Network Control System Development

J. N. Edwards
DSIF Digital Systems Development Section

The development of the DSN Network Control System has been authorized to provide centralized computer control and monitoring of Deep Space Station equipment status and data flow. The NCS is being implemented with an interim (Block I) capability for current spacecraft-support requirements. A transition (Block II) and a final (Block III) NCS, providing future spacecraft support requirements, will be implemented by a complex of minicomputers with dedicated subsystem functional capability.

I. Introduction

This is the fifth report describing the JPL DSN Network Control System (NCS). The NCS provides centralized computer control and monitoring of all the JPL Deep Space Station (DSS) equipment and data flow status. The previous reports presented (1) project plan and resources, (2) system functions and interface requirements, (3) data flow and hardware allocations, and (4) detailed descriptions of hardware and software configurations and development progress for the Block I and Block III NCS. This report discusses recent progress in hardware and software activities and describes a redefinition of implementation guidelines for the NCS.

II. Revised NCS Implementation Guidelines

A change in implementation plans for the NCS has been defined in accordance with resources and mission support requirements. Definitions are as follows:

Old name	New date	New name
Interim NCS	3rd quarter CY'73	Block I
Transition	2nd quarter CY'74	Block II
Final NCS	2nd quarter CY'75	Block III

The change in plans is associated with scheduled facility refurbishment for Block III NCS. Schedule requirements for mission support have necessitated the transitional (Block II) configuration which will provide functional features complementary to those provided by Block I. The Block II functions will be implemented with minicomputers and software scheduled for Block III. Facilities for Block II will be located in areas designated for Block III that do not require refurbishment and will provide required mission support with minimal configuration revision to attain Block III capability.

A detailed description of NCS Block II will be given in a subsequent report. The Block II configuration has essentially no impact on the Block I and III configuration status as reported herein.

III. Block III NCS Facilities

The location of the Network Data Processing Area (NDPA) for the Block III NCS is planned for JPL, Building 202. Revised cost estimates for facility modifications based on revised design requirements were submitted for approval on June 18, 1973.

The floor space allocations in the Ground Communication Facility (GCF) Central Communications Terminal (CCT) for the Communications Log Processor (CLP) and display processors have been negotiated. The GCF log magnetic tape storage area requirements are pending evaluation of the revised NCS/Mission Control Computing Center (MCCC) logging/recall interface definition.

IV. Block III NCS Hardware

The system design for the Block III NCS has continued after firm identification of the Sigma-5 computers for the Network Support Controller (NSC). The lease arrangements for processor and peripherals have been prepared, and standard interface peripherals for the NSC and real time monitor (RTM) processors have been defined.

A series of interface block diagrams for hardware interfaces has been defined for various multimode data flow paths. The hardware data flow path for received high-speed data (HSD) from Deep Space Stations is shown in Fig. 1. The GCF data signal is checked for error indication by the GCF decoder and distributed to the MCCC and the NCS receive buffer. The receive buffer then distributes to redundant Communication Log Processors (CLP) data channels. The initialized data channel-A logs data on disk and magnetic tape for the NCS GCF log. Data are distributed via the 230.4-kbs data link to the remote NDPA Communications Processor (NCP). The NCP distributes data to the appropriate RTM or other processors via the star switch controller (SSC). The redundant CLP-B logs data on disk to back up failure of prime CLP disk/tape logging.

The SSC-1/2 shown in Fig. 1 is a sequenced multiport data router. It provides bilateral communication between any of the 12 processors connected to its terminals. The SSC-1/2/3 are redundant half duplex units providing backup data paths available to each processor. Similarly, SSC-4/5 provide multipath access between the two CLP and two display processors. The SSC design is complete, and prototype models are in fabrication.

Interface definitions have been established for the processor transmit and receive communication buffers of Fig. 1. Figure 2 shows buffers and equipments utilized for wideband data (WBD) interfaces. The initialized CLP-A data is switch-selected to the transmit buffer. The WBD is sent via a voltage-to-current (V/I) converter to the coded multiplexer demultiplexer (CMDM). The CMDM accepts data blocks with numbered access priority. Data are then appended with serial error correction bits and transmitted to the DSS. Selected transmitted data are also entered into the GCF log via the initialized CLP-A. Received WBD from the DSS are decoded to detect GCF transmission errors, and distributed to the MCCC and the NCS. Received data are sent via a current-to-voltage converter to the receive communications buffer. The received data are routed to the initialized CLP-A for logging and retransmission to the NCP-A. Received data are also distributed to backup CLP-B for logging on disk. The transmit and receive buffers of Fig. 2 for WBD are the same design as for HSD and for 230.4-kbs data as shown in Fig. 1. Transmit and receive buffer specifications and prototype designs are near completion.

The NCS has a requirement to operate with a Remote Mission Operation Center (RMOC) other than via the MCCC. This configuration provides complete command-operation of a DSS by a RMOC via the GCF lines, with concurrent DSS configuration and monitoring by JPL NCS. The design of the NCS GCF filler multiplexer (GCF-FM) for the final NCS is essentially complete. Fabrication will be scheduled after testing of the prototype which has been fabricated for the Block I NCS. The GCF-FM is described in Ref. 1.

The hardware specifications for the NCS minicomputer and peripherals have been completed and reviewed for procurement. Extensive bid evaluation is in-process for hardware procurement.

V. Block III NCS Software

The software design for the Block III NCS has included iterative evaluation of the functional requirements and operations features to be provided by the system. The basic design has progressed, and has resulted in completion of a baseline design document which provides definition of all NCS subsystem design concepts and interfaces. Current effort is directed toward completion of a detailed software requirement document for each of the functional subsystems. The software design group has also generated extensive software benchmark tests and evaluation criteria for the minicomputer procurement.

The network support controller will be implemented in Block I and Block III NCS by Sigma-5 processors and peripherals. Programs for formatting and generation of predicts are being identified and configured for optimum transition between the two system configurations.

VI. Block I NCS Facility

The Block I NCS data processing area facility and equipment installations in JPL Building 202 are complete and in full operation. This includes power, air conditioning, offices, intercom, administrative TTY, magnetic tape safe, and maintenance support activities. Facilities in JPL Building 230 for GCF link communications equipments and input/output (I/O) processor equipment have been provided and checked for support of remote equipments.

VII. Block I NCS Hardware

The Block I NCS data processing hardware is installed and has been tested with applicable diagnostic software. The communications link hardware and PDP-8 processor in the Central Communications Terminal (CCT) is also installed and has been diagnostically tested. Remote display peripherals in the Space Flight Operations Facility (SFOF) are installed and are undergoing final check with software in the data processing area.

The timing system and interfaces are installed and have been diagnostically tested. The GCF-FM for multiplexed synchronous communications with an RMOC has been designed and fabricated and is ready for functional/system testing.

VIII. Block I NCS Software

A. System Configuration

The definition of tasks for the Block I software is related to the applicable DSN 822-series functional requirements and to the available hardware/software implementation subsystems as shown in Fig. 3. Functions include real-time receiving from and transmitting to Deep Space Stations. This NCS interface is via the HSD lines and the GCF HSD modem equipments. The NCS interface is provided by the software multiplex/distribution in the PDP-8 I/O communications processor located in the GCF CCT. The I/O data are transferred via a wideband data line to the real-time Sigma-5 processor. The real-time Sigma-5 provides GCF accountability for all received data, and for data processing/analysis. It also generates local/remote data displays for monitoring operational status of the DSN in real-time.

The data to be transmitted to the DSS are input by keyboard or by preprocessed magnetic tape. Tape data are stored on disk file for transmission, in accordance with remote network operations control. Selected command-configuration transmission data from the NCS are echo-checked from the DSS to NCS in real-time to confirm correct transmission to the DSS.

The Sigma-5 non-real-time processor accepts tape, card, and keyboard inputs. It does off-line preprocessing, formatting, and generation of designated schedules, sequence of events, and predicts for tracking and telemetry subsystems. These preformatted data are then transferred by tape to the real-time Sigma-5 for transmission to the various DSSs.

B. System Status

The configuration baseline design has been completed in accordance with the system functional requirements for all software. A project design review was completed for all software. Design and coding are complete for all modules in the three processors.

Software module verification testing is near completion. The acceptance test procedures have been completed and selected system testing is underway. Significant system testing progress has been achieved, with key features summarized below:

(1) System initialization has been confirmed for all processors.

(2) GCF accountability for HSD lines is functional.

(3) Real-time data are transferred from the PDP-8 to the Sigma-5.

(4) The printer dump of real-time HSD is functional.

(5) Generation of real-time data displays with multiple format paging is functional.

(6) Displays have been checked for local and remote peripheral interfaces at the processor.

(7) Formatting and processing of data on the off-line processor has been provided, with various tape transfers to the real-time machine for disk file storage.

Other features relating to NCS data transmission and verification are in final phases of verification and acceptance testing. An extended effort was required in some areas to facilitate problems relating to hardware cross-talk, operating system anomalies, and revised functional requirements. A definitive anomaly reporting system has been incorporated to identify software anomalies and assure certified corrective action. An extensive effort is being directed to provide complete design, coding, operation procedures, operations tapes, commercial diagnostics, and special system configuration diagnostics data; this will be included with system software data transfer from development to operations.

A subsequent report will describe the detailed features of the Block I NCS software design and operation.

Reference

1. Edwards, J. N., "Network Control System," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. XIV, pp. 141–145, Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1973.

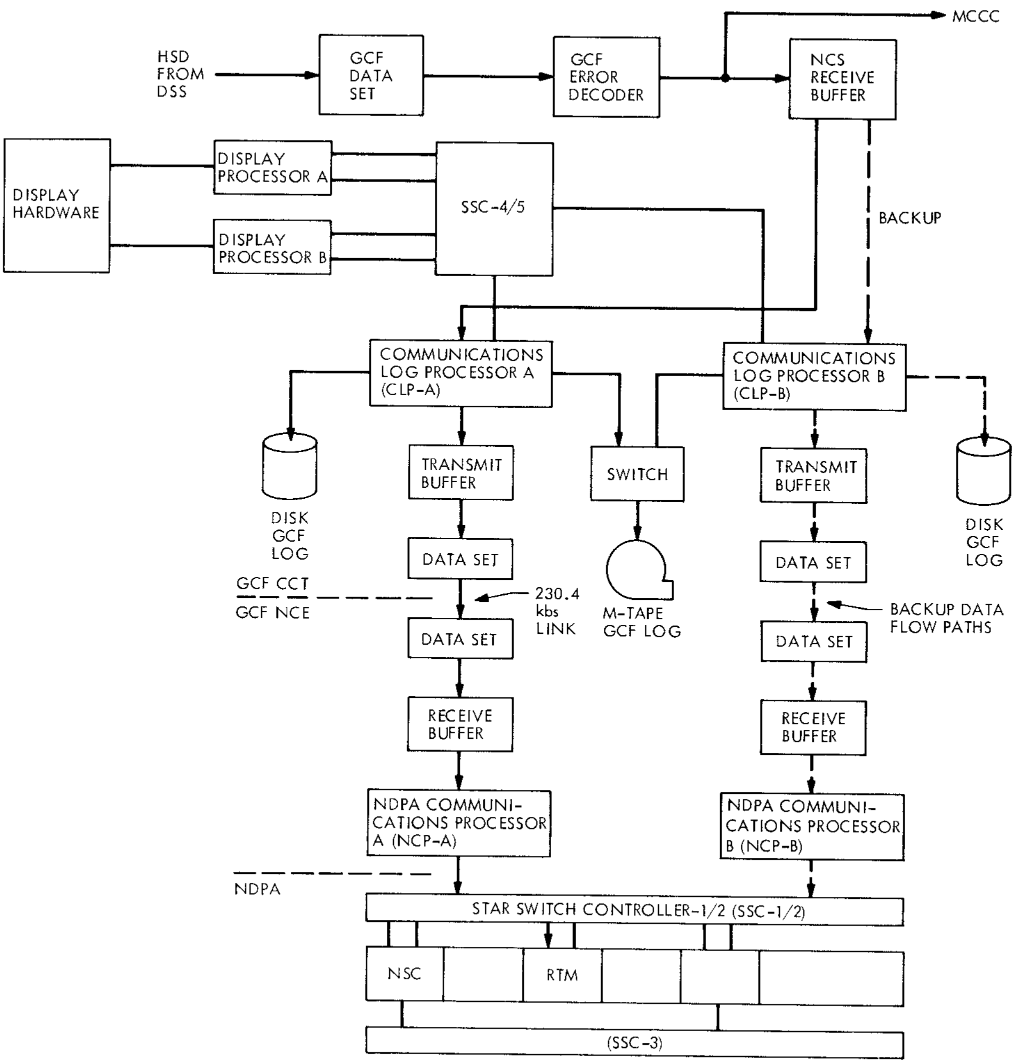

Fig. 1. DSS to NCS high-speed data receive data flow path

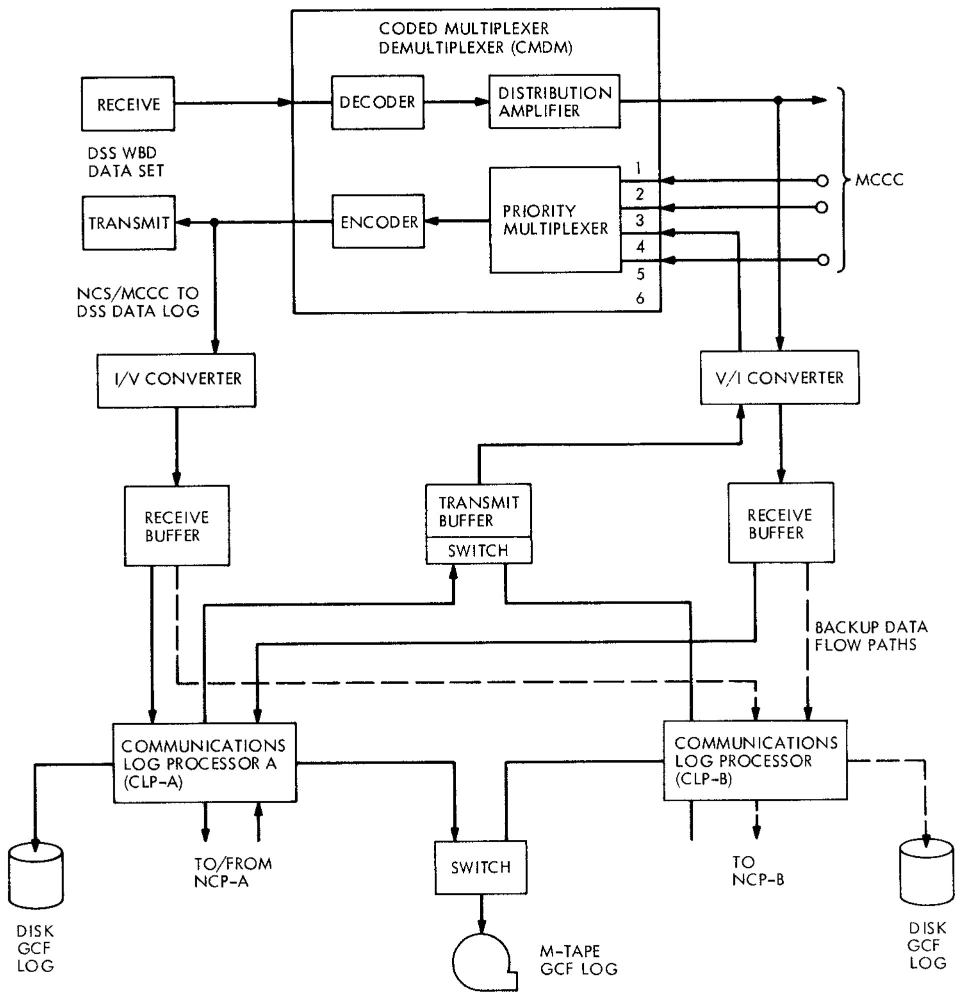

Fig. 2. NCS/DSS wideband data transmit/receive data flow path

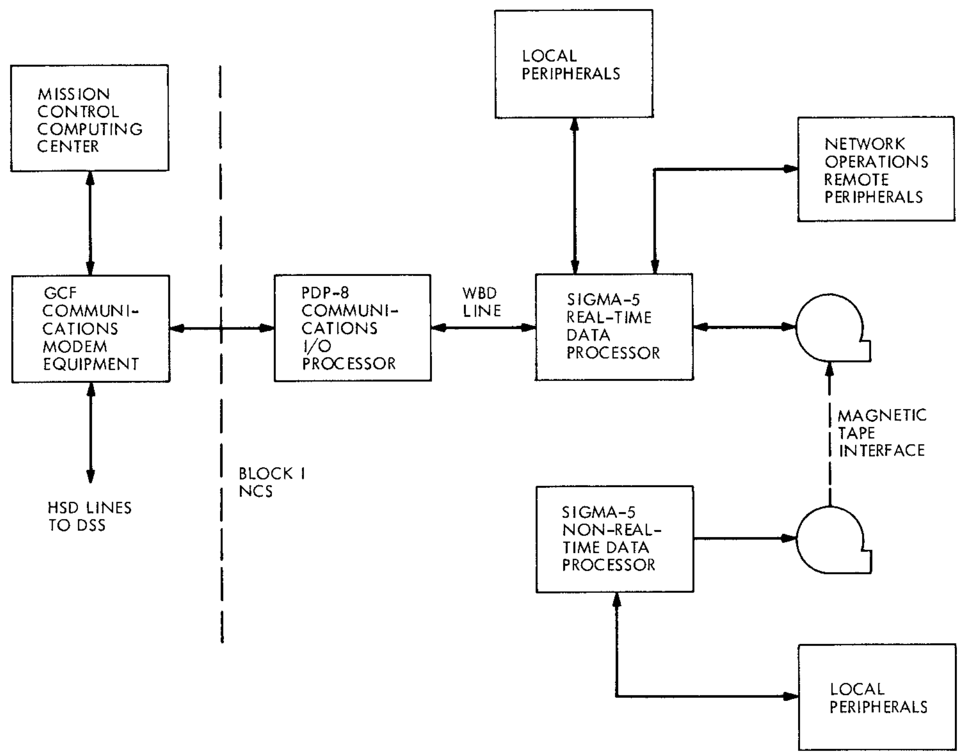

Fig. 3. Block I network control system hardware/software subsystem