# DSN System Performance Test Software

F. B. Leppla

Deep Space Network Support Section

*The Software Support Group of the Deep Space Network Support Section is continuing the development of System Performance Test (SPT) software for the Deep Space Network. During the past two and one-half years, test software has been developed for a new system, Radio Science, and many new features have been added to existing software. Plans are underway for implementation of test software for the Very Long Baseline Interferometry (VLBI) system and the Network Data Processing Area. A description of the elements of the SPT software is provided.*

## I. Introduction

In April of 1975 the Software Support Group was given the assignment of developing System Performance Test (SPT) software as part of the DSN Mark III Data System (MDS) Project. The implementation was successful in that the test software was used for the SPTs to verify system operation and performance.

The three areas that drive the development of SPT software are:

(1) New system implementations.

(2) Modifications to existing systems.

(3) Modified test techniques.

A test capability was implemented during 1978 for the then new narrow- and wide-bandwidth Radio Science System. The test software was used to verify system performance prior to the Voyager Jupiter encounters. In 1979 and 1980, the Radio Science test software was expanded to include test capabilities for the medium-bandwidth Radio Science System features. This SPT software is now being used to test the Radio Science System in preparation for Voyager Saturn encounters.

Since the completion of the MDS implementation, the test software has been modified and enhanced to meet changing system requirements and performance characteristics. The Tracking, Telemetry, and Command SPT software packages have all been modified to match operational system software or hardware changes. In some cases, the test software has to be changed to accommodate anomalies that exist in the operational software.

During the past few years, the majority of the Software Support Group's workload has been in the area of providing modifications to and sustaining existing test software. The workload emphasis changes when requirements for new systems such as Very Long Baseline Interferometry (VLBI) and the Network Data Processing Area (NDPA) are introduced. Two years hence, the initial effort for the Networks Consolidation Project (NCP) will begin.

## II. Description

The SPT software consists of two basic types of software packages. The first is devoted to real-time testing and consists of a Test Executive and several individual test tasks where each task is designed to test a particular system. The second type is non-real-time oriented and is directed towards mathematical performance evaluation where large amounts of data need to be processed.

The real-time test software is contained on one 2.5-MByte disk. This disk is presently 97 percent full and contains software and procedure files to test the Tracking, Telemetry, Command, and Monitor and Control Systems in the DSN. The Test Executive is the main program and controls all activity during execution by activation and deactivation of tasks, reading and routing of operator directives, routing of input and output data, control of peripheral devices, and performing data block dumps upon request.

The operation of the Test Executive is governed by the SPT Standard Operating System (SPTSOS) which contains I/O handlers and common software required by the executive and the test tasks. This operating system is a modified version of the computer-manufacturer-supplied operating system, which has been customized for DSN unique features and disk partitioning requirements. In actuality, four versions of the SPTSOS exist in order to be able to operate the test software in any one of four computer systems in the DSN. System generations are needed whenever the disk configurations need to be modified.

The non-real-time type of SPT software presently consists of three test packages designed for Radio Science System testing. Various types of mathematic techniques are implemented. Digital filtering and Fast Fourier Transform techniques are utilized. Data input is from Original Data Records on magnetic tapes. Planning is underway for implementation of test software for the VLBI system.

## III. System Performance Test Executive

The purpose of the SPT Test Executive (EXEC) is to coordinate the processing of Monitor, Command, Telemetry, Tracking, and ODR Validation System Performance Test Tasks. The EXEC is responsible for routing of all input directives, standard subsystem blocks (SSB), high-speed data (HSD) and wideband data (WBD) blocks to and from the proper test task. The EXEC is also responsible for activating the test tasks and configuring the communication process by operator directives. Another function of the EXEC is to transmit and dump HSD, SSB and WBD blocks as required.

The EXEC in combination with the Operating System maintains communication protocols with other processers in the Deep Space Station (DSS). Finally, the EXEC coordinates the output of operator messages, test reports and data block dumps from either the Test Tasks or from the EXEC itself.

Communication with peripheral devices (disc drives, magnetic tapes, and the operator console) and control of system resources (central processor time and memory) are all maintained by the SPTSOS. The SPTSOS is a modified version of Modular Computer Corporation's MAX III operating system. Modifications have been made to the Modcomp operator console handler and the magnetic tape handler. Special software has been added to interface with the DSN communication buffers, Frequency and Timing System and the Star Switch Controllers. Common data handling routines have been added for features such as Get Bit, Put Block, and GMT time conversions.

Currently, the SPTSOS can run in four different computers in a DSS. The SPT software is normally run in the backup Communication Monitor and Formatter Assembly (CMFA), but it is capable of running, with restrictions, in a Command Processor Assembly (CPA), a Telemetry Processor Assembly (TPA), or a Metric Data Assembly (MDA). Running in any assembly other than the CMFA eliminates the reception of high-speed data.

One of the most important features of the EXEC is the capability to read test procedures (files of operator directives) from disk storage. This capability allows system test personnel to define and use standard, repeatable test conditions which are semiautomatic during execution. The test procedure capability contains basic logical features such that procedures may start, wait, loop, and branch based on time, data conditions, or sense switch positions either in hardware or software. The procedures may call other subprocedures for execution. The procedures control the test process as well as the test software by activating tasks, informing computer operators of required actions, configuring test equipment, and timed generation and transmission of simulated data blocks.

The automatic test procedure capability allows for most cost-effective utilization of test time in the DSN. The test procedures presently contain approximately 23,000 lines of directives.

## IV. Monitor System Performance Test Task

The test software designed to verify system performance of the Monitor System is capable of simulating approximately 250 parameters in various types of data blocks. The test

software is capable of performing automatic verification on most of these parameters which are available in data block output. The simulation feature may be used to output data either as high-speed data or standard subsystem blocks.

The test procedures in combination with the test software are also used to verify all visual displays output by the system. This is accomplished by outputting detailed checklists for computer operator use and then simulating data to drive various display devices at convenient output rates. Erroneous information is also presented to the system to test system responses.

Specific test routines are coded to test (1) text data handling, (2) Antenna Pointing System drive tape preparation, and (3) backfeed data test.

The Monitor SPT software has not been updated during the past two years. The Monitor System has been stable in the DSN for that time period. Some minor changes have been made to the test procedures.

## V. Telemetry System Performance Test Task

The telemetry test software is a table-driven multimission test program capable of processing six telemetry channels simultaneously. This program, as well as all others noted in this article, may be operated either in a manual mode or through use of the automatic procedure capability. The program can control the Simulation Conversion Assembly (SCA) by generating and transmitting text and control blocks. The SCA is used to generate simulated telemetry data for testing.

Telemetry testing requires that a data path be looped to the test computer. This may be accomplished by patching of HSD lines or using computer control to configure Star Switch Controllers. The test software, either in manual or automatic mode, configures the Telemetry Processor Assembly (TPA), instructs the SCA to simulate telemetry for a particular spacecraft, and then performs various test functions on the system data. The test program may perform block header checks, block serial number sequence tests, GMT time comparisons, receiver lock tests, AGC and SNR limit checks, sync or word or bit error rate tests, and distribution curve calculations. Y-factor values may also be computed.

Anomalies in the input data are reported to the test operator. Test reports are output on periodic intervals with a final report output at the completion of a test. Test periods may be defined as a time interval or as a total number of bits to process.

The sync bit error rate test feature has recently been added to the software. Requirement definitions are being finalized for modifications to support the Galileo and International Solar Polar Mission telemetry testing requirements.

## VI. Tracking System Performance Test Task

The Tracking System Performance Test software is a multitask program which is implemented to test the three basic functions of the Tracking System. These functions are doppler, range, and angles.

The test software provides the basic capabilities to (1) validate all tracking data, as defined in the detailed Interface Design Document 820-13 (TRK 2-14) against Standards and Limits, (2) generate and transmit, via HSD or SSB, DSN Tracking System predictions, (3) simulate Monitor System inputs to the Tracking System, and (4) analyze doppler, range, and angle data types.

The doppler function is evaluated by verifying data formats, calculating long-term drift and phase jitter, computing theoretical jitter and S-band Programmed Oscillator Control Assembly (POCA) ramp delay and noise characteristics.

The range function is tested by verifying data formats and by determining range and differenced range versus integrated doppler (DRVID) characteristics. The angle data are evaluated by generating and transmitting angle predictions and then using these predictions to point the antenna. The system data output is then compared against the predicted values. Upon completion of data evaluation, a test report is generated showing test configuration, test data, and test results.

The Tracking SPT software is presently being modified to add various data analysis techniques. The Software Requirements Document (SRD) and Software Definition Document (SDD) have been completed. Development and acceptance of the software program should be completed by March 1981.

## VII. Command System Performance Test Task

There are two SPT programs for the Command System, one for the Mark III-74 Command System and another for the Command Store and Forward System. The two command systems while retaining similar characteristics are significantly different in data format, content, and timing. These basic differences and the fact that the systems were developed three years apart necessitated the development of two distinct test programs.

Both SPT programs function similarly in that they allow simulation of the DSN Operations Control Center by sending control messages to the CPA for radiation and receiving messages from the CPA consisting of acknowledgements, confirmations of radiated commands, and status reports.

Both programs maintain models of the command stacks in the CPA and predict events on the basis of received data. The SPT software predicts confirmations of radiated commands. For the store and forward capability, the software also predicts such things as the Bit-1 radiation times of commands waiting to be radiated, expected time of the next event message and contents thereof, status of the Prime Command file, Command Modulation Assembly (CMA) mode status, queue formation, and the files in the file director.

The predicted events are validated against reported events and the results indicate system performance. Test procedures have been designed to test various mission configurations. Error messages are output upon occurrence and a summary report is output at the conclusion of a test sequence. The test software is very time-critical.

The Command SPT software has been updated three times in the past two years. The design has been completed and coding has begun on modifications for Galileo and the International Solar Polar missions.

## VIII. Original Data Record Validation Task

The ODR validation software runs under the Executive Task even though the testing is not real-time oriented. The software may therefore be controlled via an Automatic Procedure File. This software provides a means for validating the CMFA-produced ODR, which is a record of all system data transmitted from a DSS.

The validation process consists of verifying the block sequences and time sequences and performing selected block dumps to a line printer. Options are available to validate all data on a tape or selected data streams. Error messages are output for missing or duplicated blocks, and a summary output is available noting percentages of data blocks available. The data content of the blocks cannot be verified.

This software, being mission-independent in nature, has not been modified in some time.

## IX. Data Block Translator Task

The Data Block Translator (DBT) task is a general-purpose table-driven software package used to format HS, WB or SSB data blocks to readable outputs on a display device. The Test Executive controls operation of this task. Transmitted or received blocks may be dumped.

Conversion routines are available for such things as (1) output ASCII string, (2) convert to decimal output, (3) convert to integer output, and (4) GMT time conversion. Fifteen different conversion routines are available. Five other routines are included to define table start and end, do logical jumps within the table, adjust data block pointers, and load alternate tables.

The tables are stored on disk with unique block identifier so they can be located rapidly when needed. A spooler file is maintained on the system disk to buffer output data at high block dump rates.

The last release of SPT software contained tables for display of 65 different data blocks.

## X. Radio Science System Performance Test Software

Three Radio Science SPT programs have been delivered to the DSN. Each program has been designed to process data from a unique type of Radio Science System data output. These types are commonly called narrow, medium, and wide bandwidth. Each program performs the same basic function on the system data tape. These programs do not need to operate in a real-time environment as the other SPT programs do. The same basic operating system is used but the disk configuration is much different for data storage requirements.

The basic process performed is to read Radio Science data from magnetic tape or tapes, decimate the data, pass the data through a Fast Fourier Transform, and store the results; then read a tracking system data tape for the same time period, extract the signal frequency, and store the results. S- or X-band data may be processed. A comparative analysis is then performed to determine relative performance of the Radio Science System. Test reports are printed and a basic spectrum analysis plot is available for output.

Some new processing techniques are being explored to be able to process more data in a shorter time span and provide better resolution. At the same time, the three Radio Science SPT programs are being combined into one program.

## XI. Summary

The SPT software is an integral part of system performance testing in the DSN. The development and use of automatic test procedures enhances the overall test capability by providing

repeatability of test configurations in a fast and efficient manner. The procedures and software have been developed in a modular manner. They may be used in total to provide a complete system test. Selected subsets may be used by DSS personnel to troubleshoot isolated system problems.

The SPT software consists of approximately 175,000 lines of source code. During the past two years many modifications have been made, especially in the areas of telemetry, tracking, and command software. New capabilities have been implemented for the Radio Science System.

The design is complete and coding has begun for a major update to the Tracking System test software. The design is complete for new test software for the VLBI System. This effort will result in approximately 20,000 new lines of code. The initial design effort is underway for software to test the NDPA.

The development of SPT software is an ongoing effort in the DSN. The basic goal is to provide a capability which provides a computerized method of verifying system performance in a repeatable, rapid and efficient manner.