Development Support — DSS 13 S-X Unattended Systems Development

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AT DSS 13 (the Venus Station), the subsystems necessary for telemetry reception from spacecraft have been placed under the control of an on-station supervisory computer (Station Controller) and various subsystem controllers, with control inputs originating from Network Operations Control Center (NOCC) at JPL, and monitor inputs from the various Station Subsystems available to the NOCC Operator. The controlled subsystems at DSS 13 include the Antenna and Servo, Microwave Configuration, Block III Receiver, and Subcarrier Demodulator Assembly.

System concepts, overall system description, computer controlled subsystem capabilities, and system testing are discussed. Testing, with control being exercised from NOCC at JPL, has been performed on both Helios and Voyager spacecraft. The test program is continuing.

I. System Concepts

The goal of the DSS 13 S-X Unattended Systems Development program is to demonstrate the capability to perform spacecraft tracking without the necessity for operator inputs at the station performing the tracking. Data are being collected and will be analyzed so as to obtain a measure of the cost effectiveness of station automation, including such factors as possible increased antenna user time availability and impact on station MTBF which may result from the added automatic equipment. Operation of the station is exercised from a remote location, such as Network Operations Control Center (NOCC) at JPL, using an overall supervisory computer (Station Controller), controlling subsystem microprocessors for each of the controlled subsystems. This supervisory computer and the subsystem microprocessors are located at the station. Control inputs from the operator at the remote location are minimal and communications with the Station Controller are via a High-Speed Data Line.

For the initial capability, it was decided to constrain the automatic capability to that required for the reception of spacecraft downlink telemetry, including Subcarrier Demodulation. (The remainder of the telemetry capability at a DSN Station is already computer controlled and could be made remote controlled with relatively minor development effort.) The subsystems chosen for modification at DSS 13 are the Antenna and Servo, Microwave Configuration, Block III Receiver and the Subcarrier Demodulator Assembly (SDA). The output of the DSS 13 SDA is transmitted to another DSN station at Goldstone for processing through the Symbol

Synchronizer Assembly (SSA) and Telemetry Processor Assembly (TPA). Subsequent transmission of telemetry data to NOCC is as now done.

These subsystems at DSS 13 have now been placed under computer control with capabilities which permit complete operation of these subsystems from a CRT Terminal located in NOCC, Bldg 230, at JPL. A block diagram of the system configuration is shown in Figure 1. The subsystem automatic control capabilities are described below.

II. System Description

A. Station Controller

The Station Controller, the supervisory computer in this system, is an 8080 based, JPL built, microprocessor, which communicates with the controlled subsystem controllers via a standard DSN star switch. All automatically controlled Subsystems, with the exception of the Antenna Controller, utilize a similar version of this 8080 based microprocessor. All communication between the NOCC Operator and the controlled subsystems is via the Station Controller, which accepts configuration, predict, and operational mode selection inputs. At the direction of the NOCC Operator, the Station Controller also controls the acquisition process.

B. 26-m Antenna and Servo

Starting with firm power on, but disconnected from the Servo Subsystem, the Antenna Controller, a MODCOMP II/25 Minicomputer, can automatically apply servo operating power, verify correct operation of the electrical and hydraulic components, and either move the antenna to any desired position or track any desired target using operator supplied pointing angle predicts. All movements are made in High-Speed Mode with controlled acceleration, at programmed speeds, until the antenna is at its desired pointing angle. The computer then automatically switches to Low-Speed Mode and tracks the computed target path. Several environmental and servo operational parameters are monitored continuously by the computer to ensure correct functioning. Table 1 "Servo Control Capabilities," Table 2 "Servo Parameters Monitored," and Table 3 "Antenna Movement Modes" list the automatic monitor and control capabilities of this subsystem.

This automated capability may be exercised either locally, using a Terminet as the computer I/O device, or remotely, using the CRT Operator Terminal in NOCC. In the latter case, the input is to the Station Controller and it directs and controls the actions taken by the Antenna Controller.

C. Block III Receiver

The Receiver Control Computer can control the receiver local oscillator frequency and provides initial conditions for the receiver tracking loop filter. Acquisition of the spacecraft downlink frequency is automatically accomplished by opening the receiver tracking loop, sweeping the local oscillator to the correct frequency, detecting the presence of the downlink, activating the tracking loop, stopping the sweep and phase-locking to the downlink carrier in a manner analogous to the actions taken manually by a skilled operator. The initial frequency, rate of sweep, acquisition time, start, and width of the sweep window are initially specified by the operator based on published predictions used by all DSN stations. These "predict" data are loaded into the Receiver Controller via the Station Controller.

D. Microwave Configuration

The configuration of the various microwave elements contained in the Cassegrain feedcone and antenna mounted electronics room is controlled by the positioning of three waveguide switches, two located in the feedcone and one located in the antenna electronics room. The positioning of these switches is under the control of the Microwave Configuration Controller and is specified by configuration information provided to the Microwave Configuration Controller by the NOCC Operator, through the Station Controller. Any possible switch position can be selected, based on configurations required by the track to be performed, e.g., "Transmitter Diplex" or "Low Noise Listen Only" modes.

E. Subcarrier Demodulator Assembly (SDA)

All of the front panel controllable, operational parameters of the Subcarrier Demodulator Assembly, whose selection is necessary for spacecraft subcarrier acquisition, are under the control of the SDA Controller. Table 4, "Controllable SDA Parameters," tabulates these parameters and their ranges. The value or position of these parameters is specified by the NOCC Operator to the Station Controller, which then directs the SDA Controller to effect selection. At the appropriate time, the Station Controller directs the SDA Controller to effect automatic acquisition of the spacecraft subcarrier.

III. System Operation

There are four modes through which the Unattended Operations Control will sequence to acquire spacecraft telemetry.

A. Station Controller Initialization

When the Station Controller Microprocessor is first initialized, it automatically enters a sequence wherein a diagnostic routine checks that the input and output ports, and the controller memory are functioning correctly. The Controller then prompts the operator on input commands required to enter the next mode.

B. Controlled Subsystem Initialization

In this mode, selected by the Operator, each of the controlled subsystems is initialized, which includes verifying the communications link through the Star Switch, verifying memory operability, and verifying input and output ports. Successful completion of this mode substantiates, insofar as software diagnostics can determine, that the control microprocessors are functioning and are ready to accept configuration and predict data. The Station Controller then automatically enters the next mode.

C. Controlled Subsystem Configuration

In this mode, the Station Controller will accept, from the Operator, the configuration and predict information peculiar to the spacecraft to be tracked. This obviously includes antenna pointing, receiver operating frequency, microwave switch positions, and SDA data rate, bandwidth, and subcarrier frequency. Upon request, the Station Controller will display to the Operator the possible choices for each controlled subsystem. Upon completion of the input configuration and predict information, the Operator loads the various subsystems by instructing the Station Controller to "TRANSFER" the entered information. The Station Controller then automatically enters the next mode.

D. Controlled Subsystem Operate

Once in this mode, the Station Controller will respond to an Operator input command to "OPERATE," and the acquisition sequence begins.

IV. Acquisition Sequencing

Upon receipt of the message "ON POINT" from the 26-m Antenna Controller, the Station Controller automatically instructs the Block III Receiver Controller to commence acquisition of the spacecraft downlink carrier. Upon receipt of the message "RECEIVER IN LOCK," the Station Controller automatically instructs the SDA Controller to commence acquisition of the telemetry subcarrier. When the SDA completes acquisition of the telemetry subcarrier, it transmits the message "SDA IN LOCK" to the Station Controller and the acquisition sequence is complete. The base band spectrum output from the DSS 13 SDA is routed, via the microwave link, to another DSN station at Goldstone for symbol synchronization and decoding and transmission via HSDL to NOCC at bldg. 230, JPL. The NOCC Operator (DSN Controller), by observing the Station Controller generated messages displayed on his CRT Control Terminal, can monitor subsequent performance on his standard display, just as he would with any other DSN station.

V. System Testing

Commencing on 1 December 1977, the system as described above has been tested using Helios and Voyager spacecraft telemetry as test signals. Both DSS 11 and DSS 12 have been used as the DSN station with which telemetry processing is accomplished. Complete single point control, as described herein, has not yet been demonstrated as the 26-m Antenna Controller integration into the system is not yet completed. However, control, configuration, and predict loading of all other controlled subsystems have been repeatedly demonstrated successfully from NOCC with no operator input to these systems being accomplished locally at DSS 13.

Complete single point control, as described in this article, is anticipated to be demonstrated in the first week of March 1978. A description of the System Software will be reported in a later DSN Summary.

Table 1. Servo Control Capabilities

Function	Capability
Operating Power Management	Can either apply to start servo system or remove to shut down servo system.
Antenna Brakes	Can apply and release brakes selectively, on either axis, or can apply and release master brake (both axes simultaneously).
Antenna Speed	Can select, for either axis, either High or Low Speed as required by difference between antenna desired position and actual position.
Pre-limit	Can override a pre-limit warning.
Disable Condition	Can reset from Disable to Operate mode.

Table 2. Servo Parameters Monitored

Function	Type Monitor
Brake Status, both axes	Switch
Speed selected, both axes	Switch
Pre-limit Status, both axes	Switch
Final Limit Status, both axes	Switch
System Disable Status	Switch
Lubrication Available, Gearboxes	Flow Switch
Right Wrap-up of Cables	Switch
Left Wrap-up of Cables	Switch
Computer Control Selected	Switch
Differential Pressure, Elevation Low Speed Servo Valve	Transducer
Differential Pressure, Elevation High Speed Servo Valve, Left	Transducer
Differential Pressure, Elevation High Speed Servo Valve, Right	Transducer
Pressure, Elevation High Speed Hydraulic Fluid System Supply	Transducer
Pressure, Elevation Low Speed Hydraulic Fluid System Supply	Transducer
Differential Pressure, Azimuth High Speed Servo Valve	Transducer
Differential Pressure, Azimuth Low Speed Servo Valve	Transducer
Pressure, Azimuth High Speed Hydraulic Fluid System Supply	Transducer
Pressure, Azimuth Low Speed Hydraulic Fluid System Supply	Transducer
Fluid Level, System Hydraulic Fluid Supply Reservoir	Transducer
Wind Speed, South West Tower	Transducer
Wind Speed, South East Tower	Transducer
Wind Direction, South West Tower	Transducer
Wind Direction, South East Tower	Transducer
Temperature, Hydraulic Fluid Supply	Transducer
75 HP Starter In-Use?	Switch
125 HP Starter In-Use?	Switch
Volume Being Delivered, 75 HP Hydraulic Pump, Left	Transducer
Volume Being Delivered, 75 HP Hydraulic Pump, Right	Transducer
Volume Being Delivered, 125 HP Hydraulic Pump, Left	Transducer
Volume Being Delivered, 125 HP Hydraulic Pump, Right	Transducer

Table 3. Antenna Movement Modes

Mode	Description
RAMP (STOP)	Used to stop the antenna movement, without stowing, for whatever need.
AZIMUTH-ELEVATION	Used for positioning the antenna to some fixed coordinates, such as the near-field collimation tower or for maintenance purposes.
SIDEREAL	Used for tracking stars. Requires entry of current set of Right Ascension and Declination coordinates for desired target.
3-DAY FIT	Used for tracking spacecraft. Requires entry of three sets of Right Ascension and Declination coordinates, for the three successive days starting with day on which track is to be accomplished.

Table 4. Controllable SDA Parameters

Parameter	Range
INPUT SOURCE	Rcvr 1, Rcvr 2, Test, Tape
VCO LOOP FILTER SHORT	On, Off
VCO LOOP BANDWIDTH	Narrow, Medium, Wide
MODULATION INDEX	0 - 30 dB
SUBCARRIER FREQUENCY	100 - 1×10^6 Hz
SYMBOL RATE	5.6 - 270,000 symbols/second
OUTPUT PORT SELECTED	Demod, Test, Tape

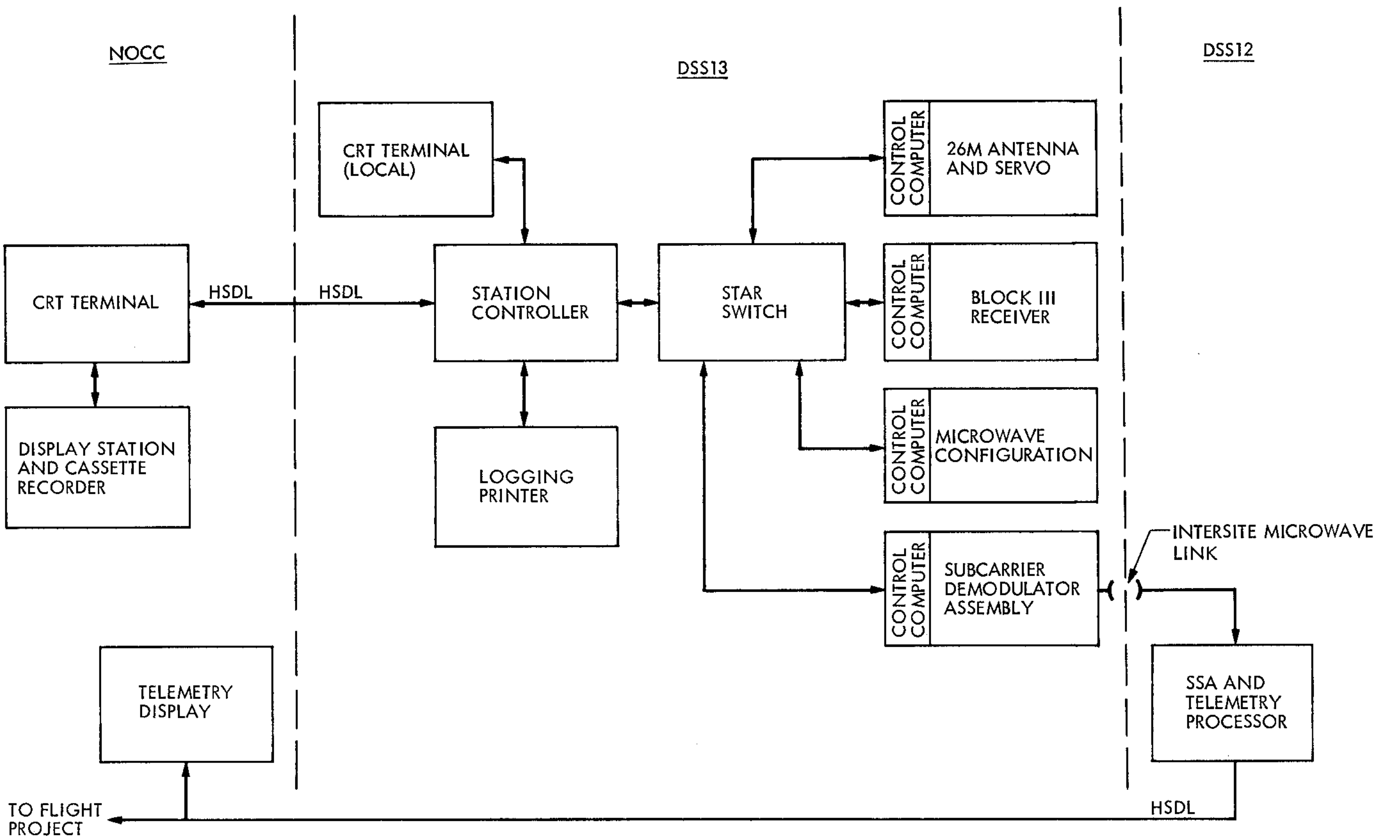

Fig. 1. DSS 13 unattended operations system configuration