DSN Tracking System—Mark III-77

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This article provides a description of the DSN Tracking System – Mark III-77 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-75 to implement the DSN Tracking System – Mark III-77 are briefly described.

I. Introduction

The DSN Tracking System is a multiple-mission system that generates radio metric data for use by Projects for spacecraft navigation. The radio metric data types are as follows:

(1) S-band doppler

(2) S/X-band doppler

(3) S-band range

(4) S/X-band range

(5) Angles

The DSN Tracking System, while multimission, must be upgraded to meet the more stringent requirements of outer planet navigation. The previous designation of the DSN Tracking System was Mark III-75 (Ref. 1) and was used for Viking, Pioneer and Helios Project support. This article describes the upgrade of the DSN Tracking System from the Mark III-75 to the Mark III-77 for additional support of the Voyager and Pioneer Venus 1978 Projects.

II. Key Characteristics

The key characteristics of the new Mark III-77 DSN Tracking System are as follows:

(1) S/X-band doppler and range data generation using precision hydrogen maser frequency standards.

(2) Simultaneous two station doppler for use in the determination of unmodelled spacecraft acceleration.

(3) Near simultaneous two station range data for the improvement of navigation accuracies during low declination angle tracks.

(4) Data time tagged to the 10-nanosecond level relative to the DSN master clock.

(5) Calibration data for the RF transmission media.

(6) Precision control of Block IV receiver and exciter frequencies for very narrow band tracking.

(7) Generation of tracking predictions for spacecraft acquisition by DSN tracking operations.

(8) Real-time validation of the DSN Tracking System performance.

(9) Real-time reporting of the DSN Tracking System status to DSN Operations Control.

(10) Generation of a Tracking Intermediate Data Record (future).

III. DSN Tracking System Functions

The Mark III-77 DSN Tracking System consists of the Deep Space Stations (DSS), Ground Communications Facility (GCF), and Network Operations Control Center (NOCC). The general functions performed in each are presented in Fig. 1.

A. DSS Functions and Modifications

The DSS functions, the subsystems required to perform those functions, and external interfaces are presented in Fig. 2. Modifications that were made in each subsystem in progressing from the Mark III-75 to the Mark III-77 are given below. Simplified Mark III-77 block diagrams depicting the subsystems and assemblies within the 26-m and 64-m antenna DSSs are presented in Figs. 2, 3 and 4.

1. Frequency and Timing Subsystem. Hydrogen maser frequency standards are being added to the 64-m subnet (DSSs 14, 43, and 63). These frequency standards will improve the DSS frequency stability by approximately two orders of magnitude which will extend precision range and doppler capability to beyond 20 AU. Hydrogen maser stability is also available at the conjoint 26-m DSSs (DSSs 42 and 61).

2. Microwave Subsystem. An acquisition aid with approximately 16-degree beamwidth has been added at DSS 12 for the initial pass acquisition of the Voyager spacecraft.

3. Technical Facilities Subsystems. A Meteorological Monitor Assembly has been added, which 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 transmitted via high-speed data lines on a post-pass basis using the Original Data Record (ODR) recall software.

4. DSS Tracking Subsystem. A major upgrade of the Tracking Subsystem is in progress. The previous Tracking Data Handling Subsystem has been replaced by the Metric Data Assembly (see Section IV, this article, for details). The Ranging Demodulator Assembly(s) was reassigned from the Receiver-Exciter Subsystem to the Tracking Subsystem. The Planetary Ranging Assembly is being modified for near sun line-of-sight angle operation in order to improve radio science data.

B. GCF Functions and Modifications

The GCF functions, the subsystems to perform these functions, and the external interfaces are given in Fig. 5. Modifications to the High-Speed Data Subsystem were the addition of the Communications Formatter Assembly at the DSN stations and the generation of a centralized Original Data Record (ODR) at the station containing the data available for HSD transmission for all DSN systems.

Future addition to the GCF will be the modification of the Data Records Processor Subsystem for the generation of a tracking Intermediate Data Record (IDR). The IDR will contain data as received from the DSN stations. Missing data will be recalled from the station ODR as necessary to meet Project commitments.

C. NOCC Functions and Modifications

The NOCC functions, the subsystems to perform these functions, and the external interfaces are shown in Fig. 6. Modifications to each assembly are described below.

1. Predictions. The Fast Phi Factor Generation Program (FPGP) was added to the prediction assembly. The FPGP provides a simplified station independent interface to the Project, wherein the Project supplies a Probe Ephemeris Tape that contains trajectory data for several months rather than several days.

2. Display. A single digital TV channel will be made available to the Projects to provide displays of DSN radio metric data performance (future).

3. Real-Time Monitor (RTM). The RTM has been modified in order to supply volume real-time Tracking System performance data in the Network Operations Control Area.

IV. DSS Tracking Subsystem

The DSS Tracking Subsystem (DTK), a part of the DSN Tracking System, performs the following three main functions:

(1) Generation of radio metric data

(2) Transmission of radio metric data

(3) Validation of the DSN Tracking System

The generation of radio metric data consists of those functions necessary to acquire doppler, range, angle, and RF transmission media calibration data. The transmission of radio metric data consists of those functions necessary to format and transmit the information to the user. The validation of the Tracking System consists of those functions necessary to verify the performance of the subsystem in the generation and transmission of the data.

DSS Tracking Subsystem functions and interfaces are presented in Fig. 7.

V. DTK Key Characteristics

The key characteristics of the DTK are as follows:

(1) Automatic configuration of the DSS Tracking Su system.

(2) Generation of range codes.

(3) Full use of the Ground Communications High-Speed Data Subsystem (HSS) for the transmission of DSN Tracking System radio metric data between the DSS and the Mission Control and Computing Center (MCCC) and/or Network Operations Control Center (NOCC).

(4) Simultaneous sampling of doppler from three spacecraft carriers at rates up to 10 per second.

(5) Simultaneous S/X-band ranging from one spacecraft.

(6) Automatic validation of DSS performance in generating radio metric data.

(7) Automatic generation of the temporary DSS tracking Original Data Record with selective recall data interlaced with the real-time data.

VI. Functional Operation

DTK functions and primary intersubsystem data flow are presented in Fig. 8. Predictions, system configuration, and data mode messages are received from the NOCC via the Ground Communications HSS and are stored by the DTK for use when requested by Network Operations. The predictions are used to provide frequencies for digital programming and control of the DSS Receiver-Exciter Subsystem (RCV) frequencies, and to provide angles for control of antenna pointing. The system configuration messages and data mode messages are used to configure, control, and validate the DTK.

Planetary range code is generated and transmitted to the RCV for modulation of the uplink carrier. Time-delayed range code is supplied to the Range Demodulator Assembly (RDA) where range correlation is determined. Range correlation is then used in conjunction with clock and RF carrier doppler in the acquisition and tracking of range and differenced range versus integrated doppler (DRVID). Doppler data generated by the RCV doppler extractor are counted by the doppler counters for up to three RF carriers.

Angles, doppler, range, and DRVID data plus status, configuration, data mode, and reference frequencies data are sampled, then formatted and transmitted via the Ground Communications HSS. Supplementary data, i.e., ground weather data, ionospheric data, and polarizer data, are sampled and inserted in the HSS data stream. A temporary ODR of all data taken in real time is maintained for selective recall to the NOCC or MCCC.

Reference

1. Chaney, W. D., "DSN Tracking System – Mark III-75," in *The Deep Space Network Progress Report 42-32*, pp. 4-13, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1976.

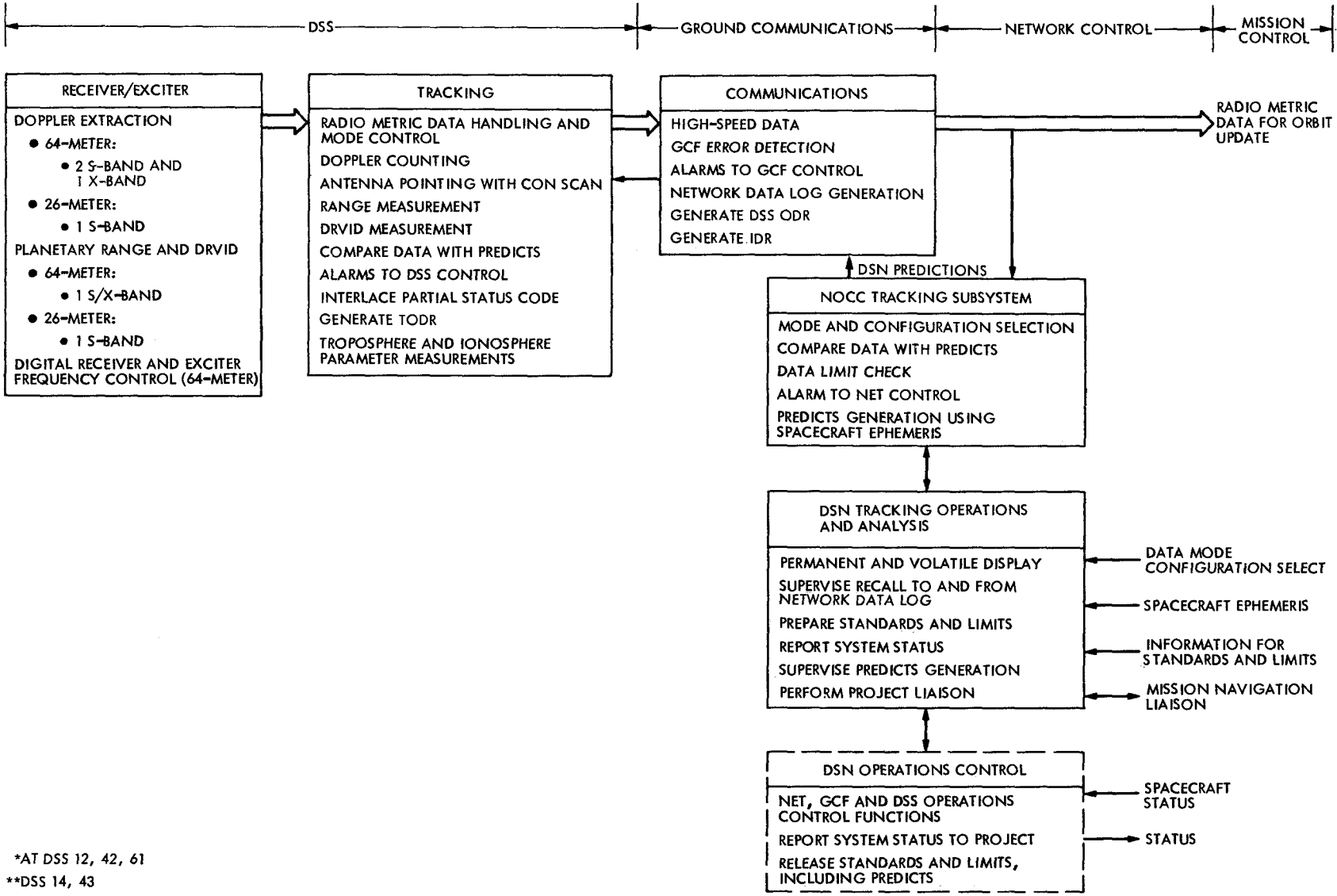

Fig. 1. Mark III-77 DSN Tracking System

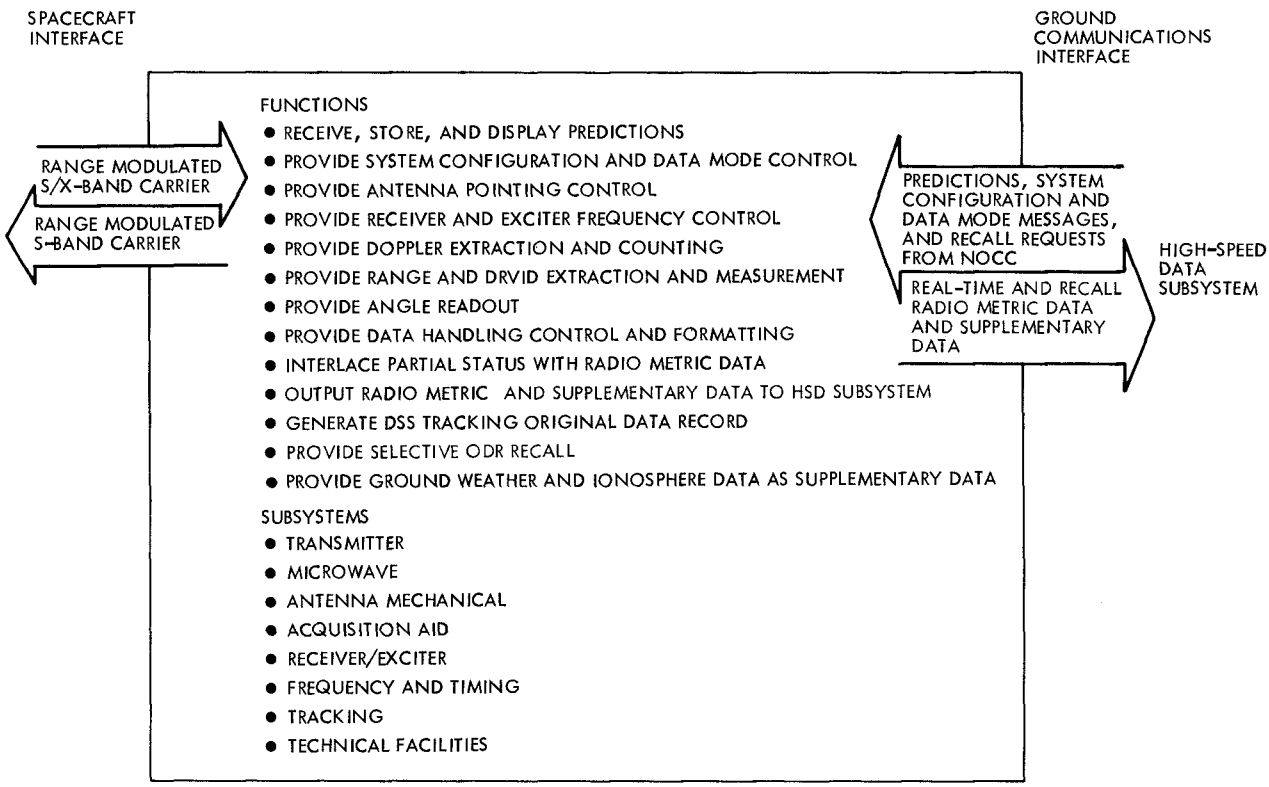

Fig. 2. DSS tracking functional requirements

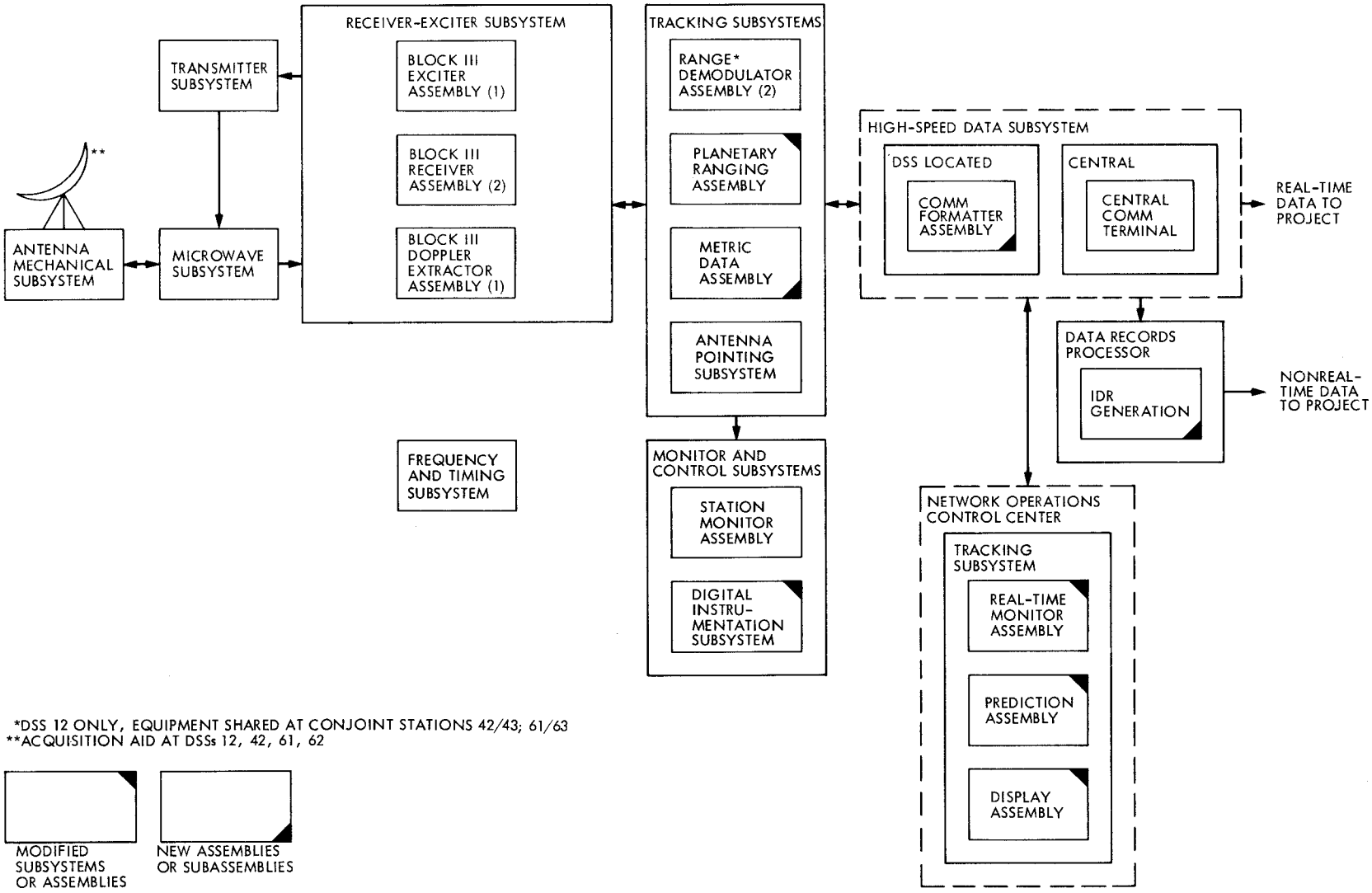

Fig. 3. DSN Tracking System—Mark III-77 26-m simplified block diagram

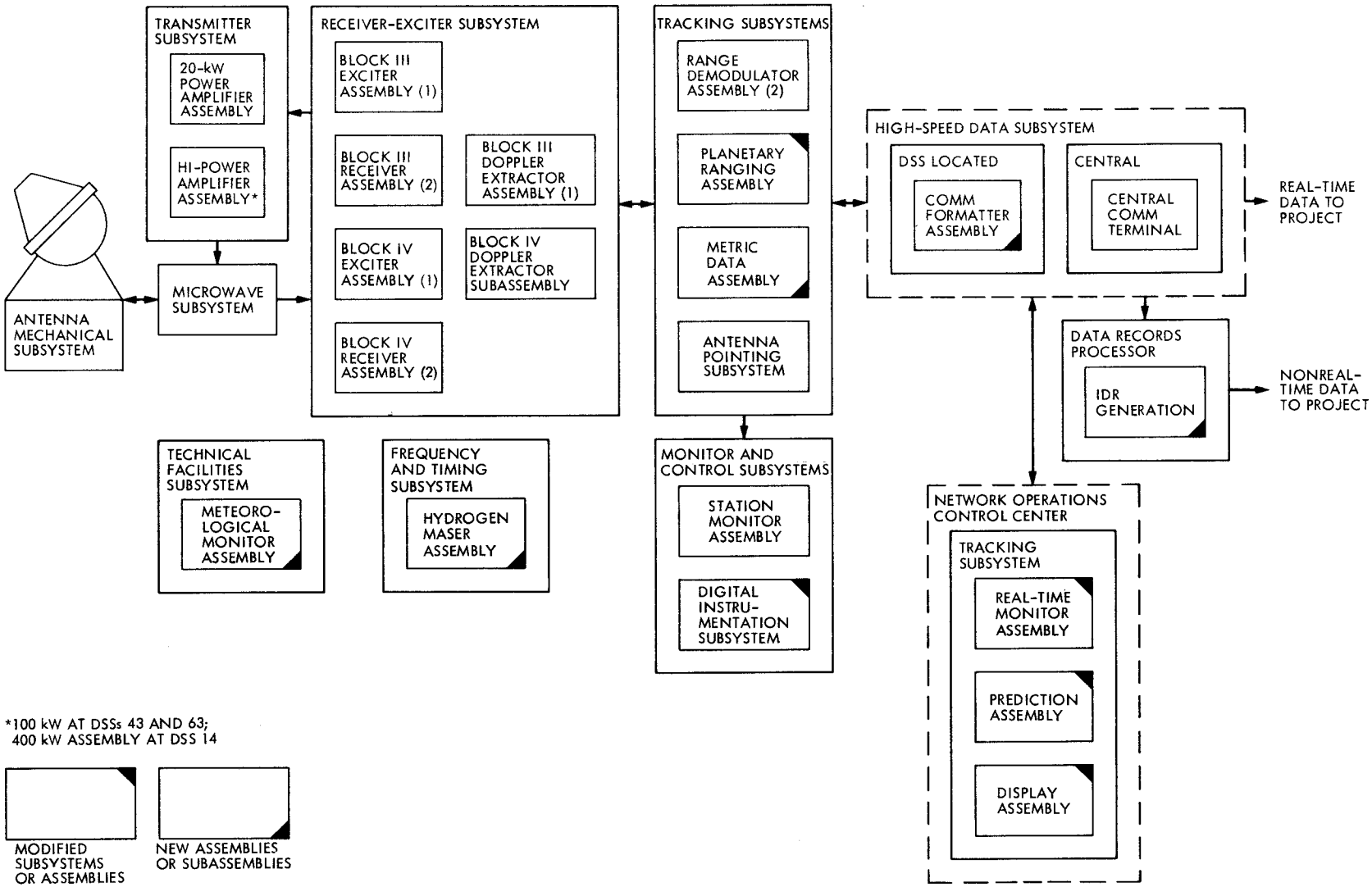

Fig. 4. DSN Tracking System—Mark III-77 64-m simplified block diagram

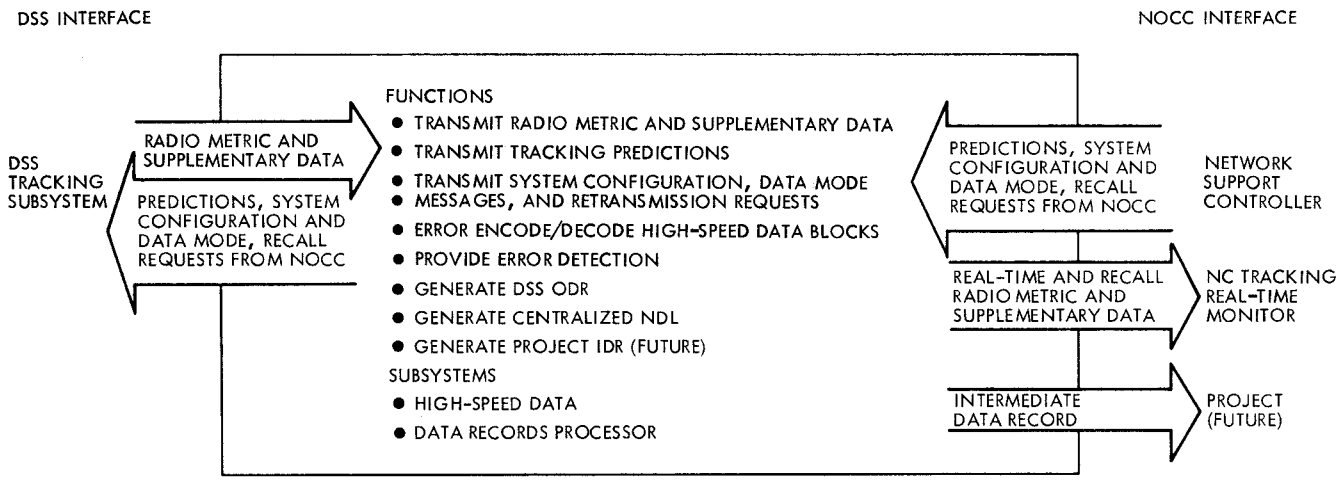

Fig. 5. Ground communications functional requirements

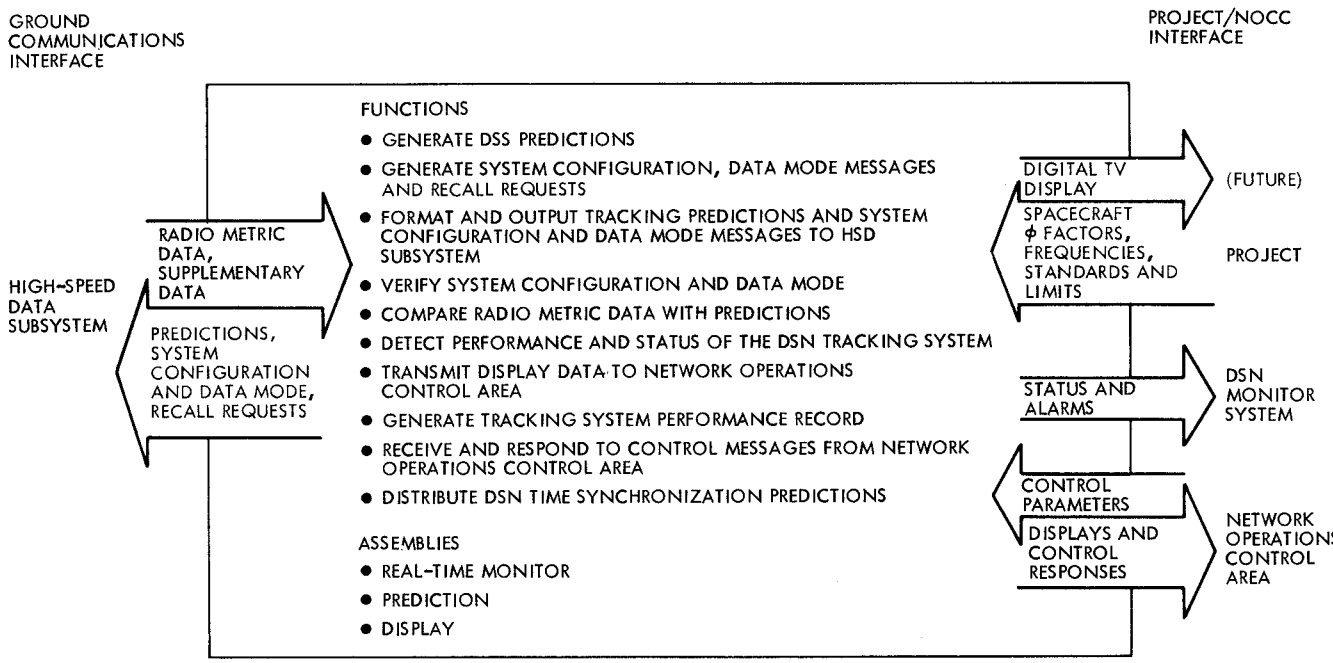

Fig. 6. NOCC tracking subsystem functional requirements

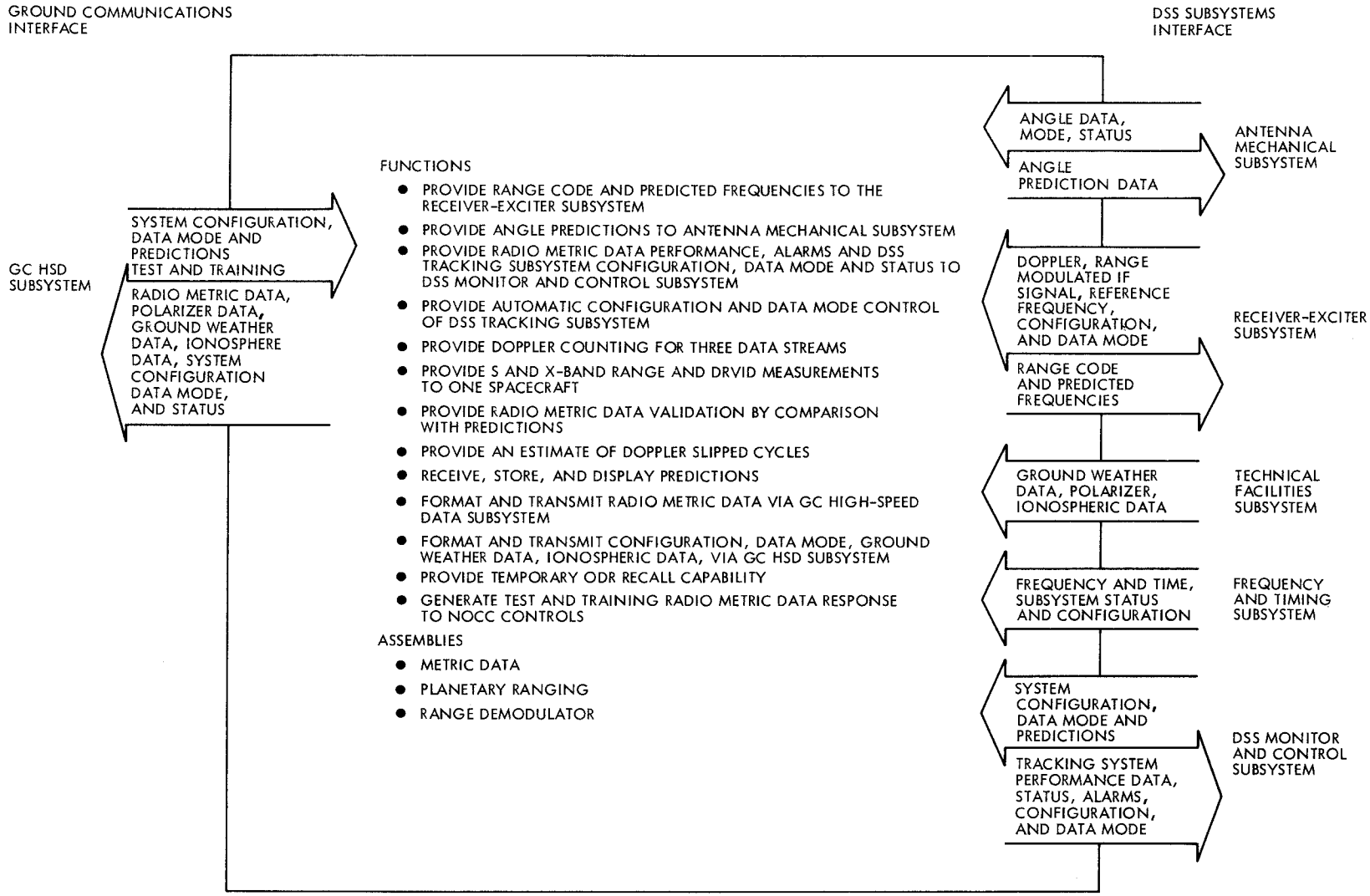

Fig. 7. DSS Tracking Subsystem functional requirements

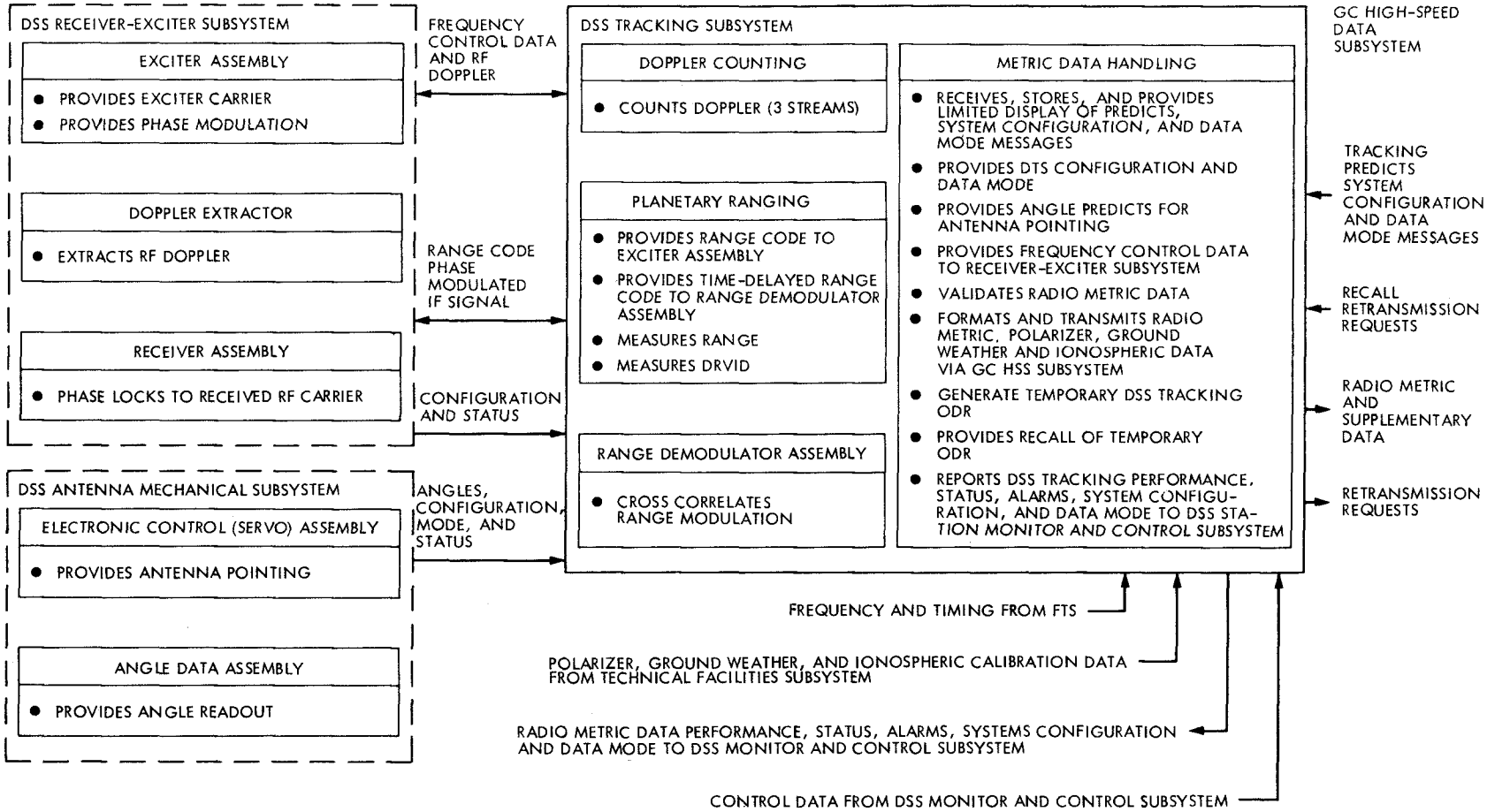

Fig. 8. DSS Tracking Subsystem functions and data flow