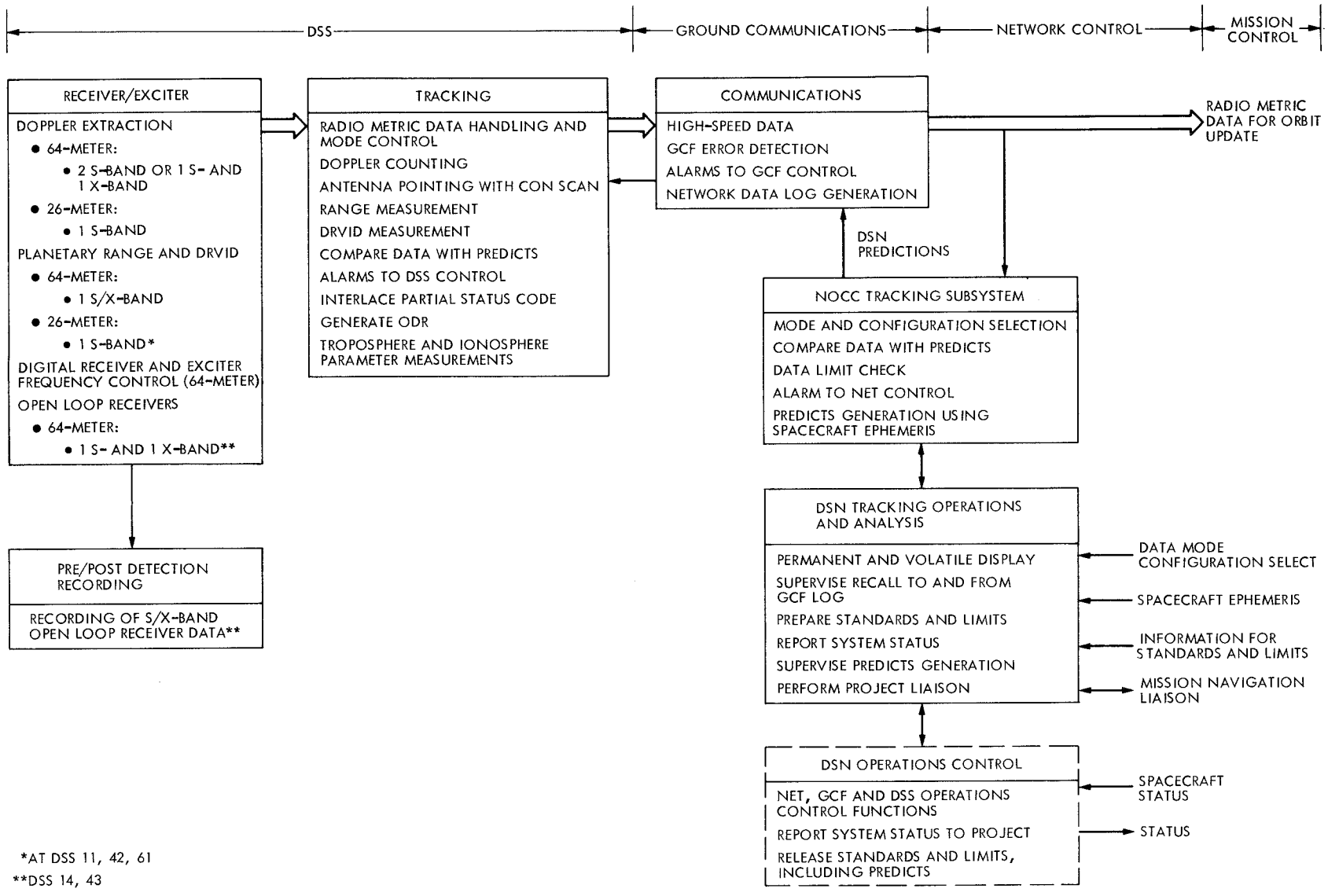

Fig. 1. DSN Tracking System — Mark III-75 functions

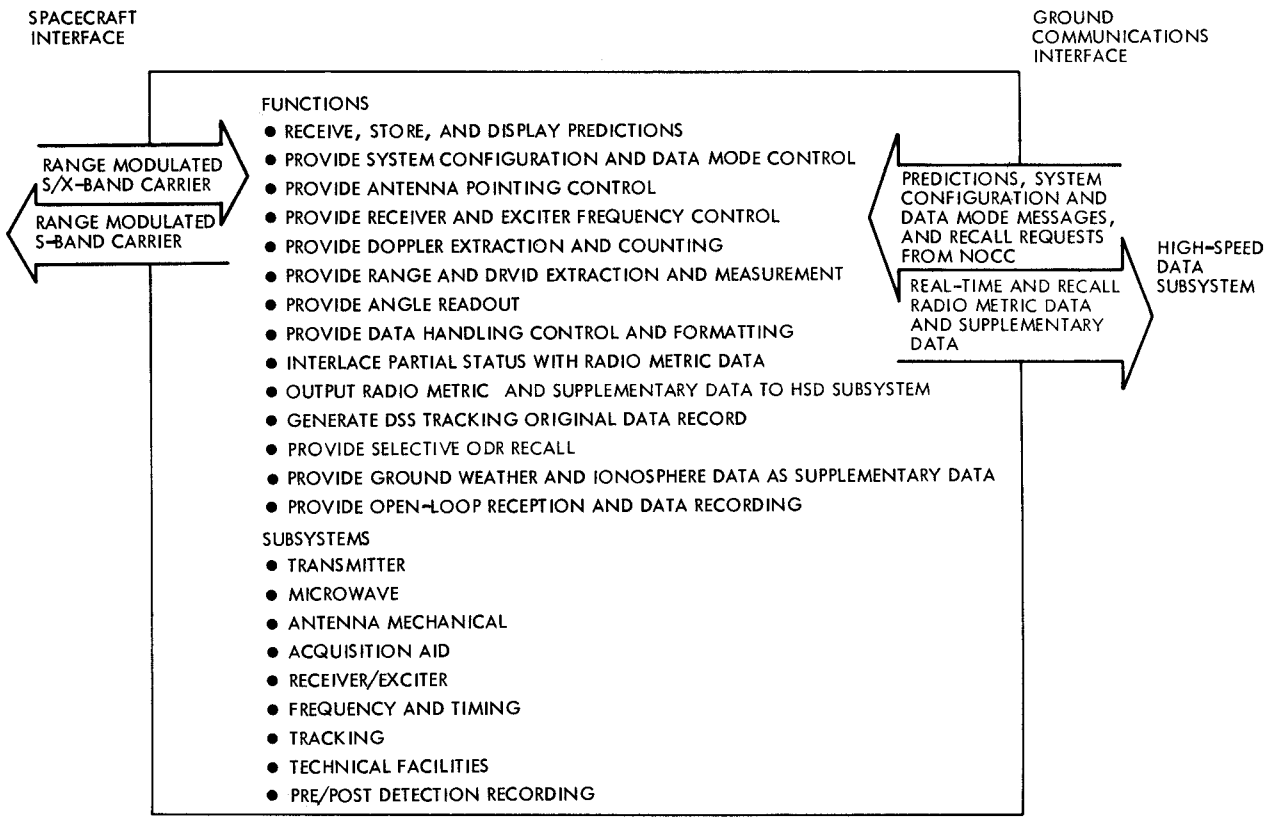

Fig. 2. DSS tracking functional requirements

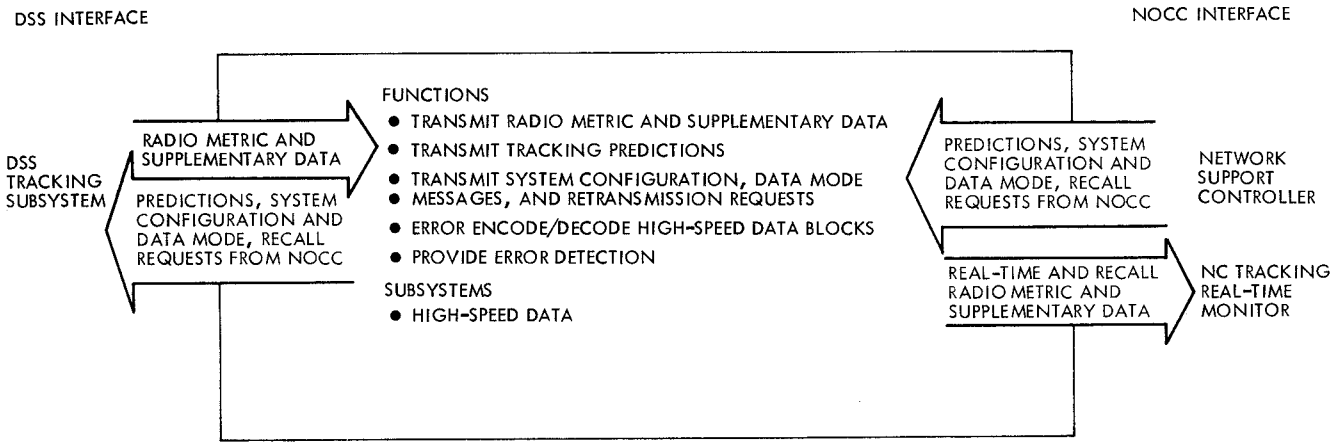

Fig. 3. Ground communications functional requirements

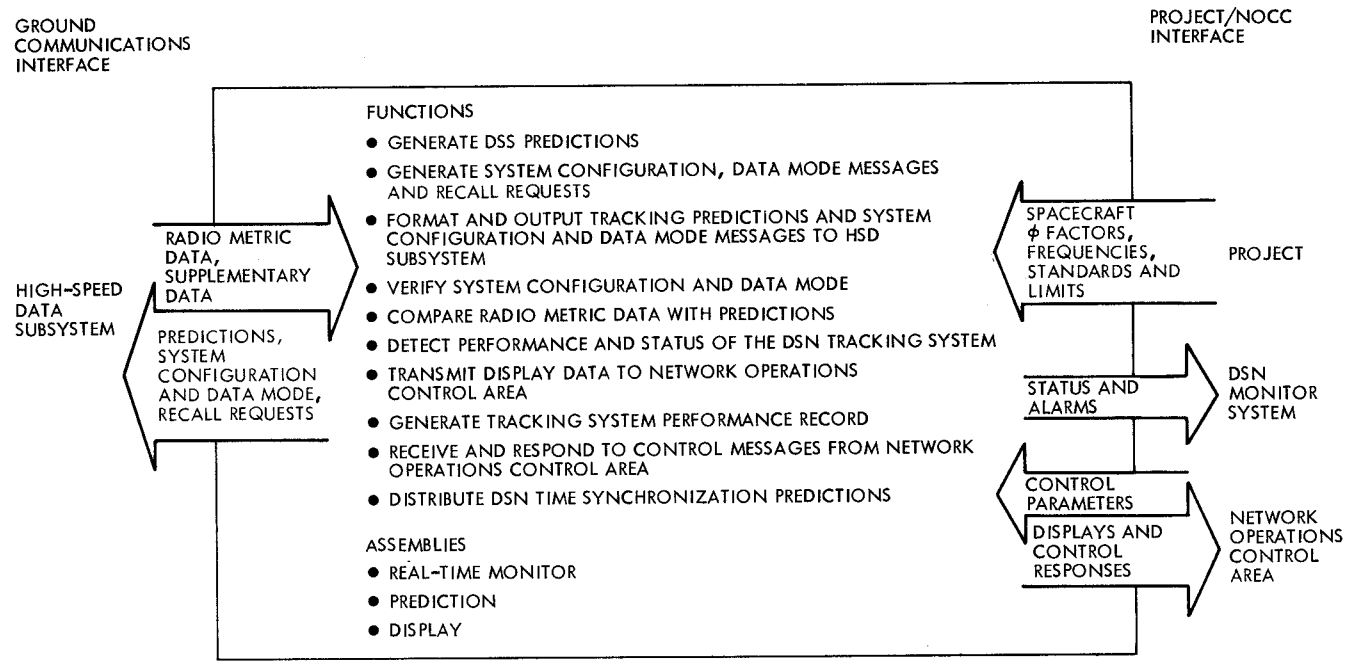

Fig. 4. NC tracking subsystem functional requirements

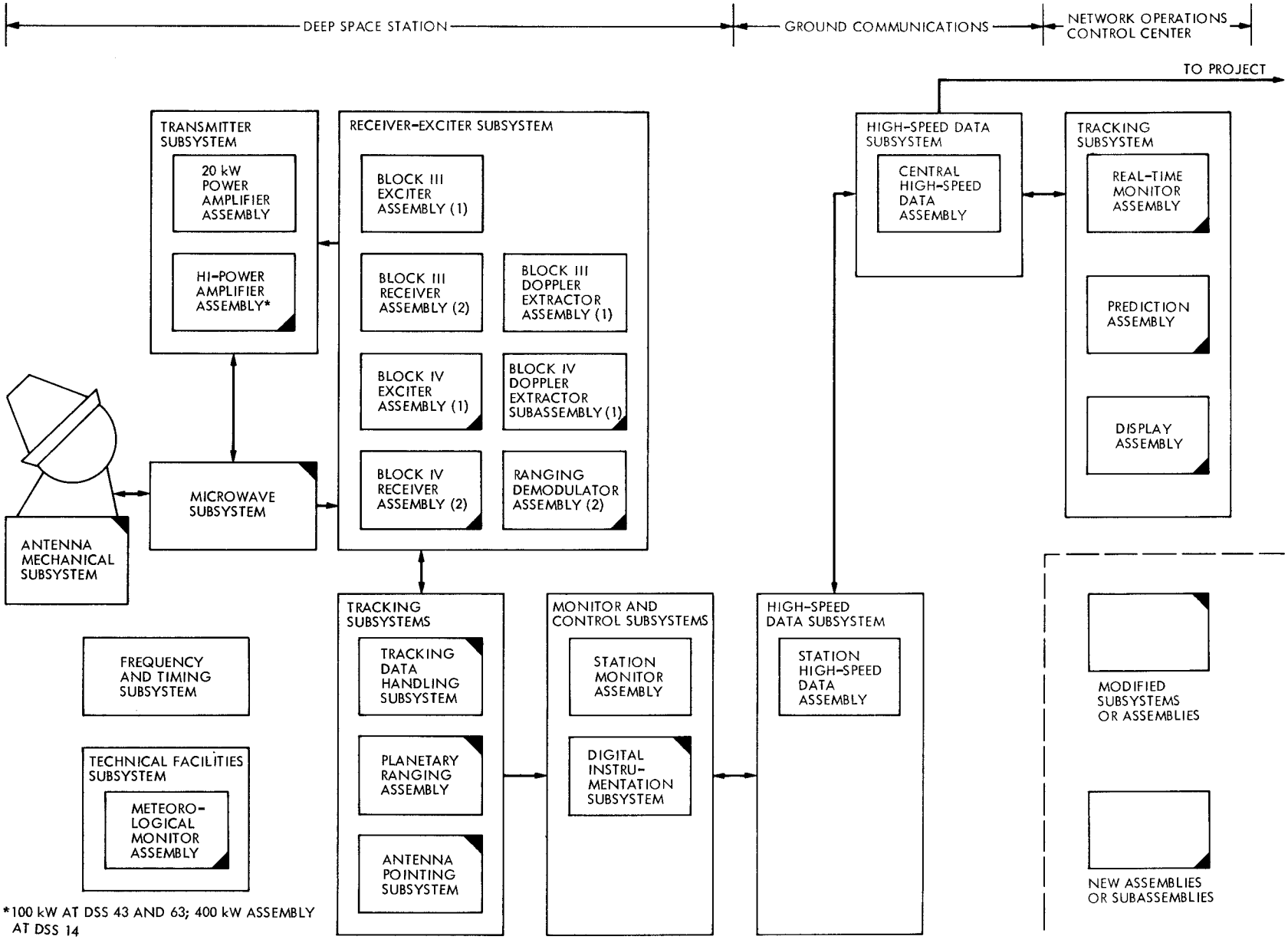

Fig. 5. DSN Tracking System — Mark III-75 64-m functional block diagram

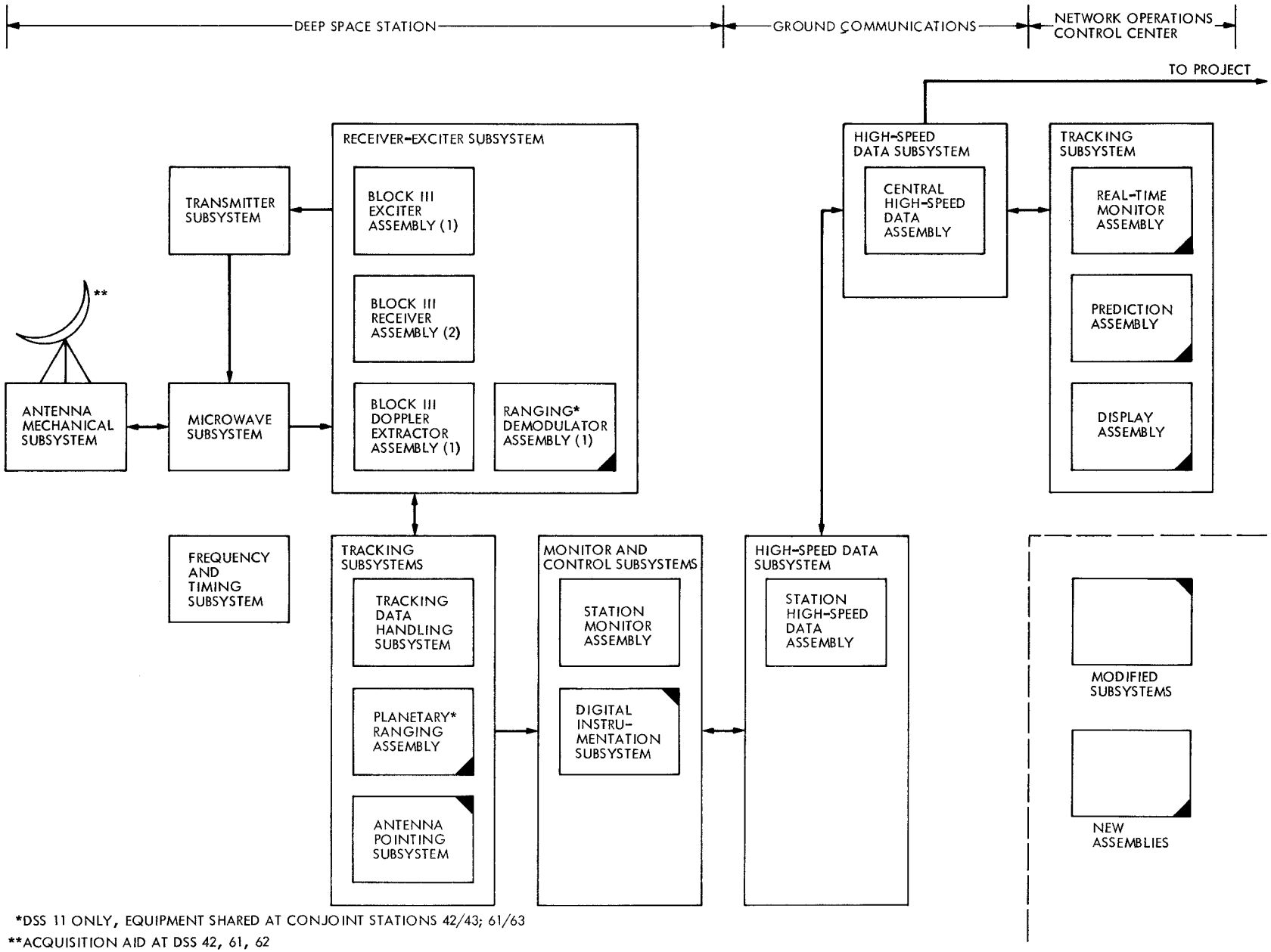

Fig. 6. DSN Tracking System — Mark III-75 26-m functional block diagram