The GCF Mark IV Implementation and Beyond

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This article presents a brief overview of the major subsystems that comprise the Mark IVA GCF along with key information on basic functionality that may be inadequately or imperfectly understood. Concluding paragraphs describe the evolving GCF System as it is currently being designed.

I. Introduction

The Ground Communication Facility (GCF) was modified in order to meet the requirements of the DSN Mark IVA implementation now nearing completion. The key characteristics of the GCF did not change markedly during this time frame (see Figs. 1–3). The underlying architecture of the GCF was left intact while modifications were initiated in order to expand the capacities of its constituent subsystems. Communications support at Goldstone, Spain and Australia was unified and consolidated under the aegis of the incipient Deep Space Communications Complex (DSCC). Economics of shared functionality have evolved whereby the collective communications capacity at each DSCC is shared by the competing demands of its DSS components. The DSN was expanded in this time frame to begin assuming responsibility for the scheduling and operation of the 26-meter network. One 26-meter antenna is located at each of the three DSCC sites. Voice, data and teletype circuits required for Spain andAustralia continue to be ordered from the NASA Communications (NASCOM) network. NASCOM Engineering has delegated to the GCF the overall responsibility for communications support between Goldstone and JPL. This has resulted in expansion of the intersite Goldstone microwave facilities that link DSCC 10 with the Communications Center known as GCF 10, and the installation of a fiber-optic communication path between the DSCC and the outlying 26-meter station.

Current plans call for continued GCF expansion in the area of capacity and augur significant changes in the area of key characteristics. High-rate missions and Very Long Baseline Interferometry (VLBI) tracks late this decade and into the 1990s provide the principal motivations toward added capability. Efficiency, generality, automation and simplification militate toward a restructuring of the communication architecture to embody layering techniques, variable size data units, and interfaces to external networks.

II. Digital Communications Subsystem

The Digital Communications Subsystem performs the exchanges of digital data blocks between the DSCC's and the Central Communication Terminal (CCT) at JPL (Fig. 4). Block multiplexing on the available communication circuits permits shared use of the lines among projects. Communication capability at each DSCC has been implemented in a modular fashion in order to save on circuit lease costs. Four configurations are possible at each DSCC:

(1) One 56 kilobits/sec (kb/s) duplex circuit

(2) One 56 kb/s duplex circuit and one 56 kb/s simplex circuit

(3) One 56 kb/s duplex circuit and two 56 kb/s simplex circuits

(4) One 56 kb/s duplex circuit and one 224 kb/s simplex circuit.

All simplex circuits carry data in the direction of the DSCC at JPL only. Configuration changes are possible by scheduling/descheduling of circuits. No software changes are required.

The Digital Communications Subsystem is composed of the following principal assemblies:

A. Station Digital Communication (SDC) and Central Digital Communication (CDC) Subsystems

The SDC and CDC Subsystems consist of all data transmission equipment including line interfaces, data sets, Network Encoders Decoders (NED), Communication Buffers (CB), digital and analog test equipment, and patch facilities for trouble isolation as well as a front-end line interface between the actual data sets and NED appearances (see Figs. 5 and 6).

The data transmission equipment is provided by NASCOM including the line interfaces/converters, data sets and common carrier interfaces associated with the overseas DSCCs.

The CDC implementation includes a 40-by-40 digital line switch that provides the connection from the data set to a particular NED/CB combination that plugs in to a specific port on one of the five Error Correction and Switching (ECS) front-end computers at the CCT. This switch expedites normal activation of data circuits and simplifies the switchover to the backup ECS in the event of hardware failure.

B. Area Routing Assembly (ARA)

The ARA is the DSN computer component that performs the GCF functions at the DSCC. Two identical Mod Comp II/25 computers are so configured: one for prime and one for backup. The ARA receives data blocks from all DSCC computers and multiplexes them to JPL on the available circuitry. In the reverse direction, data received from JPL is distributed to DSCC computers according to destination code and data type.

The ARA in cooperation with the ECS will perform error correction of data blocks by retransmission of data transferred on the 56-kb/s duplex circuit. The ARA will attempt retransmission of an unacknowledged block one time only.

The ARA accepts and transmits either 1200-bit or 4800-bit data blocks on the available circuitry. The circuits are utilized as follows:

(1) All 1200-bit data blocks will be sent on the 56-kb/s duplex line. They cannot be sent on the simplex line(s).

(2) All 4800-bit data blocks are normally sent on the simplex circuits. When necessary and if loading permits, all 4800-bit data traffic from a specified link (a link is usually equivalent to a DSS) may be moved from the simplex line to the duplex line.

Based on these facts and on the configuration possibilities discussed earlier, the following conclusions are possible:

(1) While the maximum GCF DSCC to JPL rate is 280 kb/s (56 + 224), no single link-originated 4800-bit stream may exceed 224 kb/s, and no single 1200-bit stream may exceed 56 kb/s.

(2) Error correction is normally applied to the low rate 1200-bit traffic from the DSCC.

In addition to these functions, the ARA writes Original Data Record (ODR) tape files of data transmitted. The maximum recording rate is restricted to the maximum transmission rate: 280 kb/s. Data from each DSS is normally recorded on its own tape drive although data from multiple DSSs can be combined on a single tape if desired.

C. Error Correction and Switching (ECS) Computer

The ECS is the DSN computer component resident at the JPL CCT that interfaces the communications circuits from the DSCCs. There are five ECS computers configured identically for support. Four serve a prime data handling function and one is designated as a backup. Responsibilities include servicing serial interfaces to Remote Mission Operation Centers (RMOC), Remote Information Centers (RIC), the Mission Control and Computing Center (MCCC) and the Network Operations Control Center (NOCC).

Capabilities of the ECS include the following:

(1) Error Correction of data blocks in cooperation with ARA at the DCCCs

(2) Multiple routing of data blocks to the NOCC, GCF Data Records and to any two other processing centers

(3) Delivery of data blocks predicated on the source originating the data

(4) A multilevel real-time dump facility enabling full traceability of data blocks through the program.

III. Analog Intersite Communications

The Mark IVA implementation at Goldstone left the DSS 12 antenna and front-end equipment in place approximately 13 miles from the Signal Processing Center (SPC) at the DSCC. In addition, the NASCOM STDN 26-meter antenna (DSS 16) at the Goldstone site was itself about 7–8 miles from the SPC of the DSCC. In order to transfer baseband signals to/from these two antenna sites, it was necessary to expand and enhance the existing Intersite Communications Subsystem. Microwave links were used to connect DSS 12 to SPC-10, and a fiber-optics link was installed to provide the baseband conduit between DSS 16 and SPC-10.

The existing microwave channels between DSS 12 and SPC-10 were expanded from 8 to 16 duplex channels. A channel is here defined as a communications link in one direction. The following are provided:

(1) Two receiver baseband channels

(2) Two command modulation channels and one confirmation channel

(3) One full duplex frequency and timing channel

(4) One frequency STD channel

(5) One FEA-12 surveillance TV channel

(6) Two test modulation (SIM) channels

(7) Two full duplex diversity multiplex channels that support voice, 56-kb/s wideband circuits, LAN, gateway circuits, 230.4 kb/s simplex circuit and low speed and control circuits.

At DSS 16 it was necessary to connect the front-end equipment at the receiver with the telemetry and command equipment at SPC-10 in order to provide DSN/NASCOM cross support capability for projects beginning with AMPTE. This capability was provided with the completion in July 1984 of a six-fiber underground installation of a fiber optics system with optical transmitters and receivers located both at DSS 16 and at SPC-10. At the present time, up to 3 baseband signals may be transmitted in each direction by multiplexing FM modulated carriers over the fiber optic link. Currently, there are two fibers in use for telemetry and command baseband signal transfer, with additional usage planned for voice and ultimately digital transfers when the 26-meter network is fully integrated into the DSN.

IV. Data Records Subsystem

The Data Records Subsystem is comprised chiefly of the three prime Data Records Generator (DRG) computers and one backup computer resident at the CCT. Functional components of this subsystem reside also at the DSCC in order to provide gap "fill" information for data not received in real-time. The principal function of the DRGs is to create tape Intermediate Data Record (IDR) files for project delivery.

The DRG software checks selected data streams for correct source code, spacecraft I.D., User Data Type, time tag, block serial number and error status code. The DRG detects gaps in the data and outputs real-time statistics providing the percentage of good data received. At the end of a pass, a recall operation may be initiated requesting data from the DSCC in order to improve the percent of good data on the IDR.

V. Voice Subsystem

The Mark IVA voice assemblies at the DSCCs were configured from the tactical intercom assemblies (TICS), Communications junction modules, and station switch assemblies that were previously in use. There were no changes made to the equipment at the JPL CCT end (Fig. 8). At the Signal Processing Center (SPC) of the DSCC, new communication panels were developed for use at the front console. New circuit boards were developed to bring the obsolescent TIC panels more in line with current technology.

VI. Implementation Activities

A DSN system level approach is being taken to redesign the GCF to meet the communication necessities of the 1990s. Both Local Area Networks and wide area networks will form part of this system. A software layering architecture shall be employed in these networks in order to simplify user interfaces to the system and allow modification to lower level structures without affecting the upper echelon layers. Key changes during this implementation include megabit/second communication rates from the DSCCs, automatic recall of data *before* the tracking pass is complete, processing and handling of variable size data blocks from the user and Gateway interfaces to external networks located both at the DSCC and the CCT. Most of these upgrades will be operational by 1989.

A. High-Rate DSCC Communication

The current maximum data rate from each DSCC will be increased from the present 280 kb/s to 1,544 kb/s. The design calls for this capability to be modular so that the Communications capacity at any DSCC may be incrementally adjusted to fit the combined requirements of all active projects in any given time frame. Error correction of data blocks will be extended to encompass the entire bandwidth of data transmitted from the DSCC.

B. Near Real-Time Recall

The spare bandwidth available on the DSCC communication circuits shall be utilized in order to allow recall of data blocks before the tracking pass is complete. By this method, the data that could not be successfully transmitted in real-time because of line outages or transient overloads will be shunted to a temporary data file. This data will subsequently be retransmitted when loading and line conditions allow on the excess available bandwidth from the DSCC to JPL. Independent of any operator intervention, the CCT data records function will organize the playback data into separate files and merge the blocks with the original real-time stream in order to provide the most complete data file.

C. Variable Size Data Blocks

Perhaps the most revolutionary innovation to the GCF System will be the capability of accepting variable size data units from all originating computers. Within specified minimum and maximum length constraints, the data originator shall be free to deliver to the receiver data blocks that are sized to match perfectly the application being supported. This will contribute to overall network efficiency and minimize the overhead labor required to prepare data for transmission. This is also consistent with packetization.

D. Gateway Interfaces

Gateway interfaces will be developed at the DSCC and at the CCT in order to permit data communication with networks external to the DSN. The architecture for gateway interfacing will be installed when the GCF system is upgraded. Actual gateway software will be developed upon identification of the requirement to exchange data with a particular network. The location of gateway interfaces at the overseas sites will permit circuit economies ensuing from the proximity of the external network to the DSN access point at the DSCC.

References

1. Evans, R. H., "DSN Ground Communications Facility," *TDA Progress Report 42-65*, pp. 9-18, July and August 1981, Jet Propulsion Laboratory, Pasadena, Calif., Oct. 15, 1981.
2. Mortensen, L. O., "GCF Mark IV Development," *TDA Progress Report 42-70*, pp. 161-172, May and June 1982, Jet Propulsion Laboratory, Pasadena, Calif., August 15, 1982.
3. Crowe, R. A., "Design Issues in the GCF Mark IV Development," *TDA Progress Report 42-75*, pp. 132-139, July and September 1983, Jet Propulsion Laboratory, Pasadena, Calif., November 15, 1983.

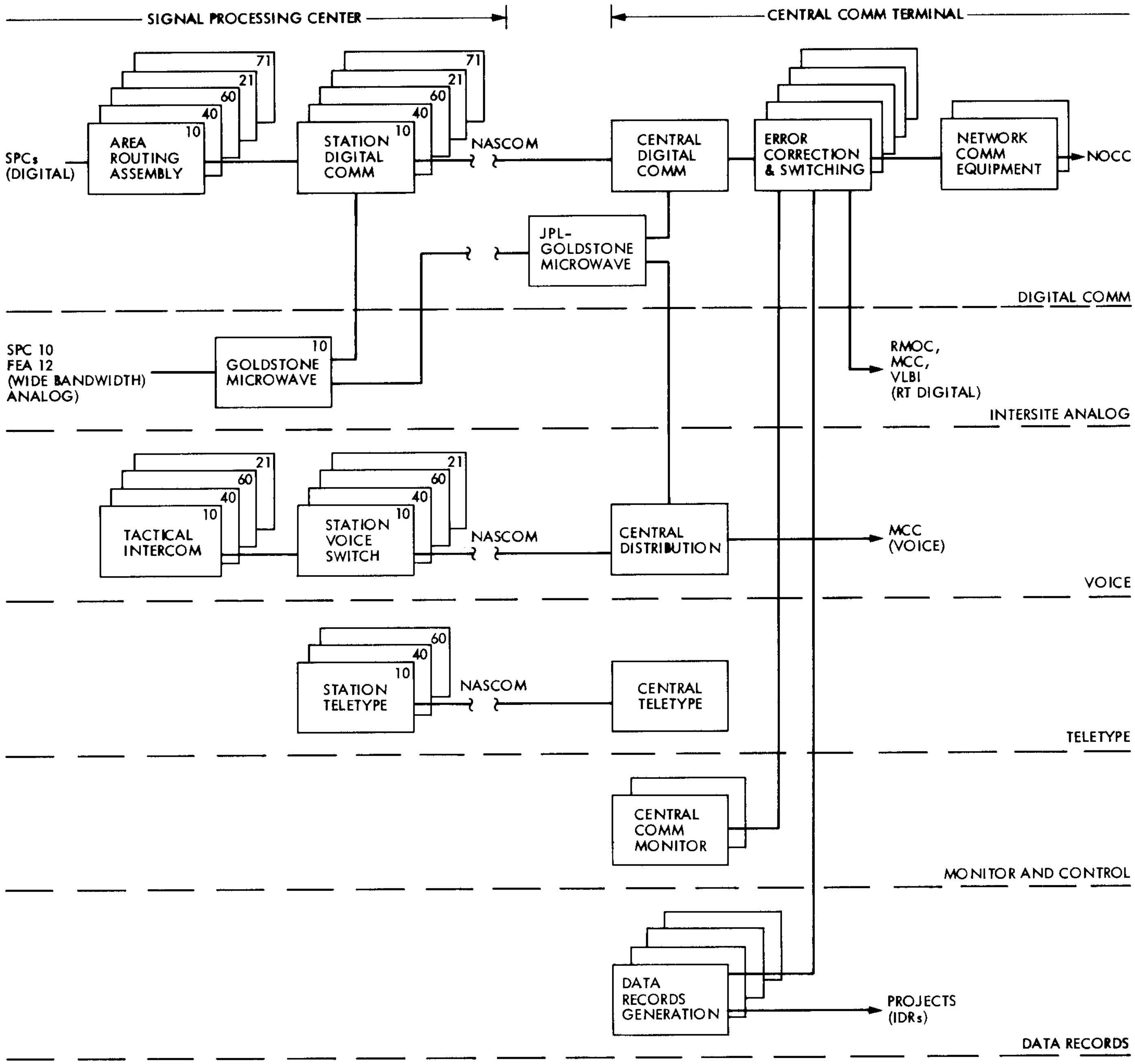

Fig. 1. Mark IV-A era GCF subsystems

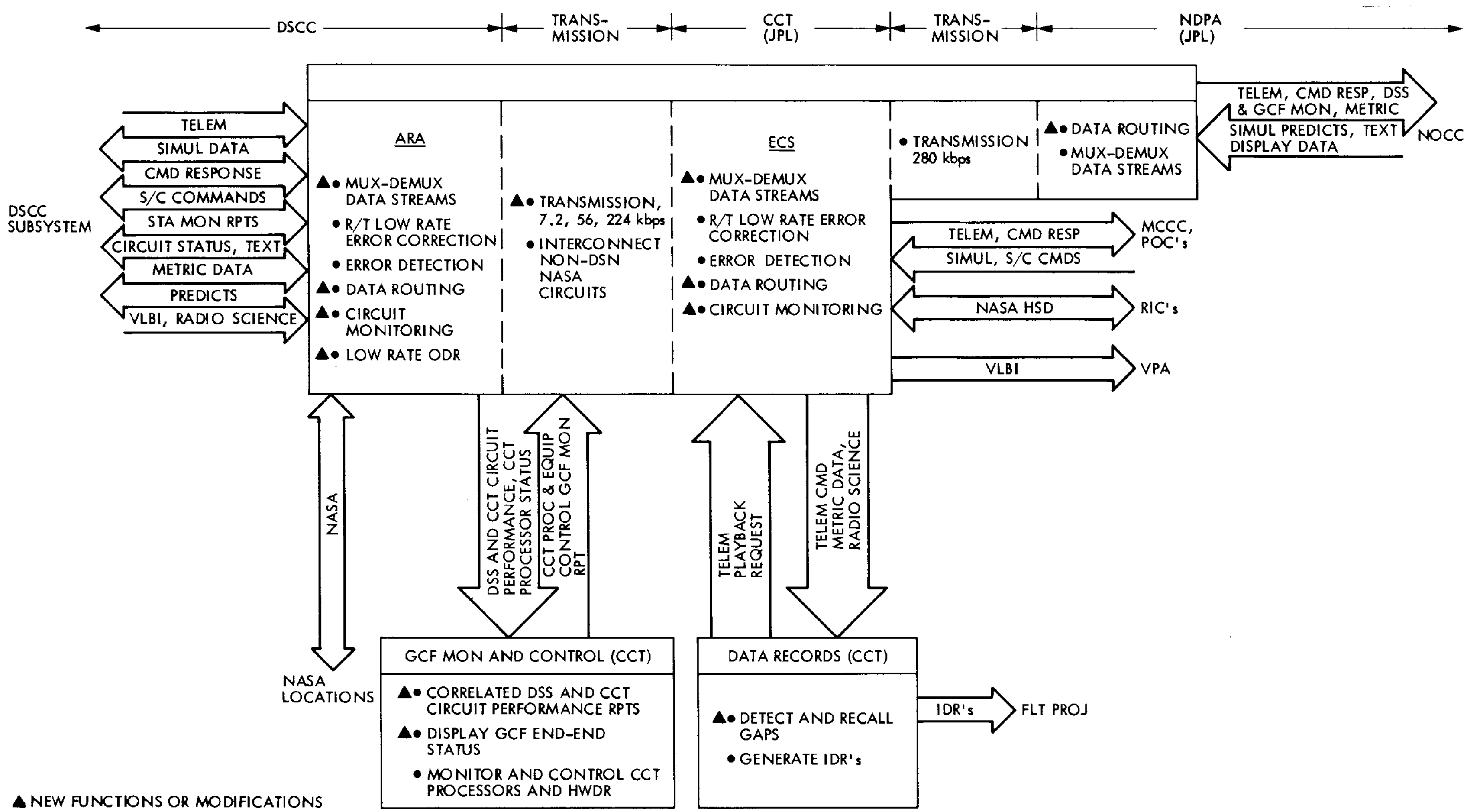

Fig. 2. Mark IV-A end-to-end digital communications, data record, monitoring, and network communications equipment functions and interfaces

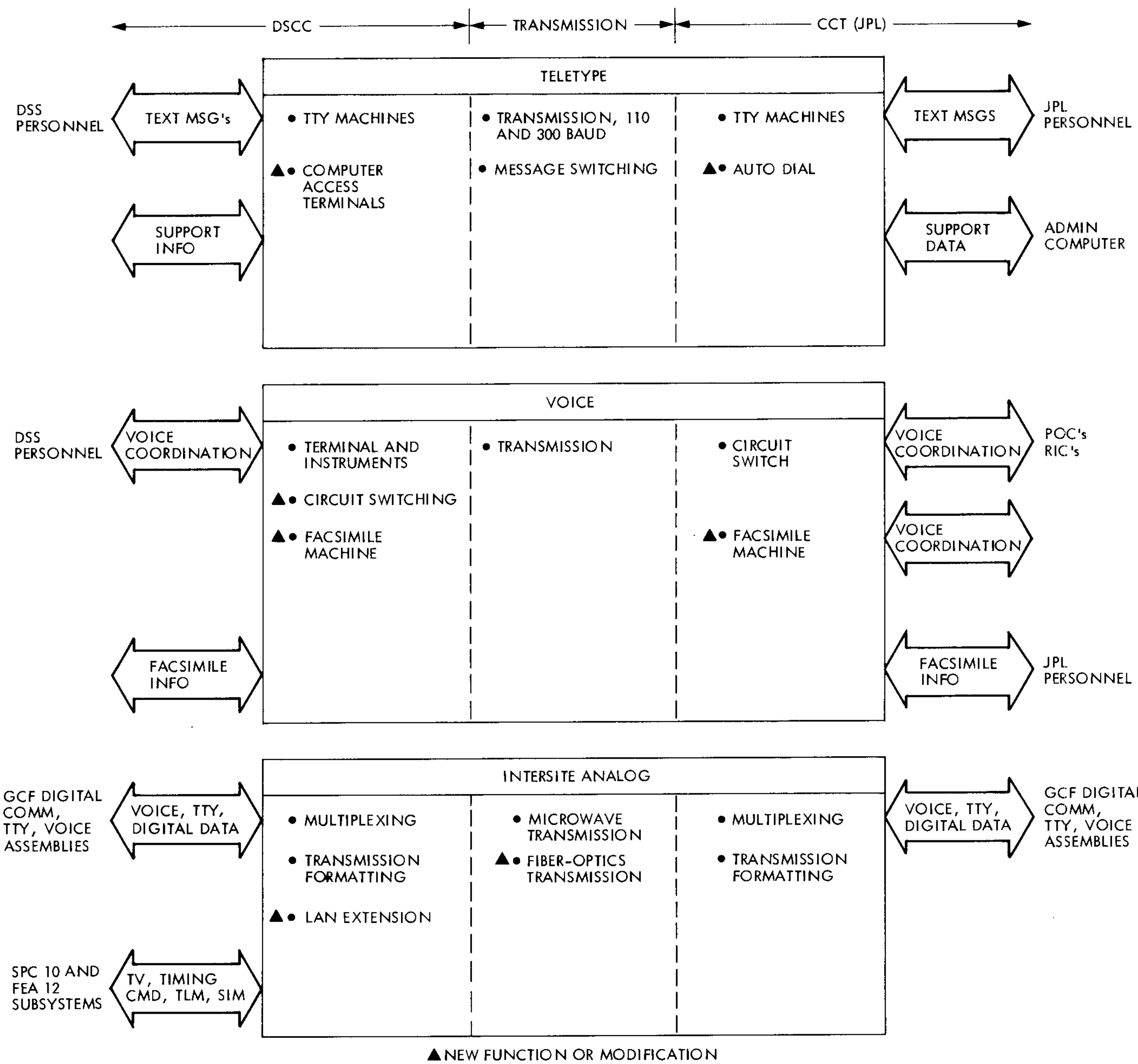

Fig. 3. Mark IV-A end-to-end teletype, voice, and intersite analog functions and interfaces

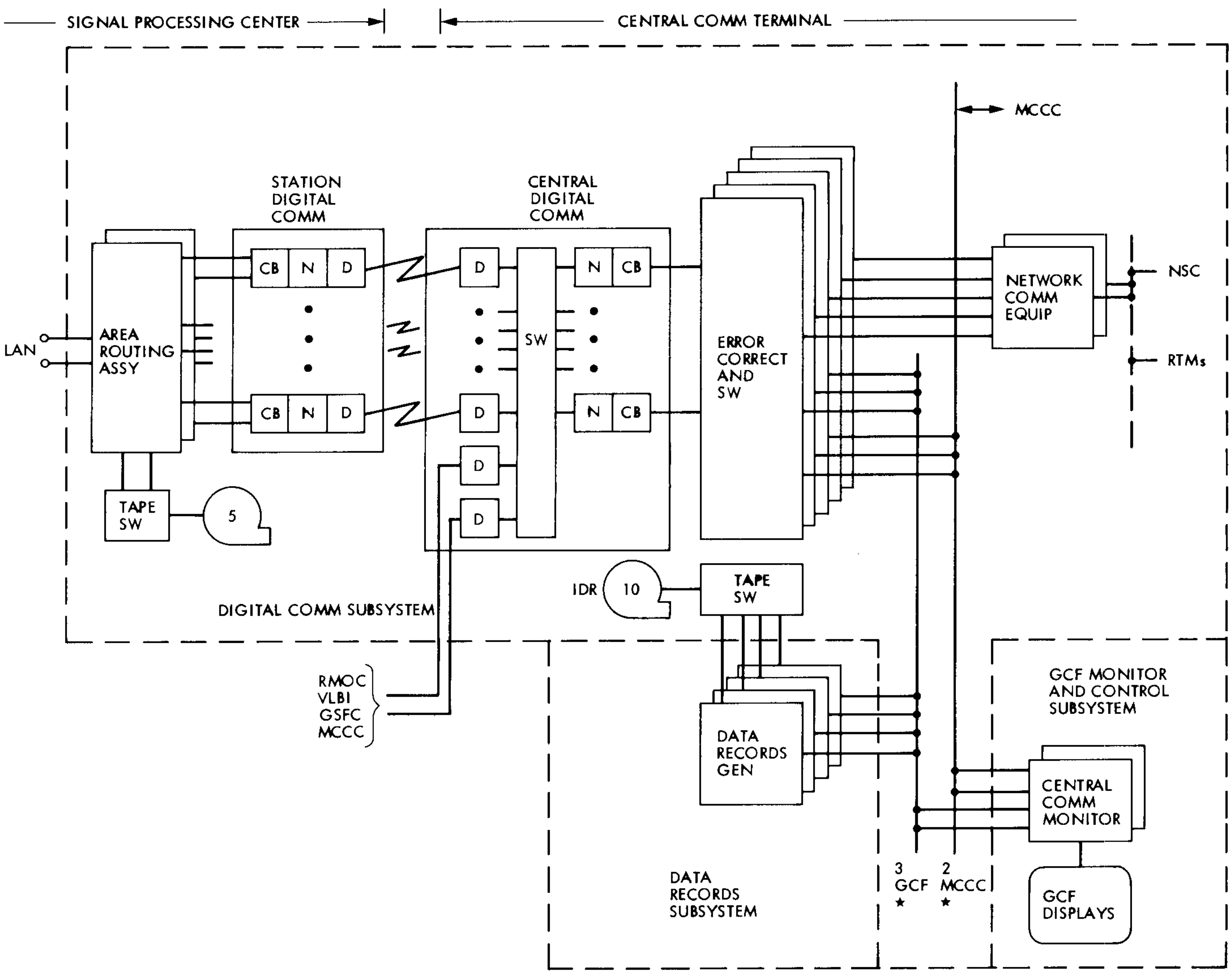

Fig. 4. Digital communiations subsystem overview of GCF digital configuration

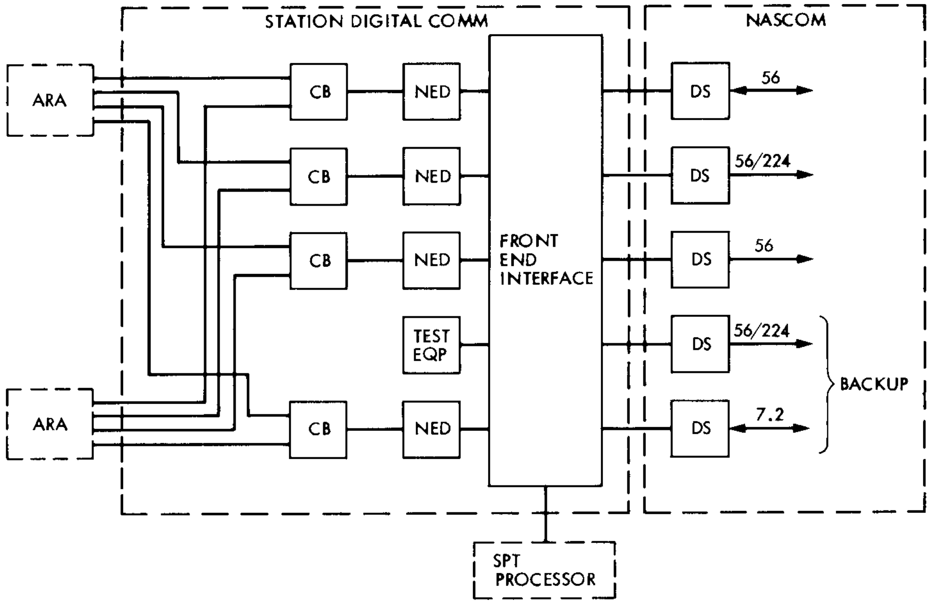

Fig. 5. Data transmission, station digital communications

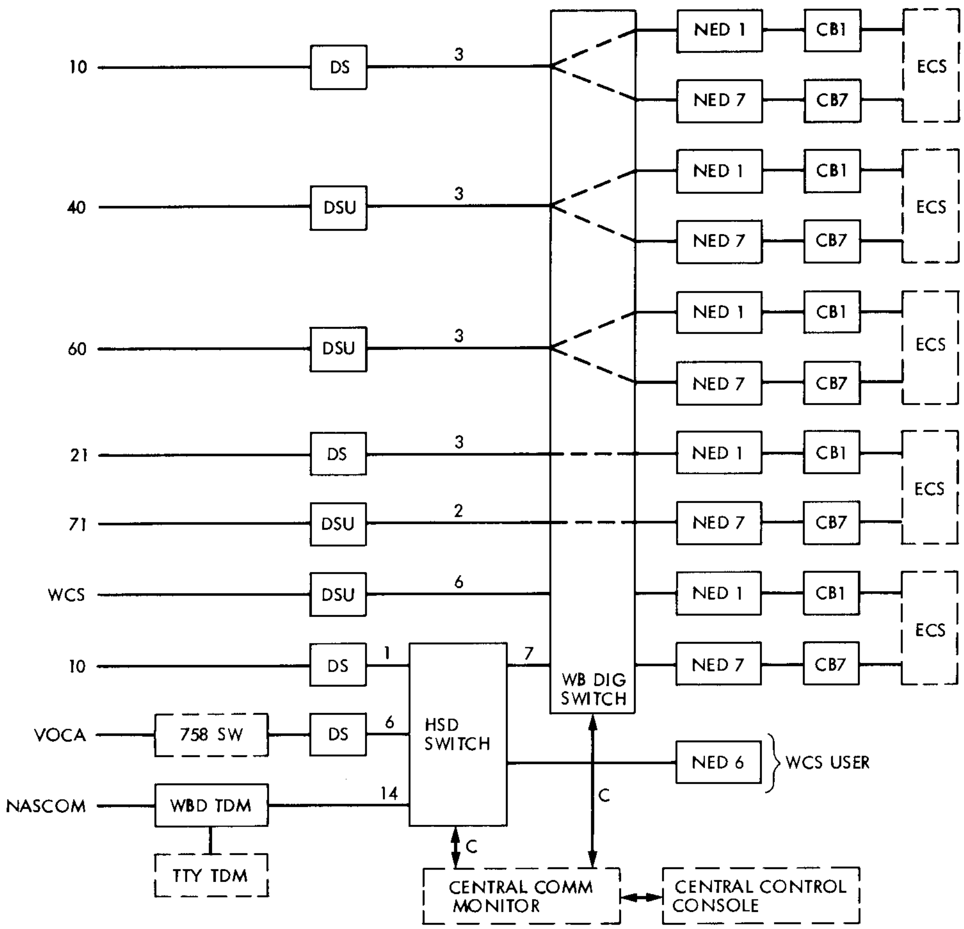

Fig. 6. Data transmission, central digital communications

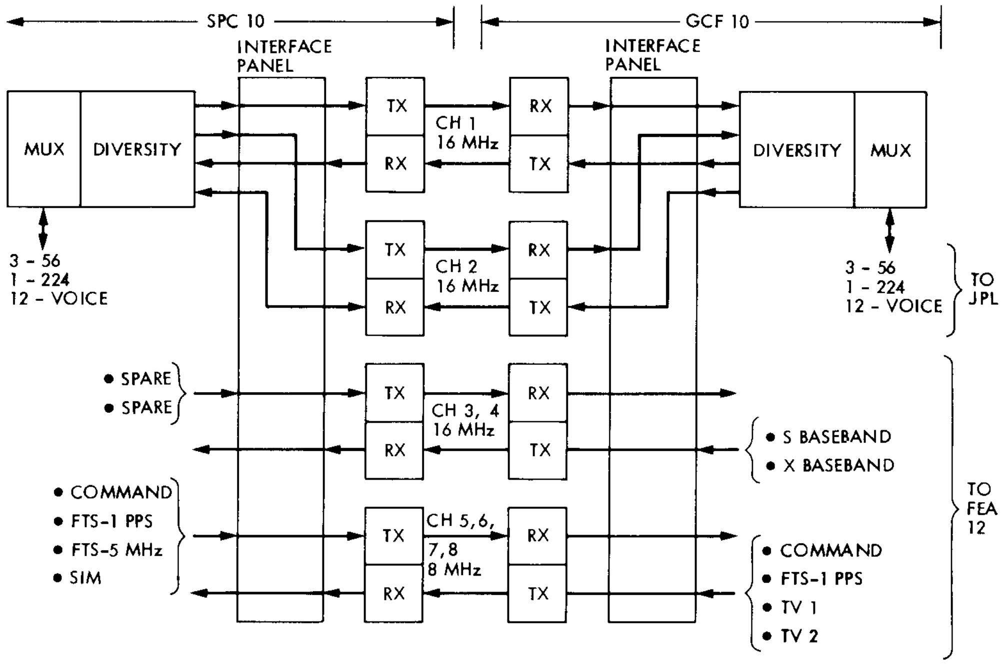

Fig. 7. Intersite microwave configuration, general design

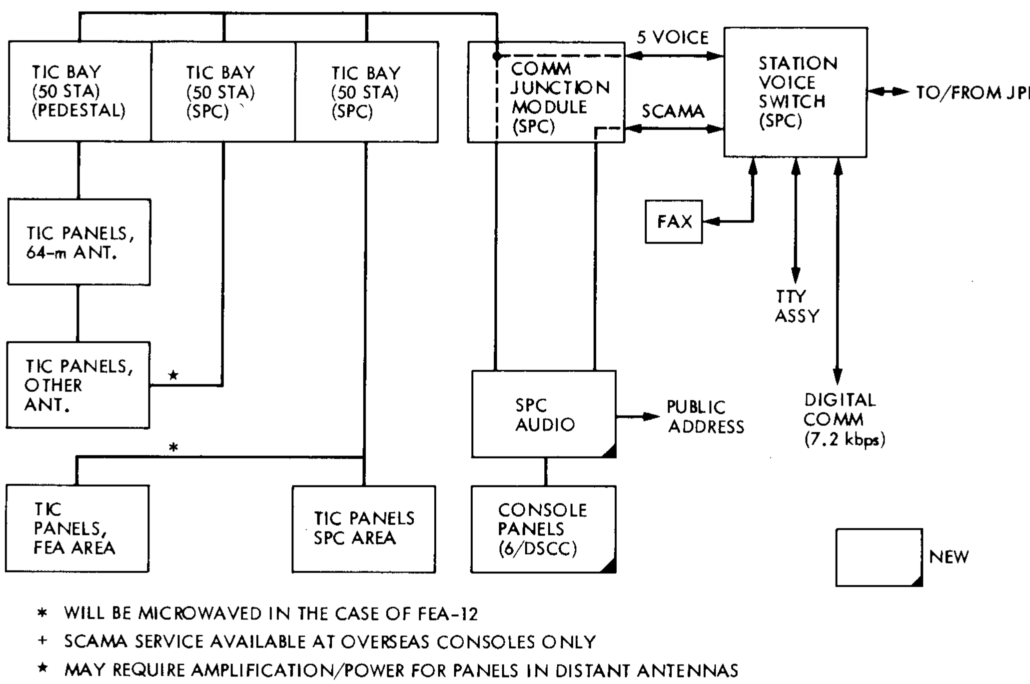

Fig. 8. DSCC voice, general design