NASA DEEP SPACE NETWORK OPERATIONS CONTROL

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ABSTRACT

Overall direction, coordination and control of the real-time activities of the NASA Deep Space Network (DSN) is the responsibility of the Network Operations Control Team located at the Operations Control Center at JPL in Pasadena. Real-time operation of the DSN is a complex task, requiring efficient interaction among operations personnel, hardware, software, communications and mechanical systems. Control is maintained by the team at JPL through allocation of responsibility for specific operational facilities to specific team members. The Network Operations Control Team is comprised of an Operations Chief, a Track Chief, and one or more Deep Space Station (DSS) Controllers. The Operations Chief is responsible for overall performance of the Operations Control Center, and provides a single point of interface with the Control Center to end user organizations. The Track Chief is responsible for overall performance of the DSN as a facility, while the Station controllers are assigned responsibility for monitoring and coordinating the operational activities at individual Deep Space Stations.

INTRODUCTION

The Deep Space Network (DSN) is a facility of NASA's Office of Space Tracking and Data Systems, under the system management and technical direction of the Jet Propulsion Laboratory. The DSN can be divided into three facilities and six systems. The three facilities are:

1) Space Flight Operations Facility (SFOF), at JPL in Pasadena.

2) Ground Communications Facility at JPL, which links all elements of the DSN by voice, teletype, high-speed and wideband telecommunications links.

3) Deep Space Communications Complexes (DSCC's) located in California, Spain, and Australia. A DSCC is composed of three Deep Space Stations (DSS's), each consisting of a 26-, 34-, or 64-meter aperture parabolic antenna and its associated support equipment.

The six DSN systems are each composed of the equipment and software necessary to perform the functions of tracking, telemetry, command, monitor and control, test and training, and radio science.

The basic function of the DSN is to provide effective and reliable tracking and data acquisition support for planetary and interplanetary space flight missions. This function includes provision of data to flight project mission operations, acceptance of commands from mission operations and transmission to stations and spacecraft, providing a record of telemetry and command data to mission operations, Network performance monitoring, generation of predictions for antenna pointing and signal acquisition, Network scheduling, and Network validation tests.

To date, the DSN has successfully supported the Ranger and Surveyor lunar projects, the Mariner missions to Mars, Venus, and Mercury, the Viking Orbiter and Lander missions to Mars, the Pioneer and Helios missions, and most recently, the Voyager missions to Jupiter and Saturn. The DSN also provides facilities to the international scientific community for experiments in radar, radio astronomy, and Very Long Baseline Interferometry (VLBI).

OPERATIONS CONTROL

Personnel

The DSN Operations Control organization is responsible for providing a central point of real-time direction and coordination to the operational Network in order to meet scheduled commitments and emergency requirements. Responsibility for the operations control real-time functions resides with an Operations Chief and a Track Chief. The Operations Chief heads the Operations Control Team (OCT), which is comprised of the Track Chief, and the Facility Chiefs for Communications, Data Processing and Data Control, and Telemetry and Command operations (see Figure 1). The OCT provides the continuous function of inter-facility coordination to ensure optimum performance of Control Center real-time systems and the timely accomplishment of scheduled support. The Track Chief heads the Network Operations Control Team (NOCT), which consists of several DSS controllers, operations support personnel, and real-time analysts (provided by the Control Center Operations Performance Analysis Group) for the command, telemetry, and tracking sytems (see Figure 2). The NOCT provides the continuous function of controlling and monitoring Network performance, to ensure systems integrity and the timely accomplishment of

committed support. Real-time resource allocation, conflict resolution, and failure recovery action are directed by the NOCT based on immediate priorities. For example, if an equipment failure occurs at a DSS during a spacecraft tracking pass, a decision must be made in real time to either fix or reconfigure the equipment, or to negotiate with the affected flight project to determine if the pass should be cancelled, or be continued with degraded capabilities. The NOCT is currently organized into five crews, each consisting of an Operations Chief, a Track Chief, and one or more station controllers.

The OCT and NOCT are staffed 24 hours per day, 7 days per week. Since the Network workload fluctuates, depending on the time of day, operations personnel are required to work rotating shifts to ensure that the same people are not always working during high or low activity periods. This is an unfortunate situation, which can lead to sleep disturbances and other problems, and it complicates an already difficult and highly responsible job.

Interfaces

The operational direction and reporting interfaces used by operations personnel in support of flight projects are implemented via dedicated voice communication nets, which are assigned for specific use in both DSN and flight project operations areas. The Operations Chief is the primary interface for real-time operations to all user projects. Advisors, who are technical specialists in a particular area, are also available to the Operations and Track Chiefs as required, in order to assist with specific problems. The Track Chief interfaces with the station controllers, who in turn interface directly with the operations crew at a DSS. During a typical spacecraft tracking pass, for example, the controller first establishes contact with the DSS on a voice net. Time synchronization is performed, station equipment configuration is determined, and the command system is validated. The controller then provides the station operations team with information regarding the pass, such as predicted signal level, round trip light time, signal-to-noise ratio, and receiver lock-up frequency. The controller will then use another voice net to discuss command, telemetry, and tracking system validation with the real-time analysts. The flight project, whose spacecraft is being tracked, will then be informed that the command system is “green” so that the project may then send commands to their spacecraft. The pass continues until its scheduled termination time, while the controller monitors the spacecraft/ground telecommunications link, making sure that all values are within acceptable limits. The controller will also direct the station crew to initiate special requests, such as bit rate changes, requested by the flight project. At the scheduled end of track, the controller directs the station tune-out, and then performs various reporting and log-keeping duties.

Operations Philosophy - Automation and Standardized Procedures

Providing end users of DSN facilities with the appropriate capabilities is a complex and difficult task, requiring the efficient and timely interaction of operations personnel, hardware, software, communications, and mechanical systems. Operation of the DSN has become increasingly complex since its inception, due to the gradual change from a mission-dependent to a mission-independent philosophy of operations. This changing philosophy has been reflected by a transition of operations personnel from highly skilled engineering specialists, to more generalized lower-skilled operators. Two factors have made this transition possible without concurrently degrading the performance or capabilities of the DSN: conversion of manually operated equipment to automatic operation, and the use of standardized operating procedures. These procedures, called Network Standard Operating Procedures (NSOP's), are continually added to or revised in response to new or changing end user requirements, new equipment installation, or software revisions. The use of automation and standardized procedures is primarily responsible for allowing the operations organization to meet the following required Network capabilities:

1) Reconfiguration of the Network from one flight project to another within 15 minutes.

2) Reconfiguration from one mode of operations to another mode, for the same flight project, within 5 minutes.

3) Control of all normal DSS operations by one operator from one location within the station.

Discrepancy Reporting

In order to maximize availability of Network services to end users, DSN management must have an effective control mechanism for the identification and correction of errors, failures, or anomalies encountered during Network operations. This control is maintained through the DSN Discrepancy Reporting System, which applies to all operations personnel and Network facilities during periods of committed support. A Discrepancy Report (DR) is required to be initiated in response to any data flow interruption, failure or discrepancy in equipment or software, procedural or human error, errors caused by inadequate documentation, or any other problem or failure adversely affecting committed support. Each DR is identified by a unique serial number, and contains many different items of information, including a description of the problem, the system involved, the DSS, the end user, the type and length of any data outage, and a description of the real-time recovery action. After a DR is initiated, it is sent to the appropriate operations organization for investigation and resolution. All DR information is maintained in a computerized data base

which is used for long-term trend analysis in order to identify and correct recurring problems.

FUTURE CHALLENGES

The DSN is not a static entity. It is continuously evolving in order to support new end users, changing end user requirements, new equipment and software, and new operations procedures. The greatest challenge currently facing the DSN is the implementation of NASA's Networks Consolidation Program (NCP), which is scheduled to be completed in 1986. NCP will provide the DSN with the capability to support near-earth and high elliptical orbit missions, in addition to current and future deep space missions. NCP will also involve the co-location of antennas so that antenna arraying techniques can be used, which will permit the tracking of spacecraft to much greater distances than is currently possible.

The operations objectives of NCP are:

1) To achieve significant cost reductions in Network operations by extensive automation of Network systems.

2) To maximize support time available to end users by minimizing loss due to facility overhead and maintenance, operator errors, and Network or spacecraft anomalies.

3) To maintain Network performance by rapid detection and correction of degradation.

4) To enable enhancements to Network performance, without impacting on-going operations.

Implementation of NCP will be a major part of the transition toward mission-independent operations, and will enable the DSN to continue to provide high levels of support to end users well into the next century.

REFERENCES

1. Deep Space Network General Requirements and Plans, Publication 820-20, Jet Propulsion Laboratory, Pasadena, CA, March 15, 1976.

2. Deep Space Network Standard Operations Plans, Publication 841-1, Jet Propulsion Laboratory, Pasadena, CA, May 24, 1982.

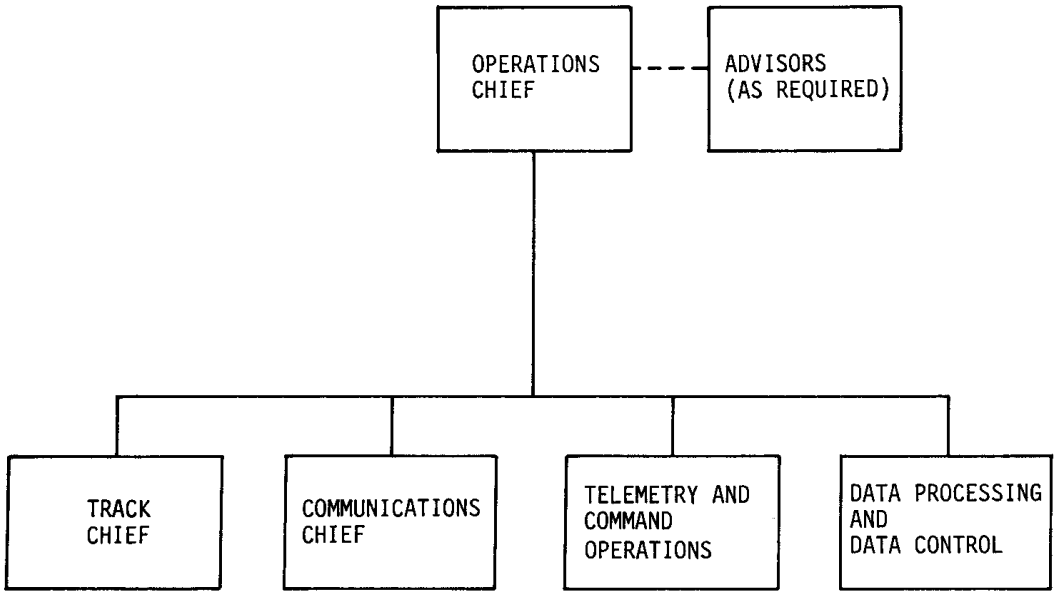

FIGURE 1. OPERATIONS CONTROL TEAM ORGANIZATION

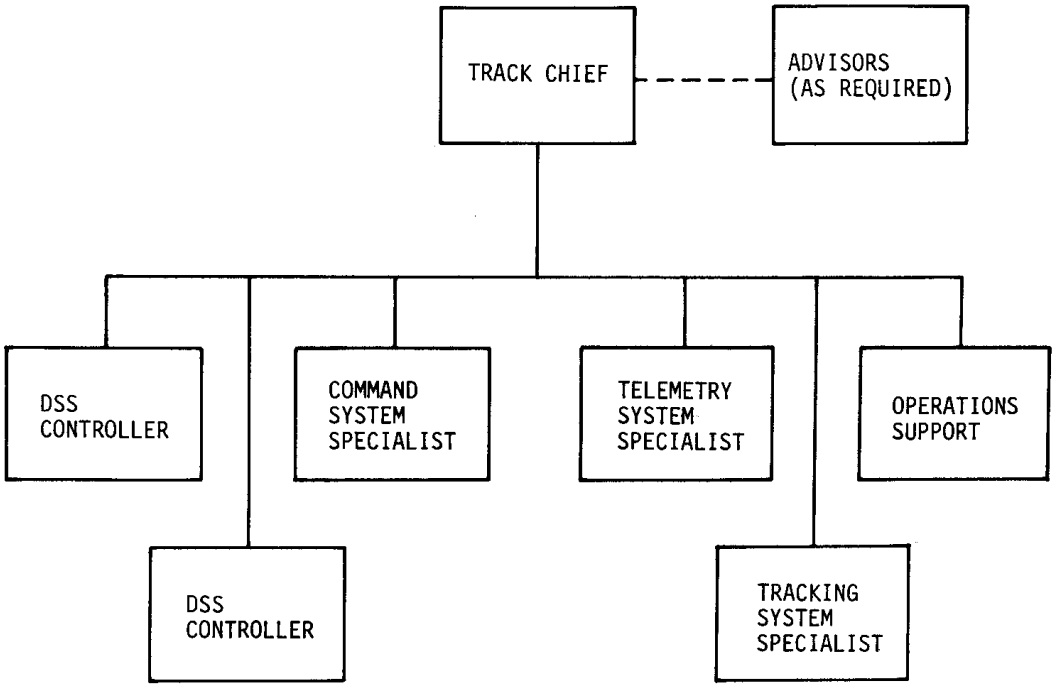

FIGURE 2. NETWORK OPERATIONS CONTROL TEAM ORGANIZATION