Network Control System

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This article provides: (1) background material describing philosophy leading to a Network Control System (NCS) function using data processing equipment separate from that equipment used by flight projects, (2) key characteristics of the NCS, (3) a listing of the functional requirements for each NCS subsystem, (4) a generic subsystem data flow description, and (5) an overall NCS data flow description.

In October of 1971 the Office of Space Sciences (OSS) and Office of Tracking and Data Acquisition (OTDA) reviewed the Planetary Mission Operations, Space Flight Operations Facility (SFOF), and network interface with the view to bringing the program control and budget functions more into line with management responsibilities. The intent is to develop an interface that would be reasonably clear in order to simplify technical management and to assure that budgeting requirements of the two offices are well understood.

The OTDA assumed responsibility for the tracking stations, NASA Communications Network (NASCOM)/ Ground Communications Facility (GCF), and network control and monitoring. These responsibilities include (1) network scheduling, (2) network predicts, (3) network performance monitoring, (4) network validation tests, (5) provision of real-time data streams to Mission Operations, (6) acceptance of commands from Mission Operations and transmission to stations and spacecraft, (7) provision of a clean record to Mission Operations of data streams for tracking, telemetry, and command, and as required, (8) participation with Mission Operations in mission simulations. The system is to be designed so that OTDA and OSS functions reside in separate hardware to provide for cleaner and more controllable interfaces.

Figure 1 depicts the flow between the DSN and the flight project and the manner in which the NCS is coupled into this flow. Inbound tracking and telemetry data and outbound command and mission simulation data are tapped off and sent to Network Control for validation and verification purposes. DSN monitor and control data are communicated between Network Control and

DSN elements. Mission information for operations control and DSN status data are exchanged via voice between Network Control and Mission Control. JPL central computers are utilized for non-operations-driven data processing.

One of the major objectives of the Mark III DSN design is to provide a multimission capability that presents a simple, fully standardized interface to using projects via standard GCF/NASCOM formats. The NCS plan maintains this objective in accomplishing the monitor and control function. It does not alter, delay, or serially process any inbound or outbound data between the flight project and tracking stations. Hence NCS outages should not have a direct impact on flight project support. Voice communications will be maintained for operations control and coordination between the DSN and flight projects and to minimize the response time in locating and directing system failures. The development schedule provides for a full-scale NCS capability by July 1, 1974.

An interim capability will be available by July 1, 1973. The interim capability will consist of flight project information on NCS displays for DSN tracking, telemetry, and command data validation and will incorporate a separate NCS processor for data validation and operations control purposes. This interim configuration requires that non-JPL flight projects maintain a tracking, telemetry, and command data processing capability in the JPL 360/75 if the network performance is to be suitably validated. The capability for July 1972 uses most of the current JPL 360/75 DSN capability.

The key functions of the DSN Control System provide the following:

(1) Real-time validation of network configuration and performance.

(2) No alteration or delay of inbound or outbound data by the validation technique. Outbound lines are shared with flight projects.

(3) Near-real-time relaying of DSN status to Mission Control.

(4) Close liaison with Mission Operations to minimize downtime and to locate and correct network failures.

(5) Network control and Mission Operations functions performed in separate hardware.

(6) A GCF Log which provides fill data, as requested by flight projects.

(7) A capability for network test and training and for participation in mission simulations.

(8) A DSN data base for network operations and performance analyses.

(9) Support for remote as well as local mission control centers.

The NCS comprises seven subsystems as follows: Tracking, Telemetry, Command, Monitor and Control, Display, Support, and Test and Training. The NCS data processing requirements for these subsystems are as follows:

Tracking

(1) Generate predictions from project-supplied state vector or from radio metric data.

(2) Control and verify system configuration and data mode.

(3) Generate tracking standards and limits.

(4) Compare radio metric data with predictions.

(5) Detect and report status of the DSN Tracking System.

(6) Transmit alarms to Monitor and Control System and DSN Operations Control Area.

(7) Generate System Performance Record for tracking.

Telemetry

(1) Control and verify selected system configuration and data mode.

(2) Generate telemetry standards and limits.

(3) Decommutate data needed for system performance analysis.

(4) Detect and report status of the DSN Telemetry System.

(5) Transmit alarms to Monitor and Control System and DSN Operations Control Area.

(6) Generate received signal level predictions.

(7) Generate System Performance Record for telemetry.

Command

(1) Control and verify selected system configuration and data mode.

(2) Generate command standards and limits.

(3) Detect and report status of DSN Command System.

(4) Transmit alarms to Monitor and Control System and DSN Operations Control Area.

(5) Generate System Performance Record for command.

(6) Generate test commands.

Monitor and Control

(1) Generate monitor standards and limits.

(2) Receive Deep Space Information Facility (DSIF), NCS, and Ground Communications Facility (GCF) monitor data.

(3) Receive Telemetry, Tracking, and Command System alarms and selected telemetry data.

(4) Detect and report status of the DSN.

(5) Transmit display data to DSN Operations Control Area.

(6) Generate subsystem-common standards and limits parameter tables.

(7) Monitor NCS configuration and performance.

(8) Generate Network Performance Record.

(9) Generate DSN operational schedules.

(10) Generate DSN operational sequence of events and historic log.

(11) Process discrepancy report data.

(12) Process ODC traceability reporting system (TRS) data.

Display

(1) Provide man/machine interface in DSN Operations Control Area for control of real-time monitors (RTMs).

(2) Format and display received RTM data.

(3) Provide remote terminal for Network Support Controller (NSC) support subsystem computer.

(4) Format and display received NSC support subsystem data.

(5) Provide consoles, displays, and working area for operations personnel.

(6) Provide a computer-driven network status display board.

Support

(1) Provide network support controller (NSC) processor, including operating system for all non-real-time programs.

(2) Load and start programs in RTMs, NSC, and GCF; provide checkpoint recovery of NSC.

(3) Provide utility print routines for demand dumps of any data being switched and routed or any data on NCS files, also non-real-time (NRT) de-log dumps of any tape.

(4) Manage disk-to-disk transfers to/from RTMs.

(5) Provide system-common standards and limits file extraction and high-speed data (HSD) output.

(6) Provide NCS development support – RTM emulator, RTM compiler, NSC compiler.

(7) Provide system-common GCF log replay data extractions (for project fill data only).

(8) Provide test HSD block (for de-bug).

(9) Receive NRT program input data in data driven mode.

(10) Encode free-form text for HSD transmission.

Test and Training

(1) Generate and control simulated data to support development, test, training, and fault isolation.

  (a) DSIF data streams to exercise GCF and NCS subsystems.

  (b) Spacecraft data patterns to exercise DSIF subsystems.

(2) Participate in mission simulation with project.

  (a) Control data flow within DSN to support mission test and training simulation.

(b) Generate simulated DSN data to supplement project simulation data.

A generic subsystem data flow chart is shown in Fig. 2. The basic structures of the tracking, telemetry, command, and monitor and control subsystems comprise real-time and non-real-time functions. The real-time function will be accomplished through the use of minicomputer-based real-time monitors. System configuration verification and system performance validation will be accomplished by comparing incoming data with established standards and limits. System performance records will be accumulated in real-time for analysis, data recall, and historical purposes. Alarm diagnosis and system status and display data will be available for real-time operations control purposes. An initialization and recovery file is maintained for initial setup and for checkpoint recovery.

The non-real-time functions will be accommodated in a network support controller. This processor will be utilized to establish standards and limits, to generate predicts, to extract system performance data, to analyze data, to extract data for standards and limits transmission to the DSIF and GCF, and to extract project fill data.

Figure 3 depicts the Network Control System data and message flow configuration, which incorporates the following:

(1) A DSN Operations Control Area located in the Mission Operations Center.

(2) Network data system real-time monitors located in the Network Data Processing Area. Processed real-time monitor data are displayed in and controlled from the DSN Operations Control Area.

(3) A network support controller in the Network Data Processing Area which is used for coordination of the real-time monitors and for network data processing. Data are output to the DSN Operations Control Area and to the Deep Space Stations.

(4) A test and training processor and operations function located in the Network Data Processing Area.

(5) A GCF terminal in Building 230 to interface with the DSN Operations Control Area and to provide the GCF log. A second GCF terminal is provided adjacent to the Network Data Processing Area.

A more detailed description of the Network Control System will be provided in a later issue of this document.

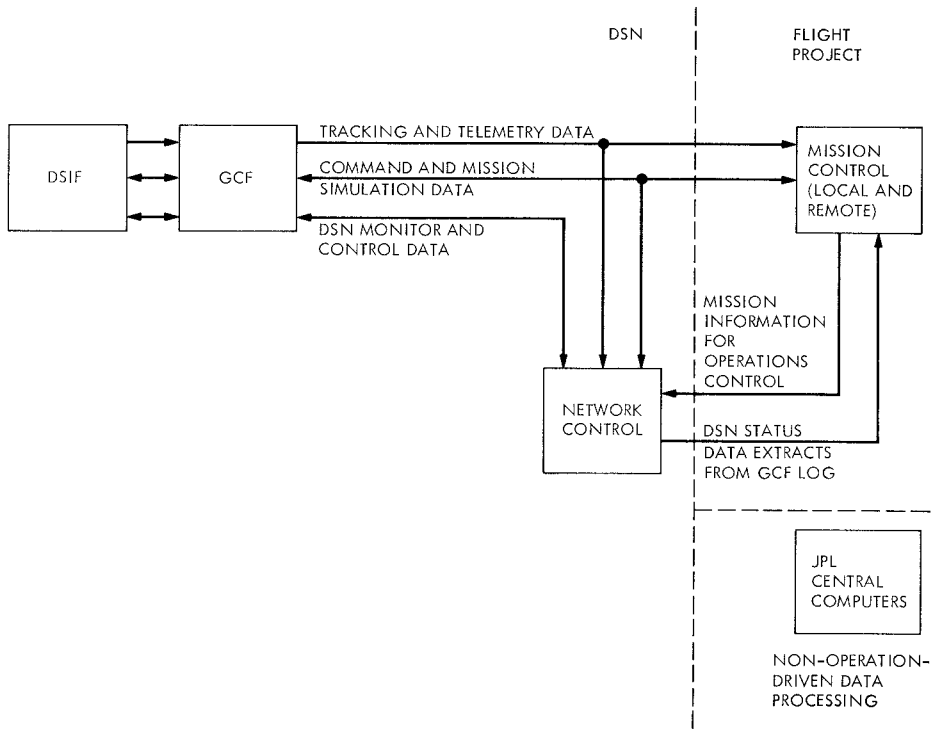

Fig. 1. DSN Control System key functional characteristics

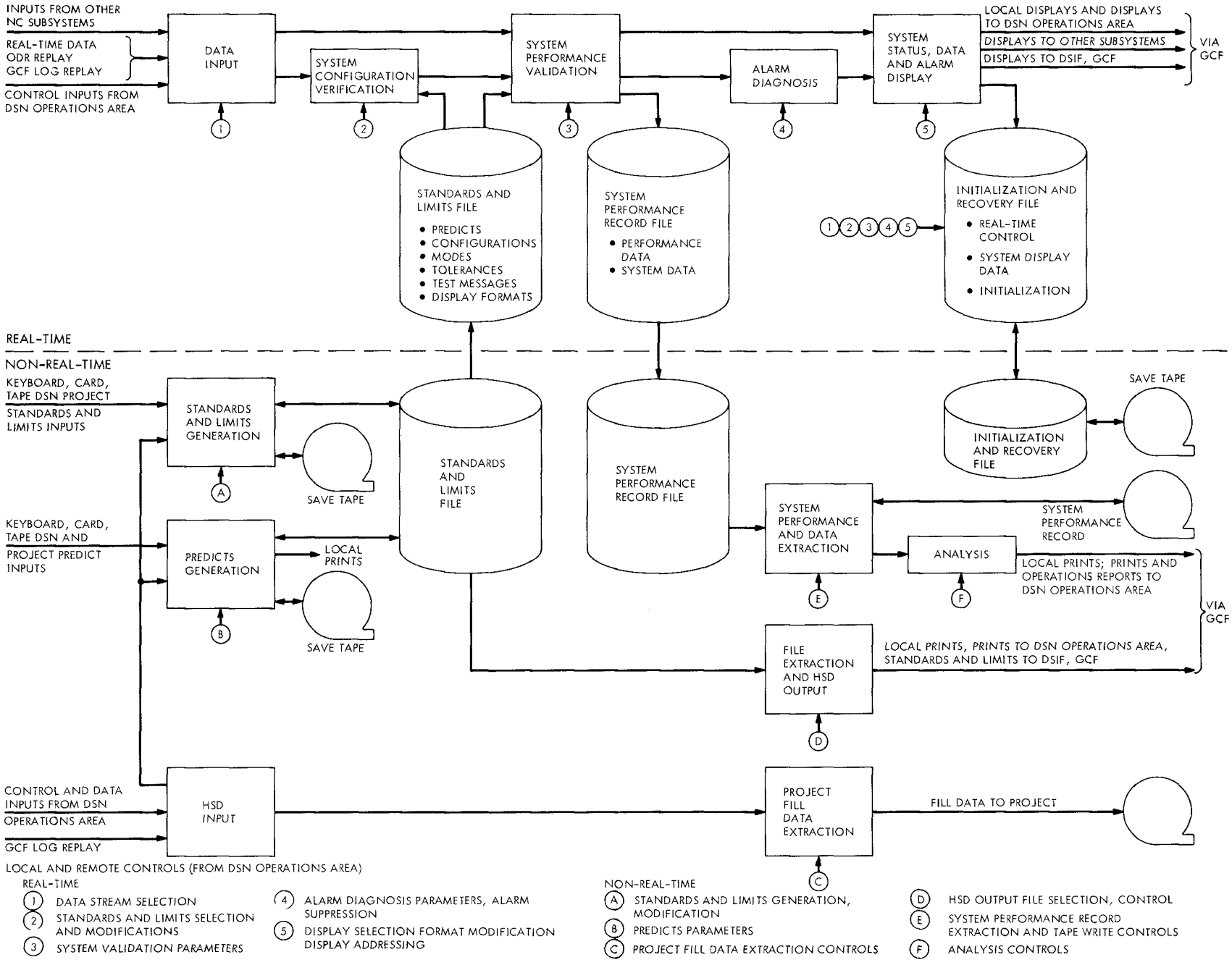

Fig. 2. Generic subsystem data flow chart

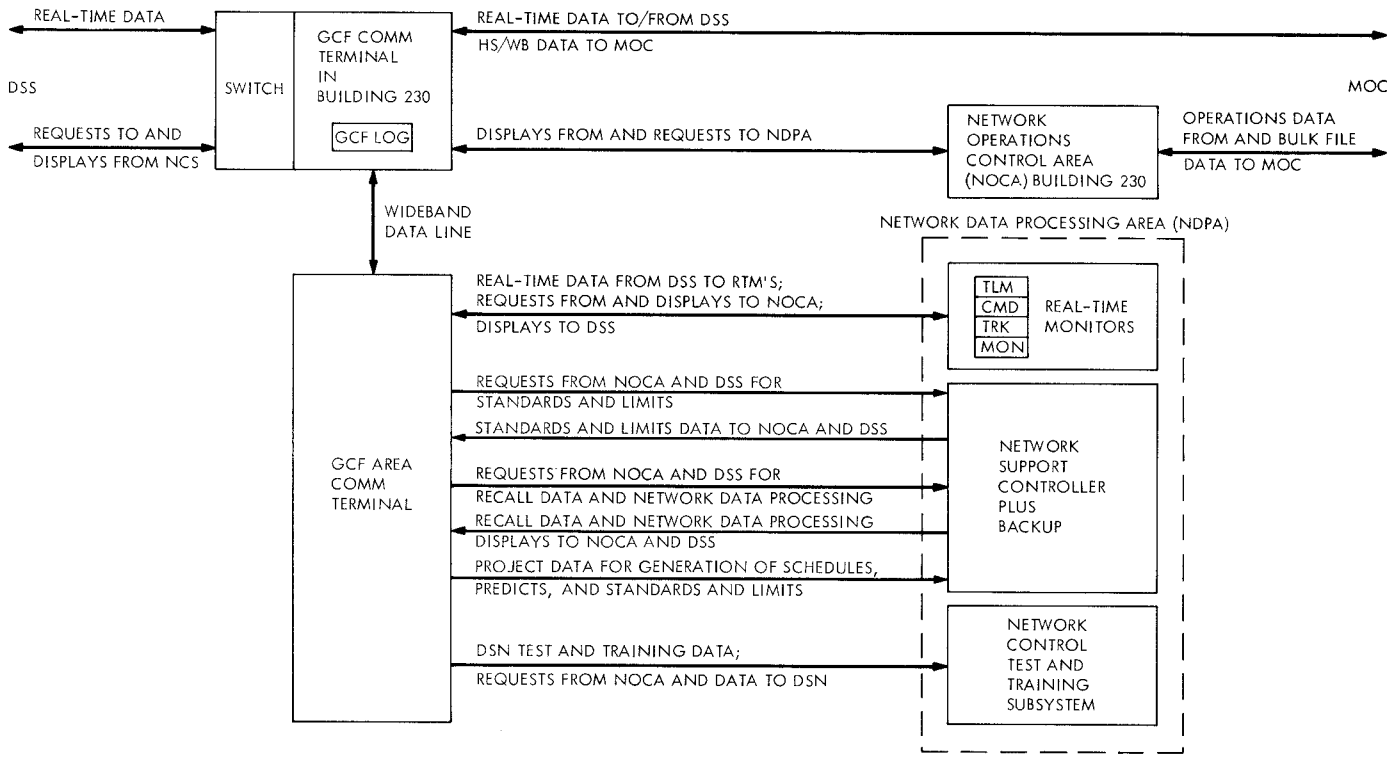

Fig. 3. Network Control System data and message flow requirements