Viking Mission Support

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Because of the February budget constraints, previous plans and schedules for Viking have been reworked to minimize the impact on readiness dates committed to the Viking Project. An improved implementation schedule has been developed to manage hardware and software progress toward Viking configurations in the DSN. Several significant reviews have been held and some new problem areas identified. In the particular case of DSS longitude accuracy, a task team has been formed to try to resolve the problem by September of this year. Operations activity in support of Viking is also introduced in this issue.

I. Introduction

A previous issue of this report (Ref. 1) described the transition from planning and negotiation to implementation and testing. With this report, the operations activity in support of Viking is introduced. As implementation gains momentum, operations activity enters the early planning stages with the release of the DSN Operations Plan in its preliminary form. The DSN Operations Plan complements the DSN Preparation Plan which addresses the specific questions of network configurations and implementation schedules at the subsystem level.

Two significant reviews have taken place during the reporting period: (1) the first DSN Progress Review, and (2) a review of Deep Space Station (DSS) Longitude Accuracies. Both are reported below.

II. Implementation

Significant progress in implementation of the DSN configurations required for Viking support is described below.

A. Network Configuration

As indicated in the previous issue, the DSN Command System for Viking has been undergoing a substantial redesign to optimize the DSN/Mission Control and Computing Center (MCCC) interfaces, increase effective storage capability, and enhance the command monitor and display capabilities. The configuration of the redesigned Command System was presented by W. G. Stinnett at the DSN Progress Review for Viking held on March 22, 1973 and is described in detail in Ref. 2.

Figure 1 shows the subsystems and the prime functions that are included in the DSN Command System.

1. DSS functional capabilities

(1) The Telemetry and Command Processor (TCP) will interface with the Ground Communications High-Speed System (GC HSS) by: (1) accepting and processing instruction and command data from the Network Control System (NCS) or Viking Mission Control and Computing Center (VMCCC), and (2) generating acknowledge and event messages for transmission to the NCS or VMCCC.

(2) The TCP will provide temporary storage of up to four high-speed data (HSD) blocks (24 command elements) for use while in the prime operational mode. The TCP will provide storage of one HSD block (6 command elements) for project backup commands. These commands are available for transmission if an emergency exists and the system is in the backup operational mode.

(3) The TCP will automatically configure the Command Modulator Assembly (CMA), based on the instruction messages received from the NCS. At the appropriate time, the TCP will automatically configure and control the CMA to accomplish command transmission to the spacecraft. TCP–CMA modes of operation will be provided to allow initialization, configuration, idle mode during non-command periods, idle mode during command periods, command transmission mode, and an abort mode.

(4) The TCP will monitor the CMA to ensure proper functioning. The TCP will automatically alarm or abort command transmission under conditions of substandard operation.

(5) The TCP will provide system data and status to DSS control.

(6) Manual entry of instruction and command data via an input/output (I/O) device will be provided.

(7) The TCP will generate a digital original data record (ODR) of all HSD blocks received or generated by the TCP. The capability will exist to replay this data to the VMCCC/NCS.

(8) The DSS will transmit idling sequences during periods when active commanding is not taking place.

(9) The DSS will transmit commands to the spacecraft at the proper time as controlled by the HSD command messages.

(10) The Orbiter command data will be Manchester-coded during transmission by the DSS.

(11) The DSS will provide for generation of the uplink carrier with the command data modulated subcarrier waveform.

(12) The DSS will transmit commands at reduced as well as full transmitter power.

(13) The DSS will provide a backup Telemetry and Command Data Handling Subsystem (TCD). This backup TCD can be utilized as a hot-standby during project-designated critical time periods. Such operation (command loading and mode) shall be controlled by VMCCC.

(14) The DSS will provide S-band transmission to the spacecraft.

2. Ground communication functional capabilities. The GC HSS will be utilized for communication between various elements of the DSN Command System. The GC will provide:

(1) GC HSD lines between the VMCCC/NCS and the DSS. During project-designated critical time periods, the GC will have the capability of providing one complete backup HSD path.

(2) GC HSD lines between NCS subsystems.

(3) Automatic HSD block error detection and flagging.

(4) Generate HSS alarms to GC control.

(5) The GC will log all command HSD blocks on the GC log tape. This log will be made available for playback of data missed on the master data record (MDR).

(6) A voice circuit between the Network Operations Control Area (NOCA) and the DSS. Upon request, during a spacecraft emergency, a voice circuit will be provided from VMCCC to the DSS for the DSS backup command operation.

3. NCS functional capabilities. The NCS will provide Network Operations personnel with the capability of controlling and verifying the DSN Command System in a multi-project support environment. The NC Command Subsystem will provide:

(1) The capability to generate and transmit the following command HSD messages to the DSS:

  (a) Mission configuration and standards and limits messages.

  (b) Test command messages.

  (c) Mode control messages.

  (d) Recall request messages.

(2) The capability to:

  (a) Detect and report the status of the DSN Command System by accepting all VMCCC- and DSS-generated HSD blocks.

  (b) Transmit alarms to NC Monitor and Control System and the Network Operations Control Area.

  (c) Perform DSN Command System configuration and mode verification.

  (d) Accomplish system performance validation.

  (e) Perform alarm diagnosis for use by Network Operations personnel.

  (f) Generate system status, data, and alarm displays for use by Network Operations personnel.

  (g) Generate system performance record for the DSN Command System.

  (h) Upon Project request, generate a project fill data tape to fill data gaps in the master data record.

B. System Data Flow Description

Figures 2, 3, and 4 are simplified block diagrams of the DSN Command System. Configuration and standards and limits messages originate in the NCS, under control from the Network Operations Control Area (NOCA), and are transmitted to the DSS. Spacecraft command data originates at the VMCCC and is transmitted to the DSS. Acknowledge and event messages originate at the DSS–TCP and are transmitted to the VMCCC and/or NCS.

The operation of the DSN Command System can be described by defining three periods of operation during a standard DSS spacecraft track; a configuration and test period, the actual spacecraft track period, and a post-track period.

1. Configuration and test period. Approximately 30 minutes prior to spacecraft acquisition by the DSS, all DSN facilities are made available to and under the cognizance of Network Operations personnel in the NOCA. From this time until just prior to acquisition, Network Operations personnel perform a DSN inter-facility readiness test. The following items are accomplished in preparation for the DSN Command System support of the spacecraft track:

(1) A test is performed to ensure that proper HSS communication exists between the TCP and the NCS. Command HSD messages are transmitted from the NCS and the TCP. The HSD acknowledge blocks from the TCP are processed and displayed at the NCS.

(2) The appropriate mission configuration and standards and limits message is transmitted from the NCS to the DSS. The TCP utilizes these data to automatically configure the CMA and to automatically monitor the DSS command functions.

(3) The prime operational modes (modes (b) through (e) below) of the TCP–CMA are tested via HSD messages from the NCS. The total modes of the TCP–CMA are:

  (a) Calibrate 1: Mode for initialization at DSS.

  (b) Calibrate 2: Mode for setting proper configuration via HSD.

  (c) Idle 1: Safe mode (command transmission not possible) with proper configuration and system checks accomplished.

  (d) Idle 2: Mode in which the system is ready for commanding.

  (e) Active: The mode in which a command is in process of being transmitted.

  (f) Abort: Mode in which the TCP–CMA automatically enters when a system failure occurs during command transmission.

(3) With the system configured for commanding, except for the RF output inhibited command, test commands are generated at the NCS and transmitted to the DSS.

The total DSN Command System function is monitored during this test command process. After successful operation, a message is transmitted to the TCP to instruct the TCP to reject any instruction message originating at the NCS. The system is then ready to receive command and control data from the VMCCC.

The above items are accomplished for all data streams scheduled for support of a given project. An additional TCD (data stream) at the specific DSS will be configured and tested during a Project-declared critical period in which a hot-standby TCD is required.

2. During track command period. Just prior to acquisition, the system is made available to the Project. The Project is capable of loading commands and controlling the Idle 1, Idle 2, and active mode of the TCD. (During critical or special command sequences, as required by the Project, the DSN Command System can be scheduled such that commands can be loaded prior to acquisition.)

Commands will be generated at the VMCCC, placed in HSD blocks, and transmitted to the TCP. The TCP command stack will provide storage of four HSD blocks of command data. These four blocks (stack modules) consist of up to six command elements each. Each command element can have up to 71 bits of command data and, at the Project's option, the command element can be timed or non-timed. The top command element in the first stack module is eligible for transmission to the spacecraft. Non-timed commands will be transmitted immediately after eligibility. Timed commands will be transmitted after eligibility and at the time specified in the HSD block. At the time of transmission of the command element, the TCP will establish the proper mode and configuration of the CMA. The command will be transferred to the CMA for immediate transmission.

For the Orbiter, Manchester coding will be accomplished in the CMA. The command data will be transmitted at 4 bps (exclusive of the Manchester coding). The DSS will generate the unique subcarrier frequency to ensure command transmission to the proper spacecraft when two or more spacecraft are in the antenna beam. The uplink carrier will be modulated by the command data subcarrier and transmitted to the spacecraft.

During the above command operations, events will cause HSD message transmission to the VMCCC. The following events will initiate message transmission to the VMCCC:

(1) A confirmed command element.

(2) An aborted command element.

(3) A DSS alarm.

(4) A response to a recall.

(5) A stack module promotion.

(6) A HSD block rejection by the TCP.

(7) An acknowledgement of the receipt of an HSD block.

During the process of Project commanding, the NCS will receive all HSD messages being received by and generated at the TCP. DSN Command System verification, alarm diagnosis, and displays to Network Operations personnel will be accomplished at the NCS. In the event of a failure or anomaly in the DSN Command System, Network Operations personnel will coordinate the failure isolation and troubleshooting required. Depending on the degree of failure, command transmission may have to be terminated. A switch to a backup HSD circuit would require recertification of communication with the TCP. A reload/reinitialization of the TCP software, or a switch to the backup TCD, would require transmission of command standards and limits and configuration data to the TCP from the NCS.

Provision will exist for the capability to enter and/or control command transmission via a manual I/O device at the TCP. A manual buffer will exist in the TCP, which will hold six command elements of up to 71 bits each. This buffer can be loaded with contingency commands via HSD messages from the VMCCC. In the event of a VMCCC or HSS failure, control of this buffer can be accomplished via the I/O device at the TCP. Commands can also be loaded and/or transmitted under voice control from the VMCCC. Selective transmission of the contingency commands, loaded via HSD, can be accomplished.

During a time-critical command sequence, in which a hot-standby TCD is scheduled for support, all HSD control is exercised from the VMCCC. Optional methods of operating the hot-standby TCD can exist.

3. **Post-track period.** During the post-track period, command data can be replayed from the DSS to fill data gaps in the GC log tape and/or the project MDR.

C. System Configuration

Figures 2, 3, and 4 give the configurations of the various elements of the DSN Command System. These three simplified block diagrams are for the 26-meter DSSs, DSS 14, and the 26/64-meter conjoint configurations.

The 26-meter DSSs, i.e., DSSs 11, 12, 62, and 44, have backup TCP–CMA strings available for hot-standby/backup use. The switch settings shown in the figures are for the prime or standard configuration.

Additional items at DSS 14 that are not available at the 26-meter DSSs are:

(1) A Block IV exciter.

(2) A 20-kW transmitter versus the 10-kW transmitters at the 26-meter DSSs.

(3) A high-power transmitter for dual-carrier mission enhancement use.

The switch settings shown in Fig. 3 are for the prime or standard configuration. As can be seen, the TCP2–CMA2 and the Block III exciter are backups to the prime strings.

Figure 4 shows the configuration of the 26/64-meter conjoint stations. Again, the switch settings shown are for the standard configuration. The TCP2–CMA2 is backup for either the TCP1–CMA1 string at the 64-meter DSS or the TCP3–CMA3 string at the 26-meter DSS.

D. Operational Constraints

1. **Time to initiate the DSN Command System.** Once the NCS and DSSs are staffed and internal facility testing and initialization are complete, the time to complete an interfacility readiness test shall not be greater than 30 minutes. This readiness test establishes HSD communication between the NCS and TCP, loads initial configuration and standards and limits in the TCP from the NCS, and generates and sends a test command from the NCS. The DSN Command System is then ready for Project use.

2. **Recovery from TCD failure.** A TCD failure requiring a TCP software reload shall take less than 15 minutes to recover the system to operational status.

During noncritical command periods, a failure in the prime TCD subsystem requiring a switch to the backup TCD subsystem shall take less than 30 minutes.

During Project-designated critical command periods, in which a hot-standby TCD is operating, a switch to the backup TCD shall take less than 5 minutes.

3. **HSD circuit failure.** A recovery from a failure requiring a switch in HSD circuits shall take less than 5 minutes.

4. **Configuration and standards and limits changes.** A change in the initial configuration and standards and limits in the TCP shall take less than 2 minutes to accomplish.

5. **Manual commanding.** A failure in the VMCCC or HSD system may require that emergency commands be transmitted to the spacecraft via the I/O device at the TCP. If the emergency commands were loaded in the manual buffer via HSD, the time to initiate transmission shall be less than 1 minute from notification by the Project. If emergency commands are loaded into the TCP via the manual I/O device, the time to initiate command transmission shall be 5 minutes for the first command and 2 minutes for each subsequent command.

6. **Command stack capacity.** The TCP command stack shall consist of four modules plus the manual buffer. Each module consists of six command elements (same for manual buffer). Each command element can contain up to 71 bits of command data.

E. Interfaces

The Deep Space Network to Viking Mission Control and Computing Center System Interface Requirements Document, Volume IV, ID-3703111, was completed and approved by the Project Manager during the period under review. This completes the family of three documents describing the Viking Orbiter, Viking Lander, and VMCCC interfaces with the DSN.

In March the Viking Lander radio system development model was brought to JPL for development compatibility tests with the DSN in Compatibility Test Area (CTA) 21. Four weeks of RF tests were completed in both the single and dual-uplink environment and no anomalies were detected. No further tests with the Viking Lander will be required until June 1974, at which time the Spacecraft Test Lander will be brought to CTA 21 to begin the final RF compatibility test series in conjunction with the Viking Orbiter.

F. Schedules

Since the previous report, the DSN has been actively pursuing the development of an implementation schedule (IMPSKED) based on monthly updates of the Division 33 Work Authorization Document Schedule (WADSKED). The IMPSKED shows progress in terms of the following milestones for each of the DSS subsystems down to the assembly levels:

Milestones	Definition
A	Functional requirements document complete
B	Design complete
C	Contract initiated, inhouse fabrication start
D	CDE/COE transfer complete
E	Subsystem implementation complete
F	Network system performance test complete

The Viking IMPSKED includes 120 line items covering all subsystems and is published in Ref. 2. The schedule is updated monthly and forms the single authoritative source for all subsequent implementation and operations planning throughout the network.

As part of the DSN support to the Viking Project, the DSN undertook to provide radar observations of the Mars surface features during the 1971, 1973, and 1975 opportunities. In the current year, the Mars radar opportunity extends from June through December and, as a consequence, ran into direct conflict with Pioneer G and Mariner Venus/Mercury requirements for in-flight mission support from DSS 14. The Viking observations were needed to verify the surface constituency for selection of the Mars landing sites, for surface roughness estimates, and for planetary ephemeris improvements.

A joint meeting between the conflicting parties was sponsored by the DSN and resulted in the development of a mutually acceptable schedule for DSS 14 support of all three project's requirements.

G. Problem Areas

One of the major problems that arose out of the DSN Progress Review held in March was the uncertainty in the DSS longitudes.

The basis of the problem is shown in Fig. 5, DSS longitude uncertainties. Prior to the completion of the estimates of DSS longitude based on Mariner 9 data, it had been assumed that the $\sigma_\lambda = 2$ meter requirement of the Viking Project could be satisfied. However, the Mariner 9-based data casts significant question on this assumption and suggests the possibility of a hitherto unsuspected "longitude drift." Possible contributing factors to the apparent "drift" are considered to be Universal Time, emphemeris uncertainties, data analysis anomalies, and DSS hardware anomalies.

A task team has been established under the leadership of D. W. Trask; its activities will be reported in subsequent issues of the DSN Progress Report. Each of these areas is to be studied by the task team with a goal for resolving the problem by September 1973.

Activity on the dual-carrier environment problem referred to in Ref. 1 continues at a somewhat reduced level at DSS 14 and DSS 13.

After completing the welding of all joints in the DSS 14 cone and hyperbola, tests of the telemetry performance under dual-carrier conditions has commenced. The results are presented by Bathker and Brown in Ref. 3.

III. Operations

With the release of the preliminary version of the DSN Operations Plan for Viking (Ref. 4), Organization 420 support for Viking may be considered to have begun. Future reports in this series will include a section on operations support in the areas of documentation, schedules, training, testing, mission support, and problem areas.

References

1. Mudgway, D. J., "Viking Mission Support," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. XIV, pp. 14–15. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1973.

2. *Deep Space Network Preparation Plan for Viking 75 Project (Preliminary)*, Document 614-20, Feb. 1, 1973 (JPL internal document).

3. Bathker, D. A., and Brown, D. W., "Dual Carrier Preparations for Viking," in *The Deep Space Network Progress Report*, Technical Report 32-1526, Vol. XIV, pp. 178–199. Jet Propulsion Laboratory, Pasadena, Calif., Apr. 15, 1973.

4. *Deep Space Network Operations Plan for Viking 75 Project (Preliminary)*, Document 614-21, Mar. 22, 1973 (JPL internal document).

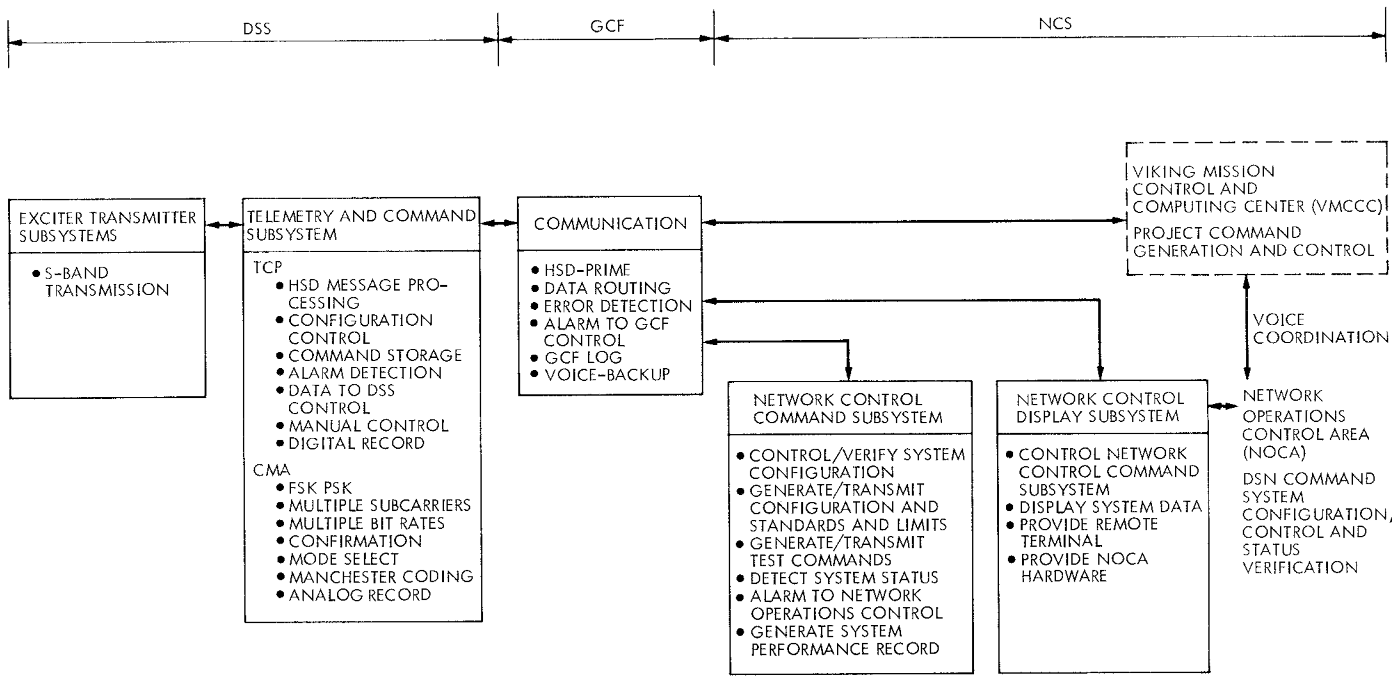

Fig. 1. DSN Command System subsystem functions for Viking 1975

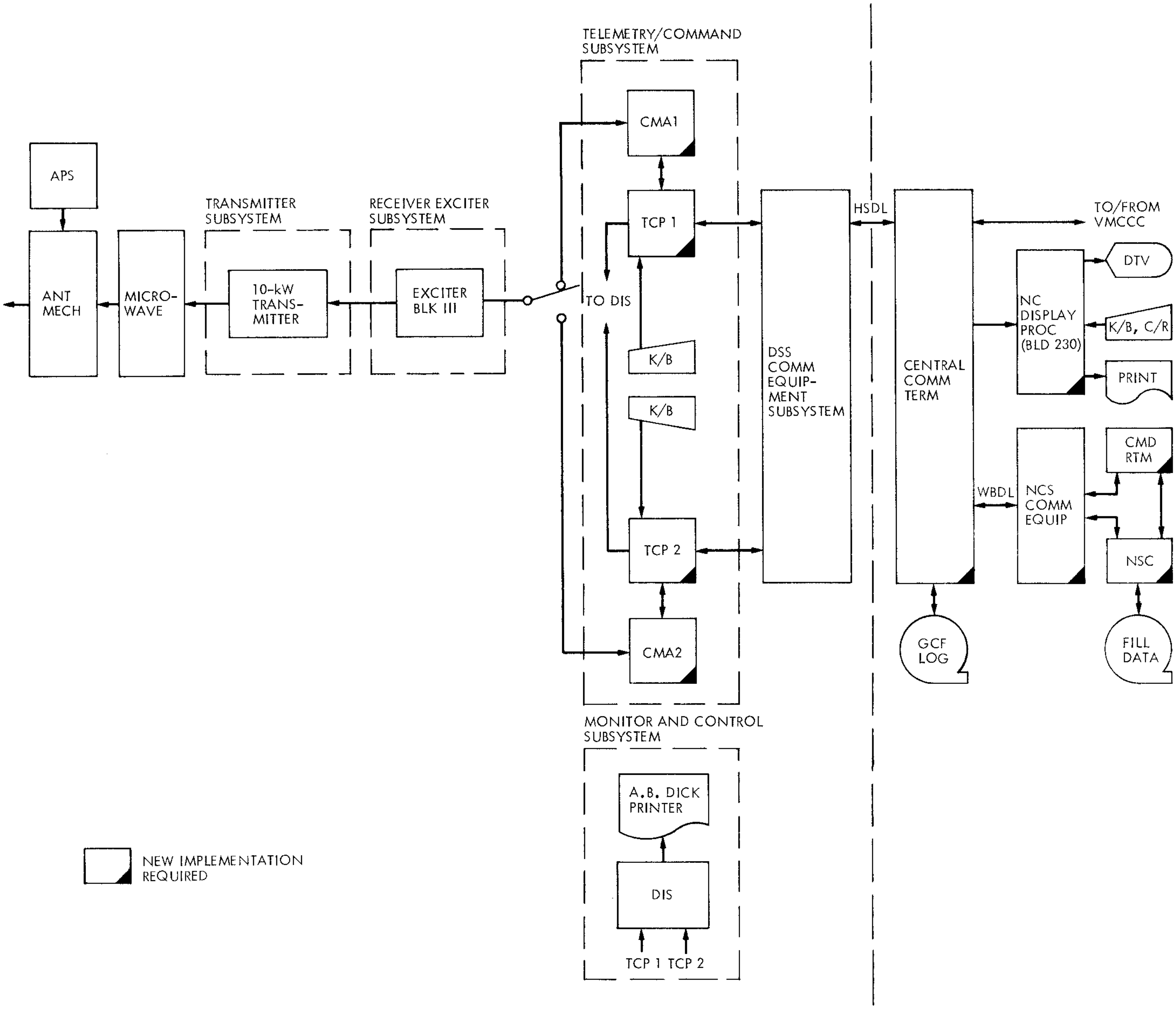

Fig. 2. DSN Command System for Viking 1975 (26-meter DSS)

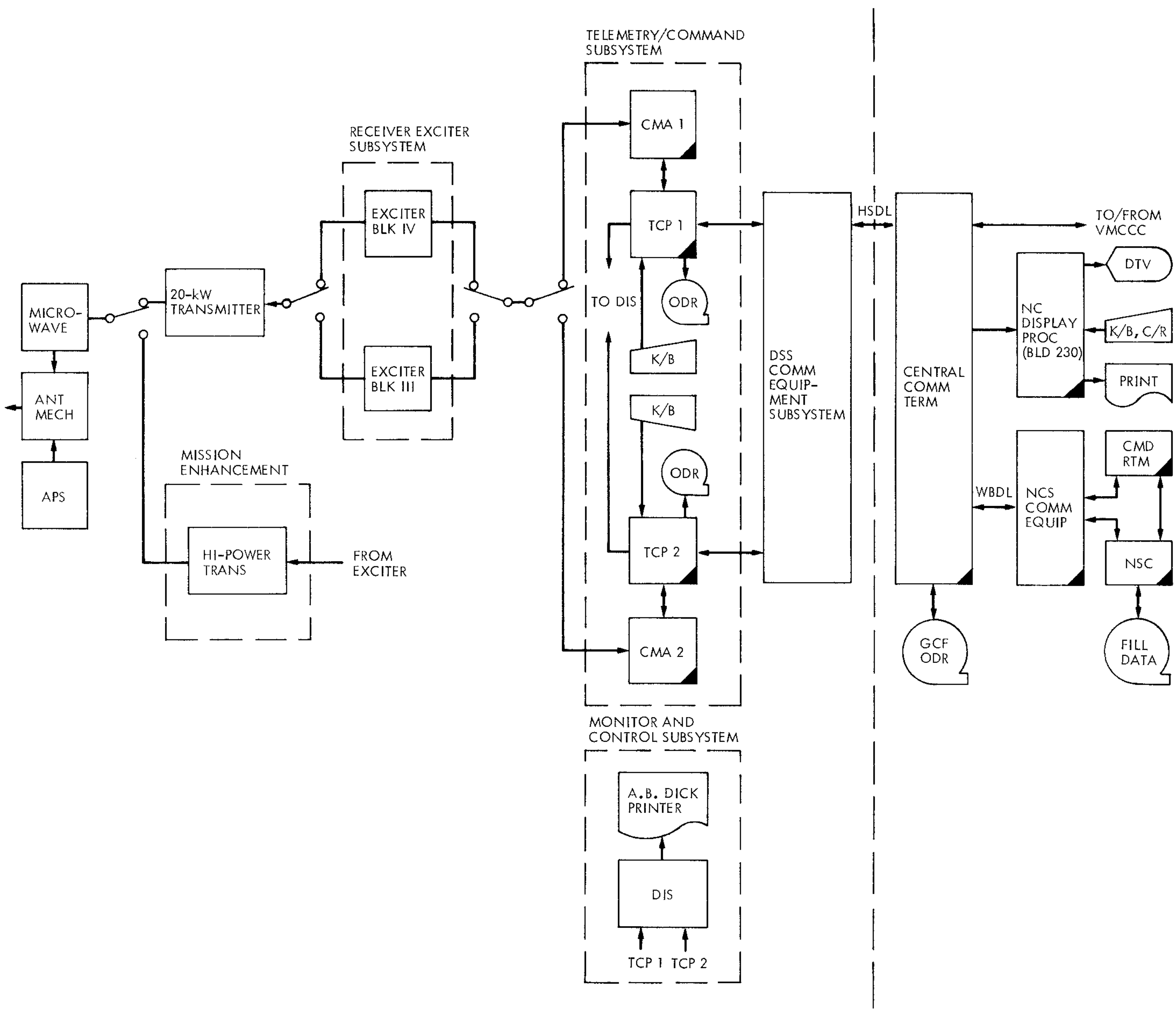

Fig. 3. DSN Command System for Viking 1975 (DSS 14)

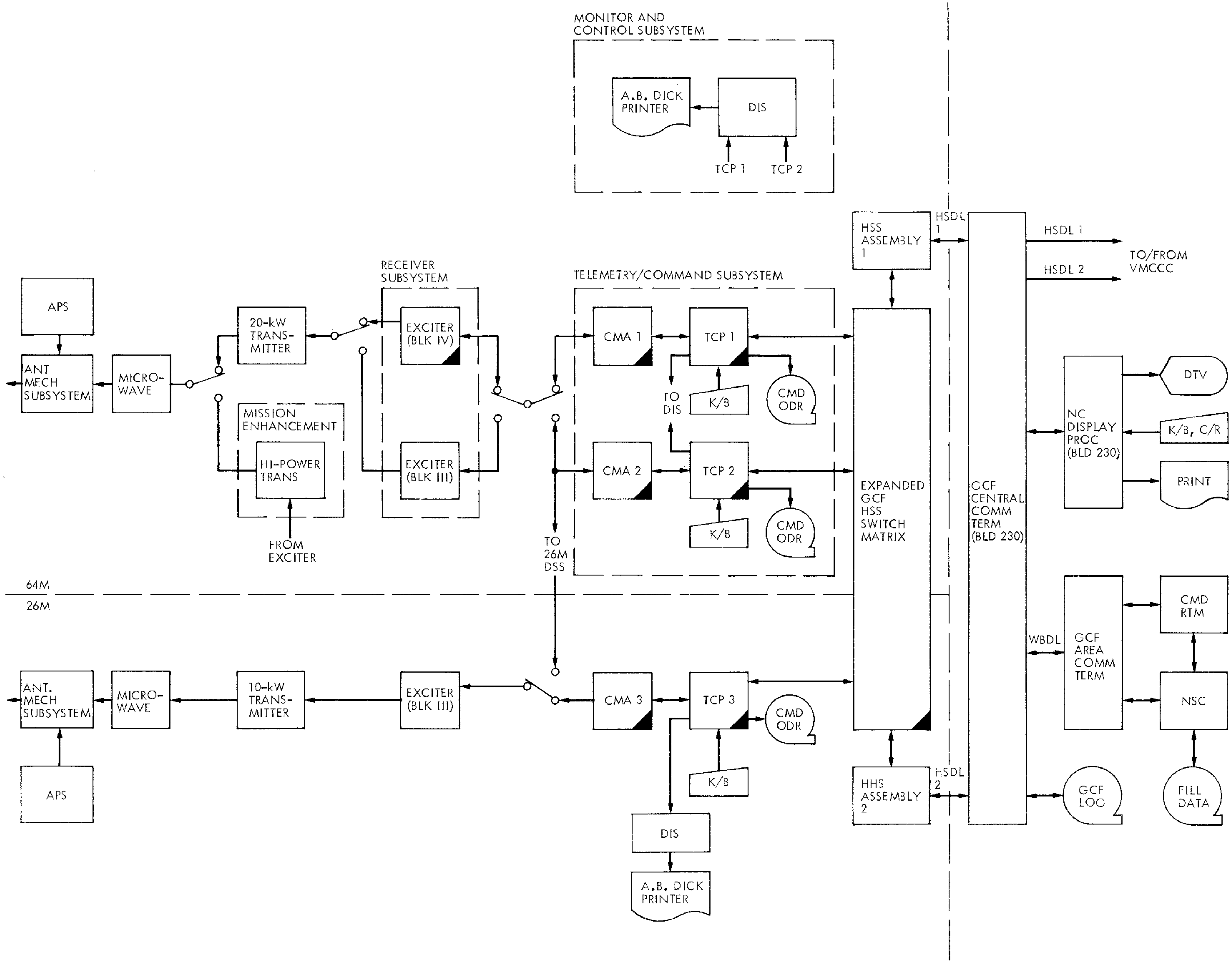

Fig. 4. DSN Command System for Viking 1975 26/64-meter conjoint stations (DSS 42/43 and DSS 61/63)

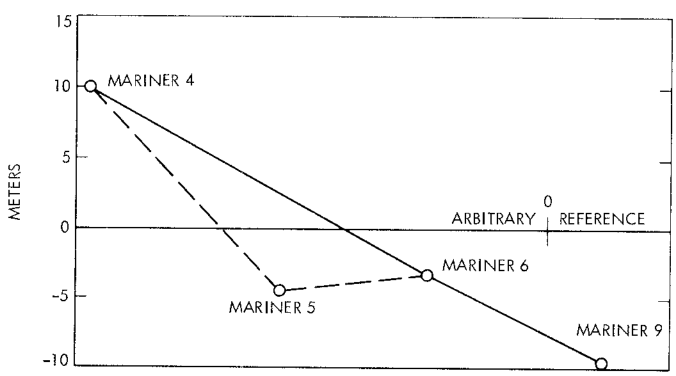

Fig. 5. DSN station location longitude drift problem