DSS Command Software Update

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A new version of the DSS Command Software has been generated for support of the Voyager Saturn encounter. The modifications, additions, and testing results for this version of the software are discussed in this article.

I. Background

The Deep Space Station (DSS) Command Software was initially implemented in late 1976 when new computers were implemented at DSS 12. Modcomp II-25 minicomputers were implemented at the stations throughout the Deep Space Network over a period of time from late 1976 through early 1978. New computers were implemented for the command, telemetry, tracking, and ground communication functions as part of the Mark III Data Subsystem (MDS) implementation project.

Prior to implementation of the new command computers at the DSS, the command data handling function was accomplished in an XDS-920 computer which was shared with the telemetry processing function. This computer system was designated the Telemetry and Command Processor (TCP). With the implementation of the new Modcomp II-25 computers, and the separation of the telemetry and command processing functions, the DSS command computer has been designated the Command Processor Assembly (CPA). The initial implementation of the CPA software was constrained to very much resemble what existed for the TCP. Due to the station-by-station implementation of the CPA, which occurred over approximately one and one-half years, the command data handling characteristics and the interface with flight projects remained the same for the CPA as had existed for the TCP.

Therefore, the initial implementation of the software for the CPA included basically the same functional characteristics as the TCP. Support for the following flight projects was provided: Pioneer 6 through 9, Pioneer 10 and 11, Helios 1 and 2, Viking, Pioneer Venus, and Voyager. The software that supported these projects, and was initially implemented in the CPA, was designated Mark III-74. The data processing characteristics were defined and used to support flight project commanding in 1976.

In 1976 and 1977, through negotiations between the Mission Control and Computing Center (MCCC), JPL Flight Project representatives, and DSN personnel, a new end-to-end command data handling system was defined. The command data handling system was termed "store-and-forward". This system took advantage of the increased processing and storage capabilities of the new DSN CPA, and better suited the characteristics of the flight project command generation functions and spacecraft data handling and storage capabilities. In this store-and-forward system, each major element of the system has data handling capabilities for complete sets of spacecraft command information. The flight project command generation software generates files of spacecraft commands to accomplish particular mission objectives. The files are then passed to the

MCCC Command System where they are stored for later transmission to the DSN. Once a Deep Space Station (DSS) has been scheduled, staffed, and initialized for the spacecraft track, the files of command information are transmitted in total to the DSS CPA where they are stored for later radiation to the spacecraft. When the uplink to the spacecraft has been established, the Flight Project Command Operator sends control messages to the DSS CPA to begin radiation of the command information. The files of command information are stored onboard the spacecraft for later automatic execution. This store-and-forward system was implemented in 1978 in the DSS CPA (as well as MCCC and Project Command Generation Software) and was designated Mark III-78.

The Voyager Project was the initial user of the Mark III-78 system. In late 1978, capabilities were developed at the German Mission Operations Center to interface with this new data handling system. The Pioneer and Viking missions continue to use the Mark III-74 data handling system but plans exist to convert the Mark III-78 system at a later date.

II. CPA Software Update Requirements

As with any new significant software package, requirements change with time and anomalies are uncovered during use of the new capabilities. In 1979, it was recognized that modifications and additions would be required for the Mark III-78 CPA software. A new version (OP-G) was scheduled such that it would be available for the Voyager 1, Saturn Encounter.

Effort began in mid 1979 for this new version of CPA software. The scope of the software update involved four areas:

(1) Recode portions of the software to permit recovery of approximately 2000 words of memory. This was necessary to accomplish items (2) through (4).

(2) Correct five Voyager Ground Data System liens.

(3) Provide capability to automatically turn off the CPA local printer during periods of low activity.

(4) Correct anomalies existing in the software.

A. Software Recode

In order to recover the necessary core memory to implement the modifications and additions required, basically two areas were changed in the CPA software. The application software was changed to "fool" the operating system such that more efficient "packing" of the command applications task could be accomplished within the available core memory.

Numerous software routines were also modified to become more efficient and thus recover core memory.

B. Voyager Liens

During the time period of use of the Mark III-78 command system, the Voyager Project identified anomalies and new requirements that they desired to be fixed prior to the Saturn encounter. The items were listed as Voyager Ground Data System liens. The liens were (see Progress Report 42-43 for description of CPA data processing capabilities):

(1) Under certain conditions the CPA would report erroneous status of the prime (first) file.

(2) Under certain conditions the CPA would report an erroneous file name for skipped command elements.

(3) Under certain conditions the CPA would generate false expired time alarms.

(4) If the project sent a control message to empty the command queue, and the queue was already empty, CPA software execution would halt.

(5) The Voyager Project desired a modification to change the algorithm for resuming file radiation, i.e., if a resume directive is received by the CPA, the CPA should not resume radiation unless all timing considerations were satisfied.

C. Automatic Turn-Off of Local Printer

Each DSS command subsystem has been implemented with a local character printer for use during software loading and initialization, and as a logging device during operations. These printers have been installed as peripheral devices for all Modcomp II-25 computers implemented in the DSN. These printers have run continuously during program operation regardless of the need for printing. With this continual running, the DSN has experienced a significant failure rate for these printers. In order to alleviate this problem, the Modcomp Operating System has been modified to turn-off these printers when not in use. This version of the operating system was incorporated in the new CPA software version.

D. Anomaly Correction

At the start of implementation of the new version of CPA software, there were thirty-one anomalies open against the CPA software. Some of the anomalies were directly associated with the Voyager liens (see paragraph B above), while others were visible to on-site personnel or by use of the System Performance Test (SPT) software. Much of the effort during this software upgrade involved correction of these anomalies.

III. CPA Software Update—Test Results

The Acceptance Test for this new version of CPA software was successfully completed in late January 1980. As previously stated, this version of the CPA software was implemented with the following scope:

(1) Recode portions of the existing software to permit the recovery of approximately 2000 words of memory.

(2) Correct the five GDS command system liens.

(3) Accommodate the updated Standard Operating System which contains provision for the turning off of the local printer during periods of minimal I/O activity.

(4) Correct DSN anomalies.

Item 1 was accomplished in this upgrade.

Item 2 was accomplished and was successfully testing during the acceptance test. In addition, a test was run in early February with the Voyager Ground Data System personnel which demonstrated clearance of these liens (test between CTA-21 and MCCC).

Item 3 was accomplished and successfully demonstrated during the acceptance test.

Item 4 was accomplished with one anomaly exception. The summary of anomaly status at time of acceptance test completion is given below.

(1) Anomalies corrected and tested 26

(2) Anomalies not repeatable 3

(3) Anomalies closed by document modification 2

(4) Anomalies open were carried as liens on transfer agreement 5

The Software Consent to Ship meeting was held on 31 January 1980. It was agreed that the software was ready to be shipped for the soak period. The software was shipped to Goldstone on 1 February 1980.

During the Voyager Ground Data System tests at Goldstone, prior to going on-line for probationary use, a Class A anomaly was discovered. The anomaly description was:

"During the process of loading command files to the CPA disk, MCCC automatically issues directory recall messages to the CPA. In addition, other directive messages are sent to the CPA during file loading. The loading is not halted during the sending of these directives (i.e., the MCCC does not wait for an acknowledge prior to continuing the load).

Under the above conditions, the CPA software is *not* sending the acknowledge messages for the directives."

The software was modified to correct the anomaly. For every block received by the CPA, a check is made to determine if any acknowledge is pending. If any acknowledge is pending, the software will immediately acknowledge (i.e., the delays in the software for acknowledgement will be bypassed).

The acceptance tests were successfully re-run at CTA-21. System Performance Test (SPT) software was modified to test the CPA software for this anomaly. In addition, a test was run with MCCC (and Voyager personnel) to demonstrate correction of the anomaly.

The second Software Consent to Ship meeting was held in early March 1980. It was agreed that the software was ready to be shipped to the Goldstone stations and CTA-21. After successful completion of the soak period at the Goldstone stations, the new version of the CPA software was distributed to all DSN stations. The Voyager Ground Data System Around-the-Net testing was completed in early May 1980 and the software was placed "on-line".

IV. CPA Software—Future Plans

The new version of the CPA software has been on-line for a number of months and has not experienced any problems that will require a software update. However, new requirements are being developed that will require changes to the software. Two versions of the Mark III-78 Command System will be required in the future.

(1) The existing version of the software will require modification to support the Pioneer 10, 11, and 12, Galileo, and the International Solar Polar Missions.

(2) A major modification to the software will be required to support the Mark IV DSN. The Mark IV DSN includes consolidation of STDN and DSN ground tracking stations which will result in requirements on the DSN to track the Highly Elliptical Earth Orbiter Spacecrafts (HEEO). The HEEO spacecrafts will require a significant increase in command bit rate (2000 bps) which will require replacement of the existing Command Modulator Assembly (CMA). This new CMA will require significant changes in the CPA software.

The two future versions of software will require development on an almost concurrent schedule. This will provide an extremely difficult challenge to the DSN implementation organization over the next few years.