Evaluation of DSN Data Processing With 7200-b/s GCF High-Speed Data Interfaces

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Test results confirm that the Deep Space Station (DSS) and Network Operations Control Center (NOCC) processing of telemetry, command, radio metric, and monitor data with the existing DSN Mark III-75 configuration will be unaffected by the recent change of the Ground Communications Facility (GCF) High-Speed Data Subsystem to a clock rate of 7200 bits per second.

I. General

A. HSD Conversion

Conversion of the GCF High-Speed Data Subsystem (GHS) (Ref. 1) to operate at a line rate of 7200 bits per second (b/s), instead of the previous 4800 b/s, was completed in early December 1976. The 7200-b/s clock rate has been used for transmissions of DSS telemetry, command, radio metric, and monitor data since that date.

Equipment of the type planned for the Network was implemented in May 1976 at the JPL-DSN Compatibility Test Area (CTA 21) and at the GCF Central Communications Terminal (CCT) to support engineering tests.

B. Analysis

Analyses of the DSN Mark III-75 Telemetry & Command Processor Assembly (TCP) and the Digital Instrumentation Subsystem (DIS) (Radio Metric and Monitor & Control) software programs indicated that the high-speed data (HSD) interface change will not adversely affect performance of those XDS-920 processors.

The only apparent effect of increasing the GHS clock rate from 4800 to 7200 b/s is that the time available for servicing serial-to-parallel input and parallel-to-serial output transfers is reduced from 5 to 3.3 milliseconds per 24-bit word.

Servicing of each such transfer requires no more than about 50 microseconds (including exit from and return to computational routines). Since the maximum number of transfer interrupts that might coincide is typically only eight, the new clock rate poses no serious timing problem. Furthermore, the servicing of HSD input and output interrupts is given priority over all other processing functions except keyboard inputs and outputs. The programs are designed to minimize keyboard input and output during normal operations.

To verify the conclusions of these analyses, a series of tests was conducted at CTA 21, and between CTA 21 and the NOCC. Those tests are described herein.

II. Test Report

A. CTA 21 On-Site System Performance Tests

The TCP and DIS were tested at CTA 21 on 2, 3, and 7 June 1976, using on-site Systems Performance Test (SPT) procedures in which the DSS high-speed data equipment is operated in a loop-back configuration. The test results showed that the DSS performance with the 7200-b/s interface compared favorably to the performance with the 4800-b/s interface.

B. CTA 21 and NOCC Interactive Test

Additional testing was conducted at CTA 21 on 10 June 1976, in which real-time data were transmitted to and from the NOCC via the GHS subsystem at a line rate of 7200 b/s.

1. Telemetry & Command Subsystem (TCD)

a. Configuration and data types

TCD software: Viking Telemetry and Command

GHS configuration: 7200 b/s

NOCC configuration: Block III Telemetry Subsystem

Simulated Viking Data were input to the DSS Telemetry Subsystem from the Simulation Conversion Assembly as follows: Viking Orbiter low rate (VO-E224) at 33-1/3 b/s, uncoded; Viking Orbiter medium rate (VO-M560) at 2 kb/s, block coded.

b. Test description. Telemetry and Command Processor (TCP) output of 2-kb/s decoded M560 and 33-1/3-b/s E224 uncoded data to the NOCC via 7200-b/s HSD line was sustained for several hours. Frame synchronization of both data types was confirmed by observation of the NOCC Block III telemetry display at the Network Operations Control Area (NOCA).

While outputting the two telemetry streams, the TCD was configured for Viking Orbiter command and placed into remote-control mode. A standard command data transfer test was conducted, and then a set of six modules of commands was transmitted from the NOCC.

High-speed data block dumps and visual display observations at the NOCC indicated that the quality of the telemetry output was not affected by the additional load of command inputs.

c. Discussion. The telemetry and command test conditions described above represent the maximum HSD input and output requirements on the TCP. A slight additional TCP load will exist when Viking high-rate (16 kb/s) data are output to the GCF Wideband Subsystem (GWB) by the Interdata-4 processor under control of the TCP. (The latter condition was not tested due to CTA 21 configurational limitations.)

The telemetry and command tests were performed only with the Viking TCP software module. However, the results can be considered as also representative of the performance to be expected for Pioneer and Helios telemetry and command processing.

2. Tracking and Monitor and Control Subsystems

a. Configuration and data types

DIS software: Multiple-mission radio metric and monitor and control (DOI-5046-OP-E)

GHS configuration: 7200 b/s

NOCC configuration: Block II Tracking Subsystem

Block III Monitor & Control Subsystem

A tracking and data handling (TDH) simulator provided 10 samples per second S-band and 10 samples per second X-band radio metric data inputs to the DIS. The normal DSS monitor interfaces from the Receiver-Exciter Subsystem, and the TCDs were also active.

b. Test description. The following operating conditions were tested with the DIS connected to the 7200-b/s GHS:

(1) An NOCC transmission of sequence of event (SOE) text data was received and output to the line printer, while HSD output of maximum sample rate radio metric data and normal monitor data continued. The SOE transmission consisted of 158 HSD blocks, and all were received without errors. The radio metric and monitor data received at NOCC appeared to be satisfactory.

(2) Floating-point tracking predicts were received from NOCC and output to a magpack tape, while HSD output of radio metric and monitor data continued satisfactorily. The predicts transmission consisted of 60 HSD blocks, and all were received without errors.

(3) An Antenna Pointing Subsystem (APS) drive tape was generated on the DIS paper-tape punch and then verified. The HSD output continued to be satisfactory while these operations were performed.

c. Discussion. The DIS operating conditions tested are representative of the expected combinations of HSD input and output.

C. Telemetry Automatic Recall

Further tests were conducted on 16 June 1976 to evaluate the performance of the Automatic Total Recall System (ATRS-III) with the HSD line rate of 7200 b/s.

1. Configuration

TCP software: Viking Telemetry & Command (DOI-5050-OP-C, Rev. A) ATRS III (DOI-5082-OP-A)

NOCC configuration: Block III Data Records Processor

2. Test description. Simulated Viking Orbiter telemetry data at 33-1/3 b/s uncoded and at 2 kb/s block coded were processed by the TCP and sent to NOCC on the 7200-b/s HSD line for a period of about 20 minutes.

A 7-track digital Original Data Record (ODR) was generated during the period of real-time processing. The ODR tape was rewound, and the ATRS-III program was loaded into the TCP and configured for remote control. The NOCC then recalled the complete ODR at the full 7200-b/s rate and recorded a Network Data Log (NDL) on the Network Log Processor (NLP). Later, an Intermediate Data Record (IDR) of these data was generated in the NOCC. The IDR summary indicated that there were no gaps on the NDL.

3. Discussion. The test confirmed that ODR recalls of HSD from the TCP can be performed at the full line rate of 7200 b/s.

D. Simulation Conversion Assembly Tests

1. On-Site HSD test. The CTA 21 on-site testing included a demonstration of satisfactory Simulation Conversion Assembly (SCA) XDS-910 performance with HSD input at 7200 b/s. The configuration and input loading were representative of the 26-meter DSS requirements, where all input is by HSD line and there is no wideband data (WBD) input.

2. HSD and WBD test with MCCC. Further SCA tests were conducted at CTA 21 on 16 June 1976 with "long-loop" data inputs from the Mission Control and Computing Center (MCCC) Simulation Center.

a. Configuration

HSD: 7200-b/s line rate

WBD: 50-kb/s line rate

SCA software: Data routing version E (DOI-5089-TP-E), which permits 2400-bit WBD blocks to be processed along with 1200-bit HSD blocks

b. Test description. Satisfactory SCA performance was demonstrated with the following loading conditions:

(1) WBD input: 16 kb/s to SCA Channel 1
HSD inputs: 2 kb/s to SCA Channel 2
33-1/3 b/s to SCA Channel 3
33-1/3 b/s to SCA Channel 4

(2) HSD inputs: 2 kb/s to SCA Channel 1
2 kb/s to SCA Channel 2
33-1/3 b/s to SCA Channel 3
33-1/3 b/s to SCA Channel 4

(Note: Condition (2) exceeds the rate which could be carried on a 4800-b/s HSD line.)

The 2-kb/s block-coded data stream from SCA Channel 2 and a 33-1/3-b/s uncoded data stream were input to the DSS Telemetry Subsystem. These streams were processed by the TCD and returned to the MCCC for validation.

c. Discussion. Simulation Conversion Assembly performance with the 7200-b/s HSD interface is satisfactory when the concurrent WBD loading is limited to 16 kb/s. Performance with additional WBD input, such as required for 64-meter DSS support of Viking 3 spacecraft simulation, could not be tested at CTA 21. However, it is expected that the Viking Project will not require maximum-level long-loop simulation by the time the GHS equipment is converted to 7200 b/s.

E. Telemetry Processing Limit Test

CTA 21 testing on 16 June 1976 included an experiment to determine whether the 7200-b/s GHS might permit the TCD to handle 4-kb/s Viking data. SCA-generated data were used for the experiment.

It was found that the 26-meter DSS configuration of the TCD was able to process 4-kb/s *uncoded* data. The TCD was not able to handle 4-kb/s *block coded* data, however, because the coded symbol rate (21.333 ks/s) is too high for the Interdata-4 block decoding function.

The TCD was also tested in a 64-meter DSS configuration where the 4-kb/s block coded data were decoded by the Block Decoder Assembly (BDA), then output by an Interdata-4 Processor to the 7200-b/s HSD line satisfactorily. In this configuration the data would ordinarily be output to the WBD line.

III. Conclusions

On the basis of the foregoing analyses and test results, it was concluded that the conversion of the GCF HSD Subsystem (GHS) to a line rate of 7200 b/s will have no adverse effect on the DSS processing of telemetry, command, radio metric, monitor, and operations control data in the DSN Mark III-75 configuration.

The use of the 7200-b/s line rate will improve certain DSS functions. For example, the time required for ODR recall via HSD line will be appreciably reduced.

IV. Comments

On the basis of these test results, it was recommended that the implementation of the 7200-b/s GCF High-Speed Data Subsystem equipment in the DSN proceed as planned.

The 7200-b/s GCF High-Speed Subsystem has been implemented throughout the Network as scheduled, and is operating satisfactorily.

Acknowledgment

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Reference

1. Glenn, M. S., "DSN Ground Communications Facility," in *The Deep Space Network Progress Report 42-36*, pp. 4-12, Jet Propulsion Laboratory, Pasadena, Calif., Dec. 15, 1976.