Mark IV-A DSCC Telemetry System Description

R. Burt
TDA Engineering Office

This article provides a description of the Deep Space Communications Complex (DSCC) portion of the Mark IV-A Telemetry System. This system is currently being designed as a replacement for the Mark III. The Ground Communications Facility (GCF) and Network Operations Control Center (NOCC) portions of the DSN Telemetry System will be changed less extensively. These changes, which are presently not well understood, will be described in later articles.

I. Introduction

The present DSN Telemetry System, the Mark III, is described in Ref. 1. The DSN is undertaking a major modification of the Mark III. The modified Network, described elsewhere in this volume, will be called the Mark IV-A, and will be implemented between 1983 and 1985. The DSCC portion of the DSN Telemetry System will be changed in two major ways as a result of the Mark IV-A DSN implementation:

(1) Two 34-meter antennas will be added to each Deep Space Communications Complex (DSCC). The arraying of those antennas with the existing 64- and 34-meter antennas will provide the equivalent of two separate 64-meter antennas or two 64-meter antennas arrayed together. To accomplish this, the DSCC will be modified to provide carrier arraying and baseband combining of three 34-meter antennas and one 64-meter antenna.

(2) The Telemetry System will be configured to support either two deep space missions and one highly elliptical orbiter, or two highly elliptical orbiters and one deep space mission. Highly elliptical orbiter (HEO) missions will have data rates up to 1.2 Msps modulated directly on the carrier. Since the maximum Ground Communications Facility (GCF) rate will be limited, data rates higher than 115 kbps will be recorded at the Signal Processing Center (SPC) and played back in non-real time.

Implementation of these changes, when combined with the existing capabilities, will prepare the network to support both DSN and HEO missions.

The DSN missions will be the following:

Pioneer 6 through 9

Pioneer 10 and 11

Pioneer Venus

Viking

Voyager

Galileo

International Solar Polar

The Highly Elliptical Orbiter (HEO) missions will be the following:

ISEE-C (International Sun Earth Explorer)

AMPTE (Active Magnetospheric Particle Tracer Experiment)

- CCE (Charge Composition Explorer)
- IRM (Ion Release Module)

OPEN (Origin of Plasmas in the Earth's Neighborhood)

- IPL (Interplanetary Physics Laboratory)
- GTL (Geomagnetic Tail Laboratory)
- PPL (Polar Plasma Laboratory)
- EML (Equatorial Magnetosphere Laboratory)

Note that there are two AMPTE and four OPEN spacecraft.

II. Key Characteristics

The key characteristics of the DSCC portion of the Mark IV-A Telemetry System are:

(1) Standard DSN data rate capability: up to 250 kilosymbols per sec (ksps).

(2) Highly Elliptical Orbiter Mission data rates up to 1.2 megasymbols per sec (Msps).

(3) Carrier arraying and baseband combining for up to 6 antennas.

(4) Deletion of analog recording.

(5) Four complete groups of telemetry equipment at each complex, each with the capacity to support one of the above missions.

(6) Demodulation of Manchester coded (Biϕ-L) or NRZ-L data modulated directly on the carrier.

(7) Maximum likelihood decoding of short-constraint-length convolutional codes and sequential decoding of long-constraint-length convolutional codes.

(8) Precise measurement of received signal level and system noise temperature.

(9) Centralized control by (and real-time reporting to) the Monitor and Control Subsystem.

(10) Production of a digital Telemetry Original Data Record (ODR) at each telemetry group with playback via local manual control or in automatic response to GCF inputs; reduced playback rates for data rates above 115 kbps.

The characteristics that reflect new or modified capabilities due to Mark IV-A design requirements, are underlined. The handling of increased data rates and demodulation of NRZ or bi-phase data modulated directly on carrier directly respond to a requirement for telemetry support of Highly Elliptical Orbiter (HEO) spacecraft. Baseband combining and carrier arraying provides for improved sensitivity to high data rate X-band signals in support of deep space telemetry and is driven by the Voyager project requirement for support of 19.2 kbps at Uranus encounter. The provision for four groups of telemetry equipment at each SPC responds to the requirement to provide telemetry support to three projects concurrently. The absence of project requirements for analog recording allows that function to be removed. The characteristics which are non-underlined exist presently in the Mark III and are discused in Ref. 1.

III. HEO Mission Data Rate and Coding Requirements

HEO missions are for the most part compatible with the existing DSN capabilities. This is illustrated in Table 1, which defines the single link data handling requirements for the HEO projects included in the Mark IV-A mission set. A telemetry single link can be defined as all of the functional elements, from the antenna(s) through an SPC telemetry group, that have been selected for support of a project. The data rate and coding requirements not supportable by the existing DSN capabilities are:

(1) Biϕ-L (Manchester coding) directly on the carrier.

(2) 600 kbps.

The combination of Manchester coding and 600 kbps data rate produces a symbol rate of 1.2 Msps. The next section describes the way these HEO requirements will be met by the Mark IV-A DSN Telemetry System.

IV. DSCC Conceptual Description

The DSCC block diagram in Fig. 1 provides a conceptual description of the portion of the Mark IV-A Telemetry System to be located at the DSCC. At each complex there will be one 64-meter antenna, three 34-meter antennas, and a 9-meter antenna. The 64-meter and 34-meter transmit/receive antennas will be able to receive an S-band plus an X-band carrier simultaneously while the 34-meter Listen Only antennas will receive either one S-band or one X-band carrier. The receivers recover the baseband signals which are routed to the Telemetry Subsystem.

The Telemetry Subsystem is arranged to provide four telemetry groups. All groups will include existing strings of equipment (Symbol Synchronizer Assembly, Maximum Likelihood Convolutional Decoder and Telemetry Processor Assembly, TPA). Groups 3 and 4 will also be equipped with the capability needed to support HEO missions. This will be accomplished by incorporating a Spaceflight Tracking and Data Network (STDN) bit synchronizer as well as a newly designed coupler for interface with the TPA. The other two Telemetry Groups (Groups 1 and 2) will be equipped with a new Baseband Assembly (BBA) which will include the functions of baseband combining, subcarrier demodulation and symbol synchronization. The BBA will be designed to accommodate either deep space or highly elliptical orbiters. HEO missions will have data rates up to 1.2 Msps (600 kbps Biϕ-L) modulated directly on the carrier. Since the maximum GCF rate will be limited, data rates higher than 115 kbps will be recorded at the SPC and played back in non-real time.

The 64- and 34-meter antennas can be arrayed by combining the carriers within the receiver subsystem. Then the detected baseband signals are combined in the BBA in either Telemetry Group 1 or Telemetry Group 2. The combined signal is then decoded in the Maximum Likelihood Convolutional Decoder and formatted for transmission to JPL in the Telemetry Processor Assembly. When combining is not required, outputs from any antenna may also be routed by any Subcarrier Demodulator Assembly, or directly to the GSTDN symbol synchronizer.

Any of the telemetry equipment groups can accept two data streams. In Groups 1 and 2, one data stream is processed by Channel A and one by Channel C. Similarly, in Groups 3 and 4, one data stream is also processed by Channel A while the other is processed by Channel B. The performance parameters for Channels A, B and C are listed in Table 2. Comparing Table 1 with Table 2, it may be noted that Data Stream 1 in Table 1 is processed by Channel A, while Data Stream 2 is processed in Channel B or C. Similarly, deep space missions require dual data stream support, which is provided by Channels A and B or C. Channel B is used to support higher rates for deep space missions unless combining is required and then Channel C is used. Channel B or C may be used to support HEO missions except for the data rates above 250 ksps, which can be supported by Channel C only.

Reference

1. Gatz, E. C., "DSN Telemetry System Mark III-77," in *DSN Progress Report 42-49*, Jet Propulsion Laboratory, Pasadena, Calif., Feb. 15, 1979.

Table 1. Single link requirements for Earth Orbiter Missions

Mission	Data stream 1	Data stream 2
OPEN-PPL	Uncoded; NRZ-L; 25 kbps	Uncoded; Biϕ-L; 600 kbps
OPEN-EML	Uncoded; 6 kbps NRZ-L; or 14 kbps	Uncoded Biϕ-L; 600 kbps early in mission, then 94 kbps
OPEN-IPL	Uncoded; NRZ-L; 2 kbps	Uncoded; Biϕ-L; 94 kbps
OPEN-GTL	Uncoded; NRZ-L; 6 kbps	Uncoded Biϕ-L; 94 kbps
ISEE-C	Convolutionally coded, K = 24, R = 1/2, NRZ-L; 64 bps	Uncoded; Biϕ-L; 256 bps. or Convolutionally coded; K = 24, R = 1/2; 512-2048 bps; Biϕ-L
AMPTE-CCE	Uncoded; NRZ-L; 1500 bps	Biϕ-L; convolutionally coded; K = 7, R = 1/2; 60,000 bps
AMPTE-IRM	Uncoded; NRZ-L; 1000 bps	

Table 2. Telemetry Subsystems 1 and 2, performance parameters

Channel A
Process one NRZ-L coded or uncoded data stream needing
Subcarrier demodulation 512 Hz to 1 MHz
Symbol synchronizing 6 to 25 ksps
Sequential decoding 6 to 10 kbps – K = 24, 32; R = 1/2, frame length variable
Block decoding; Reed Muller 32/6; up to 2 kbps
Channel B
Process one NRZ-L biphase data stream needing
Subcarrier demodulation; 512 Hz to 1 MHz or Manchester decoding: 10 sps to 1.2 Msps
Symbol synchronizing; 6 sps to 1.2 Msps
Sequential decoding 6 to 10 kbps; K = 32; R = 1/2, frame length variable
Maximum likelihood Viterbi decoding – 10 bps to 125 kbps (K = 7, R = 1/2 or 1/3)
Real-time data rates up to 115 kbps
On-site recording and non-real-time playback for data rates above 115 kbps
Channel C
Process one NRZ-L or biphase data stream needing
Baseband combining of up to 6 antenna receiver signals
Subcarrier demodulation: 10 kHz to 2 MHz
Symbol synchronizing and Manchester decoding: 4 sps to 1.2 Msps
Sequential decoding 6 to 10 kbps; K = 32, 24; R = 1/2, frame length variable
Maximum likelihood Viterbi decoding – 10 bps to 125 kbps (K = 7, R = 1/2 or 1/3)
Real-time data rates up to 115 kbps
On-site recording and non-real-time playback for data rates above 115 kbps

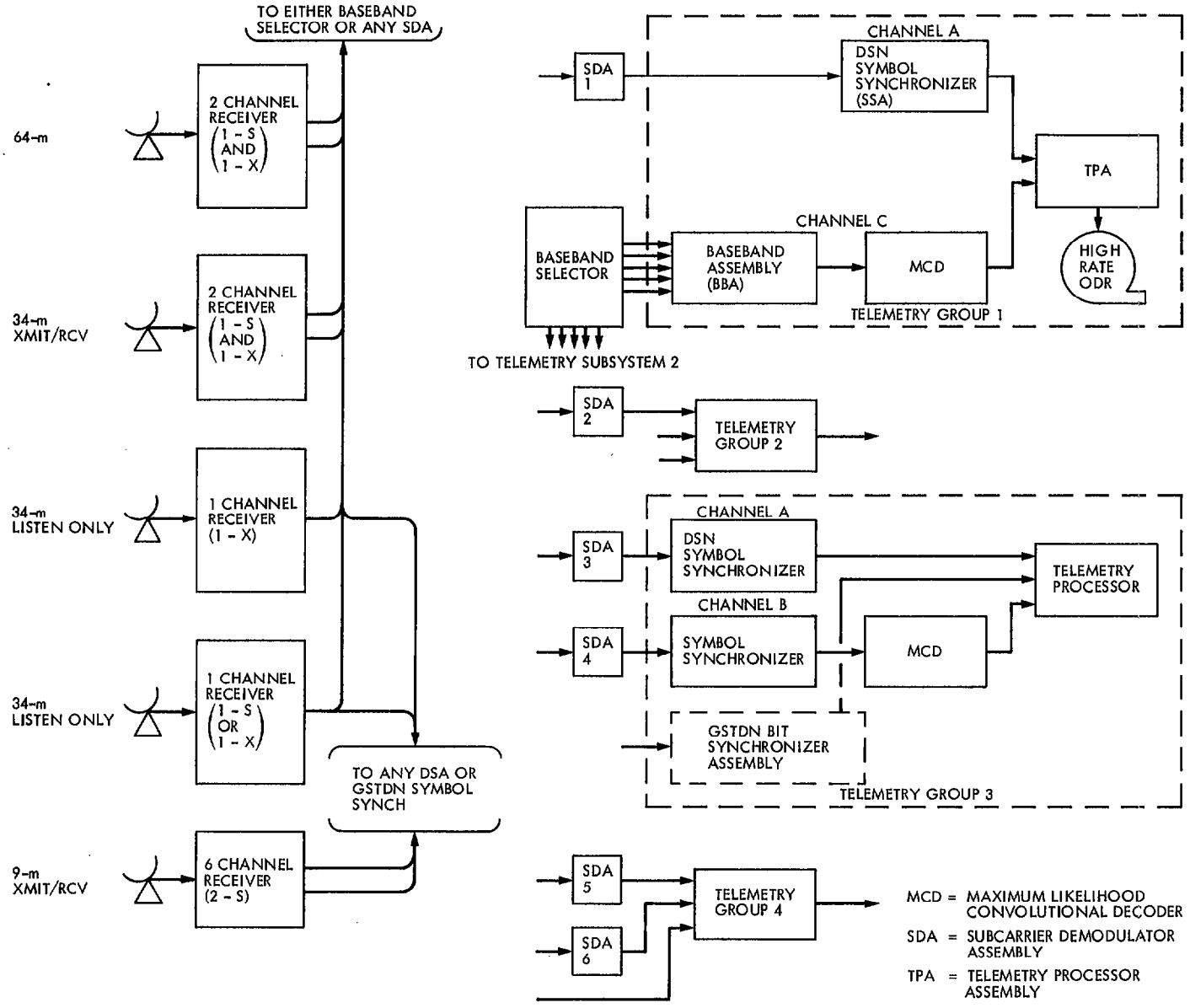

Fig. 1. Telemetry System: DSCC level block diagram