DSN Tracking System, Mark III-1979

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The Tracking System is one of eight generic DSN systems. This article describes, in functional terms, how the Tracking System performs its primary functions of signal acquisition, radio metric data generation, data transmission, and performance validation. Included are the systems functional requirements and required performance based upon identified user and DSN needs. Block diagrams of the 26-, 34-, and 64-meter DSS implementations are provided to indicate subsystem relationships and data flow paths.

I. Introduction

A. Definition

The DSN Tracking System, one of eight generic DSN systems, consists of hardware, software, personnel, and procedures necessary to perform its four primary functions in support of flight project and other radio metric data users. These four primary functions are:

(1) Perform spacecraft (source) signal acquisition (uplink and/or downlink).

(2) Generate radio metric data.

(3) Transmit radio metric data to users.

(4) Perform radio metric data validation to assure user requirements are satisfied.

Radio metric data are defined as range, range rate, and antenna pointing data, and are used by flight project navigation teams for spacecraft orbit determination, platform parameter determination, and ephemeris development; radio metric data are also used by radio science experimenters for interplanetary media investigations, relativity investigations, planetary atmosphere probes, among other experiments. In addition to the observables mentioned above, system status, configuration, data mode, and calibration (including local atmospheric and ionospheric) data are also provided to the user.

The following sections provide a functional description of the DSN Tracking System, a description of its operation, and its performance parameters through the 1983 era.

B. Key Characteristics

The key characteristics of the DSN Tracking System are:

(1) End-to-end prediction capability to efficiently and reliably generate and provide data necessary to establish and sustain spacecraft communications and for system performance validation.

(2) Automated receiver-exciter control for spacecraft acquisition and tracking from frequency profile predictions.

(3) Simultaneous dual-frequency band (S-X) doppler and near simultaneous range and DRVID (differenced range versus integrated doppler) data at 34-m and 64-m DSSs.

(4) Improved doppler quality resulting from increased automated controls, improved data reporting, improved frequency standards.

(5) Improved ranging performance at increased planetary distances through use of higher frequency range codes and improved reliability.

(6) Radio metric data time-tagged to microseconds accuracy relative to the DSN master clock.

(7) Real-time reporting of DSN Tracking System status to the Network Operations Control Center (NOCC).

(8) Generation of tracking standards and limits and performance validation by DSN Network Operations.

Each of the 26-meter DSS (Fig. 1) has the capability of generating one-way, two-way, or three-way S-band doppler and angles from a single spacecraft carrier. Each 34- and 64-meter DSS (Figs. 2 and 3) has the capability of generating one-way, two-way, or three-way S- and X-band doppler, S- and X-band range, and S- and X-band DRVID and angles. Table 1 summarizes the planned capability for doppler, range, and DRVID generation, as well as, angle drive capability.

C. Functional Breakdown

The primary functions of the DSN Tracking System are distributed among and performed by the three elements of the DSN: the Deep Space Stations (DSSs), the Ground Communications Facility (GCF), and the Network Operations Control Center (NOCC). Section II of this article and, in particular, Figs. 4, 5, and 6 delineate this distribution and provide the relevant functional performance specifications.

D. Functional Operation

Simplified block diagrams of the DSN 26-m, 34-m and 64-m DSSs for Mark III-79 are shown in Figs. 1, 2, and 3, respectively. Functional operation is as follows.

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 predictions are generated from the spacecraft (S/C) ephemeris by the Network Operations Control Center (NOCC) Tracking Subsystem. After validation, the predictions are transmitted from the NOCC to the DSS via high-speed data lines (HSDLs) for use in acquiring the S/C carrier(s) and for frequency control. The predictions are also used in DSN Tracking System performance validation.

Data mode and system configuration messages are generated by NOCC and transmitted to the DSS by HSDL or voice, and are used to select the radio metric 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 HSDL. Performance validation data consisting of doppler, range, and angle residuals, and other analytic data, in addition to calibration data consisting of ground weather data and ionosphere data, are also formatted for transmission via HSDL. An Original Data Record (ODR) is generated for post-pass recall if necessary.

The radio metric data received from the DSS by the GCF are routed to the NOCC. A log containing all data received either in real time or by recall is generated by the GCF Central Communications Terminal, and is used to generate the project-dependent Intermediate Data Record (IDR) for delivery to radio metric data users.

The radio metric data received by the NOCC are formatted for digital television (DTV) and hard copy displays to be used in performance validation, fault isolation, and analysis by the Network Operations Control Team (NOCT). A System Performance Record (SPR) is generated which includes all received radio metric and calibration data, as well as analytic data generated from comparison of received data with predictions (residuals and data noise estimates). The SPR is used for nonreal-time detailed analysis of the systems performance.

II. System Functional Requirements and Performance

A. General

The following defines specific DSN Tracking System functional requirements for the Deep Space Stations (DSSs), Ground Communications Facility (GCF), and the Network Operations Control Center (NOCC). Figures 4, 5, and 6 present the functional requirements, subsystems, and interfaces for the Deep Space Stations, Ground Communications, and NOCC Tracking Subsystem, respectively.

Availability requirements for the DSN Tracking System during noncritical periods is 96 percent, based upon utilization of a single station. Availability is increased to 98 percent if redundancy is introduced through use of multiple stations. During critical periods availability is 98 percent with single station support and 99 percent with two or more stations supporting.

B. Deep Space Station Requirements

The Tracking System functional requirements assigned to the Deep Space Stations and the subsystems which perform these functions are shown in Fig. 4. The following paragraphs further define these requirements.

1. **Prediction data.** The DSS shall receive predictions transmitted via HSDL. The prediction HSD blocks shall be tested for errors and for data outages. If a block error or outage is detected, automatic recall shall be initiated.

The DSS shall store up to 12 sets of tracking predictions, 2 sets of uplink frequency control predictions, 2 sets of receiver control predictions, and 2 sets of receiver control predictions for DSS Operations Control and for DSS radio metric data validation. A set of tracking predictions is defined as predictions for up to 8 consecutive passes with a maximum of 200 lines per pass (2 lines per HSD block) for a DSS-spacecraft combination, or in the case of uplink frequency control and receiver control predicts, the predicts shall consist of frequency/time pairs with up to 28 pairs per predicts set. The system design shall attempt to minimize the number of predicts transmissions necessary to support tracking operations. The DSS will acknowledge receipt of predicts to the NOCC by transmission of an acknowledge message.

The DSS shall display all predictions received upon demand on a centrally located hard copy device.

2. **System configuration and data mode messages.** The DSS shall receive and display system configuration and data mode messages transmitted via HSDL. The HSD blocks shall be tested for errors or outages at the DSS, and automatic recall shall be initiated if outages or errors are detected. The DSS will acknowledge receipt of configuration and data mode messages to the NOCC by transmission of an acknowledge message.

The DSS shall store and display on hard copy up to 12 system configuration and data mode messages.

3. **System configuration and data mode control.** The DSS shall configure the Tracking Subsystem and select the data mode based on the system configuration and data mode messages. The configuration and data mode selection shall be under control of software in response to system configuration and data mode messages.

4. **Antenna pointing control.** The DSS shall provide the following modes of antenna pointing control:

(1) Autotrack mode (26 m).

(2) Computer-aided mode with conical scan (34-m and 64-m DSSs) and without conical scan (26-m DSS).

(3) Computer aided from:

(a) Predictions

(b) Three-point right ascension-declination pairs

(c) Sidereal drive

(4) Manual-aided mode.

The antenna pointing control shall continuously point the DSS (assuming conscan in use at 34-m and 64-m DSSs) antenna to within ±0.004° (−0.05 dB from peak at X-band) of the center of the beam for 64-m DSSs, and ±0.010° (−0.1 dB from peak at X-band) for 34-m DSSs, and ±0.050° for 26-m DSSs. The control must be able to point the antenna under the following conditions:

Angle motion about axis:	HA ±90° from local meridian 26- and 34-m DSSs
	Dec 270° plus local latitude to 88° for northern hemisphere 26- and 34-m DSSs
	Dec 270° to 90° minus local latitude for southern hemisphere 26- and 34-m DSSs
	Az ±265° and El 6° to 89° for 64-m DSSs
Angle rates:	0.001° to 0.25° per second for 64-m DSSs
	0.001° to 0.4° per second for 34-m DSSs
	0.001° to 0.8° per second for 26-m DSSs
Wind conditions:	0-48 km/h (nondegraded performance)

5. **Frequency and timing.** The DSN Frequency and Timing System shall support the DSN Tracking System by providing interstation and intercomplex epoch time synchronization and relative clock frequency data. Data relating each station to a complex master, and the DSN master to the National Bureau of Standards (NBS) shall be provided. Required performance is as follows:

(1) Provide time and frequency synchronization to the DSN master clock. Time synchronization to better than 10 microseconds, and knowledge of frequency synchronization between 26-m DSSs and the complex master clock to less than 3 parts in 10^{13} and between the

34-m and 64-m DSSs and the DSN master clock to less than 3 parts in 10^{13} required, and less than 1 part in 10^{13} as a design goal.

(2) Knowledge of time synchronization between the DSN master clock and NBS shall be less than 5 microseconds.

6. **Receiver and exciter assembly frequency control.** The DSS shall provide software control of the receiver and exciter assembly frequencies for S/C acquisition and tracking. The frequencies shall be referenced to predictions. The receiver-exciter programmed oscillator frequency control shall be $< 3^\circ$ phase at S-band (60-second average). Frequency control resolution shall be $\leqslant 2^{-12}$ Hz per second at S-band. Exciter and receiver reference frequencies shall be reported in the radio metric data block so that reconstruction of the uplink by the project orbit determination group is accurate to 3° phase at S-band. The capability for simultaneously supporting an uplink and downlink on noncoincident frequency channels shall be provided. A monitor of receiver performance (actual receiver frequency) shall be provided.

7. **Doppler extraction and counting.** The DSS shall extract and count doppler from one S-band carrier and one X-band carrier simultaneously at the 64-m stations, one S-band and one X-band carrier from the 34-m stations, and one S-band carrier at 26-m stations.

One-, two-, and three-way doppler shall be extracted under the following conditions:

Doppler shift: ±79 km/s (mission life time)

35 km/s (single pass)

Doppler rate near Earth: 500 m/s^2

Doppler rate planetary encounter or orbit: 10 m/s^2

Integrated doppler resolution shall be < 0.005 cycle. Accuracy requirements for round-trip light time (RTLT) of 1000 seconds for 26-m stations, 2000 seconds for 34-m stations, and 10,000 seconds for 64-m stations are listed in Table 2.

Integrated three-way doppler shall conform to the same accuracy as two-way doppler except for the offset in frequency standards between the transmitting and receiving DSS. S/X-band integrated doppler, when differenced, shall be accurate to 0.1 meter per 15 minutes and 0.2 meter per 12 hours. Doppler sample rates shall be selectable at 10 per second, 1 per 10 seconds, 1 per 20 seconds, 1 per 30 seconds, 1 per minute, 1 per 2 minutes and 1 per 10 minutes. Capability shall be provided to demonstrate the required system performance.

8. **Range and DRVID generation, acquisition, and measurement.** The DSS shall extract and measure S- and X-band range and DRVID for one spacecraft using the discrete spectrum code. Code length, probability of good acquisition, DRVID, and range integration times shall be selectable under software control. Operator control inputs shall be minimized. DRVID data shall be available after an acquisition has been completed. The DSS shall provide a capability of automatically measuring and reporting the DSS ranging calibration. Ranging calibration shall be included in the radio metric data stream, along with pertinent configuration information.

Range ambiguity shall be selectable between 150 m and 150,000 km. Range and DRVID high-frequency noise errors are a function of received ranging signal power and integration time and may be reduced to < 1 m RMS by selection of longer integration times. For all other ground error sources, range is required to be accurate to $< 4.5\ \sqrt{2}$ m; the design goal is <3 m. Range and DRVID resolution shall be $\leqslant 1$ nanosecond. DRVID stability shall be < 1.0 m per 15 minutes and < 1.0 m per 12 hours.

DRVID and range data shall be output to the HSDL for each DRVID and range acquisition. Multiple range acquisitions shall be possible within the round-trip light time to the spacecraft. DRVID data between range acquisitions shall be possible.

9. **Angle readout.** The DSS shall provide the antenna axis position readout in the HA/Dec* coordinate system. Angle data shall be read out to a resolution $\leqslant 0.001^\circ$ and have an accuracy (boresight) of $< 0.05^\circ$ for 26-m DSSs, $< 0.01^\circ$ for 34-m DSSs, and $< 0.004^\circ$ for 64-m DSSs. Angle sample rates shall be 1 per second, 1 per 10 seconds, 1 per 20 seconds, 1 per 30 seconds, 1 per minute, 1 per 2 minutes, and 1 per 10 minutes.

10. **Calibration data: ground weather and ionosphere.** Ground weather data, consisting of pressure, temperature, and relative humidity, shall be provided at each DSS complex with the capability of digital sampling at rates of one per minute, one per 5 minutes, one per 10 minutes, and one per 15 minutes. Ionosphere data in the form of Faraday rotation data from polarimeter tracking of a stationary Earth satellite shall be digitized and sampled at rates of one per minute, or one per five minutes. Information to determine satellite line of sight shall be provided with the Faraday rotation data.

The calibration data (ground weather and ionosphere) shall be formatted into a calibration data block and interlaced with

*DSS 44 angle readout will be in X/Y coordinates.

radio metric data for transmission to the NOCC. Continuous recording of these data shall be provided to support scheduled recall for user IDR generation.

Ground weather data shall be provided to the following accuracies:

Pressure: $\leqslant$ 1.0 millibar ($\leqslant$ 100 N/m^2)

Temperature: $\leqslant$ 1.0°C

Relative humidity: $\leqslant$ 5 percent

Ionosphere data shall have an accuracy of $\leqslant$ 10.0° polarization angle. Continuous recording of ionospheric data shall be provided with no outage $<$ 5 minutes unless so scheduled. The user shall be provided 99 percent of the recorded ionospheric data.

11. Radio metric data handling control and formatting. The DSS shall provide identification by DSS and spacecraft for data stream control, and for selective sampling of doppler, range, DRVID, angle data, and calibration data. Data sampling shall be selectable as stated above. The radio metric data with interlaced exciter and receiver reference frequencies, system status, and system configuration and data mode shall be formatted in HSD blocks for output to the GCF High-Speed Data Subsystem. Also, calibration data (ground weather and ionosphere) shall be formatted in HSD blocks, separately from radio metric data, for output to the GCF High-Speed Data Subsystem.

12. Partial status interlace with radio metric data. The DSS shall include the partial status parameters listed in Table 3 with the radio metric data. In addition to Table 3 parameters, each DSS shall also have the capability to provide the following status parameters:

(1) Doppler residual

(2) Doppler phase jitter

(3) Estimate of doppler slipped cycles

(4) Receiver signal level (AGC) and receiver frequency

(5) Static phase error (SPE)

(6) Range residual

(7) Range and DRVID noise

(8) Ranging signal power to noise ratio (Pr/No)

Estimate of doppler slipped cycles, doppler noise, range noise, and DRVID noise shall conform to the following accuracies:

Slipped cycles: $\leqslant$ 1 cycle	Carrier signal level: $\leqslant$ 1 dB
Doppler: $\leqslant$ 0.002 Hz	Static phase error: $\leqslant$ 3°
Range: $\leqslant$ 1 nanosecond	Pr/No: $\leqslant$ 1 dB
DRVID: $\leqslant$ 1 nanosecond	

13. Radio metric and calibration data output to HSDL. Radio metric and calibration data shall be sampled and transmitted as requested. A capability shall be provided to retransmit an HSD block or blocks during an active pass in response to a replay request from the NOCC at any sample rate up to 10 samples per second.

14. DSS tracking high rate data record. A High Rate Data (HRD) Record containing all data available for replay transmission shall be made by the DSS. The HRD record shall reliably contain 99.5 percent of all data recorded within the most recent 14 hours or more and shall be available for replay within 10 minutes of a request. The radio metric data on the HRD record shall be available for replay by time span and will constitute a new data stream.

15. Station location and universal time calibrations. The DSN VLBI System shall support the DSN Tracking System by providing determination of DSS locations (longitude, distance normal to the spin axis, Z-height) and UT1 (Universal Time relative to Atomic Time) to the accuracies indicated in the various Project System Instrumentation Requirements Documents (SIRDs). Baseline parameters (length, longitude, relative Z-height, and polar motion) used in the VLBI System shall be conveyed to the flight projects by the DSN Tracking System. The capability to determine DSS location and UT1 calibrations using radio metric (two-way doppler) data shall be retained until the VLBI System capability is fully implemented and verified.

C. Ground Communications Requirements

The Ground Communications Facility HSD Subsystem transmits DSN Tracking System data between the DSS and the NOCC via HSD lines. NOCC communications between the NOCC Tracking Real-Time Monitor and the NOCC Display Subsystem is via the Wideband Data Subsystem.

The functional requirements assigned to the Ground Communications Facility and the subsystems used to perform these functions are shown in Fig. 5. The following paragraphs further define these requirements.

1. Radio metric and calibration data transmission. Ground communications shall have the capability to transmit DSS radio metric and calibration data from the DSS to the NOCC via high-speed data lines. Routing of the high-speed data blocks shall be based on destination code and UDT.

The maximum data transmission outage shall be < 15 minutes. The maximum data transmission loss due to outages or blocks in error shall be $\leqslant 2$ percent per 12 hours and < 1 percent per 10 days.

2. **Tracking predictions transmission.** Ground communications shall have the capability to transmit DSS tracking predictions from the Network Support Controller to the DSS via high-speed data circuits. Routing of the high-speed data blocks shall be based on the destination code and UDT.

3. **System configuration and data mode message transmission.** Ground communications shall have the capability to transmit system configuration and data mode messages from the NOCC to the DSS. Routing of the high-speed data blocks shall be based on destination code and UDT.

4. **Error detection and correction.** Ground Communications Facility HSD block errors or outages shall be detected and corrected by automatic recall from the transmitting source. An alarm shall be generated if reception is not achieved in five or less attempts to recall the desired data.

5. **Tracking ODR generation.** The GCF shall generate an Original Data Record (ODR) that contains > 99 percent of all data received from the DSS Tracking Subsystem. Capability for recall of radio metric data from the ODR shall be supplied.

6. **Selective recall from GCF log (IDR generation).** The GCF Central Communications shall generate an Intermediate Data Record (IDR) for radio metric data and calibration data. Data shall be selectable as project dependent and DSS independent. It shall be possible to merge in a time ordered sequence data from more than one IDR to provide up to seven days of radio metric data on a single IDR. IDR data content shall be as follows: $\geqslant 95$ percent of noncritical phase radio metric data, and $\geqslant 95$ percent of critical phase data available within 30 minutes of receipt of request and 98 percent within 24 hours. Percent of data on an IDR is relative to data available on Original Data Record at transmitting source.

D. Network Operations Control Center Requirements

The NOCC generates predictions from project-supplied ephemeris and generates data mode and system configuration messages that are transmitted via HSDL for use by the DSS in the acquisition of the S/C signal and the generation of radio metric data. The NOCC Tracking Subsystem shall generate a System Performance Record.

The functional requirements assigned to the NOCC Tracking Subsystem and the assemblies used to perform these functions are presented in Fig. 6. The following paragraphs further define these requirements.

1. **DSS predictions.** The NOCC Tracking Subsystem shall have the capability to generate DSS predictions from project-supplied ephemeris data, S/C frequencies, and S/C standards and limits consisting of uplink tuning rates and ranges. DSS predictions consist of the following parameters:

(1) GMT

(2) Angles and angle rates (HA/dec, az/el or X/Y)

(3) One-way S-band doppler and doppler rate

(4) One-way X-band doppler and doppler rate

(5) Two-way S-band doppler and doppler rate

(6) Two-way X-band doppler and doppler rate

(7) Three-way S-band doppler for up to six transmitting stations

(8) Three-way X-band doppler for up to six transmitting stations

(9) Two-way range

(10) Uplink frequency and frequency rate

(11) Receiver-exciter digital-controlled oscillator predictions

(12) Spacecraft rise-spacecraft set

(13) Round-trip light time

(14) Subcarrier Demodulator Assembly frequencies

The accuracy of predictions computed from project-supplied ephemeris is as follows:

Angles: $< 0.0035°$

Doppler: $\leqslant 0.1$ meter per second (cruise phase)

$\leqslant 0.2$ meter per second (launch phase or orbital phase)

Range: $\leqslant 5$ meters (cruise phase)

$\leqslant 45$ meters (launch phase or orbital phase)

S/C rise/set: $\leqslant 5$ minutes (approximately 1 degree), cruise or orbital phase

$\leqslant 30$ seconds (approximately 2 degrees), launch phase

Occultation events: $\leqslant 0.1$ second

Differenced range minus integrated doppler: 2 meters in 4 hours

Prediction point-to-point relative accuracy and precision shall be as follows:

Angles: $\leqslant 0.001°$

Doppler: $\leqslant 0.07$ millimeter per second

Range: $\leqslant 0.2$ meter

2. **System configuration, data mode messages.** The NOCC Tracking Subsystem shall generate system configuration and data mode messages for use by the DSS in generating radio metric data and validation of DSN Tracking System performance.

3. **Tracking predictions, system configuration, and data mode messages.** The NOCC Tracking Subsystem shall format predictions, system configuration, and data mode messages. The NOCC Tracking Subsystem shall output these messages for transmission to the appropriate DSS via HSDL.

4. **System configuration and data mode verification.** The NOCC Tracking Subsystem shall verify the system configuration and data mode by comparison of system configuration and data mode parameters against standards and limits. Alarms and/or changes in system status and configuration shall be reported to DSN Operations Control within 10 seconds after detection.

5. **Radio metric data/prediction data comparisons.** The NOCC Tracking Subsystem shall compare doppler data with predictions for two data streams. Two station range validation shall be accomplished to verify ranging performance.

6. **System performance and status detection.** The NOCC Tracking Subsystem shall detect system performance and status by the analysis of system status parameters and alarms. A capability shall be provided to isolate the alarm to the subsystem level.

7. **Status and alarms transmission to DSN Monitor and Control.** All alarms and changes in system status shall be reported to DSN Monitor and Control System.

8. **Display data transmission to Network Operations Control Area.** System status, configuration, modes, and performance parameters such as data residuals and noise estimates, HSDL status, NOCC Tracking Subsystem status, and prediction status shall be reported to the Network Operations Control Area for DTV and hardcopy display. A graphics capability shall provide plotted displays of selected radio metric parameters.

9. **Tracking system performance record.** A record for system performance, status, and alarms shall be generated for nonreal-time analysis.

10. **Control messages from Network Operations Control Area.** The NOCC Tracking Subsystem shall receive and respond to control messages transmitted from the Network Operations Control Area.

11. **DSN time synchronization performance monitor and reporting.** The DSN Frequency and Timing System shall provide interstation time synchronization to better than 10 microseconds between DSS and the DSN master clock, and to better than 5 microseconds between the DSN master clock and National Bureau of Standards. A capability shall be provided to monitor performance to this level with clock synchronization data provided to radio metric users on a regular basis.

12. **Replay requests.** Requests for replay data from the HRD record at the DSS shall be generated at the NOCC. Replay request shall be by time span and may be at any data sample interval up to 10 samples per second. Replay data shall appear as a new data stream, and may be received along with other radio metric data streams from a single DSS.

III. Summary

This article, composed primarily of excerpts from the recently released Deep Space Network Systems Requirements Document (821-9), DSN Tracking System (1979 through 1983), is intended to provide an overview of the DSN Tracking System and its functional requirements and performance characteristics. For a more detailed description including the allocation of requirements to subsystems, testing philosophy and requirements, and implementation priorities, the reader is referred to the aforementioned document. Also, for a detailed description of a major and new capability implemented in response to the failure of the Voyager 2 spacecraft receiver, Reference 1 is suggested.

Reference

1. Spradlin, G. L., "DSN Tracking System Uplink Frequency Control," *DSN Progress Report 42-53*, pp. 108-112, Jet Propulsion Laboratory, Pasadena, California, October 15, 1979.

Table 1. Planned DSS radio metric data capability

Data type	26-m DSS	34-m DSS	64-m DSS
Doppler	1 S-band	1 S-band or 1 S- and X-band	1 S-band or 1 S- and X-band
Range	N/A	1 S-band or 1 S- and X-band	1 S-band or 1 S- and X-band
DRVID	N/A	1 S-band or 1 S- and X-band	1 S-band or 1 S- and X-band
Angles	Auto track or computer aided	Computer aided with conical scan	Computer aided with conical scan

Table 2. Integrated two-way doppler accuracy

Averaging times	Accuracy
1 s	≤0.003 m per second
60 s	≤0.045 m per 60 seconds
1000 s	≤0.10 m per 1000 seconds
12 h	≤0.50 m per 12 hours

Table 3. Partical status parameters

Status	Configuration	Data mode
Doppler good-bad	Block III or Block IV doppler extractor	Sample rate
Receiver lock	Doppler receiver reference	Doppler type
Transmitter frequency lock	Doppler bias	Angle mode
Frequency standard	Exciter in use (Block III – Block IV)	Conscan mode
Timing standard	Transmitter on-off	Range code length (first component, last component)
Angle autotrack	Transmiter (klystron) in use	Range integration times
Range acquisition	Transmitter power level	
Range validity	Maser type and number	
DRVID acquisition	Angle type	
DRVID validity	FTS frequency standard	
DTK hardware/ software (self-diagnostic test)	Predicts set in use	
	Range Modulation on-off	
	Carrier suppression for ranging	
	Chopper frequency on-off	
	Pipelined acquisitions on-off	
	Prime range channel S-X	

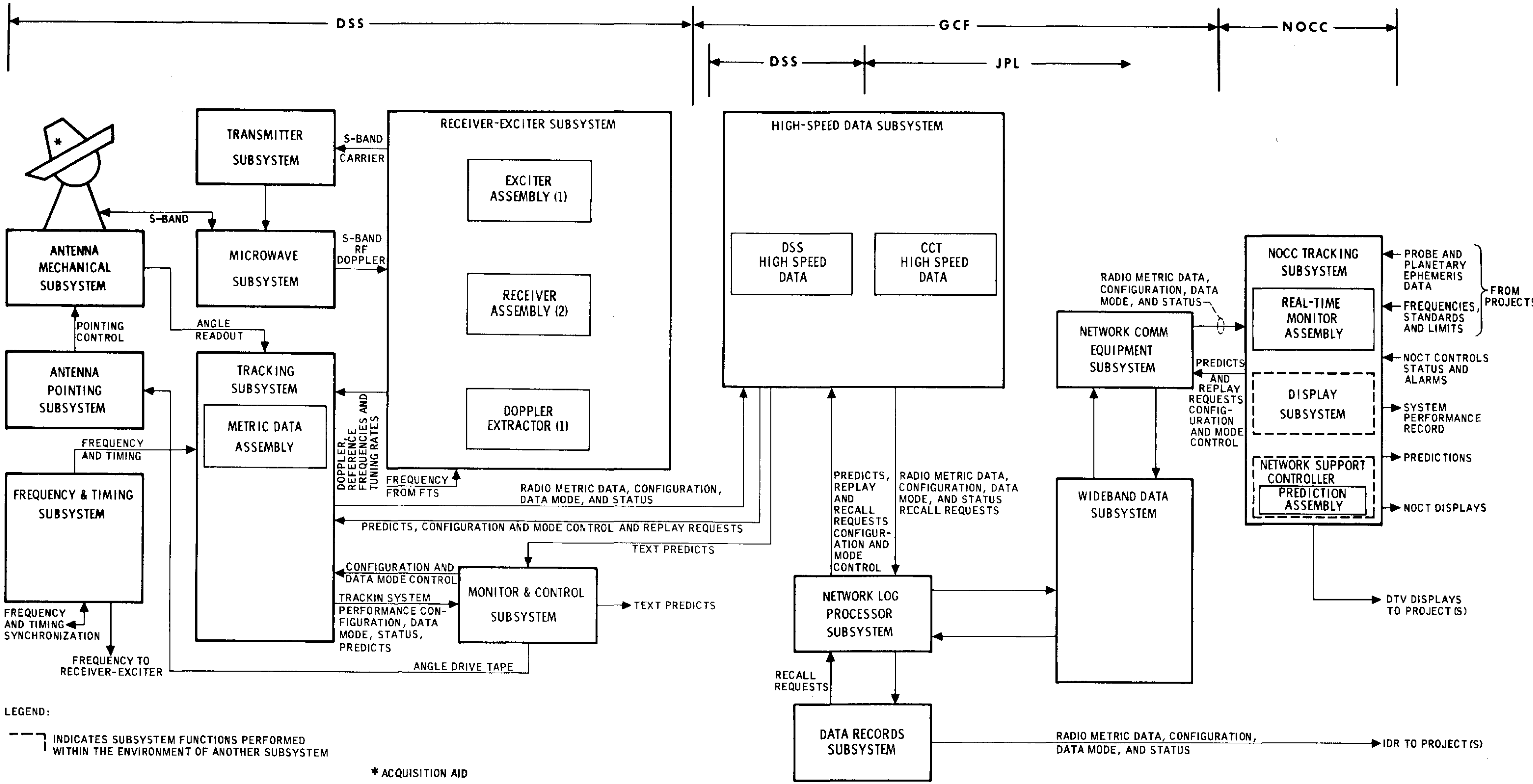
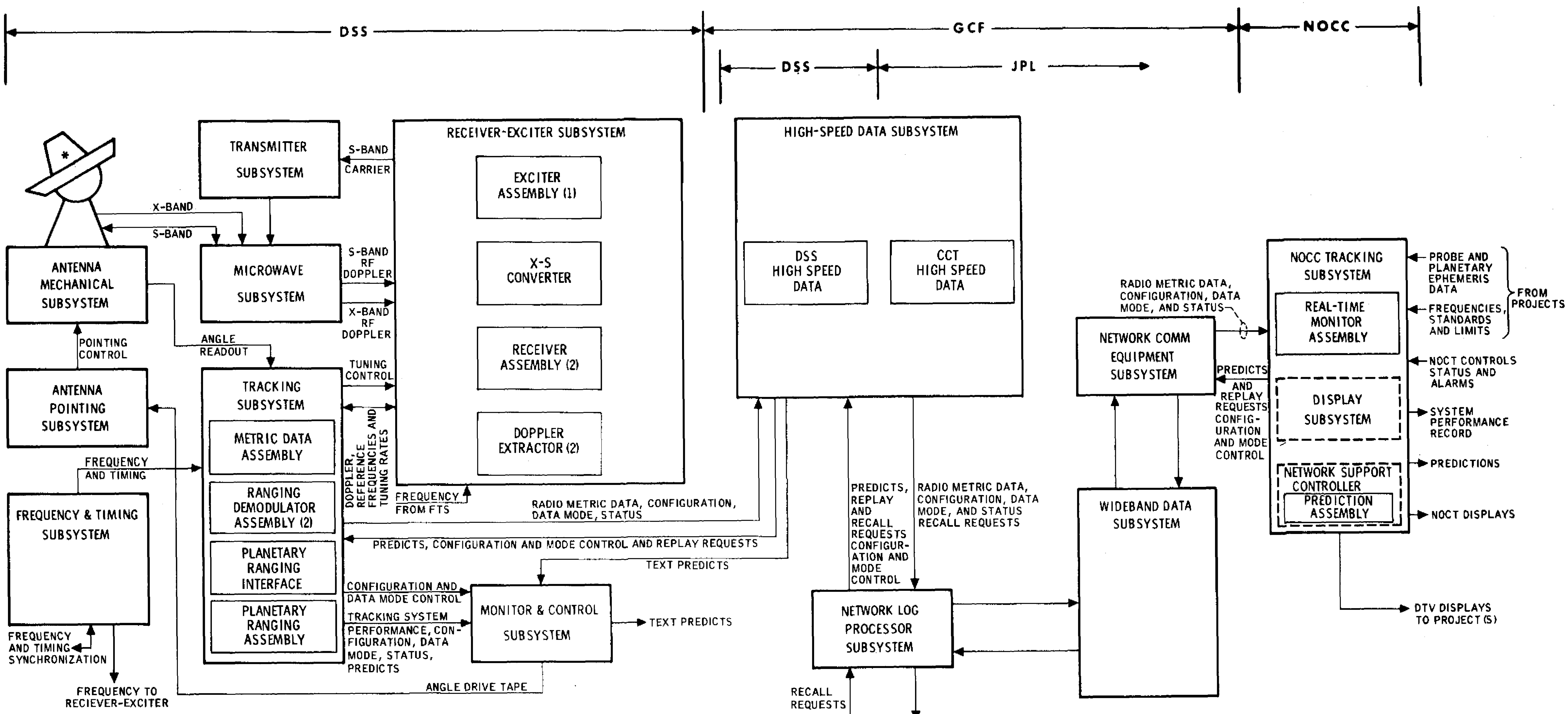


Fig. 1. DSN Tracking System 26-m DSS simplified block diagram, Mark III-1979 configuration



LEGEND:
- - -┐ INDICATESSUBSYSTEM FUNCTIONS PERFORMED WITHIN THE ENVIRONMENT OF ANOTHER SUBSYSTEM

*ACQUISITION AID

Fig. 2. DSN Tracking System 34-m DSS simplified block diagram, Mark III-1979 configuration

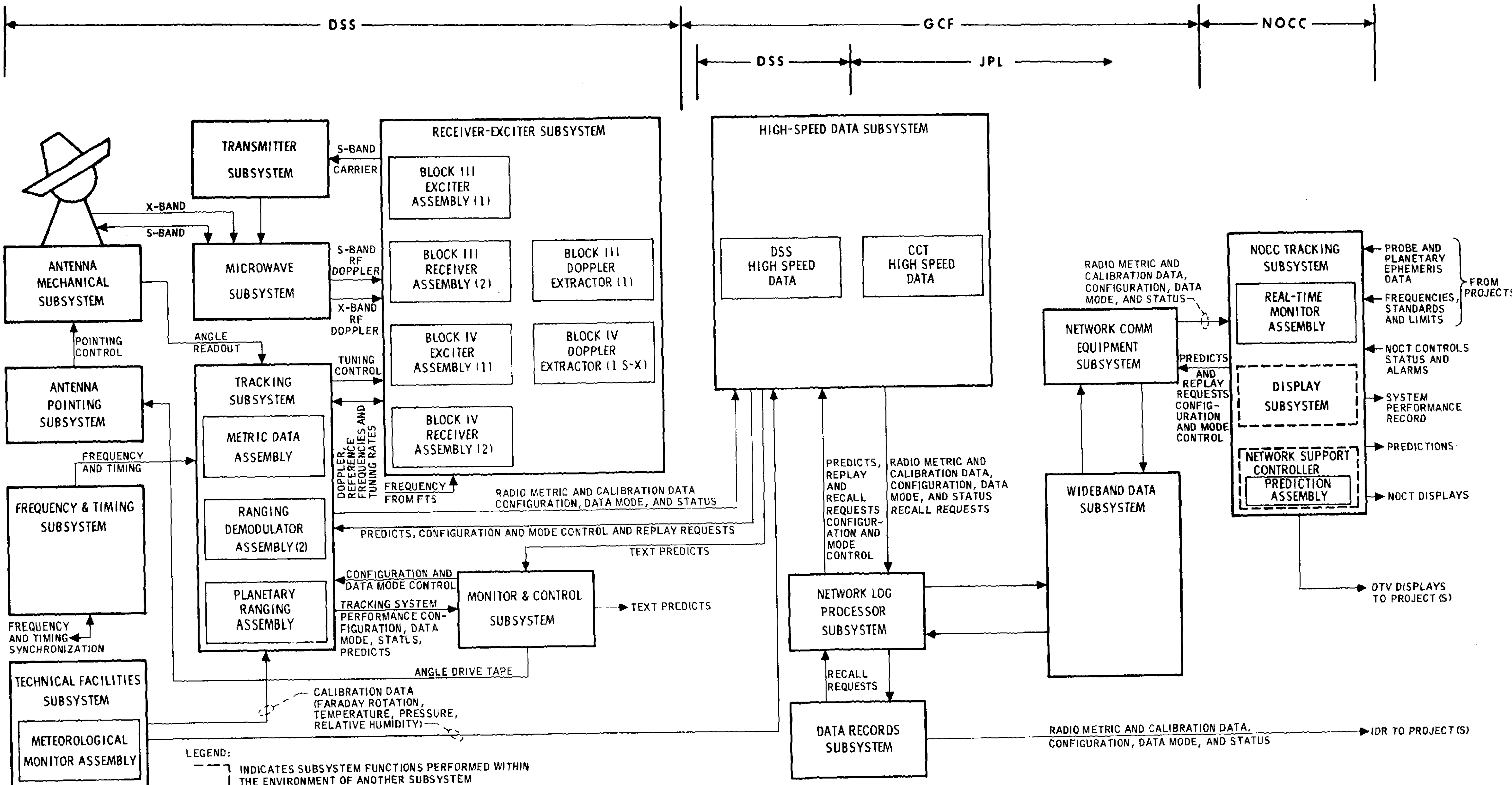


Fig. 3. DSN Tracking System 64-m DSS simplified block diagram, Mark III-1979 configuration

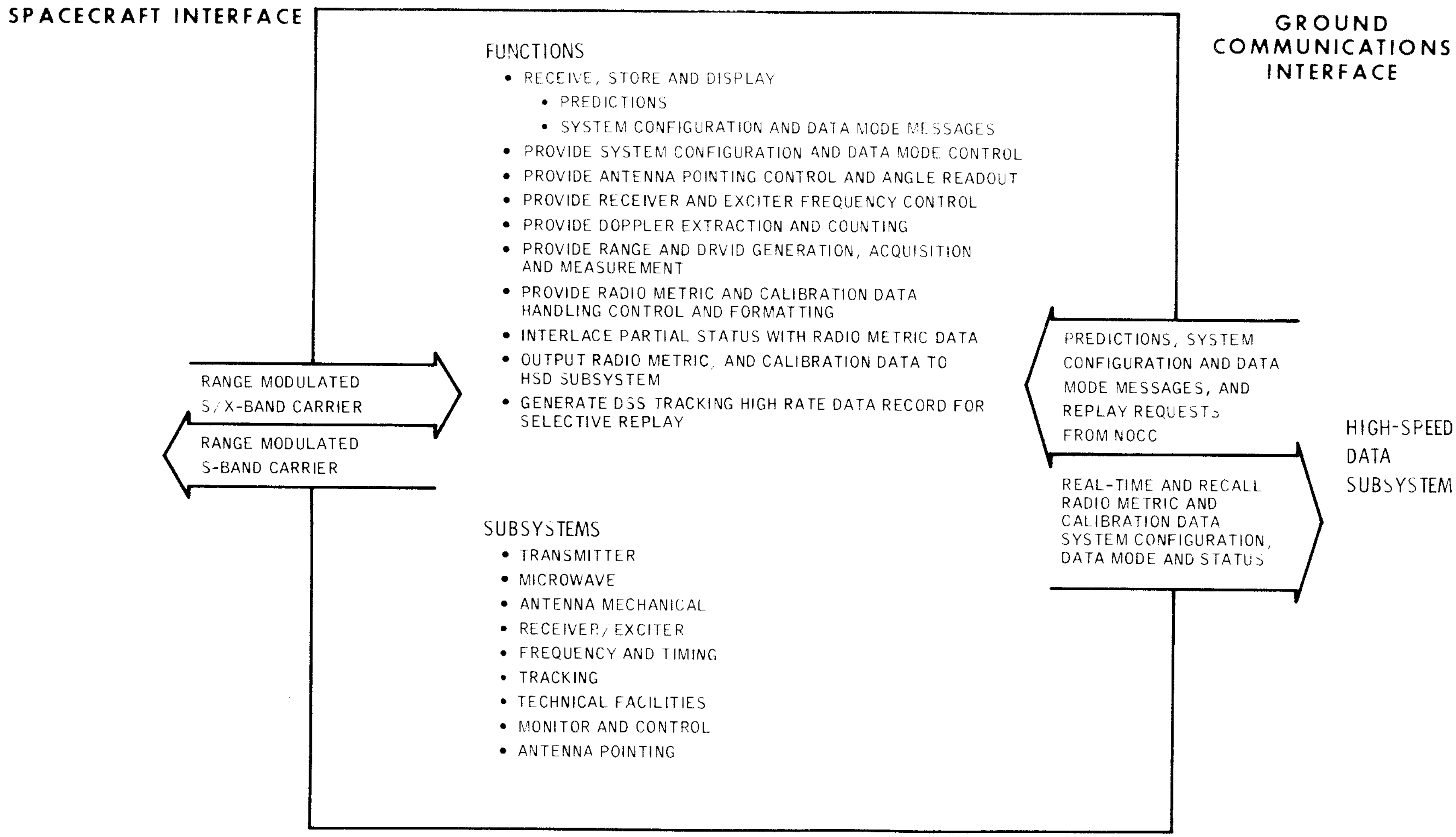


Fig. 4. DSS tracking functional requirements and interfaces for spacecraft acquisition and radio metric data generation

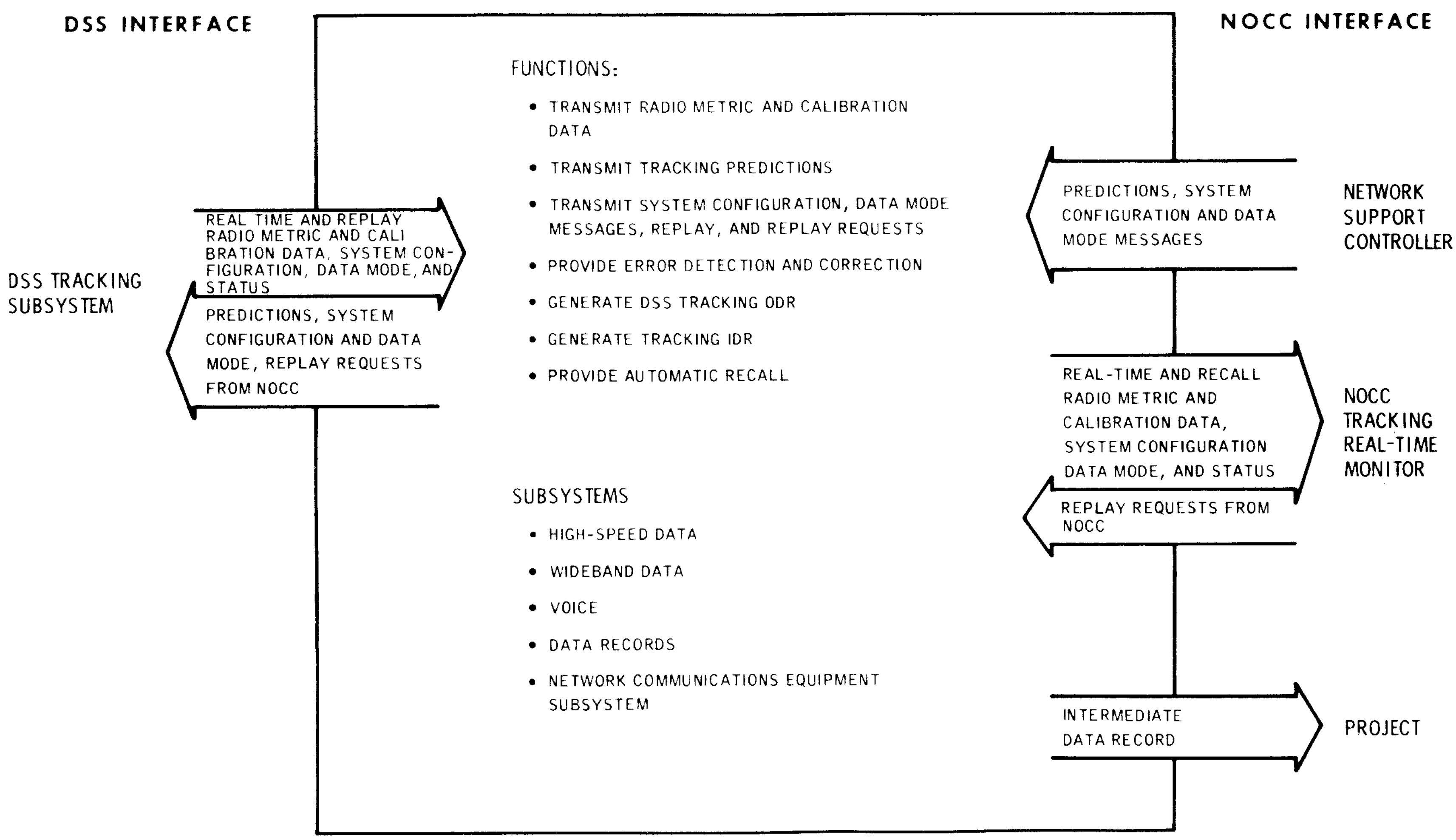


Fig. 5. Ground Communications Facility functional requirements and interfaces

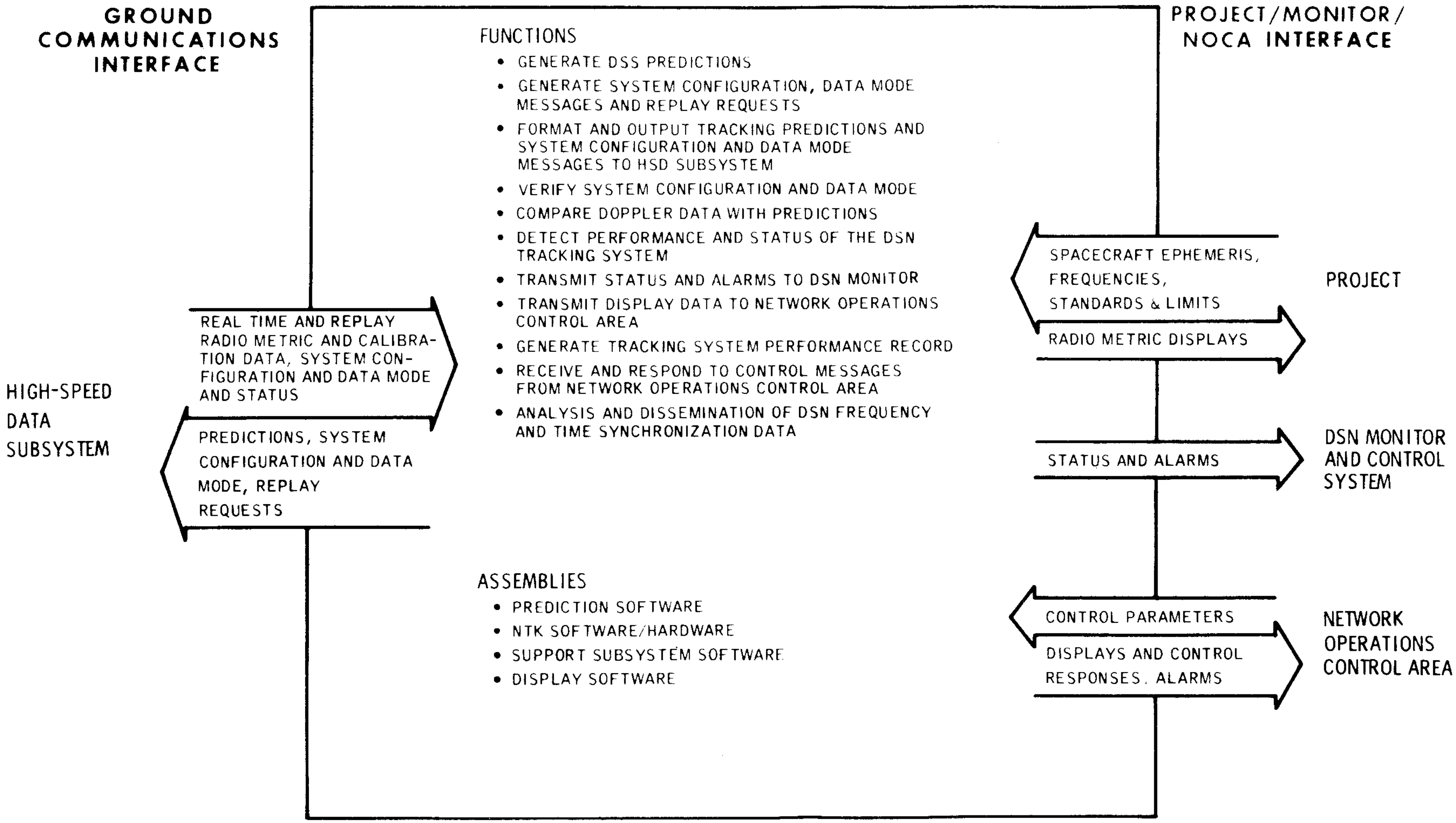


Fig. 6 NOCC Tracking Subsystem functional requirements and interfaces