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SECOND QUARTERLY DATA REPORT FOR RELIABILITY AND MAINTAINABILITY EVALUATION OF THE BASIC WIDE MICROWAVE LANDING SYSTEM AT WALLOPS ISLAND, VIRGINIA

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DATA REPORT

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16. Abstract

This is the second quarterly data report on the reliability and maintainability evaluation of the Basic Wide Microwave Landing System located at Wallops Island, Virginia. It covers the period August 1 through October 31, 1980. Chargeable failures are listed, and calculated reliability values are presented. System and subsystem mean time between failure (MTBF) and mean time to repair (MTTR) measured values are included. System MTBF's are compared with predicted and specified values.

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METRIC CONVERSION FACTORS

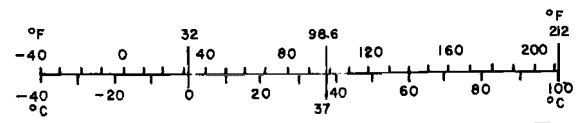
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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INTRODUCTION

PURPOSE.

The purpose of this project is the evaluation of the Microwave Landing System (MLS) Basic Wide System at Wallops Island, Virginia, to determine the operational subsystem and system Mean Time Between Failures (MTBF) and Mean Time to Repair (MTTR). Failure rates are to be calculated. All the values will be compared with those predicted by the contractor. Reliability and maintainability weak points or problems areas will be determined. This data report documents the evaluation data between the dates of August 1 and October 31, 1980.

BACKGROUND.

A reliability and maintainability project, No. 075-725-490, entitled "Reliability and Maintainability (R&M) of Basic Wide MLS at Wallops Island (NASA)," was established at the Federal Aviation Administration (FAA) Technical Center in May 1980 under the Landing System Technical Program Document No. 07-115. Reliability Engineering Section (ATC-152) personnel were assigned to support the effort under the technical administrative direction of the program manager (ACT-100E). Data collecting commenced on May 21, 1980, for the MLS and the Precision Distance Measuring Equipment (PDME) at the site.

DISCUSSION

In the first quarterly data report (report No. FAA-CT-81-14, dated April 1981), a presentation was made on the project data collection, reduction, and analysis.

The chargeable failure test data for quarterly report period August 1 to October 31, 1980, are shown in tables 1 through 4, progressing from equipment units in table 1 through the system level in table 4. The summed chargeable failure test data for the period May 21 through October 31, 1980, are shown in tables 5 through 8. The equipment levels progress from equipment units in table 5 through the system level in table 8. In table 9, the MTBF specified, predicted, and summated measured values for the Basic Wide MLS and PDME are presented.

At the element and enclosure level, all failures which meet the criteria for being counted as chargeable are used in the data calculations. The Bendix Corporation's reliability model definitions are used in computing subsystem and system values because of equipment designed graceful degradation. Appendix A is a chargeable failure list including the date, definition, and explanation. Appendix B includes all the tabulated data reported in the first quarterly data reporting period (May 21 through July 31, 1980).

Within this second reporting period failures occurred which did not meet all the criteria for being counted as chargeable. All of these failures caused the subsystem or system to not transmit. The azimuth subsystem had 29 nonchargeable failures, and the elevation subsystem had 59 nonchargeable failures. Twenty-two of the elevation subsystem nonchargeable failures were due to the azimuth subsystem's

not transmitting. When the azimuth subsystem is down (not transmitting), it does not transmit sychronization or timing signals via the intrasite cable to the elevation subsystem. If the elevation subsystem does not receive the synchronization and timing signals, it goes into executive fault and does not transmit. If the synchronization and timing signals remain off for more than 5 minutes, the elevation subsystem stops trying to restart automatically and remains down until manually restarted. Most of the downtimes of the respective subsystems related to these nonchargeable failures were attributed to the technician's not being on duty (nights and weekends). The PDME system had no nonchargeable failures.

Included in the nonchargeable failures were four main-base momentary power outages. They were a complete loss of power to the MLS equipment for 1 to 2 seconds as recorded on the Rustrak recorder. The effects of the momentary power outages on the MLS subsystems varied from 0.08 hour to 38.5 hours. Most of the extended time loss was due to the incidents occurring at night or on the weekend when the site's technical person was not on duty. The automatic restart circuits in each subsystem attempted for 5 minutes to reactivate the equipment after the return of power. In each of these momentary power outages various signals remained in the executive fault status for a period exceeding 5 minutes. Thus, the MLS subsystems remained down and required manual intervention to return them to operation. The total time lost by the azimuth subsystem was 45.58 hours. The total time lost by the elevation subsystem was 85.75 hours. The PDME system lost only momentary time, returning to service with the return of power; and, subsequently, it was down only for the actual power loss period.

The intrasite signal cable between the azimuth and elevation subsystems was severed by construction equipment. The time lost by the elevation subsystem in this incident was 95.25 hours and is considered nonchargeable. The intrasite cable carries the synchronization and timing signals from the azimuth subsystem shelter to the elevation subsystem shelter. When these signals are not actively present at the elevation subsystem, it goes into the executive fault status.

The total MLS azimuth subsystem downtime due to preventive maintenance (PM) is considered nonchargeable and consisted of 4.48 hours during this reporting period. The MLS elevation subsystem had 3.77 hours of downtime due to PM and an additional 3.70 hours of downtime due exclusively to the PM on the MLS azimuth subsystem. When PM is being performed on the elevation subsystem, the azimuth subsystem is unaffected. When the azimuth subsystem is down for PM, no synchronization or timing signals are transmitted via the intrasite cable to the elevation subsystem, causing the elevation subsystem to go into the executive fault status. PM done on the azimuth and elevation subsystems is independent of the PDME system and vice versa. No PM was done on the PDME system.

The air-conditioners and heaters had no chargeable or nonchargeable failures. There is one air-conditioner and heater in each of the azimuth and elevation subsystems' electronics shelters of which there is one in each subsystem. The azimuth subsystem's guidance antenna has two air-conditioners and heaters, and the elevation subsystem's guidance antenna has one air-conditioner and heater.

Remote control panels were installed in the air traffic control (ATC) tower. In a normal ATC installation, these remote control panels would have control of the MLS equipment when the respective subsystem is not in maintenance. At this installation, the normal duty hours of the tower personnel and the MLS site technical person were the same. In addition, since the MLS is not a production item,

some portion of it is usually being worked on by the site technical person. Therefore, the MLS was usually left in the local control status, requiring manual intervention at the site each time a subsystem required restarting. By virtue of the MLS technical persons being on the base, an MLS subsystem malfunction could be responded to within approximately 15 minutes. In addition, by virtue of the remote control panels, the ATC tower personnel would know of the MLS subsystem's continued nontransmitting status and could notify the site technical person.

The next report will cover the data collection period of November 1, 1980, through January 31, 1981.

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TABLE 1. MLS AND PDME SYSTEMS UNIT TYPES, FAILURES AND MAINTENANCE (AUGUST 1 to OCTOBER 31, 1980)

Item No.	Unit Type	Total Uptime (Hours)	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	Azimuth antenna enclosure electronics	1,790.59	3	1.50	1,675.43	596.86	0.50
2	Azimuth antenna enclosure air-conditioners (2)	*	0	*	--	--	--
3	Azimuth antenna monitor antenna	1,790.59	0	0	0	--	--
4	Azimuth electronics rack	1,790.59	1	1.00	558.48	1,790.59	1.00
5	Azimuth electronics rack air-conditioner	*	0	0	0	--	--
6	Elevation antenna enclosure electronics	1,403.46	0	0	0	--	--
7	Elevation antenna enclosure air-conditioner (1)	*	0	*	--	--	--
8	Elevation antenna monitor antenna	1,403.46	0	0	0	--	--
9	Elevation electronics rack	1,403.46	2	7.00	1,425.05	701.73	3.50
10	Elevation electronics rack air-conditioner	*	0	0	0	--	--
11	PDME antenna	2,207.00	0	0	0	--	--
12	PDME electronics rack	2,207.00	1	0.75	453.10	2,207.00	0.75
13	PDME electronics rack environmental control, refer to item 5, above	*	0	0	0	--	--

*The test data (facility logs) do not include accurate downtime or accurate repair time for the air-conditioners in the unit.

TABLE 2. MLS SUBSYSTEMS ENCLOSURES, FAILURES AND MAINTENANCE (AUGUST 1 TO OCTOBER 31, 1980)

Item No.	Enclosure	Total Uptime (Hours)*	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	Azimuth antenna enclosure	1,790.59	3	1.50	1,675.43	596.86	0.50
2	Azimuth antenna monitor antenna enclosure	1,790.59	0	--	--	--	--
3	Azimuth shelter	1,790.59	1	1.00	448.48	1,790.59	1.00
4	Elevation antenna enclosure	1,430.46	0	--	--	--	--
5	Elevation antenna monitor antenna enclosure	1,403.46	0	--	--	--	--
6	Elevation shelter	1,403.46	2	7.00	1,425.05	701.73	3.50

*The test data do not include accurate downtime or accurate repair time for the air-conditioners in the enclosure. Thus, the air-conditioner units' test data are not included in this table.

TABLE 3. MLS SUBSYSTEMS FAILURES AND MAINTENANCE (AUGUST 1 TO OCTOBER 31, 1980)

Item No.	Subsystem	Total Uptime (Hours)	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	Azimuth	1,790.59	1	1.00	558.48	1,790.59	1.00
2	Elevation	1,403.46	2	7.00	1,425.05	701.73	3.50

TABLE 4. MLS AND PDME SYSTEMS FAILURES AND MAINTENANCE (AUGUST 1 TO OCTOBER 31, 1980)

Item No.	System	Total Uptime (Hours)	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	MLS (azimuth and elevation)	1,403.46	3	8.00	2,137.57	457.82	2.67
2	MLS (azimuth only)	1,790.59	1	1.00	558.48	1,790.59	1.00
3	PDME	2,207.00	1	0.75	453.10	2,207.00	0.75

TABLE 5. MLS AND PDME SYSTEMS UNIT TYPES, FAILURES AND MAINTENANCE SUMMATION (MAY 21 TO OCTOBER 31, 1980)

Item No.	Unit Type	Total Uptime (Hours)	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	Azimuth antenna enclosure electronics	3,437.00	6	9.58	1,745.71	572.83	1.60
2	Azimuth antenna enclosure air-conditioners (2)	*	1	*	--	--	--
3	Azimuth antenna monitor antenna	3,437.00	0	0	0	0	0
4	Azimuth electronics rack	3,437.00	2	2.50	581.90	1,718.40	1.25
5	Azimuth electronics rack air-conditioner	*	0	0	--	--	--
6	Elevation antenna enclosure electronics	2,855.00	3	4.25	1,050.79	951.67	1.42
7	Elevation antenna enclosure air-conditioner (1)	*	1	*	--	--	--
8	Elevation antenna monitor antenna	2,855.00	0	0	0	--	--
9	Elevation electronics rack	2,855.00	2	7.00	700.53	1,427.50	3.50
10	Elevation electronics rack air-conditioner	*	0	0	--	--	--
11	PDME antenna	3,693.58	0	0	0	--	--
12	PDME electronics rack	3,693.58	2	13.25	541.48	1,846.79	6.63
13	PDME electronics rack environmental control, (refer to item 5)	*	0	0	--	--	--

*The test data (facility logs) do not include accurate downtime or accurate repair time for the air-conditioners in the unit.

TABLE 6. MLS SUBSYSTEMS ENCLOSURES, FAILURES AND MAINTENANCE SUMMATION (MAY 21 TO OCTOBER 31, 1980)

Item No.	Enclosure	Total Uptime (Hours)	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	Azimuth antenna enclosure	3,437.00*	6	9.58	1,745.71	572.83	1.60
2	Azimuth antenna monitor antenna enclosure	3,437.00	0	0	0	--	--
3	Azimuth shelter	3,437.00*	2	2.50	581.90	1,718.50	1.25
4	Elevation antenna enclosure	2,855.00*	3	4.50	1,050.79	951.67	1.42
5	Elevation antenna monitor antenna enclosure	2,855.00	0	0	0	--	--
6	Elevation shelter	2,855.00*	2	7.00	700.53	1,427.50	3.50

*The test data do not include accurate downtime or accurate repair time for the air-conditioners in the enclosure. Thus, the air-conditioner units' test data are not included in this table.

TABLE 7. MLS SUBSYSTEMS FAILURES AND MAINTENANCE SUMMATION (MAY 21 TO OCTOBER 31, 1980)

Item No.	Subsystem	Total Uptime (Hours)	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	Azimuth	3,437.00*	3	9.58	872.85	1,145.67	3.19
2	Elevation	2,855.00*	3	7.75	1,050.79	951.67	2.58

*The test data do not include accurate downtime or accurate repair time for the air-conditioners in the subsystems. Thus, the air-conditioner units' test data are not included in this table.

TABLE 8. MLS AND PDME SYSTEMS FAILURES AND MAINTENANCE SUMMATION (MAY 21 TO OCTOBER 31, 1980)

Item No.	System	Total Uptime (Hours)	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	MLS (azimuth and elevation)	2,855.00*	6	17.33	2,101.58	475.83	2.89
2	MLS (azimuth only)	3,437.00*	3	9.58	872.85	1,145.67	3.19
3	PDME	3,693.58*	2	13.25	541.48	1,846.79	6.63

*The test data do not include accurate downtime or accurate repair time for the air-conditioners in the operational systems. Thus, the air-conditioner units' test data are not included in this table.

TABLE 9. BASIC-WIDE MLS AND PDME SPECIFIED, PREDICTED, AND SUMMATED MEASURED MTBF VALUES

Item No.	Equipment	Specified MTBF (hours)	Predicted MTBF (hours)	Summated Measured MTBF (hours)
1	MLS system (azimuth and elevation)	1,500	1,632	475.83
2	MLS azimuth subsystem	3,000	3,030	1,145.67
3	MLS elevation subsystem	3,000	3,539	951.67
4	PDME system	3,000	2,965*	1,846.79

*The predicted values is for a DME-1 which is commercially available. It does not take into account the modifications made to the DME-1 converting it into a PDME.

APPENDIX A
CHARGEABLE FAILURES LIST
(Related to Table 1)

AUGUST 1, TO OCTOBER 31, 1980

Table 4 Item No.	Failure Item No.	Failure Date	Failure Description and Correction
1			Azimuth antenna enclosure electronics
	1 and 2	10/27 to 10/28/80	During an engineering change test earlier this month, transients occurred in the azimuth subsystem. In repairing the subsystem and bringing it up to operational status, the off-line test was run. Phase shifter positions +48 and +54 were indicated to have failed. In position +48 phase shifter serial number (S/N) 57 was removed and S/N 172 was installed. In position +54, phase shifter S/N 165 was removed, and S/N 45 was installed. There has been no feedback from Bendix Corp. as to why and what in the phase shifters went bad. Corrective maintenance time, 1.0 hour.
	3	10/31/80	The self-test error was indicated in the beam steering unit. Used procedure in manual Texas Instruments (T.I.) 6830.1 for searching read-only-memory (ROM) location. Found phase shifter position +47 was causing the error. Visual inspection showed phase shifter position +48 to have its fault light emitting diode on. Removed phase shifter S/N 172 and installed S/N 61. There has been no feedback from Bendix Corp. as to why and what in the phase shifter went bad. Corrective maintenance time, 0.5 hour.
2			Azimuth antenna enclosure air-conditioners
			none
3			Azimuth antenna monitor antenna
			none
4			Azimuth electronics rack
	1	9/9/80	The monitor panel data link fault indicated. Trouble shooting showed the BDA board (A2) in the remote control panel located in the air traffic control tower to be defective. Pulled defective BDA board and replaced it with a spare. Found integrated circuit U12 (55113) to be defective on

			the original board. Ordered a new replacement for U12. No subsystem downtime since it was operating in the local control mode. Corrective maintenance time for reinstating the remote control panel to operational status was 1.0 hour.
5	Azimuth electronics rack air-conditioner		
	none		
6	Elevation antenna enclosure electronics		
	none		
7	Elevation antenna enclosure air-conditioner		
	none		
8	Elevation antenna monitor antenna		
	none		
9	Elevation electronics rack		
	1	8/4/80	The amplitude modulator fault indicator showed this as a maintenance fault. The amplitude modulator module in the radio frequency drawer, 1A1A1A2A3, was found defective. It was replaced with a spare. Corrective maintenance time, 1.67 hours.
	2	9/25/80	Monitor timing executive fault occurred intermittently. Troubleshooting the problem found intermittent contact between the WCZ board and its chassis connection. The board number is 1A1A1A4A14. Adjusted tension of board connector contacts and reinserted the respective WCZ board. Reset the local control switches, and the system was operational. Corrective maintenance time, 5.33 hours.
10	Elevation electronics rack air-conditioner		
	none		
11	PDME antenna		
	none		
12	PDME electronics rack		
	1	8/15/80	The replay delay fault was intermittent. Troubleshooting localized the problem to board 1A2A4. Isolated problem to a cold solder joint on resistor 1A2A4R46, which was resoldered. No similar reoccurence of the problem since then. Corrective maintenance time, 0.75 hour.

APPENDIX B

FIRST QUARTERLY DATA REPORTING PERIOD
DATA TABLES

TABLE B-1. MLS AND PDME SYSTEMS UNIT TYPES, FALURES AND MAINTENANCE (MAY 21 TO JULY 31, 1980)

Item No.	Unit Type	Total Uptime (Hours)	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	Azimuth antenna enclosure electronics	1,646.41	3	8.08	1,822.15	548.80	2.69
2	Azimuth antenna enclosure air-conditioners (2)	*	1	*	--	--	--
3	Azimuth antenna monitor antenna	1,646.41	0	0	0	--	--
4	Azimuth electronics rack	1,646.41	1	1.5	607.38	1,646.41	1.5
5	Azimuth electronics rack air-conditioner	*	0	0	0	--	--
6	Elevation antenna enclosure electronics	1,451.54	3	4.25	2,066.77	483.85	1.42
7	Elevation antenna enclosure air-conditioner (1)	*	1	*	--	--	--
8	Elevation antenna monitor antenna	1,451.54	0	0	0	--	--
9	Elevation electronics rack	1,451.54	0	0	0	--	--
10	Elevation electronics rack air-conditioner	*	0	0	0	--	--
11	PDME antenna	1,486.58	0	0	0	--	--
12	PDME electronics rack	1,486.58	1	12.5	672.68	1,486.58	12.5
13	PDME electronics rack environmental control, refer to item 5, above	*	0	0	0	--	--

*The test data (facility logs) do not include accurate downtime or accurate repair time for the air-conditioners in the unit.

TABLE B-2. MLS SUBSYSTEMS' ENCLOSURES, FAILURES AND MAINTENANCE (MAY 21 TO JULY 31, 1980)

Item No.	Enclosure	Total Uptime (Hours)*	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	Azimuth antenna enclosure	1,646.41	3	8.08	1,822.15	548.80	2.69
2	Azimuth antenna monitor antenna enclosure	1,646.41	0	--	--	--	--
3	Azimuth shelter	1,646.41	1	1.5	607.38	1,646.41	1.5
4	Elevation antenna enclosure	1,451.54	3	4.25	2,066.77	483.85	1.42
5	Elevation antenna monitor antenna enclosure	1,451.54	0	--	--	--	--
6	Elevation shelter	1,451.54	0	--	--	--	--

*The test data do not include accurate downtime or accurate repair time for the air-conditioners in the enclosure. Thus, the air-conditioner units' test data are not included in this table.

TABLE B-3. MLS SUBSYSTEMS FAILURES AND MAINTENANCE (MAY 21 TO JULY 31, 1980)

Item No.	Subsystem	Total Uptime (Hours)*	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	Azimuth	1,646.41	2	8.58	1,214.76	823.21	4.29
2	Elevation	1,451.54	1	0.75	688.92	1,451.54	0.75

*The test data do not include accurate downtime or accurate repair time for the air-conditioners in the subsystems. Thus, the air-conditioner units' test data are not included in this table.

TABLE B-4. MLS AND PDME SYSTEMS FAILURES AND MAINTENANCE (MAY 21 TO JULY 31, 1980)

Item No.	System	Total Uptime (Hours)*	No. of Chargeable Failures	Total Repair Time (Hours)	Failure Rate (Per Million Hours)	MTBF (Hours)	MTTR (Hours)
1	MLS (azimuth and elevation)	1,451.54	3	9.33	2,066.77	483.85	3.11
2	MLS (azimuth only)	1,646.41	2	8.58	1,214.76	823.21	4.29
3	PDME	1,486.58	1	12.5	672.68	1,486.58	12.5

*The test data do not include accurate downtime or accurate repair time for the air-conditioners in the operational systems. Thus, the air-conditioner units' test data are not included in this table.