Operation of the DSN Command System From the Space Flight Operations Facility

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Presented is a general description of the operation of the Deep Space Network (DSN) Command System from the Space Flight Operations Facility as configured for support of the Mariner Mars 1971 mission. Included are brief descriptions of functional capabilities along with the use of these capabilities by DSN and Flight Project personnel.

I. Introduction

The Space Flight Operations Facility (SFOF) Mark IIIA Command System has been developed at JPL to meet the requirements of the DSN and *Mariner* Mars 1971 Flight Project. Although full Mark IIIA requirements have not as yet been realized, operational experience has shown that one of the key design goals has been accomplished: the control of the use of the DSN Command System from the SFOF. This capability has led to, or will lead to, the following significant network operational improvements:

(1) Mission-independent procedures, thus minimum impact on network operational support for new flight projects.

(2) Minimum participation by Deep Space Station (DSS) personnel in the operation of the DSN Command System.

(3) High-speed data message control from the SFOF of the mission configuration and standards and limits utilized by the Telemetry and Command Processor (TCP) at the DSS.

(4) Direct entry and control of spacecraft commands into the DSN Command System by Flight Project personnel at the SFOF.

(5) Automatic verification, confirmation, and alarms from the DSS requiring minimal direct network personnel participation during spacecraft commanding.

This article discusses the Command System control that exists in the SFOF for use by DSN and Flight Project personnel. The material is presented in a sequence that is representative of the nominal support given for a DSS's track during which spacecraft commanding is to take place. The major items in the sequence are:

(1) SFOF Command System initialization.

(2) Pre-acquisition Command System operations.

(3) Flight project entry of command data.

II. Basic Software/Hardware Characteristics

The Command System software in the IBM 360-75 computer is organized in a manner that allows command system data to be sent to or accepted from a unique TCP at a DSS. Multiple streams (likewise multiple active TCPs) of data are possible if the software is initialized to do so. The discussion presented here will assume only one stream of data to and from a unique TCP.

Command system data are entered into the system via an IBM 2260 I/O device [cathode ray tube (CRT) with keyboard], a card reader, or from files of data generated by other software programs. Control of the use of these data in the system (e.g., transmission to a TCP) is normally done from the 2260 I/O device but can be done from a card reader.

Data can be displayed on the 2260 CRT, digital TV (DTV), line printers, or character printers. The type of data displayed on the 2260 CRT is generally administrative data. The data displayed on the other devices are formatted output and contain information concerning the contents of Command System high-speed data blocks.

III. SFOF Command System Initialization and Access Security

Before any high-speed data messages can be received from or sent to a TCP at a Deep Space Station, the Command System in the SFOF must be initialized. The Command System software in the SFOF is designed to work with multiple streams of data on a non-interactive basis. These independent processors (9 available) are each designed to work with a unique TCP in the network. Each requires initialization by the Computer Operations Chief prior to use. The parameters of initialization of an SFOF Command Processor are:

(1) Station and TCP (α, β, or γ) designation.

(2) Spacecraft number to be utilized in the high-speed data blocks.

(3) Flight project I/O device number allowed access to the software.

(4) Command Analysis Group I/O device number allowed access to the software.

The I/O devices mentioned above in (3) and (4) are the only devices capable of entering command data into the system. The flight project device is allowed entry of data concerning commands, command enable/disables, and recall data. The Command Analysis Group I/O device is allowed entry of data concerning configuration, standards and limits, test commands, and recall data.

After initialization by the Computer Operations Chief, the SFOF Command System is then made available to the Command Analysis Group for purposes of sending HSD messages to configure the TCP software and test the system end to end.

IV. Pre-acquisition Command System Operations

After the DSS countdown checkout and SFOF command processor initialization, the Command System is available for pre-acquisition checkout prior to flight project use. Included in this checkout are the following:

(1) Ensure good high-speed data link between the SFOF and the DSS.

(2) Send mission configuration messages to the TCP.

(3) Send command system standards and limits messages to the TCP.

(4) Exercise the system end to end with a test command.

(5) Ensure system is capable of supporting flight project command activity.

The DSN Command System Analysis Group, in coordination with members of the DSN Operations Control Team, inputs data into the SFOF Command System and initiates transmission to the DSS necessary for system control and checkout. During this pre-acquisition checkout, station personnel have no required operational function except to monitor the operation of station equipment. The system can be controlled entirely from the SFOF. Only in the instance of the discovery of a problem is there a requirement for direct intervention by DSS operations personnel.

The first item of checkout is to ensure a good HSDL to and from the DSS. A recall request configuration message is utilized for this purpose. Inherent within the design of the SFOF Command Processor is the ability to automatically retransmit messages if the verification message (message reflected back from the TCP) does not match what was transmitted from the SFOF. If a failure occurs in the verification process (i.e., the verification message is not received or does not match what was transmitted), the failure is isolated to a facility where immediate steps are taken to correct the problem.

The next operational item in the pre-acquisition checkout is to send the mission configuration and standards and limits data to the DSS. Existing at the DSS is multiple-mission hardware controlled by the software in the TCP. The parameters controlling this hardware are contained within the mission configuration and standards and limits messages. Although multiple-mission software presently does not exist for the TCP or at the SFOF, the operation of the system utilizing the *Mariner* Mars 1971 TCP operational program and the SFOF software has successfully demonstrated that control of the hardware at the DSS

can be accomplished from the SFOF. With the exception of entry of flight project commands, the entry of these data from the SFOF is perhaps the most powerful tool affecting Command System Network Operations. As soon as a Multiple-Mission Command System TCP Program is available, with the corresponding capability to generate all other supported project commands from the SFOF, the transmission of mission configuration and standards and limits data from the SFOF will affect network operations significantly. Network-wide, multiple-mission command procedures will be appropriate for support of all projects.

After the proper mission configuration and standards and limits data have been transmitted to the DSS, system operation is checked with the use of a test command. The system is configured exactly as for flight project support with the exception that the DSS RF output to the transmitter is inhibited. The test command is transmitted to the DSS and enabled. Proper verification and confirmation is monitored to ensure correct operation. After successful test command confirmation, the system is declared green for flight project use.

V. Flight Project Entry of Command Data

The direct entry of spacecraft commands into the DSN Command System by Flight Project personnel has proven to be an extremely efficient method of operation.

The automatic verification, confirmation, and alarming provided by the present system has led to "monitor only" operations by network personnel. All data concerning commands are entered by Flight Project personnel, with intervention by network operational personnel only upon the occurrence of a system problem. Perhaps the efficiency of this mode of operation is best described by a history of the Command System support of *Mariner IX* as of the date of writing of this article:

Total commands transmitted	599
Maximum commands transmitted during a station's track	481

The significance of the data above is that, on one occasion, 481 commands were transmitted to the spacecraft in less than 7 hours.

The Flight Project can enter commands from an IBM 2260 I/O device, a card reader, or from command data files generated either by card reader or by other software (COMGEN Program in the case of *Mariner* Mars 1971). Commands are transmitted to the DSS by specific operator instruction in the case of 2260 or card reader control. This mode is normally used during light command activity. If heavy command activity is scheduled, the normal mode of operation is by the use of command data files. A large file of commands can be "attached" to the Command System and automatic transmission to the DSS will occur based upon status messages received from the TCP. These messages inform the software in the SFOF when there is sufficient storage available in the TCP to accept more commands. Upon receipt of this message, the SFOF automatically transmits more commands to the TCP without operator intervention. The only operator instruction necessary is to initiate file transmission.

In addition to the transmission of command data to the DSS, the Flight Project has direct control of the command enabling process. Three modes of enabling are possible. At project option, commands can be enabled immediately (enable instruction is transmitted with the command data), automatically based upon a successful verify cycle, or manually by project operator specific instruction. The immediate enable mode is not normally used. This mode could be used in the case of a spacecraft emergency where a command is required immediately. The automatic enable mode is normally used during heavy command activity. The commands are transmitted to the DSS, and if the verification message matches what was transmitted, the SFOF Command System automatically constructs an enable message and sends it to the DSS without operator intervention. In the manual mode of enabling, the project command operator sends the commands to the DSS. When he is satisfied the commands are loaded properly in the TCP, he enters a specific instruction to enable the commands.

In addition to direct control of the command and enable messages transmitted to the DSS, the project can at any time send a message to the DSS to recall the commands from the TCP. In this manner, the project can know at all times what commands are loaded and their enable status.

VI. Future Plans

Operational planning is directed toward some future date at which time all network-supported projects will utilize the DSN Command System as described in this article. In order to accomplish this goal, software will have to be developed to accommodate all projects. It is hoped that by mid-1972, *Mariner* Mars 1971, *Pioneer F*, and *Pioneer VI–IX* missions will all be utilizing the DSN Multiple-Mission Command System. With the realization of these goals, the DSN Command System will be multiple mission in operations as well as functional capabilities.