Network Control System

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This article provides information regarding implementation project team responsibilities and activities. The final Network Control System (NCS) hardware implementation configuration and the interim NCS configuration interfaces are described, and the hardware configuration for the interim NCS is discussed.

This is the second article describing the JPL DSN Network Control System (NCS). Information including (1) DSN philosophy and functional requirements, (2) key functional characteristics, (3) subsystem functions, (4) generic subsystem data flow, and (5) overall system data flow and interface diagram was contained in Vol. XI of the DSN Progress Report (TR 32-1526).

The initial JPL document formulating the NCS baseline and implementation is the DSN Data System Development Plan (DSDP)*. This document, prepared by the JPL Tracking and Data Acquisition (TDA) Planning Office, includes baseline requirements, design, management, resources, and scheduling for the final NCS to be completed by July 1, 1974. An interim NCS, including functions which are a subset of the final system capability, will provide network control functions from July 1, 1973, to July 1, 1974.

The NCS functional requirements identified by the DSDP are further defined in the DSN 822-Series NCS documents* for (1) General, (2) Tracking, (3) Telemetry, (4) Command, (5) Monitor/Control, (6) Display, (7) Support, (8) Test/Training, and (9) Communications Terminal Subsystems. These detailed NCS functional/performance requirements were prepared by DSN Systems Engineering. In conjunction, the supporting DSN Operations Group and NCS Implementation Project Engineering Group inputs have provided personnel operating-interface and hardware-capability requirements reflected in these documents.

**DSN Capabilities and Plans,* Document 803-2, Volume II–Network Control System, Data System Development Plan, Baseline Version, Sept. 1, 1972 (JPL internal document).

*JPL internal documents.

A key function of the NCS is to reduce operations costs for the DSN, while providing required FY'74/75 mission support capability. The NCS Implementation Project Team was established on May 19, 1972, within the JPL Telecommunications Division to fulfill these requirements.

The Project will implement and direct activities and supporting group functions for (1) Planning and Schedules, (2) Budgets and Costs, (3) System Design, (4) Specifications, (5) Hardware Procurement, (6) Software Support, (7) Facilities and Services Procurement/Implementation, (8) System Testing, and (9) Operations/Training Support.

The Implementation Project Team has participated in various tasks supplemental to the basic data processing system design and hardware implementation. These activities have included:

(1) Evaluation of system requirement documents and related data processing interfaces with the Deep Space Stations (DSSs) and the Mission Control and Computing Center (MCCC).

(2) Detailed facilities evaluation studies for interim and final NCS. Factors relating to buildings, power, Ground Communications Facility (GCF) interfaces, air conditioning, backup failure modes, and cost effectivity including implementation and long-term growth of operations costs, were prepared for the Site Evaluation and Selection Board review.

(3) Investigation of industry standards for computer/peripheral/communication interfaces, preparatory to specifying Deep Space Instrumentation Facility (DSIF) standards for all hardware data interfaces within the NCS.

(4) Detailed evaluation of NCS subsystem data processing functional requirements as related to the data processing capability of mini-computers and midi-computers to be specified for NCS.

(5) Evaluation of final NCS functional requirements vs. existing hardware specified for interim NCS. Interim mission support requirements were evaluated to develop a revised set of functional requirements to be fulfilled by the interim NCS.

(6) Evaluation of the GCF communication interfaces; and definition of requirements, and design of a new GCF Filler Multiplexer (GCF-FM). The GCF-FM provides automatic bit/data-block synchronization of remote high-speed and wideband data, and also merges NCS/MCCC data with the Remote Mission Operation Control (RMOC) data on a single GCF line from JPL to any DSS.

(7) Evaluation of the final NCS functional requirements vs. resources available, to define the hardware implementation configuration.

A simplified data flow requirements diagram of the final NCS is shown in Fig. 1. The key functional characteristics of the NCS are:

(1) The DSS/MCCC data link is direct via the GCF Central Communications Terminal (CCT).

(2) All DSS/MCCC traffic is recorded in the NCS GCF log, and also routed via GCF Network Communications Equipment (NCE) to the Network Data Processing Area (NDPA) for data validation, analysis, and display generation.

(3) DSIF configuration control data are transmitted from NDPA via NCE/CCT, and merged with MCCC data on GCF lines to DSS.

(4) DSN/NCS control, display, monitor, test/training, and MCCC interfaces, are all directed by DSN Operations Personnel located in the Network Operations Control Area (NOCA).

A simplified block diagram of the final NCS data flow and hardware configuration for July 1974 is shown in Fig. 2.

The GCF CCT, MCCC and associated Mission Operation Control (MOC), and NOCA are to be located at JPL, as are the GCF NCE and NDPA.

A RMOC may be connected via GCF High-Speed Data (HSD) full duplex lines for up to three project control locations remote from JPL. All inbound DSS data are received by the GCF CCT, and are switch-routed directly to the MCCC/RMOC/NCS data interfaces. The MCCC/RMOC/NCS outbound data are routed via GCF equipment directly to the DSS. With a RMOC, the outbound data are routed via the GCF-FM and GCF data sets to the DSS. The GCF-FM allows local MCCC/NCS data to be interspersed onto the same outbound HSDL to DSSs as the RMOC data, by synchronous substitution of local MCCC/NCS data blocks for RMOC GCF filler blocks.

All inbound/outbound data are also routed to the GCF CCT Comm/Log Processors. These data are logged on magnetic tape to provide the NCS GCF data log. GCF log data may subsequently be recalled by the NCS, RMOC, or MCCC for updating other data records. The GCF Comm/Log Processors route data bilaterally to the NOCA for NCS control and display. The GCF CCT Comm/Log Processors delete GCF filler blocks, sort, and route data to the communication processors in the GCF NCE. A 230.4-kbps full-duplex-mode data rate capability is planned between GCF CCT and GCF NCE.

The GCF NCE processors sort and route DSS data and NCS control/displays bilaterally between the GCF CCT and all processors within the NDPA. NCS Test and Training data are routed to GCF CCT for local or long-loop DSS testing.

The Real Time Monitors (RTMs) for Tracking, Telemetry, Command, and Monitor receive only their respective data from the GCF NCE. The RTMs provide input DSS data accountability, verification, validation, and respective Subsystem Data Records. Alarm and display data are generated to provide monitoring of all data streams and network performance in real time.

Designated RTM control data for configuring the DSSs are sent via the Network Support Controller (NSC) to the DSSs. RTM display data are generated and sent to the NOCA. Local RTM displays are available as backup for NOCA.

The NSC provides support computation for each RTM data type via a demand-responsive data processing interface. The NSC is the hub of NCS NDPA operation, but does not preclude stand-alone operation of each RTM. Data processed or generated by the RTM may be transferred to the NSC for subsequent transmission to the DSS via GCF NCE/GCF CCT. Data are also transferred from each RTM to the NSC for output on magnetic tape to provide System Data Records for each RTM. The NSC receives other data from the GCF data log in CCT, and from NOCA. These data may receive special processing in the NSC for analysis and records, or they may be formatted for transmission to DSSs, GCF CCT data log, NOCA, MCCC, or RMOC. The NSC backup processor runs support programs, for subsequent NSC processor transmission within NCS/GCF/DSN. The backup processor and its peripherals may be selected for NSC operation.

The Test and Training Subsystem (TTS) generates High-Speed System/Wideband System (HSS/WBS) test data for all NCS subsystems and NCS/DSS system testing. Testing is unique to NCS/DSS performance validation requirements, and is not a duplication of project flight data model simulation provided by the MCCC.

The NOCA, located in the Space Flight Operations Facility (SFOF) area at JPL, provides all NCS Operations display/control. All NCS processor modes and functions are selected in the NOCA, but may also be operated stand-alone locally. DSS/NCS data and equipment status is displayed in the NOCA. Incoming DSS data to the GCF CCT are formatted and routed per NOCA control. Video data formats are generated for local NOCA console selection of desired data display. NCS display data are also available for distribution to MCCC Operations video displays, and vice versa. Magnetic tape data may be transmitted bilaterally from NOCA to NDPA. Peripheral equipment data outputs are available for Network Analysis Team support. The equipment tabulations in Fig. 2 indicate the hardware configuration planned for July 1974 operational capability.

The implementation of the interim NCS will provide DSN Monitor/Control in a cost-effective configuration providing limited mission support requirements from July 1973 to July 1974.

The interim capability will be a subset of the NCS requirements identified in the 822-Series documents. The system configuration reflects performance requirements, existing hardware, and available resources. The interim NCS interface block diagram is shown in Fig. 3.

The interim NOCA will be located in the SFOF, and interim NCS data processing equipment will also be located at JPL. DSS data will be received via the GCF CCT at JPL.

The interim NCS will receive and process data from up to six HSD and one WBD GCF input data lines. All data will be routed directly from GCF to MCCC. One RMOC will be accommodated by a GCF-FM, as described for the final NCS.

The interim NCS processing for all real-time control, display, data validation, tracking, and monitoring is provided by a single central processor located at JPL. GCF input/output (I/O) functions are provided by a second small processor located in the GCF CCT, with a data link to the central processor. Local controls and displays are provided at the central processor. Controls and displays for interim NCS Operations are remoted in the SFOF area. A backup central processor is available for the real-time operations. The backup processor also performs nonreal-time data processing to support the real-time operation. Magnetic tape is used for data transfer between the real-time and nonreal-time processors. The predicts/sequence of events (SOE)/schedule data transfer interfaces from the MCCC to NCS are magnetic tape for the interim system. A GCF Tracking Data Log may be recalled to MCCC via HSDL. A subsequent interim configuration (Jan. 1974) will provide for additional MCCC data processing to be accomplished in the interim NCS backup processor.

Coordination between interim NCS Operations and MCCC Operations will be via telephone in a localized area of the SFOF. In addition, existing MCCC video displays of DSS data will be viewed by interim NCS Operations on MCCC consoles. Designated NCS monitor functions will be performed at each DSS to supplement the centralized control/monitor operations.

An interim NCS hardware block diagram is shown in Fig. 4. The display area includes interim NCS hardware/data status records, displays, and controls. The real-time video displays are part of the MCCC video system, and are not included in Fig. 4.

The data processing area includes the real-time/backup processors and associated peripherals. Switched controller/data sets to the separate areas utilize existing hardware for minimum-cost implementation.

The GCF data are preprocessed in an existing I/O processor to simplify inter-building data transfer, and to reduce core requirements of the central processor.

The interim NCS hardware/software is currently in development for July 1973 operation. Design features and applications will include future use in the final NCS where applicable.

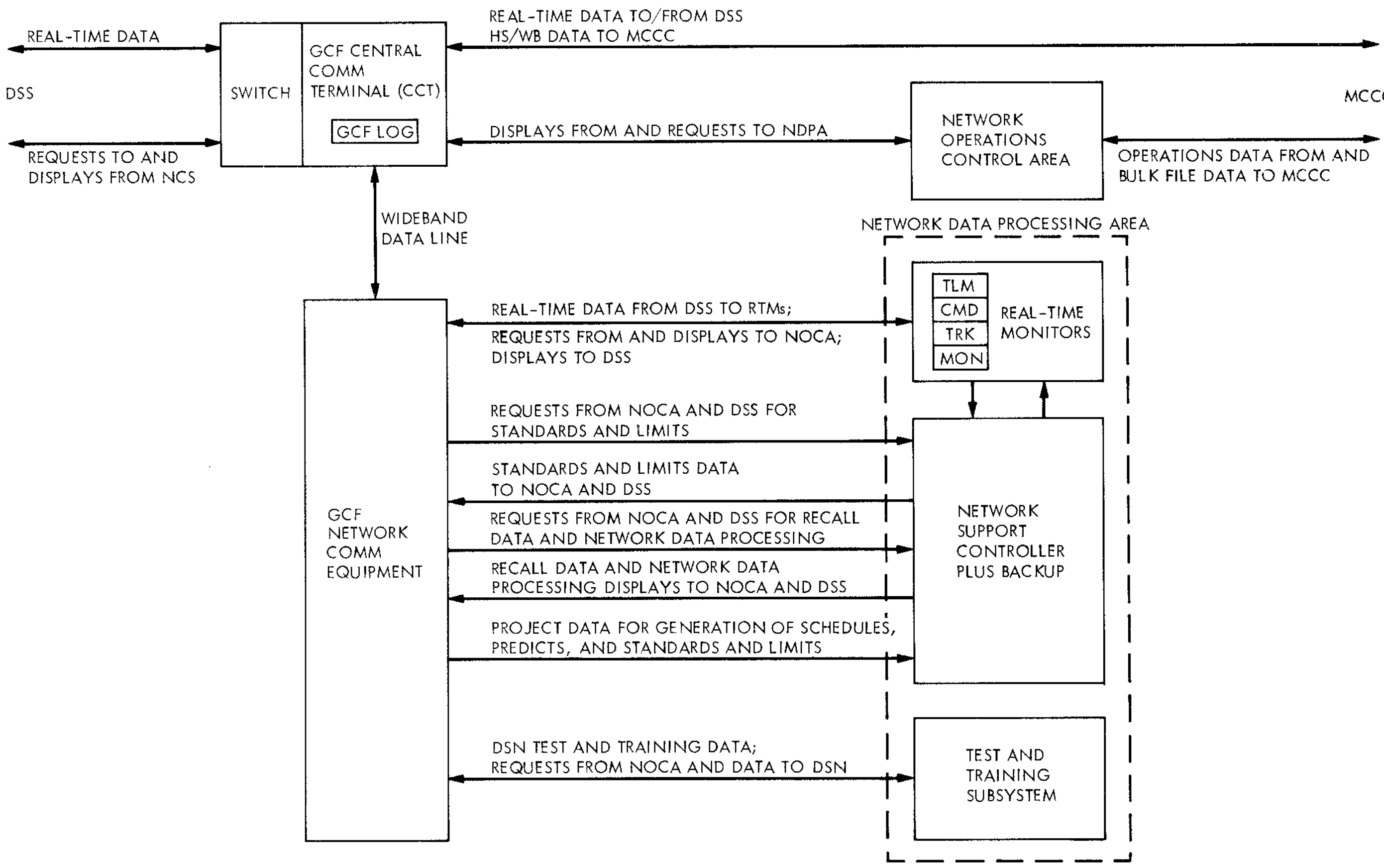

Fig. 1. NCS data and message flow requirements

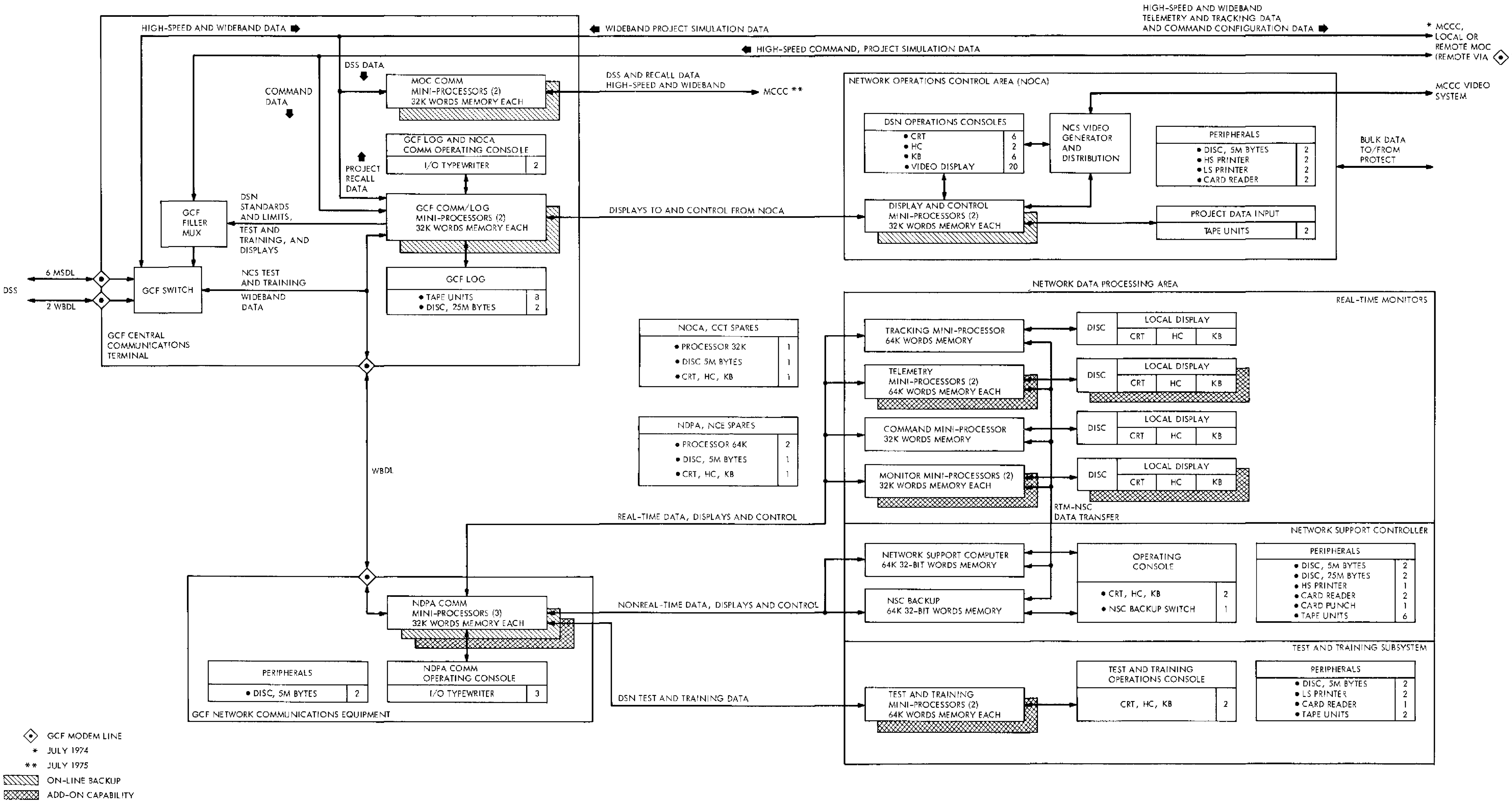

Fig. 2. NCS data and message flow, detailed configuration diagram

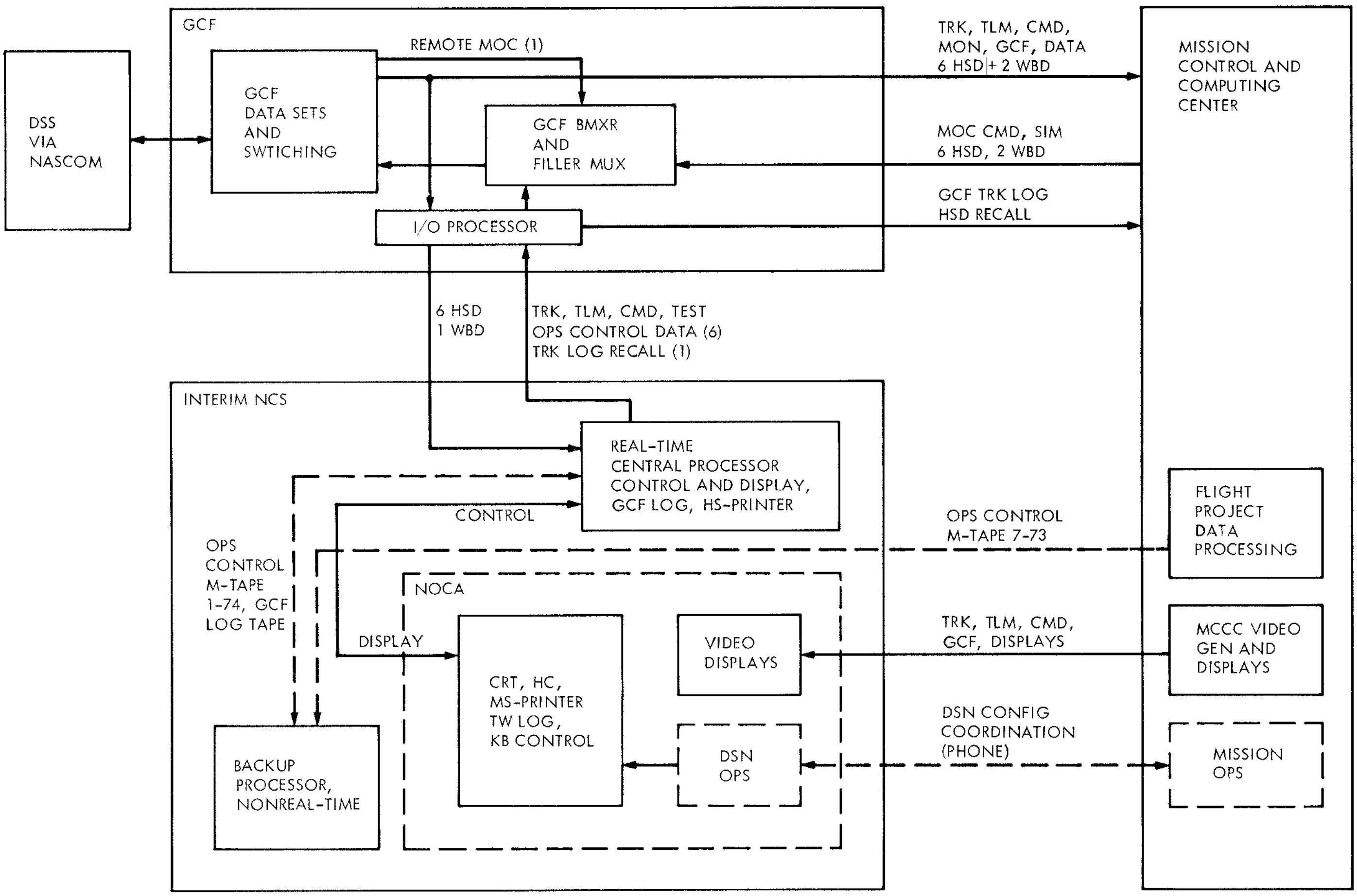

Fig. 3. Interim NCS interface block diagram

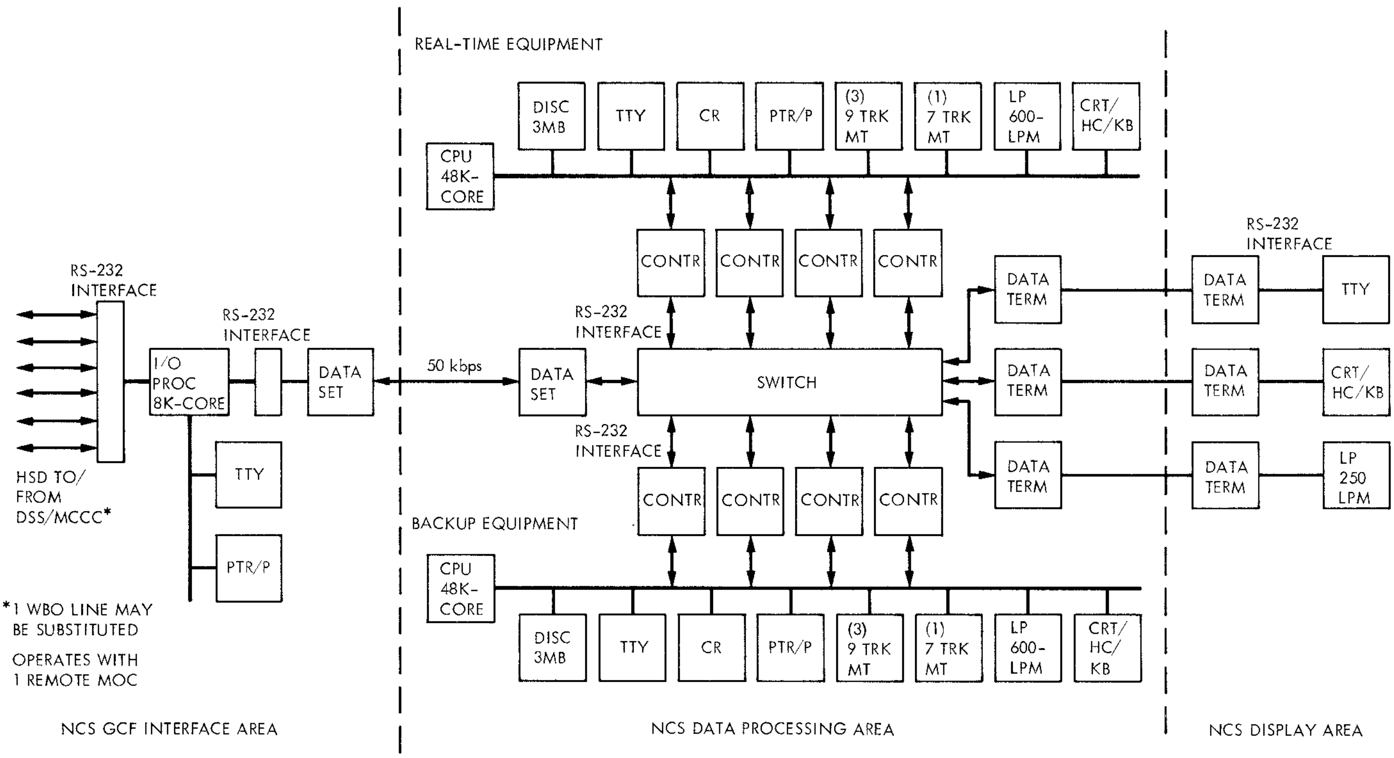

Fig. 4. Interim NCS hardware block diagram