Deep Space Network Mark IVA Description

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This article describes the general system configuration for the Mark IVA Deep Space Network. The arrangement and complement of antennas at the communications complexes and subsystem equipment at the Signal Processing Centers are described. A description of the Network Operations Control Center is also presented.

I. Introduction

The Mark IVA Deep Space Network (DSN) Implementation Project was initiated in 1980 to implement the most complex change to be made to the DSN since its inception. The objectives of the Mark IVA Project were to reduce operation costs, to improve reliability and maintainability, and to increase telemetry reception capability for support of the Voyager Uranus encounter and subsequent planetary missions. These objectives were accomplished by replacing separated, individual antenna control rooms with a centralized signal processing center at each of the three Deep Space Communications Complexes (DSCCs), adding new control and data system computers and local area networks, and building new 34-meter antennas. At the same time, 26-meter antennas from NASA's Ground Spaceflight Tracking and Data Network (GSTDN) were added to the DSN as part of the Network Consolidation Project (Ref. 1).

The Mark IVA DSN has provided outstanding support for all required critical mission activities. These missions include Venus Balloon, International Comet Explorer (ICE), Halley Pathfinder, GIOTTO, and Voyager Uranus Encounter. A significant increase in data return to the Voyager Project was possible because of the techniques developed to array the new and existing antennas for improved telemetry reception.

II. Mark IVA Network Configuration

The new network configuration is shown in Fig. 1. It consists of four antennas, a Signal Processing Center (SPC), and an Earth Orbiter Link at the DSCCs located at Goldstone, California, and Canberra, Australia. There are three antennas at the Madrid, Spain, DSCC; the 34-meter High Efficiency (HEF) antenna is to be added in 1987. Communication facilities to connect these complexes to the Network Operations Control Center are included in the DSN.

At the overseas complexes, the antennas are colocated within 1 or 2 kilometers in order to ease operations and maintenance and to enhance the capability of arraying multiple antennas. At Goldstone, the 34-meter Standard antenna is located at the Echo site which is 12 miles from the SPC at the Mars site. Also, at Goldstone, the 26-meter antenna with the Earth Orbiter Link is located 7 miles from the SPC. Each antenna within the complex has some locally mounted equipment: antenna drive and control equipment, low-noise amplifiers, receiver front ends, and transmitters. The balance of the Deep Space Communications antenna-associated equipment – antenna pointing, microwave instrumentation, transmitter control, receiver, and metric data – are located at the SPC. The SPC also includes the assignable link equipment: telemetry, command, radio metric, radio science, and Very

Long Baseline Interferometry (VLBI) processing equipment. The Complex Global equipment including the Frequency and Timing Subsystem (FTS), Test Support, and Communications are also located in the SPC. The 26-meter link equipment for Earth Orbiter communication is not located in the SPC at any of the DSCCs.

III. Antennas

Each complex is to have four antennas, configured as follows:

(1) *64-Meter*: This pre-Mark IVA antenna is configured for S-band transmission and reception and X-band reception. This is the prime antenna for deep space communications and for radio metric data, radio science data, and VLBI applications.

(2) *34-Meter Standard*: This pre-Mark IVA antenna at each complex is configured for transmission of S-band and reception of S-band and X-band. It is used for deep space communications and for radio metric data. It is also used to support high earth orbiters.

(3) *34-Meter High Efficiency*: New 34-meter High Efficiency antennas were implemented at the Australian and Goldstone complexes. (DSS 65 in Madrid will be added in 1987.) They are configured for both X-band and S-band reception and are used primarily for deep space down-link support. An X-band transmission and radio science VLBI capability is planned for addition in 1987.

(4) *26-Meter*: The 26-meter antennas were relocated in Spain and Australia to the proximity of the SPCs. The Goldstone 26-meter was not relocated. These antennas are used for S-band transmission and reception in support of Earth Orbiter and High Earth Orbiter communications and for radio metric data.

IV. Signal Processing Center

A simplified block diagram of a Signal Processing Center is shown in Fig. 2. This shows the general subsystem complement. Detailed configurations and connections are described in other articles. The SPC is configured to support operation of each antenna individually, or to array any combination of the antennas.

As indicated, antenna control, receiver/exciter, and radio metric tracking subsystem equipment is associated with each antenna as appropriate. Only transmitting antennas have exciters and tracking equipment. For the 64- and 34-meter antennas, the Telemetry and Command Subsystems are each organized into four groups while the Monitor and Control Subsystem is organized into three groups. Each group can be independently assigned; the groups are thus assigned to form up to three "links." Each "link" has the equipment necessary to support one spacecraft mission, with receiver, antenna, tracking, command, and telemetry equipment. The link can handle a single antenna or an array. Each link is controlled by a single operator stationed at the Link Monitor and Control Console. The link assignments, including the antenna and associated equipment, are performed by the Complex Monitor and Control according to an established schedule. Other subsystems provide test support, technical facilities, frequency and timing, maintenance, and radio science support. Details for the SPC System configurations are presented in other articles.

V. Earth Orbiter Link

The control and processing equipment for Earth Orbiter and High Earth Orbiter support is not integrated into the SPC. In general, the equipment is the same as that being used in the GSTDN. There are two notable exceptions: only a single spacecraft link can be supported and the telemetry processing equipment has been updated. Additionally, there is a cross-support connection that enables a spacecraft link through the 26-meter front end to be processed in the SPC. The reverse is also true in that a 34-meter Standard antenna front end can be connected to the Earth Orbiter link processing equipment.

The Earth Orbiter link support includes separate communications circuits to the Goddard Space Flight Center Network Control and Project Operations Control Centers.

VI. DSN Network Operational Control Center

Data received at the control center is forwarded either to local JPL or remote mission operations centers as shown in Fig. 3. In parallel, the data is also routed to the Network Operations Control Center (NOCC) where data monitoring and network control functions are performed. Monitoring functions are performed in the real-time monitor processors, which were retained from Mark III. The software in these computers was upgraded to be compatible with the Mark IVA design. In addition, a processor was added to perform the Network support functions, including providing predicts, sequence of events, and schedule data to the SPCs. The controllers in the NOCC are provided with displays allowing them to monitor and control network activities including Earth Orbiter link activities.

VII. Communications

The communications between the SPCs and the Central Communications Terminal (CCT) at JPL were modified as part of the Mark IVA Project. This modification permits the cost-effective utilization of available circuits while still providing the flexibility to protect critical data. The communications processor at the SPC is capable of multiplexing data from all of the SPC links into a single circuit or of transmitting critical data in a separate complex circuit.

Reference

1. Yeater, M. L., Herman, D. T., and Sanner, G. E., "Networks Consolidation Program," in *The Telecommunications and Data Acquisition Progress Report 42-59*, July and August 1980, p. 107–120, Jet Propulsion Laboratory, Pasadena, Calif., Oct. 15, 1980.

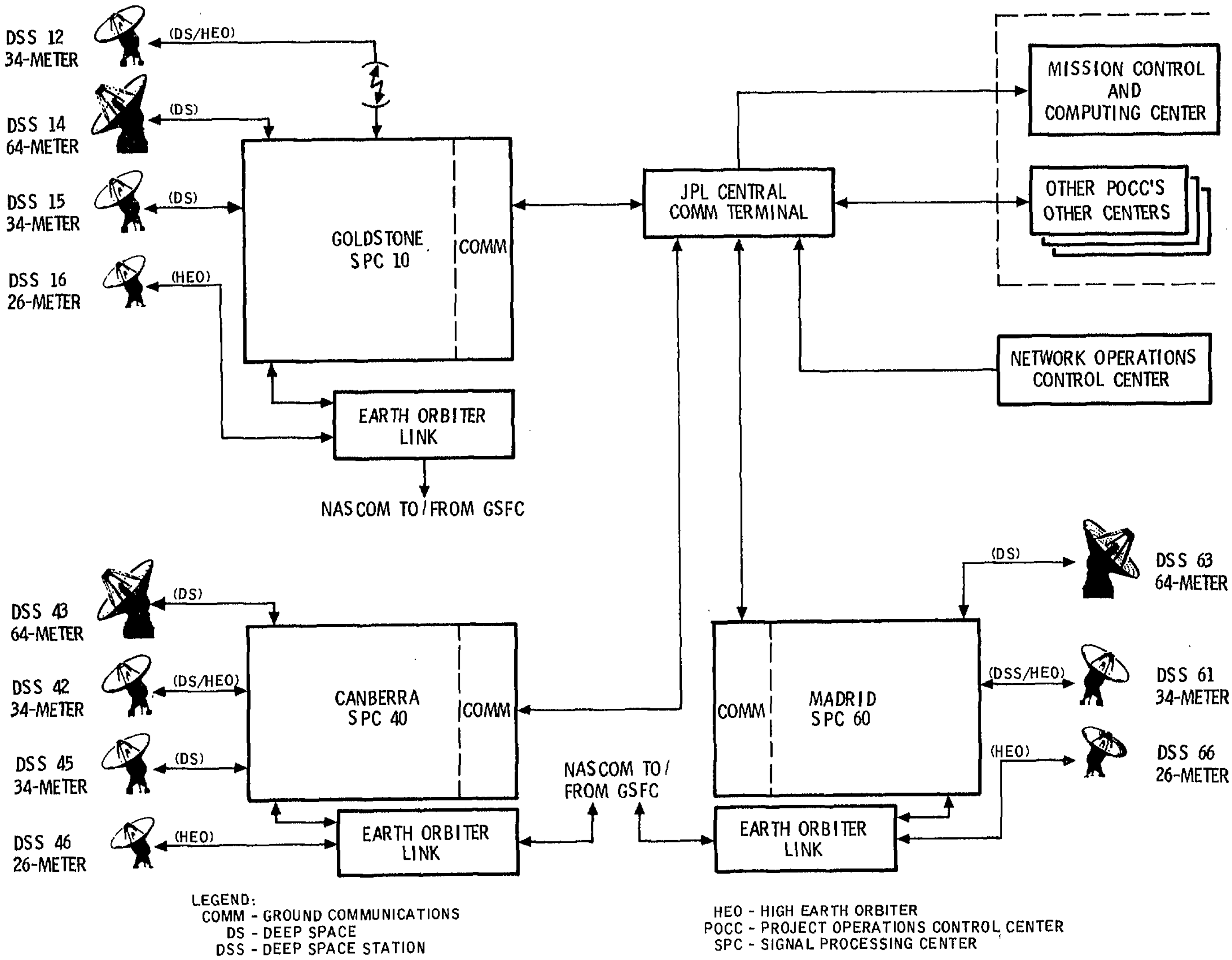

Fig. 1. Deep space network Mark IVA configuration

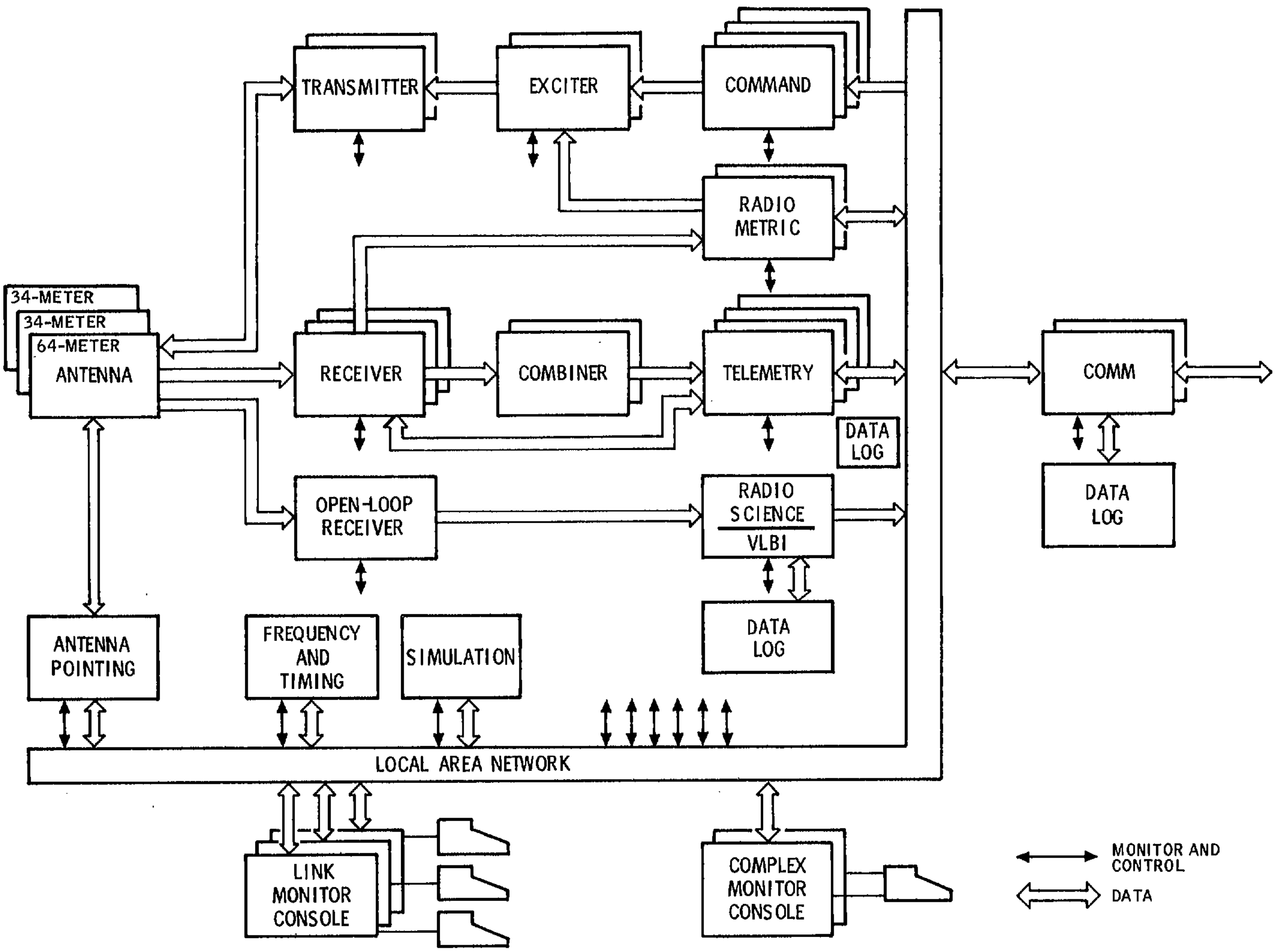

Fig. 2. Mark IVA Signal Processing Center, simplified block diagram

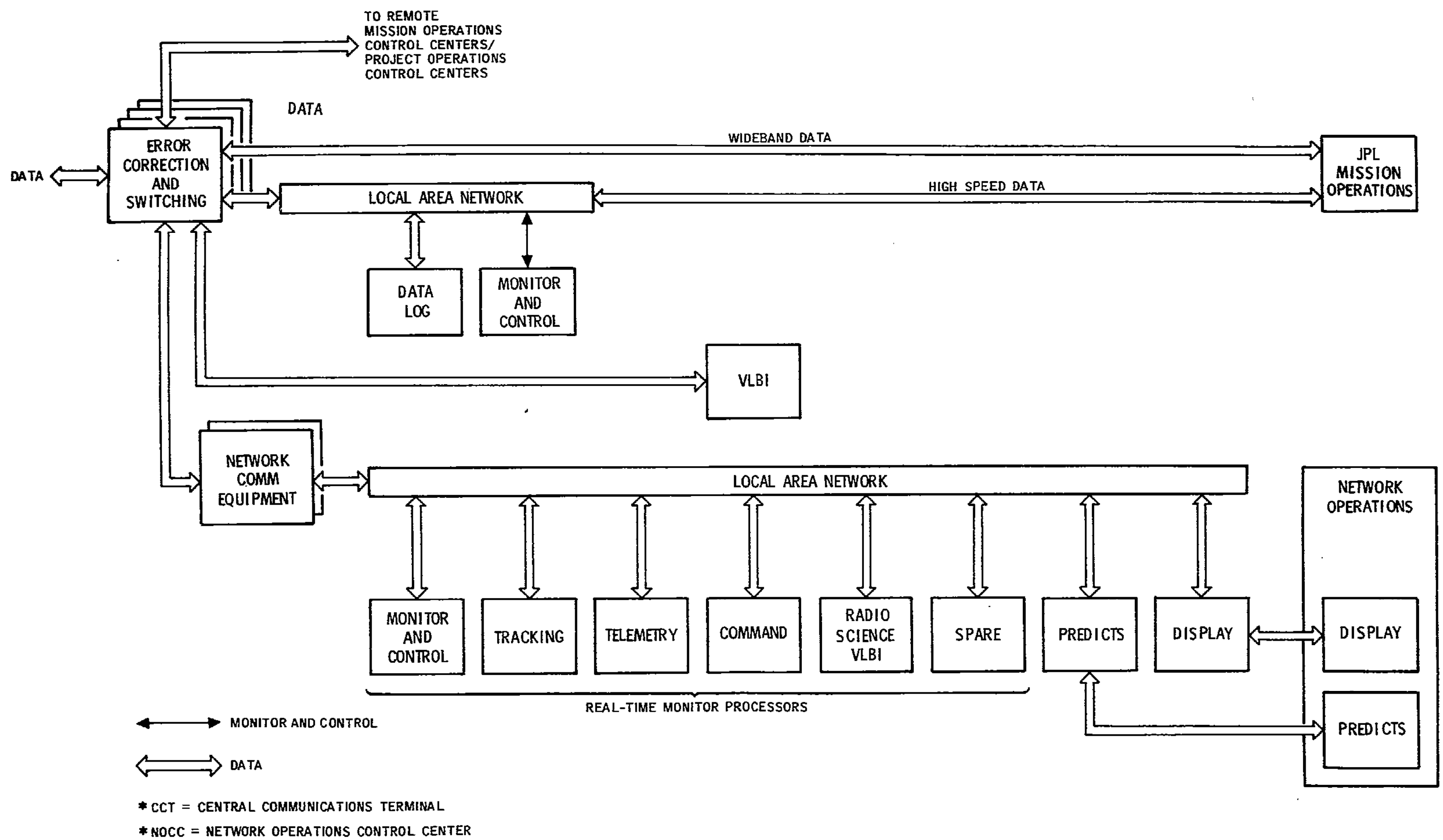

Fig. 3. Mark IVA NOCC, simplified block diagram