Preliminary Maintenance Experience for DSS 13 Unattended Operations Demonstration

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This article summarizes the maintenance data base collected for 15 weeks of recent unattended and automated operation of DSS 13. During this period, DSS 13 has been receiving spacecraft telemetry while being controlled remotely from JPL in Pasadena. Corrective and preventive maintenance manhours are reported by subsystem for DSS 13 including the equipment added for the automation demonstration. The corrective and preventive maintenance weekly manhours at DSS 13 averaged 22 and 40, respectively. The antenna hydraulic and electronic systems accounted for about half of the preventive and corrective maintenance manhours. A comparison is presented for overall preventive and corrective maintenance manhours for a comparable attended DSN station, DSS 11.

I. Introduction

The tracking time now available to the end user at a Deep Space Station is reduced by time spent for maintenance, operator training, checkout and calibration. The efficiency of the DSN would be greatly increased if the time for these other functions were decreased. Also, the reliability of the DSN may be increased by reducing the load on operations personnel.

As a result of these potential improvements in DSN efficiency and reliability, a research program was started several years ago at DSS 13. The station has now been automated and is being operated in an unattended mode for spacecraft telemetry reception. Data are now being collected to evaluate this operation.

This article will present the preliminary maintenance experience at DSS 13 for unattended, automated operation. Both corrective and preventive maintenance are considered, and where possible, comparisons are made to a manned operation at DSS 11. Before this maintenance data is presented, the automated system and its capability will be described.

II. DSS 13 Description — Automated Station

DSS 13 is a 26-meter station at Goldstone, California. Central control and monitor for this station are done from JPL in Pasadena by an operator at NOCC. This automated and remote operation only for spacecraft telemetry reception was implemented in 1978. The operator enters configurational

control and predicts. Monitor data are also available to him. The station is (1) powered up, (2) checked out, (3) spacecraft telemetry is acquired and tracked, and, (4) the station is shutdown, all remotely from Pasadena without an operator at the station. There is automatic antenna shutdown capability in case of high winds or certain servo drive failures.

The telemetry stream from DSS 13 is sent to DSS 11 for bit detection and then via high speed data lines to the flight project at JPL. Work is underway so bit detection can be done at DSS 13.

The DSS 13 unattended operations design uses microprocessors or minicomputers on each controlled subsystem for (1) configurational control, (2) monitoring, (3) operation, and (4) checkout.

A central station microprocessor is used for supervision of subsystem monitor and control processors. The antenna, microwave, and receiver subsystems are now under centralized control. Only downlink capability is now available; however, uplink capability will be implemented in 1979. The 100-kilowatt S-band transmitter and exciter subsystem will be added during 1979. While DSS 13 has been in the unattended mode, telemetry data has been provided to the Voyager, Pioneers 10 and 11, and Helios projects.

The following section will describe the maintenance experience during this initial remote unattended operation of DSS 13.

III. DSS 13 Maintenance Data Base

The maintenance data base for DSS 13 operation under remote, automated operation from NOCC in Pasadena is shown in Tables 1 and 2. These data are for the 15-week period of June 18, 1978 through September 24, 1978. The data are summarized in weekly increments. Corrective maintenance is shown in Table 1 and preventive maintenance in Table 2. The maintenance data are broken down by subsystem. An asterisk next to the DSS 13 subsystem means that this equipment has been added for this demonstration.

IV. Discussion of Results

A. DSS 13 Corrective Maintenance

The corrective maintenance at DSS 13 averaged 22.2 manhours per week with a standard deviation of 12.8 during this period. Shown below is the percent of corrective maintenance manhours for each subsystem.

Subsystem	Corrective maintenance manhours %
Antenna electronic systems	38.1
Block III SDA	17.1
Antenna hydraulic systems	10.6
108 kHz subcarrier oscillator microwave link transmission	9.5
Antenna terminet	7.7
Antenna clock	6.1
Block III receiver	4.7
High-speed data line microwave link channel	3.0
Antenna control computer (MOD COMP II/25)	2.6
Maser compressor	0.6
	100.0

The antenna electronic and hydraulic systems and the Block III SDA account for over half of the corrective maintenance manhours. Note that in Table 1 about half of the subsystems, such as the maser refrigerator, required no corrective maintenance.

B. DSS 13 Preventive Maintenance

The preventive maintenance at DSS 13 averaged 39.5 manhours per week with a standard deviation of 14.8. Shown below is the percent of preventive maintenance manhours for each subsystem.

Subsystem	Preventive maintenance manhours %
Antenna hydraulic systems	43.9
Antenna electronic system	15.3
Maser compressor	11.1
Block III receiver	8.8
Block III SDA	6.5
108 kHz subcarrier oscillator	5.1
Antenna control computer (MOD COMP II/25)	4.5
Maser refrigerator	3.8
Station controller (8080 based microcomputer)	0.7
High speed data line microwave link channel	0.3
	100.0

The antenna hydraulic and electronic systems account for over half of the preventive maintenance manhours. About half of the subsystems received no preventive maintenance during this period, as shown in Table 2.

C. Comparison of DSS 13 Corrective and Preventive Maintenance

Several key subsystems had vastly different percentages of corrective and preventive maintenance as shown below.

Subsystem	Percent of total corrective maintenance %	Percent of total preventive maintenance %
Antenna electronic system	38.1	15.3
Block III SDA	17.1	6.5
Antenna hydraulic system	10.6	43.9

For example, while the antenna electronic system accounted for 38.1% of the total corrective maintenance manhours, this system only received 15.3% of the total preventive maintenance manhours. The same relationship was true for the Block III SDA. On the other hand, the antenna hydraulic system received 43.9% of the total preventive maintenance manhours and only 10.6% of the corrective maintenance manhours. These results indicate that perhaps there could be a shift in preventive maintenance to reflect corrective maintenance experience in order to optimize the overall maintenance effort.

D. Maintenance for the Traditional Subsystems Versus the Subsystems Added for This Demonstration

The subsystems added for this demonstration are shown by asterisks in Tables 1 and 2. The percent of preventive and corrective maintenance for these subsystems is shown below.

Subsystem	Preventive maintenance %	Corrective maintenance %
Subsystems added for this demonstration	10.6	28.9
Traditional subsystems	89.4	71.1
	100.0	100.0

The subsystems added for this demonstration required about 29% of the corrective maintenance and received only 11% of the preventive maintenance. Note that some of the "traditional" subsystems were automated for this demonstration, such as the antenna electronic and hydraulic systems.

E. Comparison of Maintenance at DSS 11 with DSS 13

The average weekly maintenance manhours for DSS 11 and DSS 13 are shown below.

Maintenance	Average weekly manhours DSS 11	DSS 13
Corrective maintenance	153.5	22.2
Preventive maintenance	56.4	39.5
	209.9	61.7

The DSS 11 data is from Ref. 1 for the period May 14 through July 9, 1978. Both the corrective and preventive maintenance manhours at DSS 11 are more than at DSS 13. However, DSS 11 has more equipment than DSS 13. For example, DSS 11 has two receivers, two SDA's, two masers, etc., whereas DSS 13 has only one of each. Shown below is the average weekly maintenance manhours for "comparable" systems at DSS 11 and DSS 13.

Maintenance	Average weekly manhours For "comparable" systems DSS 11	DSS 13
Corrective maintenance	153.5	27.2
Preventive maintenance	56.4	51.4
	209.9	78.6[a]

[a](37.5% of 209.9)

In this comparison, we made the conservative assumption that if DSS 13 had had two SDA's, for example, then the preventive and corrective maintenance for SDA's would have been doubled at DSS 13. In actual practice, this factor should be somewhere between one and two. However, even with this conservative assumption, the corrective maintenance at DSS 13 only increased by 22.4% and the preventive maintenance by 30.2% in order to correct for the redundant systems at DSS 11. For comparable systems, we see in the above table that the preventive maintenance manhours are about the same at both stations but the corrective maintenance manhours are much higher at DSS 11.

Another interesting result is that at DSS 11 about three-fourths of the actual maintenance manhours are for corrective maintenance, whereas at DSS 13, about three-fourths of the

actual maintenance manhours are for preventive maintenance, as shown below.

The data suggests that unattended operation may reduce maintenance manhours. There are other factors, however, that may be responsible for the differences between the two stations in total maintenance manhours and the breakdown between preventive and corrective maintenance. For example, DSS 13 has substantially different equipment, schedule of operations, performance verification requirements, and type of personnel than DSS 11.

Maintenance	DSS 11 %	DSS 13 %
Corrective maintenance manhours	73	26
Preventive maintenance manhours	27	74
Total maintenance manhours	100	100

Acknowledgement

We wish to thank Earl Jackson for supplying the DSS 11 and DSS 13 data and for providing insight into station operation.

Reference

1. Remer, D. S., and Lorden, G. "Initial Economic and Operations Data Base for DSS 13 Automation Test," *DSN Progress Report 42-49*, Jet Propulsion Laboratory, Pasadena, Calif., pp. 78-85.

Table 1. DSS 13 corrective maintenance activities in manhours, 1978

	6/18	6/25	7/2	7/9	7/16	7/23	7/30	8/6	8/13	8/20	8/27	9/3	9/10	9/17	9/24	Total	%
Corrective Maintenance																	
26-m antenna																	
Hydraulic systems		1.0	0.5		6.0	4.0	13.5	4.0				1.5	5.0			35.5	10.6
Electronic systems	13.0		3.0	4.0	19.5	7.0	42.0	17.0	0.5	6.0		7.0		4.0	4.0	127.0	38.1
*Control computer (MOD COMP II/25)		1.0	2.5	4.0			1.0									8.5	2.6
*Clock		12.0		8.3												20.3	6.1
*Terminet		16.3	1.0										2.0		6.5	25.8	7.7
*Microprocessor																	
Waveguide configuration assembly																	
Low noise amplifier (maser) maser compressor refrigerator										2.0						2.0	0.6
Block III receiver																	
Block III SDA				5.0	7.5						3.0					15.5	4.7
*108 kHz subcarrier oscillator (microwave link transmission)						2.5			18.5	14.0	29.0	6.0	18.5			57.0	17.1
*Station controller (8080 based microcomputer)																31.5	9.5
*Star switch controller																	
*SDA controller																	
*Block III receiver controller																	
*Waveguide configuration assembly controller																	
High speed data line																	
*Data set																	
*Microwave link channel										1.5				8.5		10.0	3.0
TOTAL	13.0	30.3	7.0	21.3	33.0	13.5	56.5	21.0	19.0	23.5	32.0	14.5	25.5	12.5	10.5	333.1	100.0

*Equipment added for automation demonstration

Table 2. DSS 13 preventive maintenance activities in manhours, 1978

	6/18	6/25	7/2	7/9	7/16	7/23	7/30	8/6	8/13	8/20	8/27	9/3	9/10	9/17	9/24	Total	%
Preventive Maintenance																	
26-m antenna																	
Hydraulic systems	4.0	6.0	4.0	12.0	19.5	10.0	24.0	15.0	27.5	23.0	29.0	19.5	8.5	52.5	6.0	260.5	43.9
Electronic systems	8.5	14.0	18.5	9.5	3.0	9.0	0.5	10.5	1.0	0.3	7.0		0.5	0.5	8.0	90.8	15.3
*Control computer (MOD COMP II/25)					3.5	6.0					1.5				15.5	26.5	4.5
*Clock																	
*Terminet																	
*Microprocessor																	
Waveguide configuration assembly																	
Low noise amplifier (maser)																	
maser compressor	3.5	26.5	8.5			5.5								12.0	10.0	66.0	11.1
refrigerator	8.0	2.0		5.5			4.0				1.0				2.0	22.5	3.8
Block III receiver	26.5					2.5	4.0	8.5		1.5	3.0	4.5	1.5			52.0	8.8
Block III SDA		0.5	1.0		0.5	3.0	5.5					9.0	7.0	10.0	2.0	38.5	6.5
108 KHz subcarrier oscillator (microwave link transmission)		2.0	2.0	1.5	2.0		2.5					20.0				30.0	5.1
*Station controller (8080 based microcomputer)															4.0	4.0	0.7
*Star switch controller																	
*SDA controller																	
*Block III receiver controller																	
*Waveguide configuration assembly controller																	
High speed data line																	
*Data Set																	
*Microwave Link Channel								2.0								2.0	0.3
TOTAL	50.5	51.0	34.0	28.5	28.5	36.0	40.5	36.0	28.5	24.8	41.5	53.0	17.5	75.0	47.5	592.8	100.0

*Equipment Added for Automation Demonstration