Operations of the Reconfigured Ground Communications Facility Central Communications Terminal and the Network Operations Control Center

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The Ground Communications Facility (GCF) Central Communications Terminal and Network Operations Control Center (NOCC) hardware was rearranged, supplemented, and modified and software programs changed to provide an improved GCF and NOCC operational environment and capability. This report addresses Control Center Operations Section (371) activities required to make the 1981 changeover from the old to the new GCF and NOCC configuration.

I. Introduction

A requirement to reduce GCF and NOCC computer count and to provide for an improved operational capability led to the GFC-NOCC reconfiguration effort. The hardware and software changes required to implement the reconfiguration requirements were addressed in Refs. 1 to 3. As previously reported, the GCF-NOCC reconfiguration was essentially completed in April 1981 and provided the following:

(1) A much improved operational capability to monitor and control GCF subsystems.

(2) Reduction in minicomputers from 20 to 16.

(3) Reduction in computer programs from 8 to 6.

(4) Reduction in magnetic tape handling.

(5) Reduction in operator workload due to centralized monitor and control capability, thereby providing a base for reduced manning in the Central Communications Terminal (CCT).

Personnel from DSN Data System Section (338), Control Center Operations Section (371), Deep Space Network Support Section (377), and TDA Engineering Office (430) worked together to develop and implement reconfiguration plans. The plans provided for the transition from the old to the new GCF-NOCC configuration to be accomplished without interruption of the GCF and Network Data Processing (NDP) operations support committed to Flight Projects and other DSN users. The changeover required extensive operator training and considerable integration and testing of equipment and software.

II. Reconfiguration Implementation

To assure that ongoing projects and other DSN users were provided committed operational support it was necessary to implement the reconfiguration in phases which resulted in the coexistence in the CCT of the old and the new configuration. The original configuration of the elements of the GCF, CCT and NOCC involved in the reconfiguration is shown in Fig. 1. To provide for the development and testing of the new software programs and hardware interfaces two additional Mod-Comp minicomputers were installed (by Section 338) in the CCT. These computers became the temporary Error Correction and Switching (ECS) and Data Records Generation (DRG) assemblies and, along with the existing backup Central Communications Monitor (CCM) and Network Communication Equipment (NCE) computers, provided an interim ECS-DRG-CCM-NCE string which processed both high-speed and wideband data.

The interim string was used for development and testing and also provided for informal operator training and general familiarization with the new equipment and software programs. The additional ModComps were connected to the existing CCT equipment and to the Mission Control and Computing Center (MCCC) interfaces, thereby permitting development, testing, and training to be done in a realistic environment.

Beginning in July 1980 installation activities began to implement the GCF-NOCC Reconfiguration Engineering Change Order 79.112. As a result, operations simultaneously operated equipment and software in both the old and new configuration. The resultant configuration was the test configuration shown in Fig. 2. The test configurations improved the ability of operators to acquire on-the-job training in equipment and software which resembled the final GCF-NOCC configuration. From January-April 1981, installation activities took place which resulted in an operational version of the GCF-NOCC configuration. The reconfigured GCF-NOCC, shown in Fig. 3, was used to support Voyager 2 encounter with Saturn.

III. Reconfiguration Operational Phases

The operation of the GCF-NOCC reconfiguration was accomplished in two phases, the first using the test configuration shown in Fig. 2 and the second using the operational configuration shown in Fig. 3. An orderly transition from the old to the new configuration required considerable planning by and coordination between personnel from Sections 338, 371, and 377 and Office 430. A GCF-NOCC Reconfiguration Project Team, headed by J. P. McClure, Section 338, developed and implemented reconfiguration installation, testing, training and support plans. Section 377 prepared two excellent Training Materials Packages (TMP). One of the TMPs covered all of the GCF, CCT and NOCC subsystems and the other TMP applied specifically to the Central Communications Monitor Assembly. In addition, Section 371 prepared and implemented a GCF-NOCC Reconfiguration Operations Support Transition Plan and a Communications Operations Support and Training Plan. The Section 371 plans, supplemented by those prepared by the Reconfiguration Project Team, formed the basis for the operations of the reconfigured GCF-NOCC.

In May 1980, the Communications and Data Processing Operations Group (Section 371), in coordination with the GCF Subsystem Group (Section 338), established an interface which took advantage of operator training opportunities provided during the development phase of the ECS/DRG/CCM software programs. Participation by Operations personnel in the early stages of software testing resulted in their becoming familiar with the new configurations and provided a basis for the development of personnel training packages. During the hardware/software development phase, many GCF and NOCC subsystem verification and acceptance tests were supported by Communications and NDP Operations personnel, and they gained valuable operating experience. Unfortunately, Communications and NDP Operations personnel were unable to take maximum advantage of the training opportunities afforded during the development phase since the priority for limited operations resources was given to the task of preparing for the critical support of Voyager 2's encounter with Saturn.

As ECO 79.112 implementation activities progressed, Operations was able to operate the interim configuration in a parallel mode. Committed support was provided using the old configuration and at the same time the data were processed in the new configuration. The parallel mode of operations provided a means to verify the validity of the performance of the new hardware and software by allowing a comparison of the data processing results of the two configurations.

IV. Flight Project and DSN User Support

The GCF-NOCC Reconfiguration Operations Support Transition Plan prepared by the Mission Coordination Group, Section 371 was implemented beginning on December 1, 1980. Operational support was provided to Flight Projects and other DSN users using the interim configuration.

A. Pioneer Project Data Interfaces

The DSN to Pioneer Project Mission Operations Control Center (PMOCC) was the first interface verified. Telemetry/ Command data from the DSSs were parallel-routed to both the Error Detection Correction (EDC) and Network Log Processor (NLP) computers and to the new ECS-DRG-CCM string. The preliminary testing verified that DSN support

committed to the Pioneer Project could be met using the new hardware and software programs.

The next step was to support the Pioneer Project using only the new configuration. This began on March 10, 1981, and verified the operational capability of the new/revised GCF and NOCC subsystems to support the Pioneer Project. The testing established the following:

(1) That the new ECS, DRG, CCM, NCE, Digital Display Processor (DDP) and Video Assembly Processor (VAP) software and software interfaces operated properly.

(2) That the new hardware interfaces were compatible and functional.

(3) That Intermediate Data Records (IDR), a deliverable data product, could be properly generated in accordance with DSN-Pioneer Project IDR Interface Agreements.

The Pioneer Project evaluated the support provided by the new CCT configuration and concurred that DSN commitments to them were being met.

B. Helios Project Data Interfaces

Development and implementation of the ECS to MCC router interface was successfully completed and this allowed Helios Project testing to begin in mid-February 1981. Tests were scheduled which successfully verified the operational interface between the MCCC and the German Space Operations Center (GSOC), using the ECS to Router interface to pass high-speed data blocks between the MCCC and GSOC. The next step was the scheduling of Deep Space Station (DSS) to MCCC/GSOC demonstration passes. These tests successfully demonstrated that the new configuration could provide DSN committed support to the Helios Project.

C. Viking Project and DSN User Data Interfaces

On April 5, DSS demonstration passes verified that the Viking Project could be supported using the new configuration. Also successfully demonstrated was the DSN's capability to support DSN users. Very Long Baseline Interferometry (VLBI) and Tracking Calibration Data (TCD) demonstration passes processed data using the new configuration. VLBI/TCD IDRs were generated and met IDR Interface Agreement commitments.

D. Voyager Project Data Interfaces

Testing to verify the DSN's capability to meet its commitments to the Voyager Project using the new configuration was much more complex than for other flight projects and required extensive planning and support from all elements of the DSN and MCCC.

1. **IDR generation test.** A Voyager Project IDR generation test was scheduled in August 1980 using the new ECS-DRG-CCM interim string and the ECS-MCCC Router interface. Telemetry data from DSS 12 support of Voyager 2, Spacecraft 32, were processed. The test had as objectives the following:

(a) Error Correction Switching Computer:

(1) Process high-speed data from Station 12.

(2) Log all data on magnetic tape generating Front End Records (FER).

(3) Transmit data to the DRG across GCF Star Switch Controllers (SSC).

(4) Transmit data to MCCC Routers (RTR) across GCF MCCC SSCs.

(5) Receive/transmit Automatic Total Recall System (ATRS) messages to Station 12 during postpass ATRS activities.

(6) Generate and transmit CCM report.

(b) Data Records Generator Computer:

(1) Log high-speed data from ECS on big disc by data stream.

(2) Provide data throughput status reports in real-time.

(3) At end of pass, recall missing data from station using ATRS and log on big disc.

(4) Merge real-time and recall data from big disc to magnetic tape; generate an IDR.

(5) Generate and transmit CCM report.

(c) Central Communications Monitor Computer:

(1) Receive ECS-DRG reports and generate displays.

(d) MCCC Router:

(1) Receive data from ECS across the GCF MCCC SSCs.

Analysis of the test results, including Voyager Data Management Team processing of the IDR, established that Voyager data could be processed by the new hardware and software and that DSN to MCCC high-speed data interfaces were satisfactory.

2. **MCCC Router interface.** The extensive development, testing, and training requirements placed a great demand on the limited ECS-DRG-CCM-Router capability. Close coordi-

nation was necessary to assure maximum and efficient utilization of the new equipment/software programs. After considerable DSN and MCCC testing, the ECS-MCCC Router interface was successfully established with the MCCC Router software transferred from Development to MCCC Operations on March 20, 1981.

3. Ground data system tests. Voyager Ground Data System (GDS) tests to validate telemetry, monitor, tracking, and command data end-to-end system operations were successfully supported. The facilities of CTA-21 (Compatibility Test Area, JPL) were used for the April 1 and April 6 GDS tests. On April 13, a third GDS test was completed with DSS 43. The Voyager Project considered the tests very successful and with all GDS test objectives met all further testing was cancelled.

V. GCF Wideband Subsystem

ECO 79.112 also provided for changes to the GCF WB subsystem and those changes were implemented simultaneously with the changes to the NOCC Display Subsystem and other GCF subsystems. Wideband Network Encoder Decoders (NED) replaced Coded Multiplexer Demultiplexers (CMDs) in the CCT. The NED installation along with installation of new WB unbalanced switches, WB customer interfaces, customer distribution assemblies, and other changes to the WB subsystem allowed wideband data to be processed by the old system or the new system or both at the same time. The interim wideband capability was used to support Voyager and VLBI wideband tests.

VI. Cutover to New Configuration

The testing necessary to verify that the new GCF-NOCC configuration could meet the DSN's committed support requirements was now complete and it was mutually agreed that the cutover to the new configuration could take place. At 8:30 a.m. April 20, all flight support was assigned to the new configuration and the old configuration decommitted. Ten of the 16 computers that were part of the new configuration were placed on-line. Yet to be converted were three EDC Computers, which were to become ECSs 1, 2, and 3, and one High Speed Switch (HSW) Computer and two NLPs, which were to become DRGs 1, 2, and 3. The conversion began immediately after the old equipment was decommitted, and at the end of April 20 all but one EDC and the two NLPs were converted to their new configuration. The two NLPs were converted to DRGs the week of April 20, but due to hardware malfunctions difficulty was experienced converting EDC 4 to become ECS 4. After considerable coordinated effort by Sections 371 and 338 the EDC was finally converted to ECS 4 on May 31.

With communications and NDP support being provided using the new configuration, Operations began experiencing problems that had not been evident when they operated the interim configuration. Operations initiated approximately 120 Discrepancy Reports, from April 20 to June 4, which described problems/failures with the ECS hardware/software/interfaces.

The DRGs also experienced problems, but to a much lesser degree. The operational performance of the new GCF CCT-NOCC configuration became a matter of concern because of the inordinate amounts of problems/failures. With DSN committed to support Voyager 2 encounter with Saturn in the new configuration, it was essential that the operational performance of the reconfigured GCF CCT-NOCC improve considerably. To this end, Section 338 reactivated the GCF-NOCC Reconfiguration Task Team to systematically define the problems, to determine the reasons for the problems, and to implement solutions.

The team meetings began June 10 and continued on a weekly basis until August 13, The team's activities resulted in minor software and hardware changes and operational procedure revisions which when implemented resulted in a decided improvement in the operational performance of the new configuration. That the team's efforts paid off was evident by the fact that Voyager 2's encounter with Saturn was an outstanding success. Contributing to that success was the excellent communications and network data processing operations support provided using the new configuration.

VII. Summary

The GCF-NOCC reconfiguration effort was very complex and required extensive coordination and planning by Sections 371, 338, and 377 and Office 430. Many implementation problems were encountered and were resolved by a coordinated effort of all concerned. The implementation challenges were met and the operational support committed to flight projects and DSN users was successfully accomplished using the reconfigured GCF-NOCC.

DSN Engineering and DSN Operations learned many important lessons during the long period required to develop, test, and implement the GCF-NOCC reconfiguration. DSN Engineering/Operations agree that the lessons learned should be applied to future implementation activities. Summaries of the lessons learned are:

(1) Need for close coordination between Engineering and Operations beginning early in the development of major implementation tasks.

(2) Need for documented operational testing and training plans early in the implementation phase. Early knowledge by Operations of testing/training requirements can provide time needed to properly develop the resources required to train/test operations personnel to operate complex new systems.

(3) Need for early development of documentation which describes the new hardware and software capabilities and functions.

(4) Need to implement means for testing new capability, to the maximum extent, independent of the use of operational equipment.

(5) Need to form combined Engineering/Operations teams early in the implementation phase. The team's objectives to be the development and implementation of detailed plans which document the steps necessary to take a major new capability from the development to the operational support phase.

References

1. McClure, J. P., "GCF-NOCC Reconfiguration," in *The Deep Space Network Progress Report 42-55*, pp. 86-89, Jet Propulsion Laboratory, Pasadena, Calif., Feb. 1980.

2. Bremner, D. S., and Hung, C. K., "Ground Communications Facility and Network Operations Control Center Reconfiguration," in *The Deep Space Network Progress Report 42-58*, pp. 108-109, Jet Propulsion Laboratory, Pasadena, Calif., Aug. 1980.

3. McClure, J. P., "GCF-NOCC Reconfiguration," in *The Deep Space Network Progress Report 42-66*, pp. 288-290, Jet Propulsion Laboratory, Pasadena, Calif., Dec. 1981.
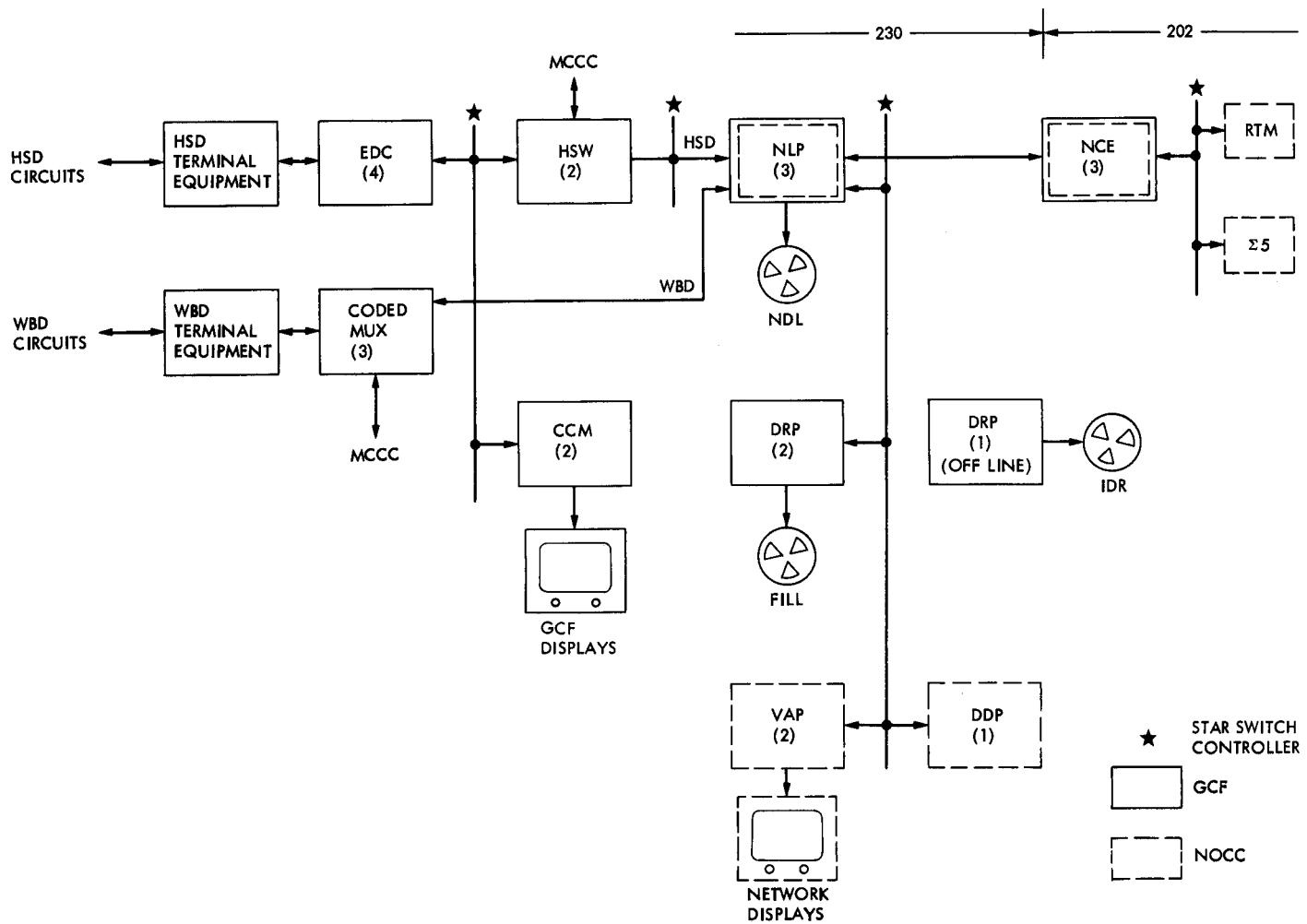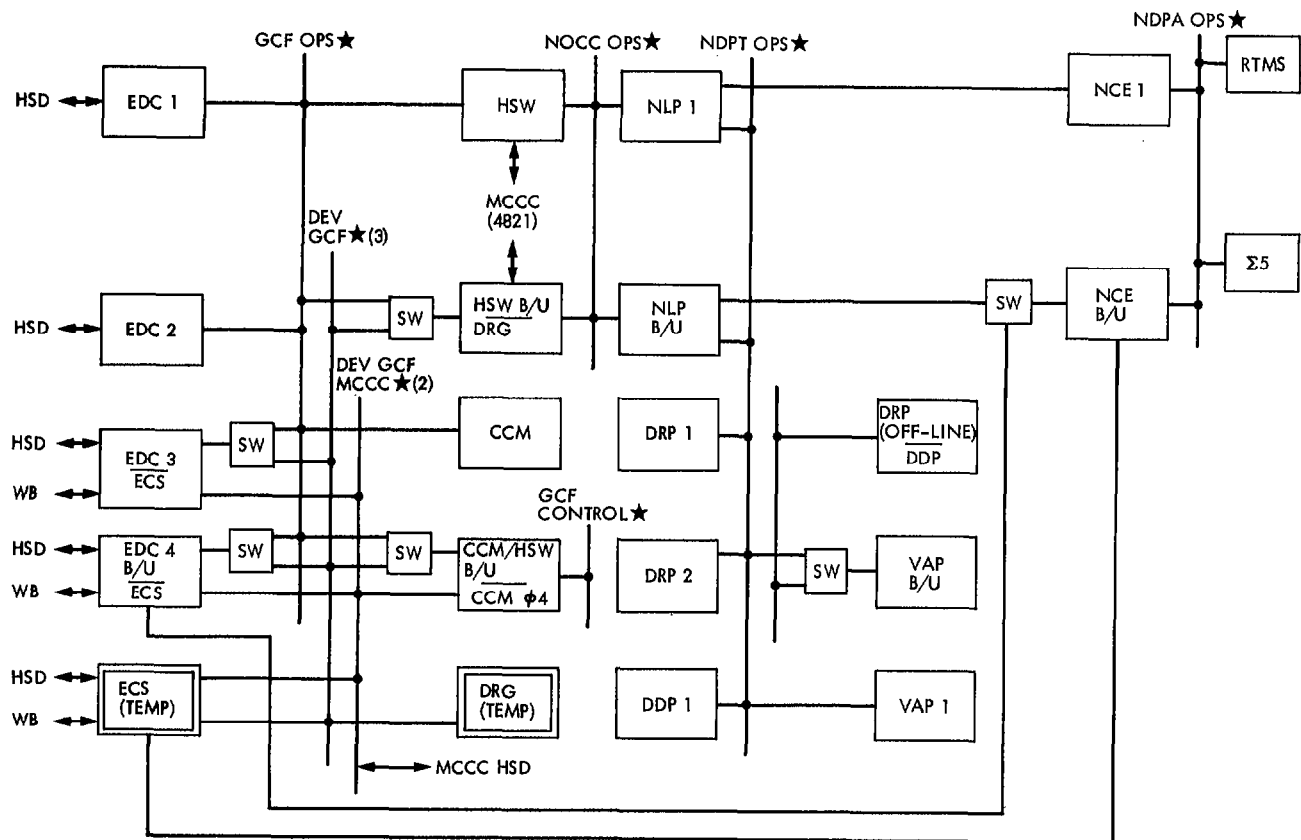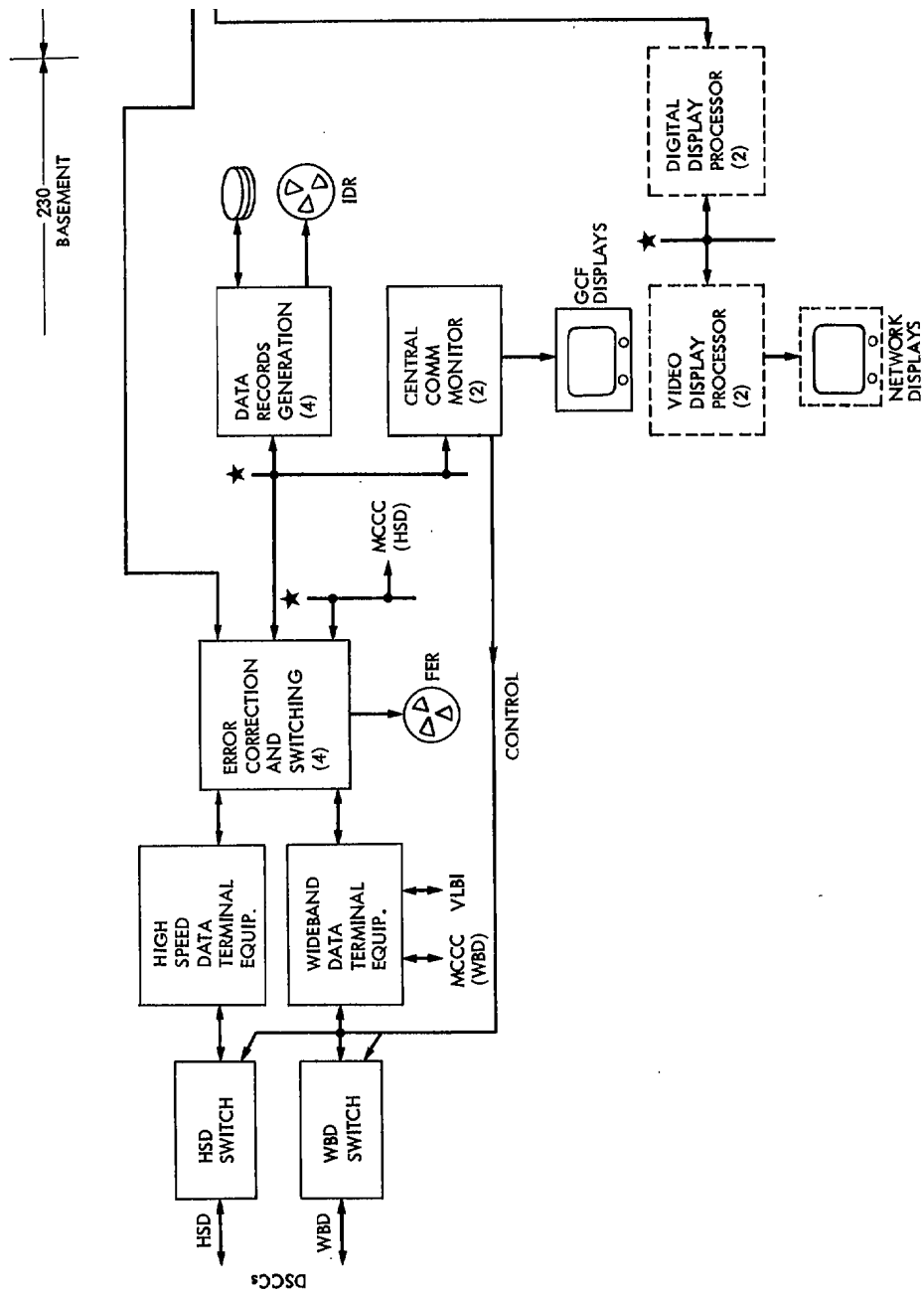
Fig. 1. Original GCF CCT-NOCC configuration

Fig. 2. Test configuration

Fig. 3. Reconfigured GCF-NOCC

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