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AIR WEAPONS CONTROL SYSTEM 412L

QUARTERLY RELIABILITY PROGRAM

REPORT NO. 8

(AWCS-SQR-8R1)

1 April 1963

Prepared for

Electronics Systems Center
412L Systems Project Office
L. G. Hanscom Air Force Base, Massachusetts

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Military Communications Department
General Electric Company
Syracuse, New York

Contract No. AF 19(628)-513

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INTRODUCTION

This report, AWCS-SQR-8, is written under Contract No. AF 19(628)-513 and prepared at the request of the 412L SPO. It covers the progress of the AWCS 412L reliability effort during the fourth quarter of 1962. The report is divided into two sections; Part I which covers the systems reliability effort and Part II which covers the equipment reliability effort.

PART I
SYSTEM RELIABILITY

A. SYSTEM RELIABILITY ANALYSIS (See Chart 1 for schedule data)

1. USAFE Simulation Program Model (SE-DOES)

During the past quarter, General Electric has received Air Force comments on the draft copy of the SE-DOES study. The final report is in the process of final revision and reproduction. It is scheduled to be published during the first week of 1963. No further work is being pursued on this project pending direction and concurrence of the Air Force.

2. AWCS - 412L Operational Support Study (TEMPO)

There has been no further work on this study during the past quarter. Plans have been made and proposed study objectives have been prepared for Air Force consideration for calendar year 1963.

3. Reliability Demonstration Testing

Late in this quarter, some preliminary plans were made to prepare reliability demonstration plans for the various groups of AN/GPA-73 equipments. Early during the first quarter of 1963, the first of these test specifications will be prepared and submitted to the 412L SPO. During the balance of the quarter, all of the test specifications are to be prepared. These tests are prepared to be incorporated into the Category II testing program.

The basic nature of these test specifications will follow the general outline and philosophy developed in AWCS-ER-1R1. MIL-R-26474, Table 1 of Section 4, will be used as the acceptance criteria.

B. MAINTAINABILITY

During the past quarter, some preliminary data on maintainability developed during Category I testing was presented to the Air Force Operation Evaluation Board. The

412L MANAGEMENT CONTROL CHART

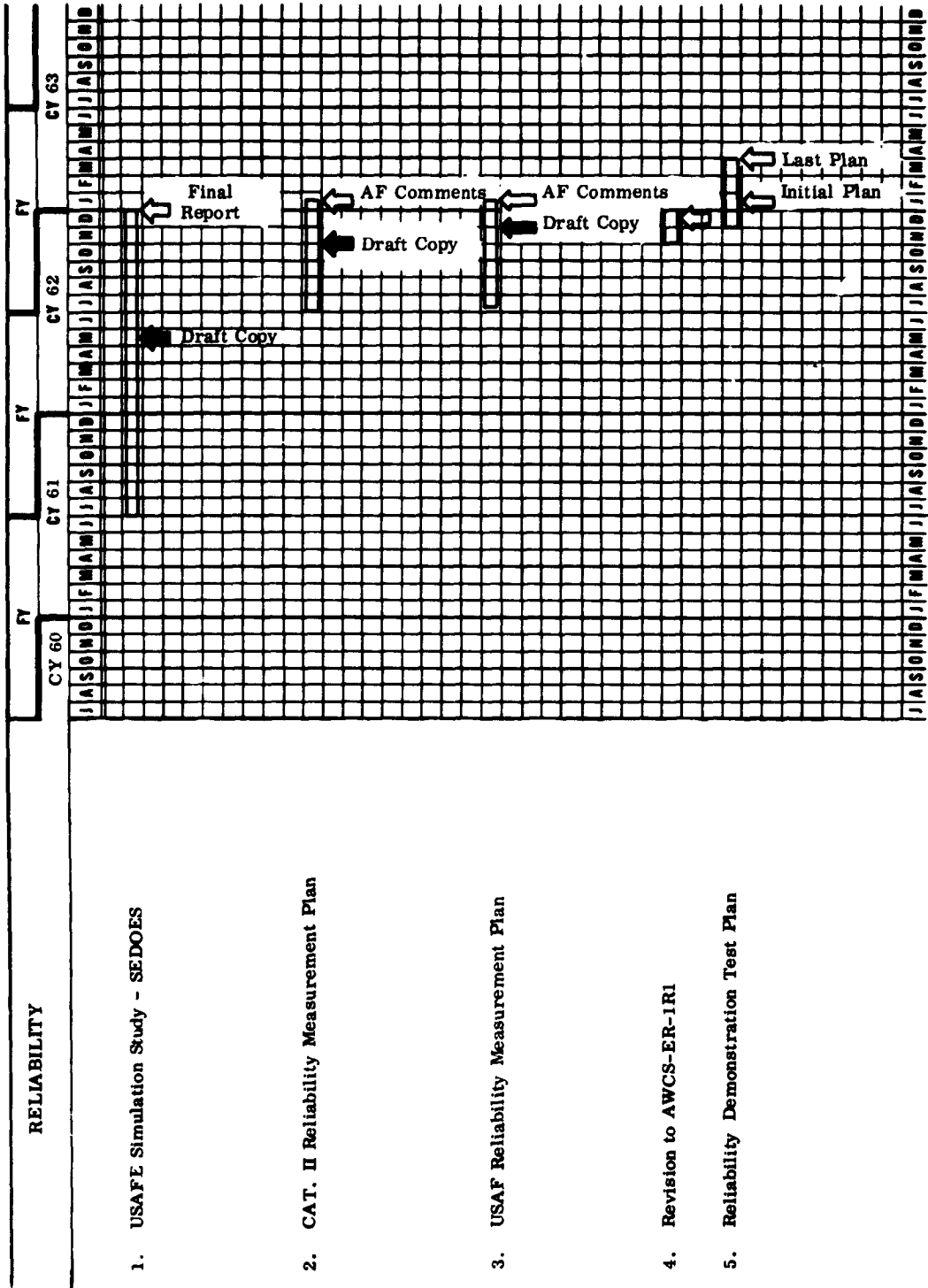


Figure 1. System Reliability Analysis Documentation Schedule

mean-time-to-repair data for each group of AN/GPA-73 equipment where data was available is given below:

Equipment Group	MTTR (Hours)
FSA-12	0.92
OA-1723	1.00
OA-1724	0.6
OA-1718	1.16
FSA-21	0.41
FSA-23	1.85
OA-3232	0.62
FSA-31	1.54

Weighted average for
GPA-73 0.87 hours

These repair times listed indicate the repair time goals of 0.1 and 0.05 hours are not being achieved. Part of the reasons for this are due to the following:

- 1) The test environment is different from the operational environment.
- 2) All "software" has not been on site.
- 3) The performance monitor group has not been utilized to the fullest extent.

Special tests conducted at Category I site during November 1963 indicate that time-to-find-failure rates of 12 minutes on some groups are within reason. It is anticipated with some degree of confidence that repair times in the vicinity of 0.2 and 0.35 hours can be realized. General Electric realizes that these results are not meeting the goals and is creating a committee to study the problem. A member of this committee is from the Reliability Engineering Unit.

C. SUBCONTRACTORS

1. Radio Corporation of America

- a. Converter Groups, AN/GKA-10 and AN/GKA-11.

Environment and reliability demonstration tests at Camden, N. J., according to General Electric drawing 8523659, for the Converter Group have been completed

satisfactorily. A final report giving test data and results will be submitted by the subcontractor.

b. Monitor Transmitter Group, AN/GKA-13

The Monitor Transmitter Group Reliability Demonstration Test conducted at Camden, N.J., according to General Electric drawing A8527465, was completed satisfactorily during this reporting period. In accordance with the Life Test Specification acceptance criteria, the test was terminated at the end of 650 hours of normal operation with an accept decision. The occurrence of one failure was within the accept region for 650 hours of test time.

2. North Electric Company

The inplant failure report for this quarter are summarized below:

Component Classification	No. of Reported Failures	Remarks
Capacitors	43	Considered random fail.
Resistors	47	Considered random fail.
Relays	44	Considered random fail.
Transformers	247	Failure analysis reveals that most of these units were rejected because of faulty test set-up. Corrective action has been taken.
Diodes	74	Considered random fail.
Transistors	390	Considered random fail.

There were three systems tested and shipped this past quarter and the above failures are considered within expectations.

The reports from USAFE indicate that the Electronic Switching Center is performing satisfactorily after it has been installed and checked out.

The final report of the reliability demonstration test has been delayed slightly, but will be available the first part of January 1963.

3. American Astro Systems, Inc.

The operation of the mobile refrigeration system continues to perform very well since the original failures of early 1962. The design changes on the oil pump pin have been completed. This is action covered by ECR 862.

The refrigeration pumps and chiller bases continue to operate with little or no trouble where changes have been incorporated.

The equipment from American Astro is very nearly completed at this time. No visits have been made during this quarter.

4. Sprague Corporation (formerly Leach Corporation)

Engineering Change Record 801 has been processed by engineering to correct the deficiencies in the 60 and 150 kw motor generator sets which were reported for this subcontractor in the last quarterly report.

5. TEMPCO (formerly Fenske, Fedrick, and Miller, Inc.)

There is no change on the status of the Geographic Data Projection equipment from the last quarterly report.

6. Cook Electric Co. (Data Stor. Div.)

Most of the work in non-standard part areas was accomplished during the past quarter. A very small portion is left to accomplish during the first quarter of 1963.

The tape transport has been working very well in the field without an abnormal number of failures.

7. General Electric Company - Distribution Assemblies Department

There are no changes to report on this subcontractor during this quarter.

8. General Electric Company - Specialty Control Department

During the fourth quarter of 1962, the predicted MTBF for the 15 kw static frequency converter was increased from 7500 hours to 8200 hours. The reliability goal for the 15 kw static frequency converter is 10,000 hours MTBF.

Qualification testing has been started and when completed, a final report on the cycling test and prediction will be supplied by the subcontractor.

9. General Electric Company (TPO)

The following data has been accumulated from the Dynamic Data Projector operating test at Building No. 15 Electronic Park, Syracuse, New York, through November 1962.

Component	No. of Failures
Erase filament	10
Write filament	17
OPA-1 PW board	3
ZA-1 PW board	2
Control fluid pump	2
Other	2

The above list constitutes the major failures that have been logged on the Dynamic Data Projector (Serial No. 1) during a ten month operating period. Seventeen of these failures were incurred by the erase and write filament units; however, this number is within the expected failure rate originally predicted for the filaments.

Although the filament failure rate is considerably higher than for other component parts of the system, it is considered to be within the state of the art. The dualization of the vacuum optical system has been based on the high failure rate of the filaments. It is expected that the predicted availability for the Dynamic Data Projector will be met through utilization of the redundant features of this system.

10. General Electric Company - Defense Systems Department

A final prediction based on revised component part failure rates, for the Receiver Group, AN/GKA-12, has been completed. These estimates are:

MTBF - 1430 hours

MTTR - 10 minutes

Availability - 99.988%

11. Summary of Subcontractors

Table 1, "Summary of Subcontractor Reliability," is attached to give a current over-all view of the subcontractors associated with 412L system.

D. MTBF, MTTR, AND AVAILABILITY FIGURES

The following tables are prepared to show the expected MTBF, MTTR, and Availability predictions for the 412L system and subsystems.

Table 2 lists the data of the various subsystems and systems of 412L. This data is computed assuming redundancy of the various subsystems in a netted configuration as indicated on the chart.

Table 3 is data obtained from the Air Force. A typical site of radar equipment is configured to determine the data for a typical CRC site.

Table 4 is data predicted for the AN/GPA-73. The data is listed by groups. Since the equipment can be configured in a large variety of ways, a typical CRC configuration is given.

Table 5 lists the data for the communications subsystem. Again, because of the many sets available for configuration, a typical site was used in predicting the subsystem reliability.

Table 6 lists the data for the ancillary subsystem groups.

Table 1. Summary of Subcontract Reliability

Subcontractor	Equipment Name	MTBF Reliability Goal	MTBF Reliability Prediction	Reliability Measured or Demonstrated
RCA	Converter Group	350 hour MTBF	350 hour MTBF	Test run and report not out
RCA	Monitor Transmitter	1210	1210	MTBF verified by test
American Astro, Inc.	Cooling Equipment	15,000 hour MTBF on major components	Lowest MTBF per component 76,000 hours	Several design problems being fixed ECR No. 862
Sprague Corp.	Motor Generator	5,000 hours MTBF	6,850	Not available
TEMPCO	Iconorama Projector P.S. and Symbol Generator	S.G. 610 hours MTBF P.S. 910 hours MTBF	S.G. 610 hours MTBF P.S. 910 hours MTBF	755 hours MTBF 1,211 hours MTBF
Cook Electric	Tape Transport	4,000 hours MTBF	2,500 hours MTBF	Not available
G. E. DAD	Power Dist. Panels	838 hours MTBF	16,000 hours MTBF	Not available
G. E. SCD	15-kw Static Freq. Converter	10,000 hours MTBF	8,200 hours MTBF	Not available
G. E. TPO	Light Valve	50 hours MTBF	50.35 hours MTBF	Not available
G. E. DSD	Receiver Group	833 hours MTBF	1430 hours MTBF	500 hour test completed
North Electric	Electronic Switching Center	800 hours MTBF	806 hours MTBF	MTBF verified by test

Table 2. AWCS 412L Subsystem Reliability Predictions Netted Single System

Subsystem	31 December 1962		
	MTBF (hours)	MTTR (minutes)	Availability (%)
Data Acquisition	7,000*	42	99.99
Data Processing and Display	13.59*	8.28	98.98
Communications	5,000*	54	99.98
Ancillary	3,300	23	99.99
Overall System	13.47	8.52	98.97
*Predictions based on redundancy			

Table 3. Data Acquisition Subsystem Reliability Predictions

Equipment	31 December 1962		
	MTBF (hours)	MTTR (minutes)	Availability (%)
AN/FPS-7C	167	36	99.64
AN/FPS-20	184	84	99.25
AN/GPS-4	92.5	54	99.03
AN/FPS-6	143	36	99.58
AN/MPS-14	143	36	99.58
AN/UPX-6	603	54	99.85
Radar Signal Processor	184	12	99.89
Typical Subsystem*	91.66	44.5	99.66
*Single site reliability prediction - every component failure assumed a subsystem failure.			

Table 4. Data Processing and Display Subsystem Reliability Predictions

Equipment	31 December 1962		
	MTBF (hours)	MTTR (minutes)	Availability (%)
AN/FSA-12	17.90	6	99.44
OA-1723	8.96	12	97.82
OA-1724	16.68	6	99.40
OA-1718	60.50	6	99.83
AN/FSA-21	4.50	6	97.83
AN/FSA-23	24.87	12	99.20
Status Display	42.07	12	99.53
Situation Projection	34.78	12	99.43
Performance Monitor	61.27	12	99.67
Typical Subsystem*	1.74	8.28	92.55

*Single site reliability prediction - every component failure assumed a subsystem failure.

Table 5. Communication Subsystem Reliability Predictions

Equipment	31 December 1962		
	MTBF (hours)	MTTR (minutes)	Availability (%)
Electronic Switching Center	800	6	99.99
Flight Control Package	189	10	99.92
Subscriber Sets	9090	10	99.99
AN/TRC-24	258	56	99.68
R-278	2000	66	99.95
R-361	2100	78	99.94
T-217	700	114	99.73
BC-639	2680	60	99.97
AN/FGC-25	1000	132	99.78
AN/FGC-20	1000	57	99.91
Typical Subsystem*	1931	59	99.95

*A single-site link reliability prediction.

Table 6. Ancillary Subsystem Reliability Predictions

Equipment	31 December 1962		
	MTBF (hours)	MTTR (minutes)	Availability (%)
Temperature Control Group	5000	30	99.99
Prime Power Group	8950	10	99.99

Table 7 lists the cabinets in the AN/GPA-73 with their predictions.

Table 8 lists each of the sites of 412L equipment and is a prediction of expected failures and MTBF for each site. The numbers contained in these predictions are based on total number of failures and do not reflect the effect of a failure on the system usage.

E. RELIABILITY MEASUREMENTS

1. Systems Reliability Measurements

Preliminary Category I Field Test Report, No. 5, was completed and distributed during the quarter. The report emphasized reliability measurements of the mean-time-between-failures (MTBF) on a cabinet and equipments group level. The data is summarized in Part II, paragraph C.3a of this report.

Preliminary Category I Field Test Report, No. 6, was completed and distributed during this quarter. The report contained maintainability measurements in terms of mean-time-to-repair (MTTR) on a cabinet and equipment group level. The data is summarized in Part II, paragraph C.3a of this report. Data for Preliminary Reports 5 and 6 was recorded in a Category I Testing Environment which had as a primary objective to demonstrate the performance of the AN/GPA-73.

It had been planned to complete the final Category I Field Test Reliability Report during the reporting period as mentioned in Report No. 7 (AWCS-SQR-7), Part I, paragraph E.1, 30 September 1962. Extension of the Category I tests beyond 1 September 1962 has delayed the completion of the final Category I Field Test Reliability Report. It was agreed that the cut-off date for data would be 1 November 1962. It is expected that rough draft of the final report will be available in January 1963. The final report will up-date the preliminary reports and will include component failure rates based on the data gathered during Category I tests.

Table 7. Predicted 412L Cabinet Failure Rates

Cabinet No.	Failures/ 1000 Hrs.	Total No. of Boards in Cabinet
1	23.50	1297
2	19.66	1098
3	19.46	1068
4	7.13	431
5	0.92	44
6	5.78	338
7	2.88	169
23	14.22	775*
24	1.68	136*
26	10.74	524
27	4.15	122
28	4.26	65
29	5.46	259
30	10.54	581
34	13.39	786
35	9.46	590
36	6.36	351
37	13.52	576
38	5.53	287
39	16.84	1013
44	10.54	602
45	5.41	372
46	3.21	92
47	2.78	182
52	25.23	1443
53	22.16	1339
54	7.73	400
55	4.98	249
56	14.19	825*
59	7.37	418

*Minimum number of boards used in any environment; total number of boards is dependent on number of consoles used at the given site.

Table 7. Predicted 412L Cabinet Failure Rates (Continued)

Cabinet No.	Failures/ 1000 Hrs.	Total No. of Boards in Cabinet
60	5.63	153
61	7.55	434*
62	3.81	216
63	4.02	132
64	7.69	391
65	3.31	142
66	5.05	318
67	2.35	142
68	2.64	135
72	1.55	-
73	2.29	-
75	0.75	44
76	4.83	155
77	6.15	302
78	0.91	-
80	1.54	39
82	1.54	39
83	0.03	-
84	2.90	42
85	0.27	-
88	4.82	234
89	0.91	-
93	2.22	-
95	2.30	-
96	0.01	-
97	0.02	-
98	2.20	98
99	3.54	8
100	2.01	8
109	18.33	1057

*Minimum number of boards used in any environment; total number of boards is dependent on number of consoles used at the given site.

Table 7. Predicted 412L Cabinet Failure Rates (Concluded)

Cabinet No.	Failures/ 1000 Hrs.	Total No. of Boards in Cabinet
110	3.14	56
111	8.40	412
112	4.06	208
130	0.23	-
131	0.12	-
140	1.84	33

Table 8. Predicted 412L Site Failure Rates for Contractor-Furnished Equipment

Site	Site Failures/ 1000/hrs.	Site MTBF (hours)
A	488.10	2.05
B	342.93	2.92
C	145.55	6.87
D	485.62	2.06
E	485.62	2.06
F	154.09	6.48
G	619.66	1.61
H	557.47	1.79
I	365.73	2.73
J	516.86	1.93
K	170.05	5.88
L	145.55	6.87
M	145.55	6.87

The "Proposed AWCS 412L Systems Test Procedure for Reliability Measurements and Failure Reporting During Category II Field Tests" was submitted during the third quarter of 1962. The document was discussed during the Reliability Coordination meetings. It was also discussed with the Category II Test Director. No official approval has been received. It is expected that this will delay the Category II Reports. The failure reporting system has been started.

2. Equipment Reliability Measurements

Equipment reliability measurement data and failure investigation information is contained in Part II of this report.

Monthly in-factory reliability unit test reports for September, October, and November 1962 were completed and distribution is being made within the company. Because of the decreased production, the October and November reports were combined. Summary information from these reports is contained in Part II, paragraph C.1 of this report.

F. TRAINING AND EDUCATION

The following Product Service Engineering memos used by Field Service and operating personnel were initiated by Reliability Engineering during the fourth quarter of 1962:

- 1) LT-4 printed wire board - Prevention of Q5 transistor failure.
- 2) Converter Cabinet (26) OA-1723 - Stepping switch lubrication instructions.

Two one-hour reliability indoctrination sessions were held for Machine Shop foremen.

Five reliability films were shown to the Reliability Unit personnel.

The "Reliability by Design" course was reinstated this quarter. The course is prepared and presented to design engineering and other professional personnel. It consists of the following subject matter:

- 1) Probability and Statistics
- 2) Distribution Functions
- 3) Reliability Prediction

- 4) **Reliability Testing**
- 5) **Reliability Measurements**
- 6) **Chemical Reaction and Reliability**
- 7) **Heat Transfer and Reliability**
- 8) **Mechanical Design and Reliability**
- 9) **Radiation Effects and Reliability**
- 10) **Component Mechanisms of Failure**
- 11) **Circuit Design Analysis**
- 12) **Case History**

This course is conducted for 16 weeks at two hours per week and its purpose is to develop the criteria for making decisions during the design period.

G. MEETINGS

The following meetings were held the quarter, pertaining to 412L System Reliability:

- 1) 11 October 1962 with 412L SPO, RADC, and AFPR at Syracuse, N. Y.
- 2) 25 October 1962 with 412L SPO, GEEIA.
- 3) 26 October 1962 with 412L SPO, RADC and OEB at Rome, N. Y.
- 4) 30 October 1962 with 412L SPO, MITRE at Waltham, Mass.
- 5) 30 November 1962 with 412L SPO, RADC, ESD and AFPR at Syracuse, N. Y.

PART II
EQUIPMENT RELIABILITY

Reporting continuity is maintained with previous program reports. Items requiring further activity based on previous reports, and not discussed in this report, indicates no action on the project during the current reporting period.

A. STANDARDS

1. Specification Activity

The work on a detailed device specification covering diode 1N2032-2 is still in process. Both suppliers of this diode have submitted draft copies of a proposed specification in MIL format. It has been learned recently there is other activity underway toward establishing a MIL Specification on another diode type (1N3826A) which could be directly substituted for type 1N2032-2. To avoid duplication of effort, this possibility is being fully investigated before proposing a MIL Specification on type 1N2032-2.

B. COMPONENTS

1. Failure Investigation

a. Cathode Ray Tube (16AMP7)

The 16AMP7 cathode ray tube is used for display purposes in the AN/GPA-73 equipment. The new version of this tube (refer to AWCS-SQR-4, Part II, paragraph B. 1a, 30 December 1961; and AWCS-SQR-5, Part II, paragraph B. 1a, 30 March 1962; AWCS-SQR-6, Part II, paragraph B. 1a, 30 June 1962; and AWCS-SQR-7, paragraph B. 1a, 10 October 1962) is still being evaluated as design changes are incorporated.

The five tubes received from the now approved second source are still undergoing evaluation and have passed the 4,000-hour point without catastrophic failure. Several parameters including beam current and high voltages were measured each working day (5 times per week) to check degradation of the tube. These measurements will be included in the report now being prepared. The tube, at this point, appears to be superior in a number of ways to tubes presently used. The present evaluation will be concluded at the 5,000-hour point and a report will be issued at that time.

b. Circuit Breaker (7724036-17), Heinemann

This circuit breaker is used in the AN/GPA-73 system to protect power supplies against overloads. The contact problem experienced with this circuit breaker (refer to AWCS-SQR-7, Part II, paragraph B. 1b, dated 30 September 1962) has been resolved by replacing same with a newly designed circuit breaker. The new unit has been evaluated by DSD Component Standards and was found to satisfactorily pass all qualification tests. General Electric No. 77C700632 has been assigned to this improved component and future designs will incorporate its use.

Equipment already in the field was not retrofitted. A study indicated that the trouble occurred when the circuit breaker was used as an (OFF-ON Switch). If used only as a protective device, it operates satisfactory. An EN has been issued cautioning against using the circuit breaker as a switch.

c. Quartz Delay Line, General Electric No. 7759986-1

This line is used in the AN/FSA-31 Signal Processor area and has a delay time of 2732.6 ± 0.01 microseconds with a carrier frequency of 33.8 mc. A report was received that a malfunction due to a poor thermostat control occurred with this device. The correct operating temperature is normally maintained by a fine heater inside a rough heater. The rough heater in this case was over-riding the fine heater due to a split in the mercury column of the controlling switch. Replacement of the mercury switch solved the problem. The vendor for this unit, Anderson Labs, has been contacted and future orders will have an improved mercury switch in the control circuit.

d. Luminescent Panel, General Electric No. 7226520

The failure of a panel during a Munson Road test was reported and is being investigated. The panel on each console is used by the console operator to write in a low ambient. The failure of this panel was due to an open connection caused by porous solder. Investigation is underway to determine if this condition is prevalent in other panels.

e. Tube Type 6021

Because of several failures of circuit boards OPA-1 and OPA-3, which were apparently corrected by replacement of tube 6021, a study of the application of this tube was undertaken. In the above application, the tube operates in conjunction with ZA-1 and ZA-2 circuit boards. The possibility of increasing 6021 tube grid leakage becoming great enough to cause circuit malfunction was of concern. Twenty tubes which had been removed from apparently defective boards were tested and then placed in operating circuits. Nine tubes out of the 20 were found to operate properly. Further study is continuing to determine what condition might exist which would cause tubes that are apparently good to malfunction in equipment operation.

2. Data Reduction and Dissemination

A summary of the indicated performance record of semiconductors procured for this program is given in table 9.

The cumulative failure rate is based upon the accumulated total of major (catastrophic type) failures and total unit test hours developed by testing samples from each lot shipped.

An additional summary of long term life test results is given in table 10. This data results from samples of one lot out of each four being life tested beyond 1000 hours.

3. Test Program (Reliability Engineering Laboratory)

a. Lamps (327)

This lamp is used in the display console to provide a visual indication of circuit conditions. The test for these lamps has reached the 13,107-hour point with results as follows:

35 units at 28v - 31 failures
35 units at 23v - 16 failures
35 units at 21v - 6 failures

The test is cycled fifteen minutes on and fifteen minutes off, to simulate actual operating conditions. The rated voltage for the lamps is 28 volts and the lamps are operated at 21 volts in the AWCS 412L. One additional failure has occurred since the last quarterly report. This would result in 412,545 device hours and reflect a 1.45 percent per 1,000 hour failure rate. Indications are that the test is in the wear out phase and closer monitoring is now being employed. These lamps are used redundantly in the system and since failures can be easily detected, no replacement on a planned schedule is suggested.

b. Transistors

The transistor life test was started in January 1961, to monitor vendor performance, and to date 12,802,000 device hours at rated conditions have been accumulated on 1,322 units. The results accumulated to date for all the transistors on life test are summarized in table 11.

4. Sub-Contracted Test Program

a. General

The test program conducted at independent testing laboratories has been completed. The prime considerations for placing these tests with independent laboratories was the need for unavailable and expensive special equipment, and economics.

All tests have been concluded and reports have been issued on the components except the tests on carbon resistors, trimming potentiometers, and the miniature relays. These remaining reports will be written and issued by the next reporting period.

5. Special Studies and Investigations

a. Zeroing Amplifier Board (ZA-1)

The ZA-1 board performs, electronically, the function of an electromechanical sampling switch that was once used in the system. Each board contains two identical circuits, or channels, which form part of the zeroing circuit. Three boards have been tested for 7,760 hours. The boards have been operating satisfactorily during this test. The

Table 9. Summary of Vendor Performance

Vendor	Semiconductor Type	No. Lots	Total Qty.	Unit Test Hours x/1000	Cumulation Failure Rate %/1000 Hrs.
Clevite	JAN1N277	21	551,000	2090	0.39
General Instrument	"	5	150,000	550	0.0
Hughes	"	8	64,522	880	0.57
Transistorn	"	3	31,600	330	0.30
General Instrument	USAF1N645	4		440	0.0
Rheem	1N691	2	24,500	220	0.46
Sperry*	1N691	3	12,500	330	4.2
Hughes	1N198B	114	3,092,216	12,540	0.26
CBS	"	5	95,000	550	0.91
Erie	"	65	1,473,309	6,050	0.15
Sylvania	"	9	766,000	990	0.10
Transistorn	"	10	100,000	1110	0.40
Sylvania	USN2N388	4	50,000	440	0.68
General Electric	USN2N396A	13	88,435	1430	0.07
General Electric	2N525	5	39,606	550	0.18
General Instrument	2N595	2	7,500	145	0.69
Philco	2N599	7	39,764	770	0.39
General Transistor	2N604	17	158,507	1870	0.11
Sylvania	2N604	3	54,000	330	0.0
Fairchild	2N697	2	11,306	220	0.0
Texas Instrument	2N697	2	7,300	135	0.46
Rheem	2N697	2	29,000	220	0.91
Fairchild	2N699	2	13,000	135	0.45
Rheem	2N699	1	10,000	110	0.91
Texas Instrument	2N699	3	7,827	330	0.0
Texas Instrument**	2N1039	1	2,000	110	1.8
Texas Instrument**	2N1403	10	27,435	800	1.9
RCA	2N1450	40	476,470	4400	0.55
General Transistor	2N1450	21	286,163	2310	0.17
Sylvania	2N1450	5	86,000	550	0.36
Motorola	2N1646	27	199,211	2970	0.71
Texas Instrument	2N1646	21	273,896	2310	0.65

Table 9. Summary of Vendor Performance (Cont.)

Vendor	Semiconductor Type	No. Lots	Total Qty.	Unit Test Hours x/1000	Cumulation Failure Rate %/1000 Hrs.
Sylvania	2N1646	15	132,000	1650	0.24
Western Electric	2N1646	1	10,000	110	0.0
General Electric	2N1646	22	202,233	1235	0.28
<p>*Sperry was initially a sole source, however, due to poor performance, another and better source was developed. Rheem has been purchased by Raytheon but the diode is available.</p> <p>**Single Source Items.</p>					

Table 10. 10,000-Hour Life Test Data

Vendor	No. Lots	Semiconductor Type	Cumulative Failure Rate % Per 1000 Hours			
			2500 Hr.	5000 Hr.	7500 Hr.	10,000 Hr.
Motorola	1	2N1646	0.73	0.36	0.24	0.27
	5	"	0.73	0.36	0.85	1.46
	9	"	0.73	0.91	1.58	2.73
	13	"	0.36	0.91	1.33	1.06
	17	"	1.1	0.55	0.73	0.64
	21	"	0	6.2		
	25	"	0.73	11.6		
<p>These failure rates are being investigated. The vendor has been contacted and data on field performance is being obtained.</p>						
Texas Instrument	1	2N1646	2.9	2.0		1.18
	6	"	1.1	0.55		
	10	"	0.36	0.36		0.27
	14	"	0	0.18		0.09
	15	"	1.5	(Term- inated)		
	18	"	0.36	0.18		0.27
	20	"	1.1	0.55		0.455
	22	"	0.72	0.36		

Table 10. 10,000-Hour Life Test Data (Cont.)

Vendor	No. Lots	Semiconductor Type	Cumulative Failure Rate % Per 1000 Hours			
			2500 Hr.	5000 Hr.	7500 Hr.	10,000 Hr.
Sylvania	1	2N1646	1.45	0.91		0.54
	5	"	0	0	0	0
	9	"	0			
	13	"	0			
	16	"	0			
Western Electric RCA	1	2N1646	0	0	0	
	15	2N1450	2.9	2.5		
	20	"	0	1.8		
	24	"	0.36	0.73		
	34	"	1.1	0.91		
	38	"	0.36	0.18		
	42	"	0.36			
	48	"	0	0		
Sylvania	1	2N1450	1.82			0.638
	5	"	1.09	0.91		0.455
	9	"	0.71	0.35		
	13	"	1.45			
General Instrument	E-36	2N1450	0	0	0	0
	K-01	"	0	0		
	130-C-1-B	"	0	0		
Texas Instrument	6	2N1403	4.6	2.86		
	9	"	2.9		0.86*	(Terminated)
Texas Instrument	3	USA2N697	1.1	0.73		0.091
Rheem	1	USA2N697	0.36			
Texas Instrument	1	2N699	0	0		
Rheem	1	2N699	0.36			
Philco	1J1	2N599	0.91	0.36		0.28

Table 10. 10,000-Hour Life Test Data (Cont.)

Vendor	No. Lots	Semiconductor Type	Cumulative Failure Rate % Per 1000 Hours			
			2500 Hr.	5000 Hr.	7500 Hr.	10,000 Hr.
G. E.	GN-1	2N396A	0.36	0.18		0.09
	EX-1	"	0.36	0.18		0.09
	5-PP	"	0	0		
	10-PA	"	0	0	0	0
	1-DE	"	0	0	0.18	0.09
Sylvania	1	USN2N388	1.82	1.28	1.21	0.82
	013		0.36			
Sylvania	1	2N604	0.36	0.18	0.485	
General Instrument	K-42	2N604	0	0	0	0
	114-C-1-B	"	0	0		
	111-F-1-A	"	0.36			
*At 6500 hours.						

Table 11. Reliability Engineering Transistor Test Data

Transistor Type	Manufacturer	No. Hrs.	Qty.	Total Device Hours	Power Dissipation	Degradation Failures		Catastrophic Failures		Total Maj. & Cat. Failures	Expected Failure Rate %/1000 Hrs.
						I _{BO} Major/Minor	H _{FE} Major/Minor	Short	Open		
USN2N388	General Instrument	3,000	110	330,000	150	/	/	/	/	0	0.0
USN2N388	Sylvania	15,000	60	900,000	150	8	/	1	/	9	1.0
USN2N388	Sylvania	9,000	30	270,000	150	/	/	/	/	0	0.0
USN2N396A	General Electric	15,000	60	900,000	150	/	/	/	/	0	0.0
USN2N396A	Toshiba	6,000	40	240,000	150	/	/	/	/	0	0.0
USN2N599	Philco	14,000	60	840,000	250	4	/	/	/	4	0.48
USN2N604	General Instrument	13,000	60	780,000	120	6	1	/	1	8	1.1
USN2N697	Rheem	7,000	50	350,000	600	1	1	/	/	1	0.28
USN2N699	Rheem	7,000	43	301,000	600	2	/	/	/	2	0.66
USN2N699	Fairchild	13,000	60	780,000	600	/	1	/	/	1	0.12
USN2N1403	Texas Instrument	15,000	60	900,000	250	4	2	6	1	11	1.2
USN2N1450	General Instrument	14,000	60	840,000	120	5	2	1	/	6	0.71
USN2N1450	Radio Corporation of America	15,000	59	885,000	120	1	3	/	/	4	0.45
USN2N1450	Sylvania	15,000	48	720,000	120	/	/	1	2	3	3.41
USN2N1646	Sylvania	13,000	60	780,000	150	/	1	/	/	0	0.0
USN2N1646	General Electric	6,000	60	360,000	150	1	/	/	/	1	0.28

nominal drift is +10 millivolts. There was one failure in associated equipment which resulted in a 48 millivolt drift but this was corrected by replacing a defective vacuum tube in the OPA-1 board.

The 7,760 hour figure far exceeds the performance of the electromechanical switch that it replaced (less than 500 hour life).

C. RELIABILITY MEASUREMENTS

1. In-Factory AN/GPA-73 Reliability Reporting Data From Unit Test

The following charts and figure present significant data collected from in-factory reporting for September, October and November 1962:

- 1) Charts 12 (September) and 13 (October-November) are summaries of the electrical-type defects reported for semiconductors used on printed-wire boards. The data originates at the circuitron machine (a programmed tester capable of point-to-point resistance measurement). In summary, the percentage of failed transistors and diodes is as follows:
 - (a) Transistors - 0.99 percent (September)
 - 0.77 percent
 - (b) Diodes - 0.23 percent
 - 0.20 percent
- 2) Charts 14 (September) and 15 (October-November) are summaries of the electrical-type defects reported for semiconductors used on units which were dynamically tested with simulated inputs.
- 3) Chart 16 is a summary of the data presented in charts 12 through 15.
- 4) Chart 17 is a summary of reported component electrical defects grouped by diodes, transistors, tubes and all other components used on units tested during September, October and November 1962. The data originates from dynamic unit test stations.
- 5) Figure 2 is a graphic representation of semiconductor electrical defects reported from the circuitron and unit test levels.

**Table 12 . Semiconductor Electrical Defects on Boards At Circuitron
(September)**

Semiconductor Type	Number Used on Boards Tested on Circuitron	Number of Electrical Defects Reported	Percentage %
1N93	1	0	0.00
1N198B	179,775	404	0.22
1N277	45,969	79	0.17
1N457	1,245	4	0.32
1N538	220	0	0.00
1N645	3,213	3	0.09
1N691	1,242	1	0.08
1N746A	850	7	0.82
1N751A	4,163	24	0.58
1N752A	81	0	0.00
1N754A	45	0	0.00
1N756A	283	0	0.00
1N1521A	142	0	0.00
1N1522A	123	4	3.25
1N2032-2	2,451	37	1.51
2N335	163	5	3.07
2N338	165	1	0.61
2N388	1,671	10	0.60
2N396A	1,630	8	0.49
2N492	1	0	0.00
2N525	94	2	2.13
2N553	78	0	0.00
2N595	480	14	2.92
2N599	1,053	5	0.47
2N604	7,319	83	1.13
2N697	1,228	18	1.47
2N699	983	7	0.71
2N1026A	81	0	0.00
2N1039	400	6	1.50
2N1123	78	1	1.28
2N1253	78	0	0.00
2N1403	957	10	1.04
2N1436	*	2	*
2N1450	24,043	257	1.07
2N1646	26,941	242	0.90
2N2004	160	0	0.00

* The total quantity used during this period is not available.
EN-47 specified usage of the 2N1436 transistor.

**Table 13. Semiconductor Electrical Defects on Boards at Circuitron
(October-November)**

Semiconductor Type	Number Used on Boards Tested on Circuitron	Number of Electrical Defects Reported	Percentage %
1N93	129	1	0.78
1N198B	288,291	551	0.19
1N277	71,787	106	0.15
1N457	2,086	5	0.24
1N538	1,201	5	0.42
1N645	2,871	3	0.10
1N691	1,496	0	0.00
1N746A	3,480	11	0.29
1N749A	558	0	0.00
1N751A	4,724	23	0.49
1N752A	238	0	0.00
1N754A	99	0	0.00
1N756A	2,248	0	0.00
1N1521A	158	1	0.63
1N1522A	427	1	0.23
1N2032-2	4,210	43	1.02
2N335	380	5	1.32
2N338	877	0	0.00
2N388	3,250	29	0.89
2N396A	3,367	21	0.62
2N492	31	1	3.23
2N525	638	6	0.94
2N553	134	0	0.00
2N595	1,317	20	1.52
2N599	1,784	6	0.34
2N604	14,733	151	1.02
2N697	2,614	21	0.80
2N699	1,190	22	1.85
2N1026A	710	4	0.56
2N1039	743	5	0.67
2N1123	134	0	0.00
2N1253	134	3	2.24
2N1403	1,321	13	0.76
2N1436	*	8	*
2N1450	41,111	435	1.06
2N1646	47,120	180	0.38
2N2004	1,344	12	0.89

* The total quantity used during this period is not available.
EN-47 specified usage of the 2N1436 transistor.

**Table 14. Semiconductor Electrical Defects Reported at Unit Test
(September)**

Semiconductor Type	Number Used on Assemblies Tested at Unit Test	Number of Electrical Defects Reported	Percentage %
1N93	146	0	0.00
1N198B	209,070	72	0.03
1N231	40	17	42.50
1N250B	345	0	0.00
1N277	50,746	58	0.11
1N429	20	0	0.00
1N457	1,785	3	0.17
1N458	18	2	11.11
1N459	201	0	0.00
1N538	2,831	5	0.18
1N629	960	3	0.31
1N645	2,985	0	0.00
1N691	1,746	2	0.11
1N746A	1,110	0	0.00
1N749A	489	0	0.00
1N751A	4,726	20	0.42
1N752A	130	0	0.00
1N754A	156	1	0.64
1N756A	618	1	0.16
1N758A	64	0	0.00
1N914	168	0	0.00
1N1202	294	0	0.00
1N1521A	118	0	0.00
1N1522A	123	1	0.81
1N1524A	18	0	0.00
1N1600	142	0	0.00
1N2032-2	2,985	5	0.17
1N3016B	30	0	0.00
1N3022B	18	1	5.56
2N335	431	6	1.39
2N338	264	0	0.00
2N388	2,534	16	0.63
2N396A	1,498	27	1.80
2N492	118	1	0.85
2N525	532	3	0.56

**Table 14. Semiconductor Electrical Defects Reported at Unit Test (Cont.)
(September)**

Semiconductor Type	Number Used on Assemblies Tested at Unit Test	Number of Electrical Defects Reported	Percentage %
2N553	114	1	0.88
2N595	654	6	0.92
2N599	1,231	4	0.32
2N604	8,343	30	0.36
2N682	79	2	2.53
2N697	1,786	8	0.45
2N699	1,043	3	0.29
2N1026A	134	0	0.00
2N1039	529	2	0.38
2N1123	124	3	2.42
2N1132	359	1	0.28
2N1157	215	0	0.00
2N1253	104	1	0.96
2N1403	1,107	2	0.18
2N1450	29,286	76	0.26
2N1646	32,109	123	0.38
2N2004	204	1	0.49

Table 15. Semiconductor Electrical Defects Reported at Unit Test
(October-November)

Semiconductor Type	Number Used on Assemblies Tested at Unit Test	Number of Electrical Defects Reported	Percentage %
1N93	1,121	1	0.09
1N198B	290,878	92	0.03
1N231	34	8	23.53
1N250B	555	2	0.36
1N277	77,916	40	0.10
1N429	54	1	1.85
1N457	2,545	5	0.20
1N458	177	0	0.00
1N459	116	0	0.00
1N538	9,231	7	0.08
1N629	1,970	1	0.05
1N645	3,406	0	0.00
1N691	1,860	0	0.00
1N746A	2,080	1	0.05
1N749A	713	2	0.28
1N751A	5,056	8	0.16
1N752A	326	5	1.53
1N754A	358	1	0.28
1N756A	2,598	0	0.00
1N758A	357	1	0.28
1N914	92	0	0.00
1N1202	576	1	0.17
1N1521A	240	0	0.00
1N1522A	309	0	0.00
1N1524A	20	0	0.00
1N1600	236	0	0.00
1N2032-2	4,129	1	0.02
1N3016B	447	2	0.45
1N3022-B	20	0	0.00
2N335	713	0	0.00
2N338	185	0	0.00
2N388	5,632	26	0.46
2N396A	3,769	14	0.37
2N492	235	0	0.00
2N525	1,335	2	0.15
2N553	131	0	0.00
2N595	1,528	6	0.39
2N599	1,946	18	0.92
2N604	10,442	32	0.31
2N682	123	9	7.32
2N697	2,669	9	0.34
2N699	2,015	3	0.15
2N1026A	693	0	0.00

**Table 15. Semiconductor Electrical Defects Reported at Unit Test (Cont.)
(October-November)**

Semiconductor Type	Number Used on Assemblies Tested at Unit Test	Number of Electrical Defects Reported	Percentage %
2N1039	713	0	0.00
2N1123	181	1	0.55
2N1132	922	0	0.00
2N1157	339	1	0.29
2N1253	134	1	0.75
2N1403	1,598	1	0.06
2N1450	41,535	53	0.13
2N1646	43,382	51	0.12
2N2004	1,340	0	0.00

Table 16. Electrical Defect Summary for Circuitron and Dynamic Unit Testing

Month	CIRCUITRON TESTING			UNIT TESTING		
	Number of Boards Tested	Average No. of Component Defects Per Board	Total No. of Defective Components	Number of Units Tested	Average No. of Component Defects Per Unit	Total No. of Defective Components
September	5,458	0.55	2,990	8,031	0.13	1,060
October-November	8,695	0.46	4,034	13,623	0.12	1,667

Table 17. Summary of Component Electrical Defects at Unit Test

The columns are identified as follows:

- A - Number of components used during the month
- B - Number of defects reported
- C - Percent reported defective
- D - Percent of the total defects

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COMPONENT	A	B	C	D	A	B	C	D
Diodes	282,024	191	0.07	29.6	407,410	175	0.04	29.2
Transistors	82,798	316	0.38	49.0	120,847	227	0.19	37.9
Tubes	2,842	47	1.65	7.3	7,904	98	0.12	16.4
All Others	—	91	—	14.1	—	99	—	16.5
TOTAL	—	645	—	100.0	—	599	—	100.0

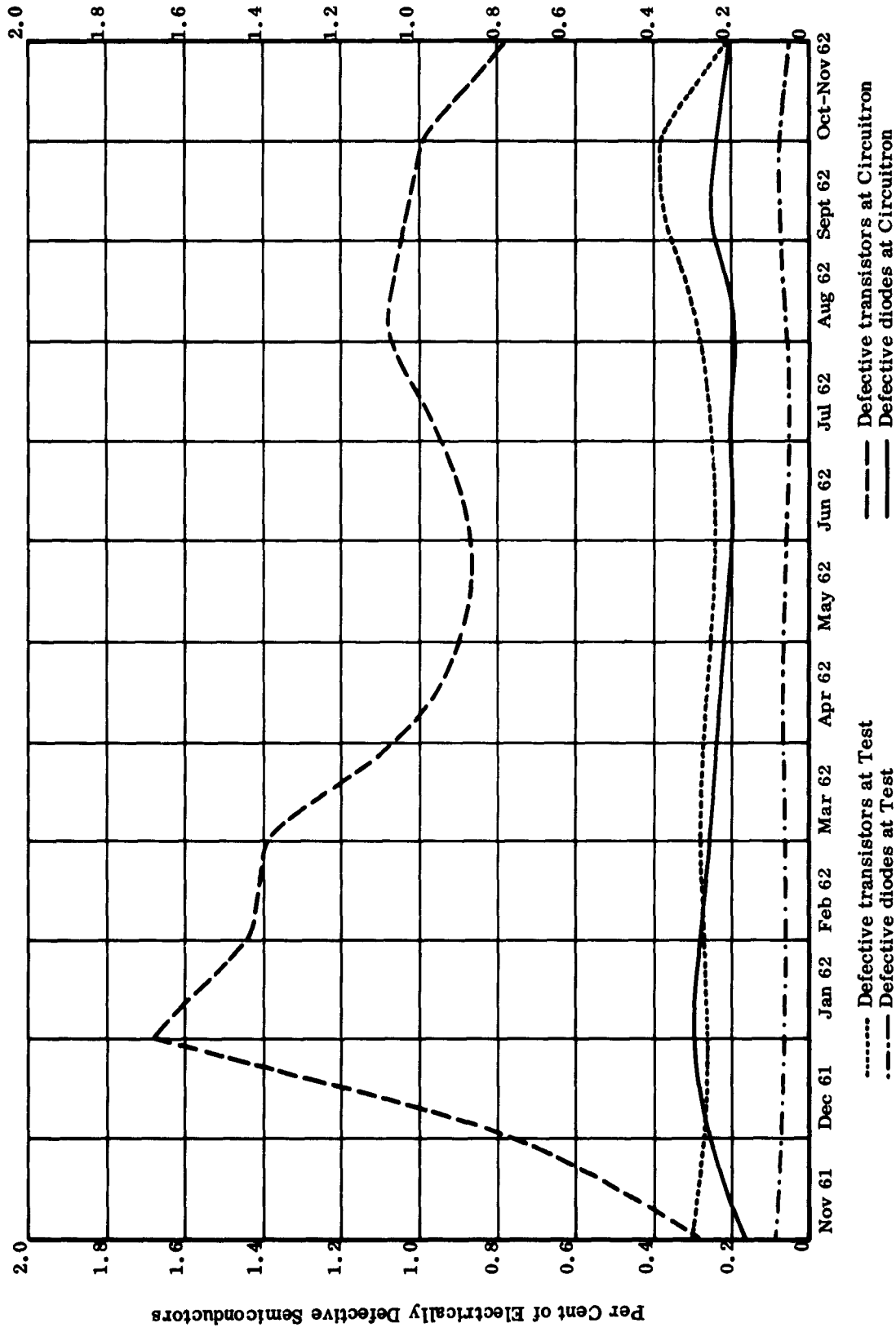


Figure 2. Monthly Semiconductor Electrical Defect Graph

2. In-Factory AN/GPA-73 Reliability Data From Environmental Tests

Four cabinets of the AN/GPA-73 were given humidity tests in accordance with contract requirements. The four cabinets were cabinet numbers 3, 27, 130, and 140. The cabinets were tested before the humidity test. Test of the cabinets after the humidity test has not been completed.

Failed parts are being accumulated and analysis of the failures is in progress. Some of the parts which are being analyzed are; delay lines, drawing numbers 7727987P10 and 7745772; capacitors, drawing number 7742523P22; transistors, 2N1646, 2N1450, 2N697, and 2N604; resistors, type RN70B; and transformer, drawing number 7747362.

Preliminary results indicate that the failures were caused by the humidity rather than random failures which would normally be expected during the testing period after humidity exposure. It is expected that the results of the analysis will be available for the next reporting period.

3. Category I, II and III Testing

a. Category I Test Reliability Data

Preliminary Reports No. 5 and 6 were distributed during the quarter and from these reports, the following tables (Nos. 18-22) and figures (Nos. 3-24) were generated. The predicted values presented in these tables and figures are current as of the time the measurements were made (August 1962). They may not agree with the values appearing in Part I of this report. Any differences in the predicted values is due to the fact that Part I data apply to general usage and Part II data are derived from specific configurations.

All MTBF and MTTR measurements presented in Part II are in terms of hours. Data for these measurements were recorded in a Category I testing environment which had as a primary objective to demonstrate the performance of the AN/GPA-73.

The final report for Category I testing is being prepared and will be available during the first quarter of 1963.

Table 18. AN/GPA-73 Cabinet MTBF Measurements for Verona Category I Test Site

Cabinet (Serial No.)	Measured MTBF (Hours)	Upper 90% MTBF Limit	Lower 90% MTBF Limit	Predicted MTBF (Hours)	Operational Hours	No. of Failures
Det.-Trkr. Gp. AN/FSA-12						
1 (1)	75.27	96.19	59.72	42.55	3,914	52
3 (1)	44.28	53.21	36.99	51.39	3,941	89
4 (1)	169.67	246.78	120.54	140.25	4,072	24
6 (2)	117.61	165.48	85.67	173.01	3,293	28
Surv.-Id. Gp. OA-1723						
24 (1)	127.50	179.40	92.87	595.24	3,570	28
26 (2)	90.91	118.80	70.65	93.11	4,000	44
26 (4)	148.67	222.21	103.21	93.11	3,122	21
27 (1)	167.24	249.96	116.10	240.96	3,512	21
27 (5)	205.88	327.76	135.56	240.96	3,294	16
28 (1)	350.67	806.13	177.55	234.74	2,104	6
28 (6)	239.92	417.25	148.02	234.74	2,879	12
32 (13)	83.22	107.17	65.59	59.88	4,078	49
Htg. Data Gp. OA-1718						
44 (1)	162.60	234.56	116.34	94.88	4,065	25
46 (1)	517.33	1,892.68	200.26	311.53	1,552	3
46 (2)	109.07	180.71	69.73	311.53	1,527	14
47 (1)	96.54	162.99	60.77	359.71	1,255	13
47 (2)	97.00	154.43	63.87	359.71	1,552	16

Table 18. AN/GPA-73 Cabinet MTBF Measurements for Verona Category I Test Site (Cont.)

Cabinet (Serial No.)	Measured MTBF (Hours)	Upper 90% MTBF Limit	Lower 90% MTBF Limit	Predicted MTBF (Hours)	Operational Hours	No. of Failures
Site-to-Site D. L. Gp.						
OA-1724						
35 (1)	158.16	241.37	107.71	105.71	3,005	19
36 (1)	205.56	394.46	117.83	157.23	1,850	9
37 (1)	204.91	366.50	123.85	73.96	2,254	11
39 (7)	70.48	91.53	55.08	59.38	3,242	46
Weapons Control Gp.						
AN/FSA-21						
52 (3)	40.11	51.12	31.89	39.64	2,126	53
53 (4)	107.55	159.01	75.18	45.13	2,366	22
54 (5)	N.A.	N.A.	N.A.	129.37	N.A.	N.A.
55 (1)	N.A.	N.A.	N.A.	200.80	N.A.	N.A.
56 (3)	113.06	177.14	75.37	70.47	1,922	17
59 (1)	192.64	344.55	116.43	135.69	2,119	11
60 (3)	172.90	317.25	102.01	177.62	1,729	10
60 (4)	211.33	485.82	107.00	177.62	1,268	6
60 (5)	190.17	437.16	96.29	177.62	1,141	6
61 (3)	139.38	235.32	87.75	132.45	1,812	13
61 (4)	88.57	132.38	61.49	132.45	1,860	21
63 (2)	185.29	395.43	98.63	248.76	1,297	7
66 (3)	187.92	326.81	115.94	198.02	2,255	12
67 (2)	N.A.	N.A.	N.A.	425.53	N.A.	N.A.

N.A. = Not Available

Table 18. AN/GPA-73 Cabinet MTBF Measurements for Verona Category I Test Site (Cont.)

Cabinet (Serial No.)	Measured MTBF (Hours)	Upper 90% MTBF Limit	Lower 90% MTBF Limit	Predicted MTBF (Hours)	Operational Hours	No. of Failures
Jammer Trkng. Gp.						
AN/FSA-23						
109 (3)	63.34	84.66	48.33	54.56	2,407	38
110 (1)	N.A.	N.A.	N.A.	318.47	N.A.	N.A.
110 (2)	N.A.	N.A.	N.A.	318.47	N.A.	N.A.
111 (1)	228.80	580.71	108.95	119.05	1,144	5
Perf. Mon. Gp.						
OA-3232						
72 (2)	N.A.	N.A.	N.A.	645.16	N.A.	N.A.
73 (2)	N.A.	N.A.	N.A.	436.68	N.A.	N.A.
75 (3)	N.A.	N.A.	N.A.	1,333.33	N.A.	N.A.
75 (4)	N.A.	N.A.	N.A.	1,333.33	N.A.	N.A.
76 (2)	163.50	480.88	71.48	207.04	654	4
77 (2)	96.89	185.93	55.54	162.60	872	9
N.A. = Not Available						

Table 19. Board Failure Rates
 (Based on testing at Verona Category I Test Site on the following Cabinets:
 1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-4, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
AC-1	12,601	0	0.000	0.000	0.237	0.022
AD-1	3,914	0	0.000	0.000	0.764	0.013
*AQ-1	86,108	6	0.070	0.030	0.138	0.015
AQ-2	3,914	0	0.000	0.000	0.764	0.025
BP-1	558,968	0	0.000	0.000	0.005	0.009
BP-2	327,212	1	0.003	0.000	0.014	0.009
BP-3	91,765	0	0.000	0.000	0.033	0.008
*CA-1	367,060	11	0.030	0.017	0.050	0.014
*CA-2	373,367	12	0.032	0.018	0.052	0.014
CC-1	25,965	0	0.000	0.000	0.115	0.021
CC-2	66,822	0	0.000	0.000	0.045	0.042
CD-1	3,914	0	0.000	0.000	0.764	0.013
CG-1	8,714	0	0.000	0.000	0.343	0.009
CL-1	189,837	0	0.000	0.000	0.016	0.004
CO-1	3,914	0	0.000	0.000	0.764	0.017
CS-1	93,936	0	0.000	0.000	0.032	0.022
CT-1	11,742	0	0.000	0.000	0.255	0.010
CT-2	11,742	0	0.000	0.000	0.255	0.007
CT-3	11,742	0	0.000	0.000	0.255	0.006
*DA-1	196,774	16	0.081	0.051	0.123	0.016

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)
 (Based on testing at Verona Category I Test Site on the following Cabinets:
 1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-4, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
DE-1	3,914	0	0.000	0.000	0.764	0.008
DE-2	3,914	0	0.000	0.000	0.764	0.009
DE-3	23,484	0	0.000	0.000	0.127	0.014
DE-4	3,914	0	0.000	0.000	0.764	0.011
DR-1	195,397	1	0.005	0.000	0.024	0.025
DR-2	131,258	1	0.008	0.000	0.036	0.024
DR-3	25,351	0	0.000	0.000	0.118	0.026
DR-4	44,218	0	0.000	0.000	0.068	0.016
DR-5	3,914	0	0.000	0.000	0.764	0.010
DR-7	7,828	0	0.000	0.000	0.382	0.020
DV-1	3,914	0	0.000	0.000	0.764	0.009
FB-1	27,398	0	0.000	0.000	0.109	0.016
FD-1	3,914	0	0.000	0.000	0.764	0.004
FD-2	7,828	0	0.000	0.000	0.382	0.017
FF-1	494,262	6	0.012	0.005	0.024	0.015
FF-2	243,342	4	0.016	0.006	0.038	0.018
FR-1	3,914	0	0.000	0.000	0.764	0.023
FS-1	3,914	0	0.000	0.000	0.764	0.018
HL-1	412,894	8	0.019	0.010	0.035	0.011
HL-2	1,328,518	20	0.015	0.010	0.022	0.014

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)

(Based on testing at Verona Category I Test Site on the following Cabinets:
1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-4, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
HL-3	1,668,250	34	0.020	0.015	0.027	0.015
HL-4	199,637	4	0.020	0.007	0.046	0.008
*HL-5	2,874,459	61	0.021	0.017	0.026	0.016
HL-6	405,894	1	0.002	0.000	0.012	0.014
LD-1	52,938	0	0.000	0.000	0.056	0.032
*LD-3	26,436	4	0.151	0.051	0.346	0.032
*LD-4	297,941	16	0.054	0.034	0.082	0.032
LG-1	140,004	0	0.000	0.000	0.021	0.011
LG-3	135,029	1	0.007	0.000	0.035	0.019
LL-1	3,914	0	0.000	0.000	0.764	0.015
LT-1	460,966	5	0.011	0.004	0.023	0.017
LT-2	31,312	0	0.000	0.000	0.095	0.016
LT-3	461,684	5	0.011	0.004	0.023	0.014
*LT-4	83,275	4	0.048	0.016	0.110	0.012
LT-5	44,954	0	0.000	0.000	0.067	0.014
MD-1	346,778	11	0.032	0.018	0.052	0.030
MD-2	300,935	1	0.003	0.000	0.016	0.030
MD-3	365,563	11	0.030	0.017	0.050	0.030
ME-1	3,914	0	0.000	0.000	0.764	0.011
NC-1	43,054	2	0.046	0.008	0.146	0.028

*Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)
 (Based on testing at Verona Category I Test Site on the following Cabinets:
 1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-5, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
NC-2	3,914	0	0.000	0.000	0.764	0.012
*ND-1	1,078,244	18	0.017	0.011	0.025	0.008
ND-2	265,458	2	0.008	0.001	0.024	0.014
ND-3	208,912	4	0.019	0.007	0.044	0.017
OC-1	20,592	0	0.000	0.000	0.145	0.005
PB-1	31,312	0	0.000	0.000	0.095	0.0004
PC-1	7,828	1	0.128	0.007	0.606	0.018
RD-1	90,175	0	0.000	0.000	0.033	0.023
RD-4	3,914	0	0.000	0.000	0.764	0.018
RI-1	352,260	3	0.009	0.002	0.022	0.023
RQ-1	43,054	2	0.046	0.008	0.146	0.014
RS-1	3,914	0	0.000	0.000	0.764	0.014
RS-2	46,968	0	0.000	0.000	0.064	0.013
SA-1	176,130	1	0.006	0.000	0.027	0.028
SC-1	342,609	10	0.029	0.016	0.049	0.019
SC-2	30,758	0	0.000	0.000	0.097	0.014
*SD-1	667,662	15	0.022	0.014	0.035	0.011
SG-1	3,914	0	0.000	0.000	0.764	0.004
SH-1	3,914	0	0.000	0.000	0.764	0.019
SH-2	3,914	0	0.000	0.000	0.764	0.012

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)
 (Based on testing at Verona Category I Test Site on the following Cabinets:
 1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-5, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
SH-3	3,914	0	0.000	0.000	0.764	0.019
SL-1	18,602	0	0.000	0.000	0.161	0.010
SL-2	133,759	3	0.022	0.006	0.058	0.014
SL-3	226,126	5	0.022	0.009	0.046	0.015
SL-4	66,248	0	0.000	0.000	0.045	0.008
SL-5	103,286	0	0.000	0.000	0.029	0.016
SL-6	89,090	0	0.000	0.000	0.034	0.014
SM-1	46,968	0	0.000	0.000	0.064	0.015
SS-1	82,194	0	0.000	0.000	0.036	0.036
ST-1	3,914	0	0.000	0.000	0.764	0.026
TG-1	15,656	0	0.000	0.000	0.191	0.008
TG-2	3,914	0	0.000	0.000	0.764	0.006
VM-2	2,366	0	0.000	0.000	1,264	0.014
VO-2	3,914	0	0.000	0.000	0.764	0.023
*WC-1	367,060	15	0.041	0.025	0.063	0.011
WC-2	373,367	6	0.016	0.007	0.032	0.009
WM-1	6,348	1	0.158	0.008	0.747	0.008
WP-1	6,348	0	0.000	0.000	0.471	0.016
ZA-1	68,036	5	0.073	0.029	0.154	0.047
ZA-2	4,426	0	0.000	0.000	0.676	0.047

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)
 (Based on testing at Verona Category I Test Site on the following Cabinets:
 1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-5, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
ADR-1	4,990	0	0.000	0.000	0.599	0.004
ALD-1	7,344	0	0.000	0.000	0.407	0.004
*AND-1	27,224	2	0.073	0.013	0.231	0.005
AND-2	7,309	0	0.000	0.000	0.409	0.004
AND-3	2,495	0	0.000	0.000	1.198	0.002
*BBD-4	2,407	1	0.415	0.021	1.969	0.002
*BBD-10	6,806	1	0.147	0.007	0.696	0.005
BBD-11	23,995	1	0.042	0.002	0.198	0.002
BBD-12	23,536	0	0.000	0.000	0.127	0.005
BBD-17	11,768	0	0.000	0.000	0.254	-
*BGG-1	125,875	4	0.032	0.011	0.073	0.010
*BGG-2	61,933	6	0.097	0.042	0.191	0.007
BOB-1	2,495	0	0.000	0.000	1.198	0.010
DCD-1	2,495	0	0.000	0.000	1.198	0.014
DCP-2	14,970	1	0.067	0.003	0.317	0.008
DCP-3	54,448	0	0.000	0.000	0.055	0.008
DLB-1	24,810	0	0.000	0.000	0.121	0.012
DLB-2	4,962	0	0.000	0.000	0.603	0.014
DLB-4	4,962	0	0.000	0.000	0.603	0.005
DLB-5	34,734	0	0.000	0.000	0.086	0.006

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)
 (Based on testing at Verona Category I Test Site on the following Cabinets:
 1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-5, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
DLB-6	4,962	0	0.000	0.000	0.603	0.008
DLB-7	62,382	0	0.000	0.000	0.048	0.025
DLB-9	124,320	0	0.000	0.000	0.024	0.006
DTR-1	2,495	0	0.000	0.000	1.198	0.011
*DYC-1	23,536	4	0.170	0.058	0.389	0.010
ESP-1	11,728	0	0.000	0.000	0.255	0.013
GAM-1	17,377	0	0.000	0.000	0.172	0.008
*GAM-2	2,495	1	0.401	0.020	1.900	0.014
GAM-4	17,916	1	0.056	0.003	0.265	0.008
*GAM-5	13,612	2	0.147	0.026	0.463	0.007
GAM-6	16,589	0	0.000	0.000	0.180	0.008
INA-1	2,495	0	0.000	0.000	1.198	0.011
INT-1	14,263	1	0.070	0.004	0.332	0.009
INT-2	11,768	1	0.085	0.004	0.403	0.022
INT-3	16,758	0	0.000	0.000	0.178	0.007
INT-4	11,768	1	0.008	0.004	0.403	0.007
INT-5	11,768	0	0.000	0.000	0.254	0.005
INT-6	21,692	0	0.000	0.000	0.138	0.005
*INT-7	16,758	10	0.597	0.325	1.011	0.016
*INT-12	2,495	1	0.401	0.020	1.900	0.007

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)
 (Based on testing at Verona Category I Test Site on the following Cabinets:
 1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-5, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
INV-1	7,221	0	0.000	0.000	0.414	0.008
ICA-1	19,848	0	0.000	0.000	0.151	0.005
LDR-1	28,972	1	0.035	0.002	0.164	0.008
LDR-2	11,768	0	0.000	0.000	0.254	0.007
LJM-1	27,224	1	0.037	0.002	0.174	0.013
LJM-4	2,495	0	0.000	0.000	1.198	0.002
LTE-1	75,570	0	0.000	0.000	0.040	0.010
MAD-1	9,924	0	0.000	0.000	0.301	0.022
MDB-1	2,495	0	0.000	0.000	1.198	0.028
MDB-2	2,495	0	0.000	0.000	1.198	0.028
MGG-2	12,447	0	0.000	0.000	0.240	0.007
MGG-3	4,990	0	0.000	0.000	0.599	0.007
MGG-4	6,806	0	0.000	0.000	0.439	0.007
MGG-5	27,224	0	0.000	0.000	0.110	0.008
MGG-7	4,962	0	0.000	0.000	0.603	0.007
*MGG-8	4,962	1	0.202	0.010	0.955	0.007
NWK-1	2,495	0	0.000	0.000	1.198	0.023
NWK-2	2,495	0	0.000	0.000	1.198	0.017
NWK-3	2,495	0	0.000	0.000	1.198	0.001
NWK-5	2,495	0	0.000	0.000	1.198	0.004

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)

(Based on testing at Verona Category I Test Site on the following Cabinets:
1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-5, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
*OPA-1	111,390	8	0.072	0.036	0.130	0.009
*OPA-2	28,526	3	0.105	0.029	0.272	0.007
OPA-3	153,961	4	0.026	0.009	0.059	0.009
OPA-5	28,526	1	0.035	0.002	0.166	0.008
ORG-3	27,224	0	0.000	0.000	0.110	0.007
ORG-4	6,806	0	0.000	0.000	0.439	0.003
ORG-5	6,806	0	0.000	0.000	0.439	0.008
OSC-1	2,407	0	0.000	0.000	1.242	0.005
OSC-2	2,407	0	0.000	0.000	1.242	0.004
*PAD-1	6,806	3	0.441	0.120	1.139	0.014
RAM-7	43,176	1	0.023	0.001	0.110	0.027
RAM-8	43,176	0	0.000	0.000	0.069	0.023
RAM-9	43,176	0	0.000	0.000	0.069	0.027
RAM-12	6,806	0	0.000	0.000	0.439	0.004
RFC-1	2,495	0	0.000	0.000	1.198	0.001
RFC-2	2,495	0	0.000	0.000	1.198	0.002
RLB-1	11,768	1	0.085	0.004	0.403	0.028
RLB-2	6,806	0	0.000	0.000	0.439	0.015
RLB-3	11,768	0	0.000	0.000	0.254	0.021
RLB-4	18,574	0	0.000	0.000	0.161	0.011

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)
 (Based on testing at Verona Category I Test Site on the following Cabinets:
 1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-5, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
RLB-7	149, 129	0	0.000	0.000	0.020	0.028
RLB-8	598, 248	18	0.030	0.019	0.045	0.027
RLB-9	41, 152	0	0.000	0.000	0.073	0.024
RLB-10	24, 810	0	0.000	0.000	0.121	0.032
RLB-11	44, 658	0	0.000	0.000	0.067	0.027
RLB-15	583, 854	22	0.038	0.025	0.054	0.026
RLB-17	71, 220	1	0.014	0.001	0.067	0.026
RTT-1	2, 495	0	0.000	0.000	1.198	0.006
SAM-1	14, 688	0	0.000	0.000	0.204	0.014
SIN-1	2, 407	0	0.000	0.000	1.242	0.005
SIC-1	2, 407	0	0.000	0.000	1.242	0.008
SMB-1	9, 804	0	0.000	0.000	0.305	0.009
STA-1	29, 772	1	0.034	0.002	0.159	0.014
SWC-2	2, 495	0	0.000	0.000	1.198	0.001
SWC-3	2, 495	0	0.000	0.000	1.198	0.009
SWC-4	12, 035	0	0.000	0.000	0.248	0.008
*SWG-1	11, 768	2	0.170	0.030	0.535	0.005
TDB-1	2, 495	0	0.000	0.000	1.198	0.024
TPH-2	2, 407	0	0.000	0.000	1.242	0.007
*TSS-1	2, 495	1	0.401	0.020	1.900	0.007

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 19. Board Failure Rates (Cont.)

(Based on testing at Verona Category I Test Site on the following Cabinets:
1-1, 3-1, 26-2, 26-4, 27-1, 27-5, 53-4, 61-3, 61-5, 109-3, 60-3, 60-4 and 60-5.)

Board Type	Accumulated Board-Hours	Number of Failures	Measured Failures/1000 Hrs.	Lower 90% Confidence Limit	Upper 90% Confidence Limit	Predicted Failures/1000 Hrs.
TSS-2	2,495	0	0.000	0.000	1.198	0.010
TYD-1	9,924	1	0.101	0.005	0.478	0.008
TYD-2	19,848	1	0.050	0.003	0.239	0.008
TYD-3	19,848	0	0.000	0.000	0.151	0.008
TYD-4	9,924	1	0.101	0.005	0.478	0.008
TYD-5	9,924	1	0.101	0.005	0.478	0.008
TYD-6	9,924	0	0.000	0.000	0.301	0.004
TYE-1	4,962	0	0.000	0.000	0.603	0.003
TYT-1	4,962	0	0.000	0.000	0.603	0.007
VDR-1	25,380	0	0.000	0.000	0.118	0.006
VEG-2	9,924	0	0.000	0.000	0.301	0.035
VSM-1	42,110	0	0.000	0.000	0.071	0.012
VSM-2	11,768	0	0.000	0.000	0.254	0.012

* Lower 90% Confidence Limit exceeds predicted Failures/1000 Hours.

Table 20. AN/GPA-73 MTBF Data for Watertown Category I Test Site

Unit	Serial Number	Measured MTBF (m _m)	Upper 90% MTBF Limit (m _{u1})	Lower 90% MTBF Limit (m _{l1})	Predicted MTBF (m _p)	Failure Rate (Failures/1000 Hours)	
						Predicted	Measured
1	3	42.33	54.68	33.27	42.55	23.50	23.62
3	3	35.92	45.15	28.92	51.39	19.46	27.84
4	3	181.91	325.37	109.95	140.25	7.13	5.50
7	8	N.A.	N.A.	N.A.	347.22	2.88	N.A.
Detector Tracker Grp. AN/FSA-12		N.A.			18.88	52.97	N.A.
24	3	91.33	140.99	61.57	595.24	1.68	10.95
26	3	65.85	93.43	47.71	93.11	10.74	14.52
27	4	84.06 *	133.83	55.35	240.96	4.15	11.90
28	5	196.22	376.55	112.48	234.74	4.26	5.10
30	6	48.18	64.40	36.77	94.88	10.54	20.76
Surveillance-Identification Grp. 0A-1723/GPA-73		15.82			31.88	31.37	63.23
34	1	27.81	34.42	22.69	74.68	13.39	35.96
37	2	77.90	117.58	53.63	73.96	13.52	12.84
Site-to-Site D.L. Grp. 0A-1724/GPA-73		20.49			37.16	26.91	48.80

N.A. = Not Available

Table 21. AN/GPA-73 MTTR Data for Verona Category I Test Site

Cabinet (Serial No.)	No. of Failures*	Measured MTTR (Hours)
1 (1)	48	1.07
3 (1)	66	0.86
4 (1)	18	0.93
6 (2)	23	0.81
Detector-Tracker Grp. AN/FSA-12		0.92
24 (1)	27	0.77
26 (2)	40	1.04
26 (4)	18	1.21
27 (1)	18	0.92
27 (5)	17	0.91
28 (1)	7	0.51
28 (6)	13	0.72
32 (13)	40	1.30
Surveillance-Identification Grp. 0A-1723/GPA-73		1.00
44 (1)	26	1.32
46 (2)	12	1.43
46 (1)	4	1.96
47 (1)	14	0.86
47 (2)	16	0.79
Height Data Grp. 0A-1718/GPA-73		

* N-K
N. A. = Not Available

Table 21. AN/GPA-73 MTTR Data for Verona Category I Test Site (Cont.)

Cabinet (Serial No.)	No. of Failures*	Measured MTTR (Hours)
35 (1)	19	0.81
36 (1)	10	0.22
37 (1)	11	0.39
39 (7)	45	0.64
Site-to-Site Data Link Grp. 0A-1724/GPA-73		0.60
53 (3)	52	0.19
53 (4)	23	0.58
54 (5)	3	0.56
55 (1)	3	0.57
56 (3)	18	0.39
59 (1)	10	0.77
60 (3)	11	0.27
60 (4)		0.39
60 (5)	7	0.46
61 (4)	21	0.39
61 (3)	14	0.29
63 (2)	8	0.58
66 (3)	13	0.89
Weapons Control Grp. AN/FSA-21		0.41

* N-K
N. A. = Not Available

Table 21. AN/GPA-73 MTTR Data for Verona Category I Test Site (Cont.)

Cabinet (Serial No.)	No. of Failures*	Measured MTTR (Hours)
109 (3)	35	1.83
110 (1)	2	1.34
110 (2)	2	3.67
111 (1)	• 6	1.56
Jammer Tracking Grp. AN/FSA-23		1.85
72 (2)	N.A.	N.A.
73 (2)	3	0.57
75 (3)	1	0.17
75 (4)	N.A.	N.A.
76 (2)	5	0.25
77 (2)	10	0.87
Performance Monitor Grp. 0A-3232/GPA-73		N.A.
8 (1)	12	1.09
9 (1)	11	2.03
Radar Signal Processor AN/FSA-31		1.54

* N-K
N.A. = Not Available

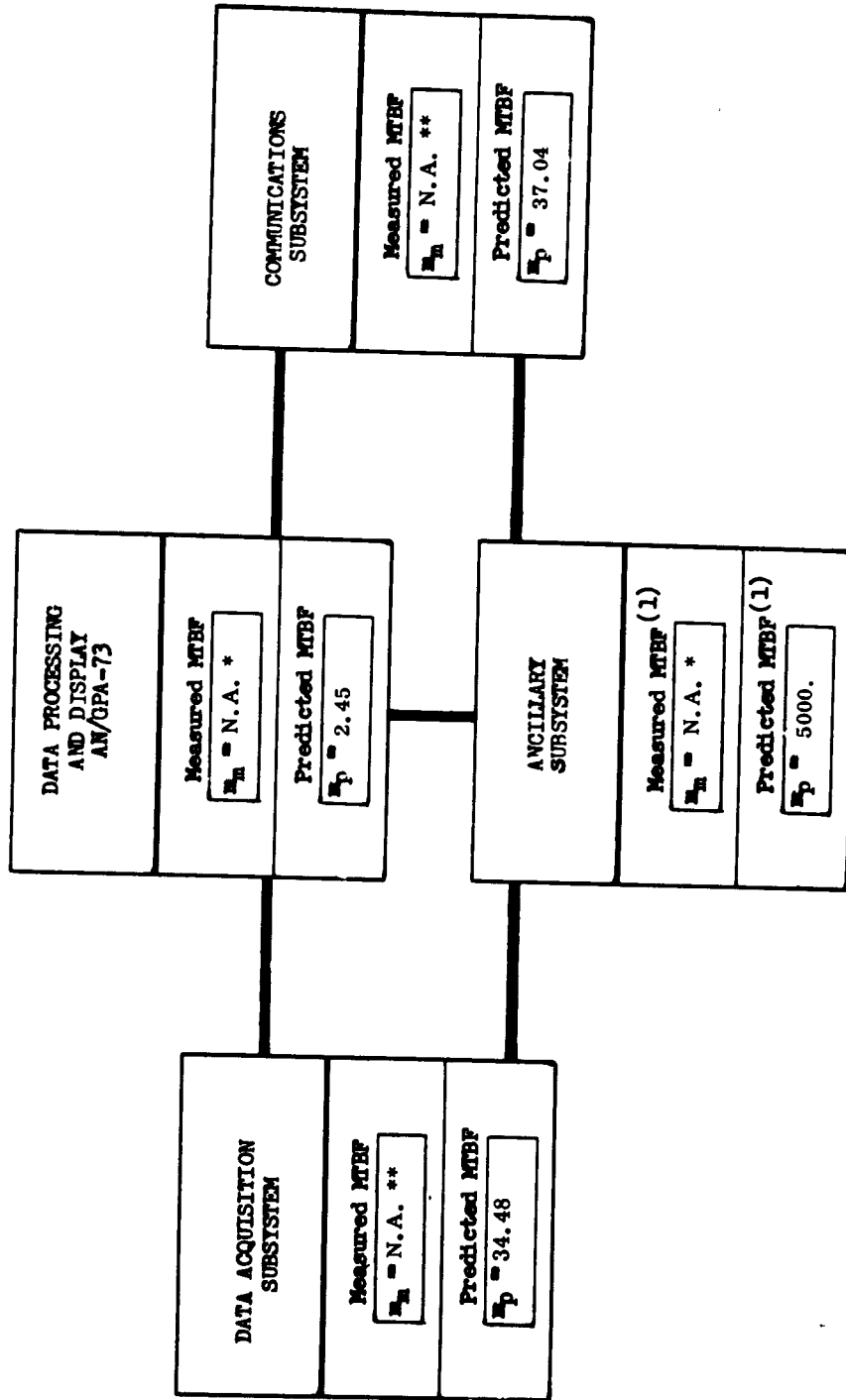
Table 22. AN/GPA-73 MTTR Data for Watertown Category I Test Site

Cabinet (Serial No.)	No. of Failures*	Measured MTTR (Hours)
1 (3)	11	0.51
3 (3)	38	1.02
4 (3)	7	0.31
7 (8)	3	0.17
Detector-Tracker Grp. AN/FSA-12		0.80
24 (3)	7	0.44
26 (3)	21	0.72
27 (4)	5	0.71
28 (5)	N.A.	N.A.
30 (6)	29	1.80
Surveillance-Identification Grp. 0A-1723/GPA-73		N.A.
34 (1)	66	1.11
37 (2)	20	1.28
Site-to-Site Data Link Grp. 0A-1724/GPA-73		1.15

* N-K
N.A. = Not Available

AWCS 412L
OPERATING SUBSYSTEMS

VERONA TEST SITE

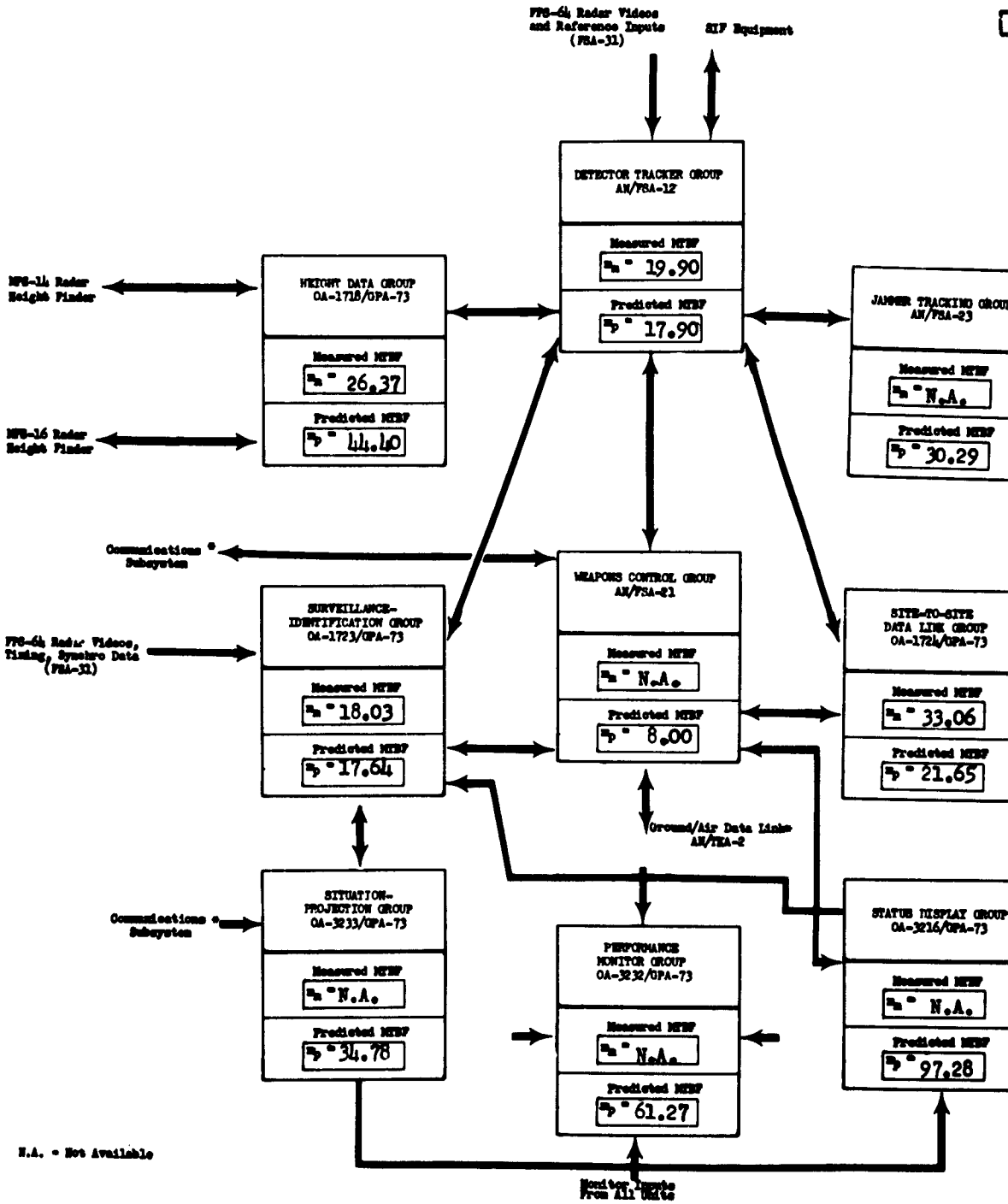


* To be supplied later.
** To be supplied later contingent upon availability of failure information.

(1) Average Per Unit

Figure 3. AWCS 412L Subsystem MTBF Data

DATA PROCESSING AND DISPLAY SUBSYSTEM
AN/GPA-73



N.A. - Not Available

Figure 4. Data Processing and Display Subsystem

DATA PROCESSING AND DISPLAY SUBSYSTEM
AN/GPA-73

VEHICLE TEST SITE

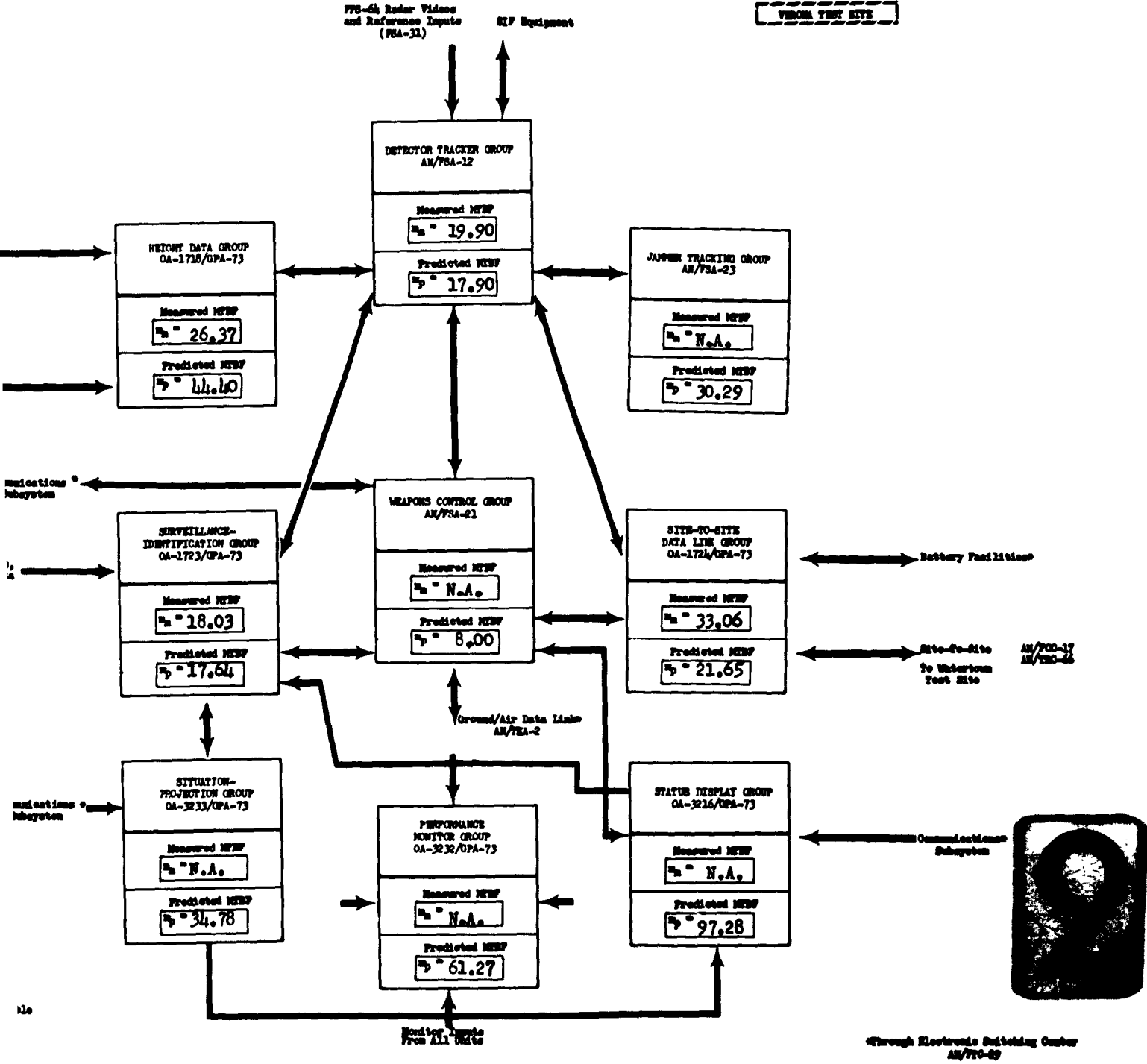


Figure 4. Data Processing and Display Subsystem MTBF Data

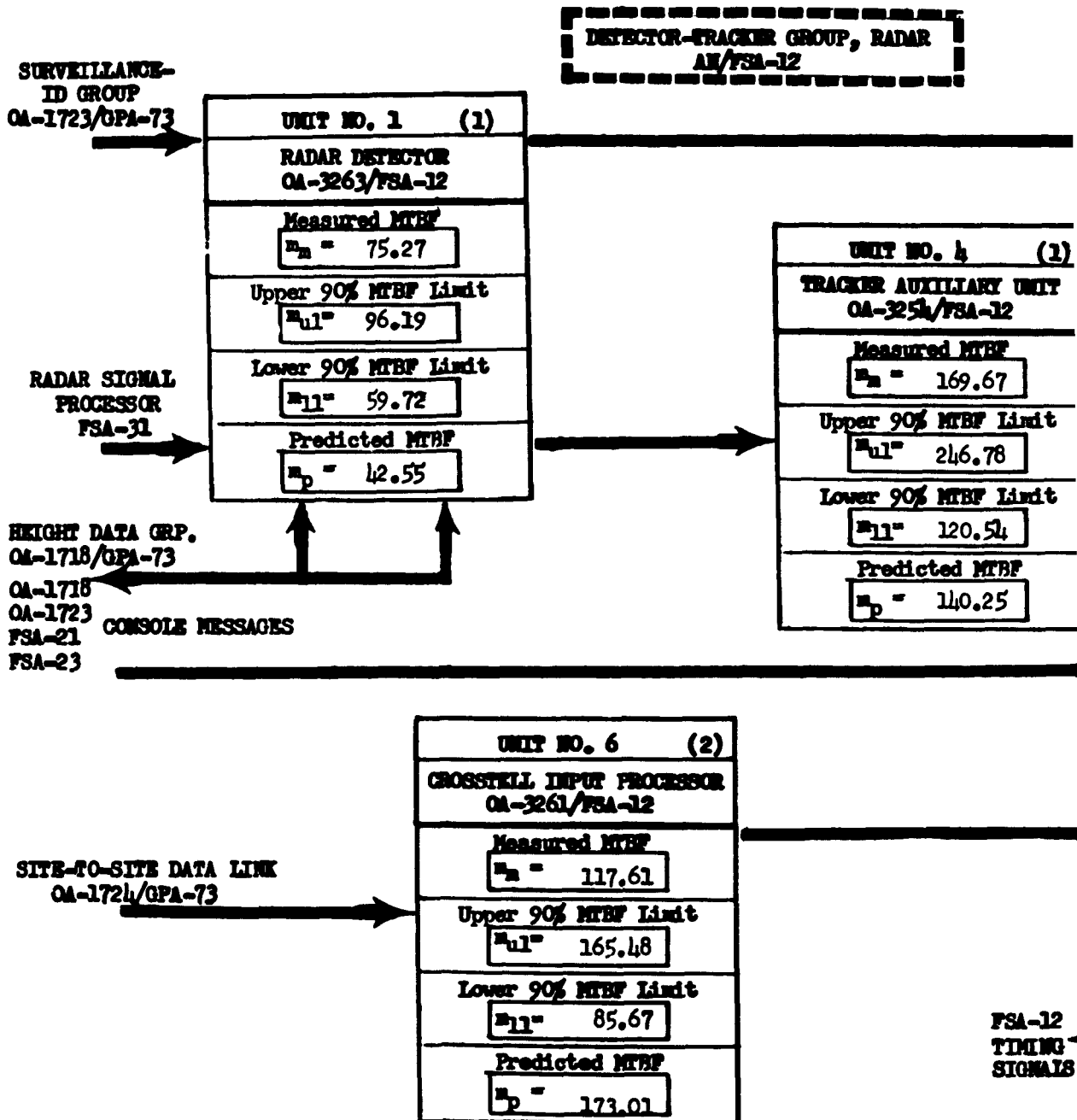


Figure 5. Detector-Tracker Gro

DETECTOR-TRACKER GROUP, RADAR
AN/FSA-12

SURVEILLANCE-
ID GROUP
OA-1723/GPA-73

UNIT NO. 1 (1)
AR DETECTOR 3263/FSA-12
Measured MTBF $m_m = 75.27$
Upper 90% MTBF Limit $m_{u1} = 96.19$
Lower 90% MTBF Limit $m_{l1} = 59.72$
Predicted MTBF $m_p = 42.55$

WEAPONS CONTROL GROUP
FSA-21

VERONA TEST SITE

UNIT NO. 4 (1)
TRACKER AUXILIARY UNIT OA-3254/FSA-12
Measured MTBF $m_m = 169.67$
Upper 90% MTBF Limit $m_{u1} = 246.78$
Lower 90% MTBF Limit $m_{l1} = 120.54$
Predicted MTBF $m_p = 110.25$

DATA PROCESSING
MASTER TIMING SIGNALS

UNIT NO. 3 (1)
DIGITAL TRACKER OA-3255/FSA-12
Measured MTBF $m_m = 44.28$
Upper 90% MTBF Limit $m_{u1} = 53.21$
Lower 90% MTBF Limit $m_{l1} = 36.99$
Predicted MTBF $m_p = 51.39$



UNIT NO. 6 (2)
CROSSKILL INPUT PROCESSOR OA-3261/FSA-12
Measured MTBF $m_m = 117.61$
Upper 90% MTBF Limit $m_{u1} = 165.48$
Lower 90% MTBF Limit $m_{l1} = 85.67$
Predicted MTBF $m_p = 173.01$

FSA-12
TIMING
SIGNALS

TRACK DATA TO ALL
DATA PROCESSING EQ.

Figure 5. Detector-Tracker Group, Radar AN/FSA-12 MTBF Data

SURVEILLANCE - IDENTIFICATION
 OA-1723/GPA-73

PROJECTION DISPLAY CONVERTER
 OA-3251/GPA-73

DIGITAL TRACKER
 OA-3255/FSA-12

UNIT NO. 32 (13)
TRACK DATA PROCESSOR OA-3253/GPA-73
Measured MTBF $m_m = 83.22$
Upper 90% MTBF Limit $m_{u1} = 107.17$
Lower 90% MTBF Limit $m_{l1} = 65.59$
Predicted MTBF $m_p = 59.88$

UNIT NO. 26-1 (2)
SURV.-ID DISPLAY CONVERTER OA-3219/GPA-73
Measured MTBF $m_m = 90.91$
Upper 90% MTBF Limit $m_{u1} = 118.80$
Lower 90% MTBF Limit $m_{l1} = 70.65$
Predicted MTBF $m_p = 93.11$

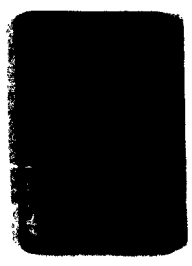
UNIT NO. 27-1 (1)
SURVEILLANCE CONSOLE OA-3102/GPA-73
Measured MTBF $m_m = 167.24$
Upper 90% MTBF Limit $m_{u1} = 249.96$
Lower 90% MTBF Limit $m_{l1} = 116.10$
Predicted MTBF $m_p = 240.96$

UN
IDENTI
QA
Me
m_m
Upper
m_{u1}
Lower
m_{l1}
Pr
m_p

RADAR DATA
 (VIDEO)
 (TIMING)
 (SYNCHRO)

UNIT NO. 24 (1)
RADAR DATA PROCESSOR OA-3217/GPA-73
Measured MTBF $m_m = 127.50$
Upper 90% MTBF Limit $m_{u1} = 179.40$
Lower 90% MTBF Limit $m_{l1} = 92.87$
Predicted MTBF $m_p = 595.24$

RAD
 OA-



**SURVEILLANCE - IDENTIFICATION GROUP
OA-1723/GPA-73**

PROJECTION DISPLAY CONVERTER
OA-3251/GPA-73

VERONA TEST SITE

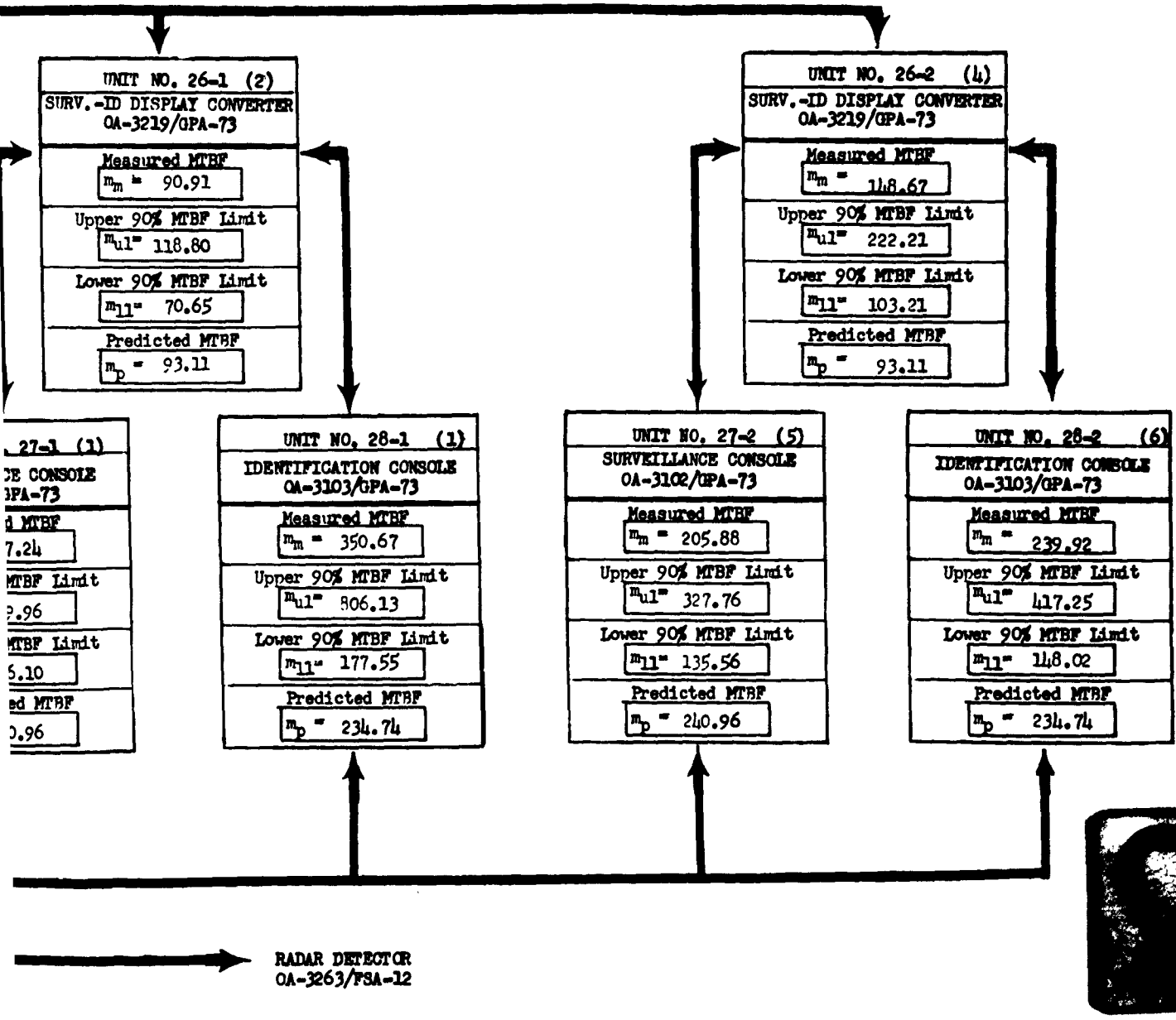
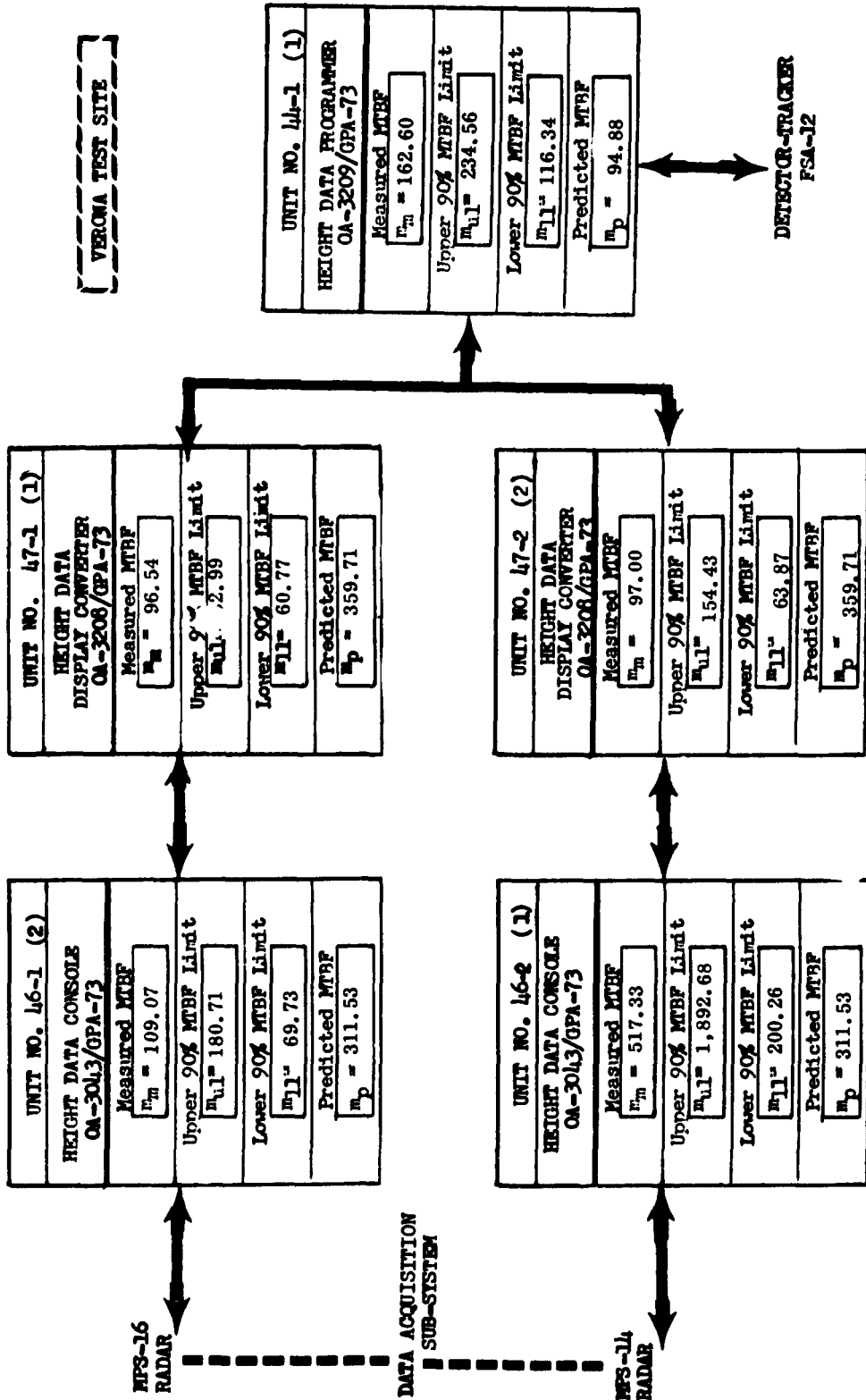


Figure 6. Surveillance-Identification Group, OA-1723/GPA 73 MTBF Data

HEIGHT DATA GROUP
OA-1718/GPA-73

VERONA TEST SITE



N.A. - Not Available

Figure 7. Height Data Group, OA-1718/GPA-73 MTBF Data

**SITE-TO-SITE DATA LINK GROUP
OA-1724/GPA-73**

DIGITAL TARGET INTERCEPT
TRACKER
FSA-12

VERONA TEST SITE

UNIT NO. 39-1 (7)
DATA LINK CENTRAL OA-3104/GPA-73
Measured MTBF $m_m = 70.48$
Upper 90% MTBF Limit $m_{ul} = 91.53$
Lower 90% MTBF Limit $m_{ll} = 55.08$
Predicted MTBF $m_p = 59.38$

UNIT NO. 37-1 (1)
MESSAGE PROCESSOR OA-327/GPA-73
Measured MTBF $m_m = 204.91$
Upper 90% MTBF Limit $m_{ul} = 366.50$
Lower 90% MTBF Limit $m_{ll} = 123.85$
Predicted MTBF $m_p = 73.96$

COMMUNICATION
SUB-SYSTEM

UNIT NO. 35-1 (1)
COORDINATE CONVERTER OA-329/GPA-73
Measured MTBF $m_m = 158.16$
Upper 90% MTBF Limit $m_{ul} = 241.37$
Lower 90% MTBF Limit $m_{ll} = 107.71$
Predicted MTBF $m_p = 105.71$

UNIT NO. 36-1 (1)
BATTERY DATA LINK OA-3252/GPA-73
Measured MTBF $m_m = 205.56$
Upper 90% MTBF Limit $m_{ul} = 394.46$
Lower 90% MTBF Limit $m_{ll} = 117.83$
Predicted MTBF $m_p = 157.23$

N.A. = Not Available

Figure 8. Site-to-Site Data Link Group, OA-1724/GPA-73 MTBF Data

WEAPONS CONTROL GROUP
AR/78A-02

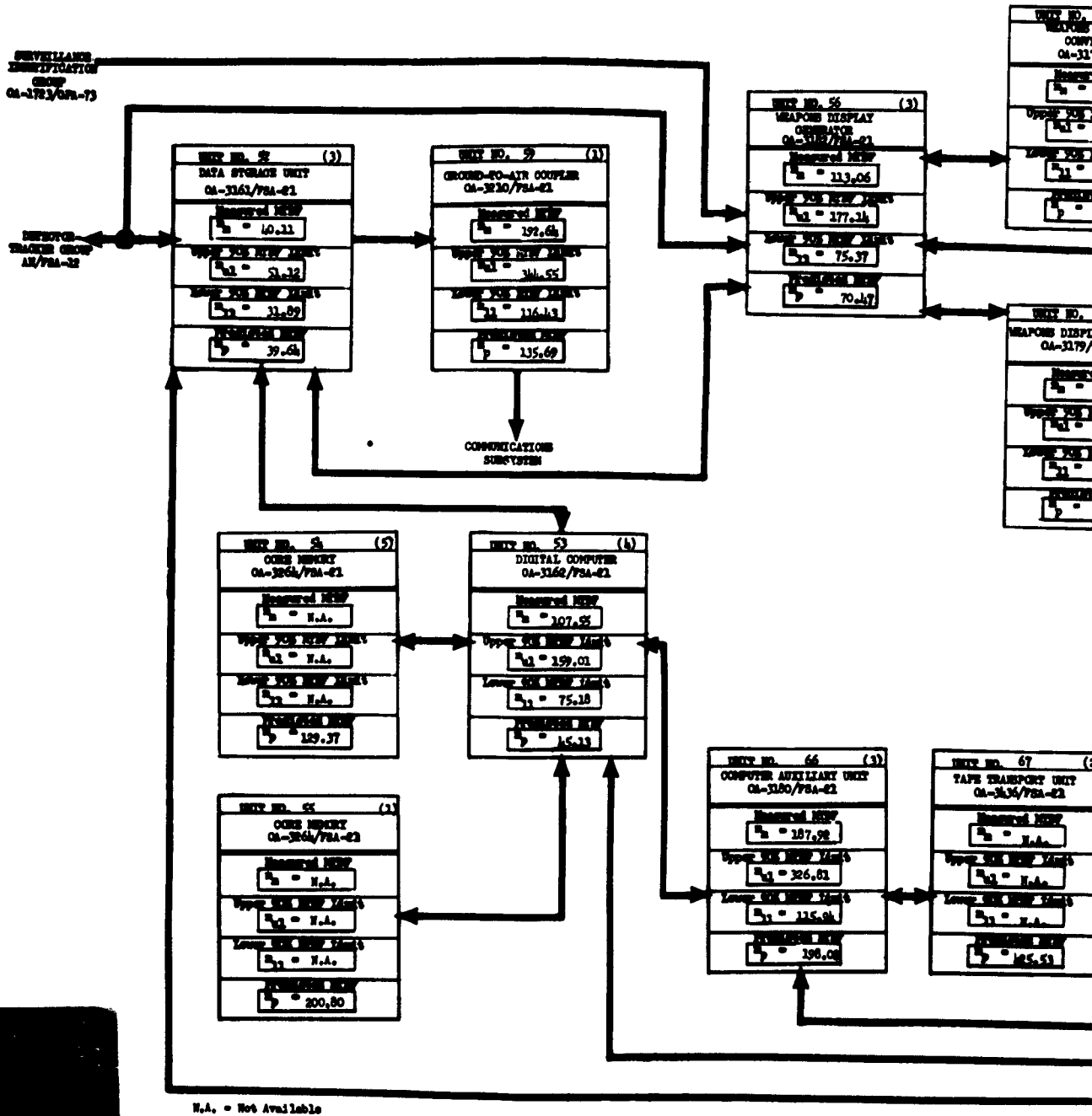


Figure 9. Weapons Contr

WEAPONS CONTROL GROUP
AN/FSA-21

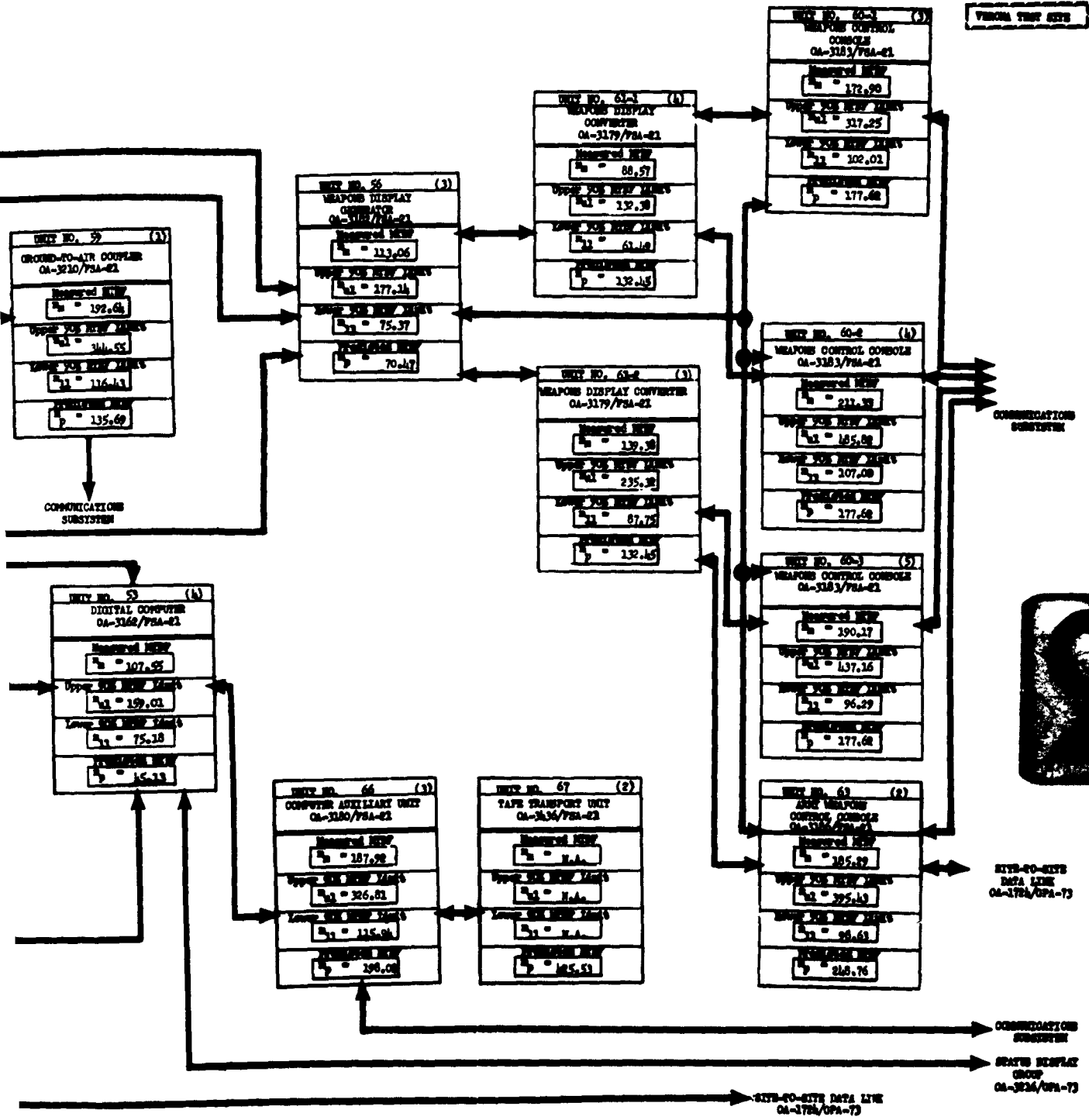
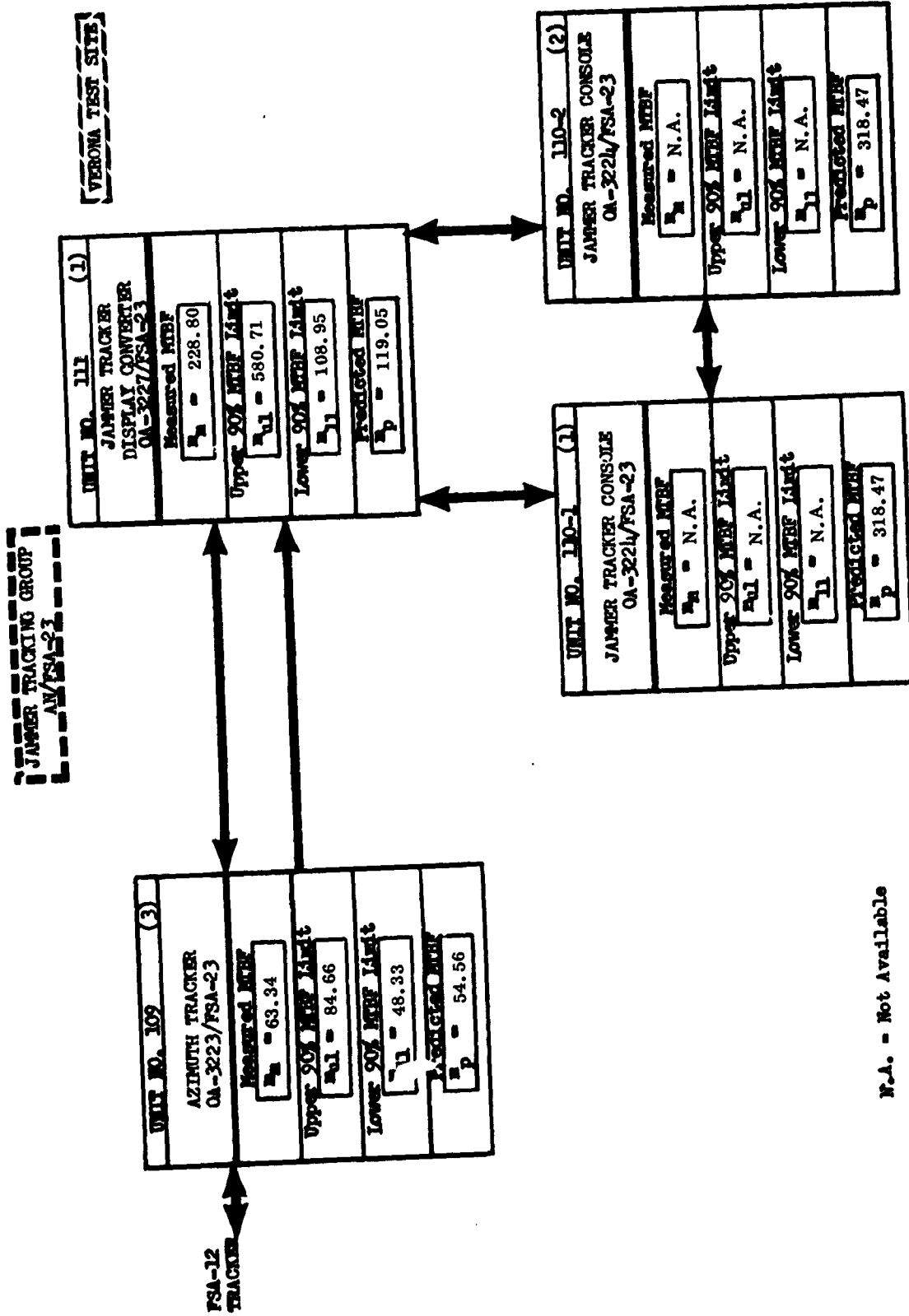


Figure 9. Weapons Control Group, AN/FSA-21 MTBF Data



N.A. = Not Available

Figure 10. Jammer Tracking Group, AN/FSA-23 MTBF Data



PERFORMANCE MONITOR GROUP
OA-3232/CPA-73

VERBIA TEST SIDE

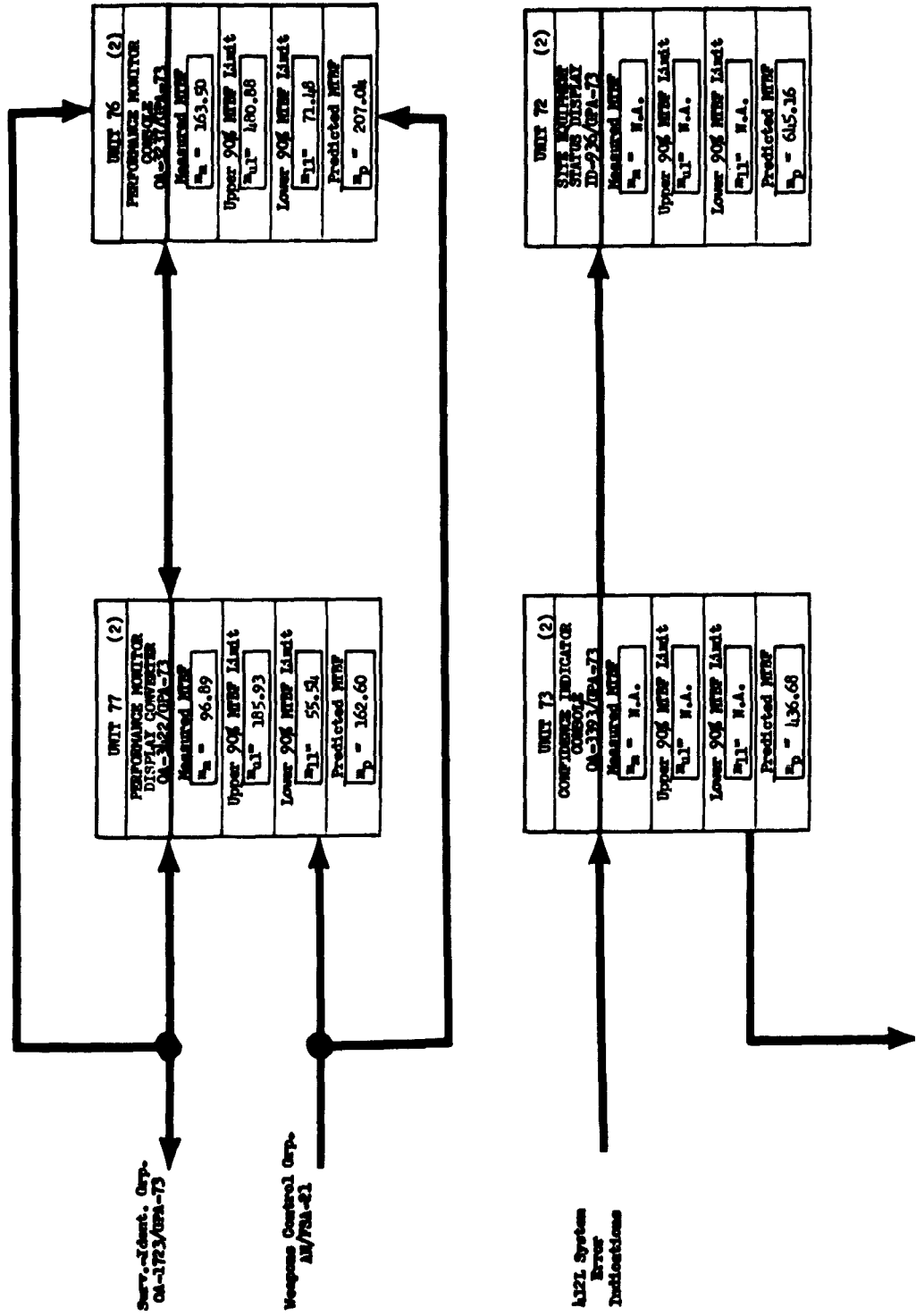
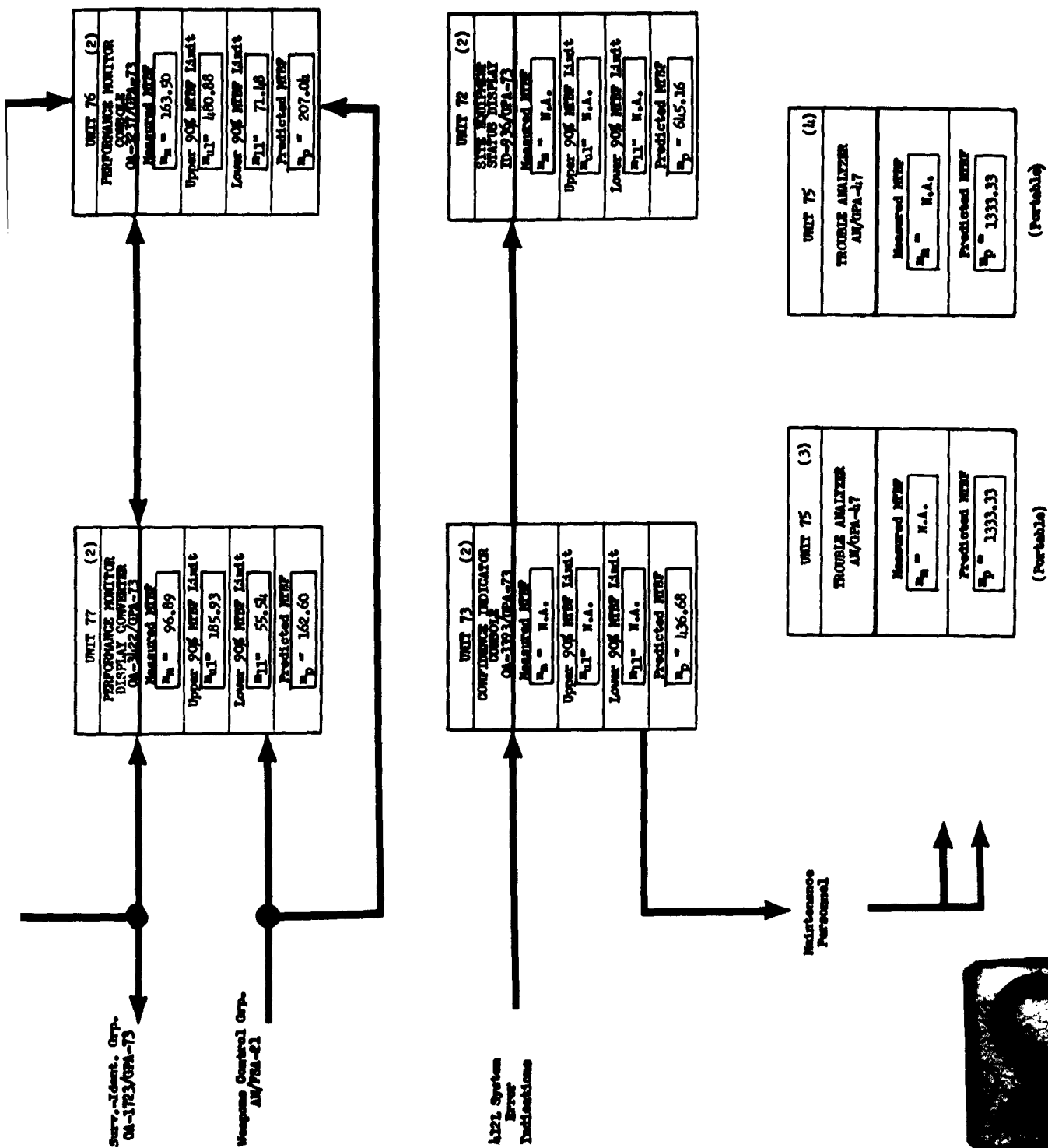


Figure 11. Performance Monitor Group, OA-

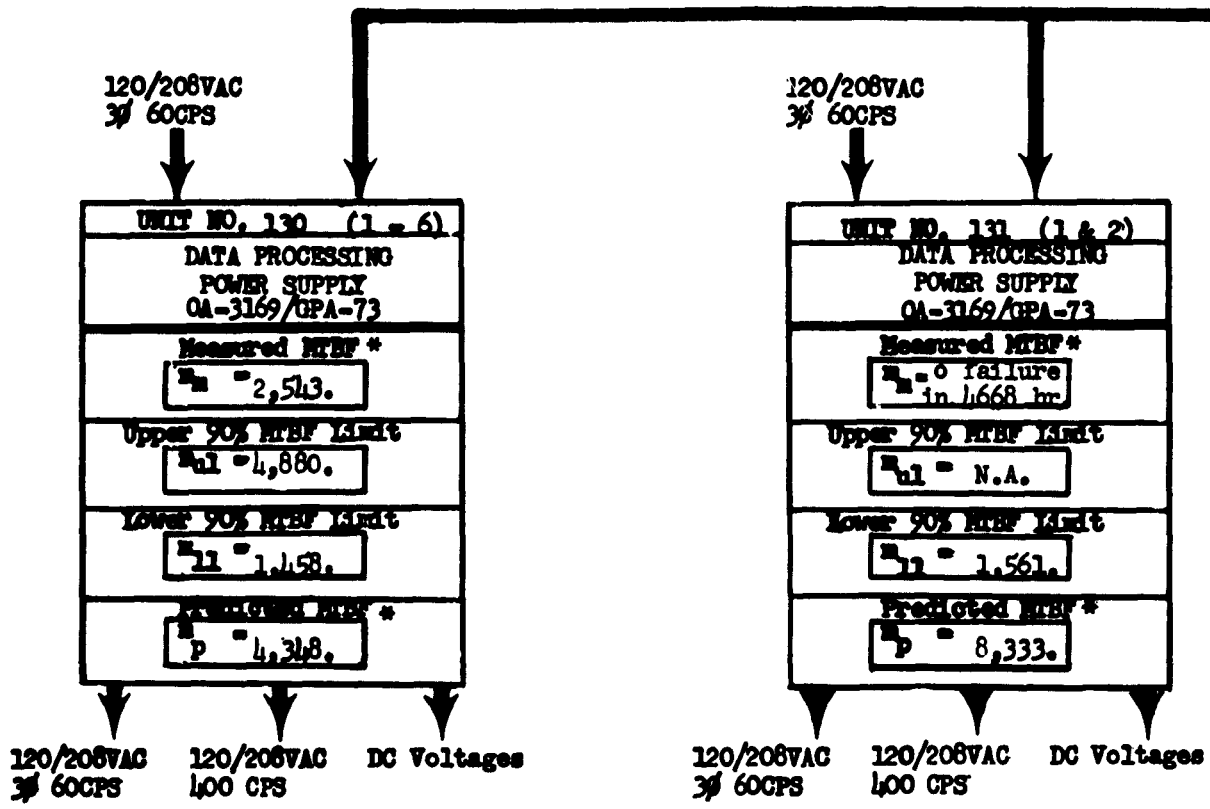


N.A. = Not Available

Figure 11. Performance Monitor Group, OA-3232/GPA-73 MTBF Data

POWER SUPPLY SETS

120/
3/1



TO DATA PROCESSING CABINETS

Average Per Unit



POWER SUPPLY SETS

120/208VAC
3 ϕ 400 CPS

VERONA TEST SITE

120/208VAC
3 ϕ 60CPS

UNIT NO. 131 (1 & 2) DATA PROCESSING POWER SUPPLY OA-3169/GPA-73
Measured MTBF* $\lambda = 0$ failure in 1,668 hr
Upper 90% MTBF Limit $\lambda_{u1} = \text{N.A.}$
Lower 90% MTBF Limit $\lambda_{l1} = 1,561.$
Predicted MTBF* $\lambda_p = 8,333.$

120/208VAC
3 ϕ 60CPS

120/208VAC
400 CPS

DC Voltages

D CABINETS

120/208VAC
3 ϕ 60CPS

UNIT NO. 110 (1 - 6) DISPLAY POWER SUPPLY OA-3151/GPA-73
Measured MTBF* $\lambda = 2,023.$
Upper 90% MTBF Limit $\lambda_{u1} = 4,066.$
Lower 90% MTBF Limit $\lambda_{l1} = 1,120.$
Predicted MTBF* $\lambda_p = 513.$

120/208VAC
3 ϕ 60CPS

120/208VAC
400 CPS

DC Voltages

TO DISPLAY CABINETS



Figure 12. Power Supply Set MTBF Data

RADAR SIGNAL PROCESSOR GROUP
AN/FSA-31
(Part of Data Acquisition Subsystem)

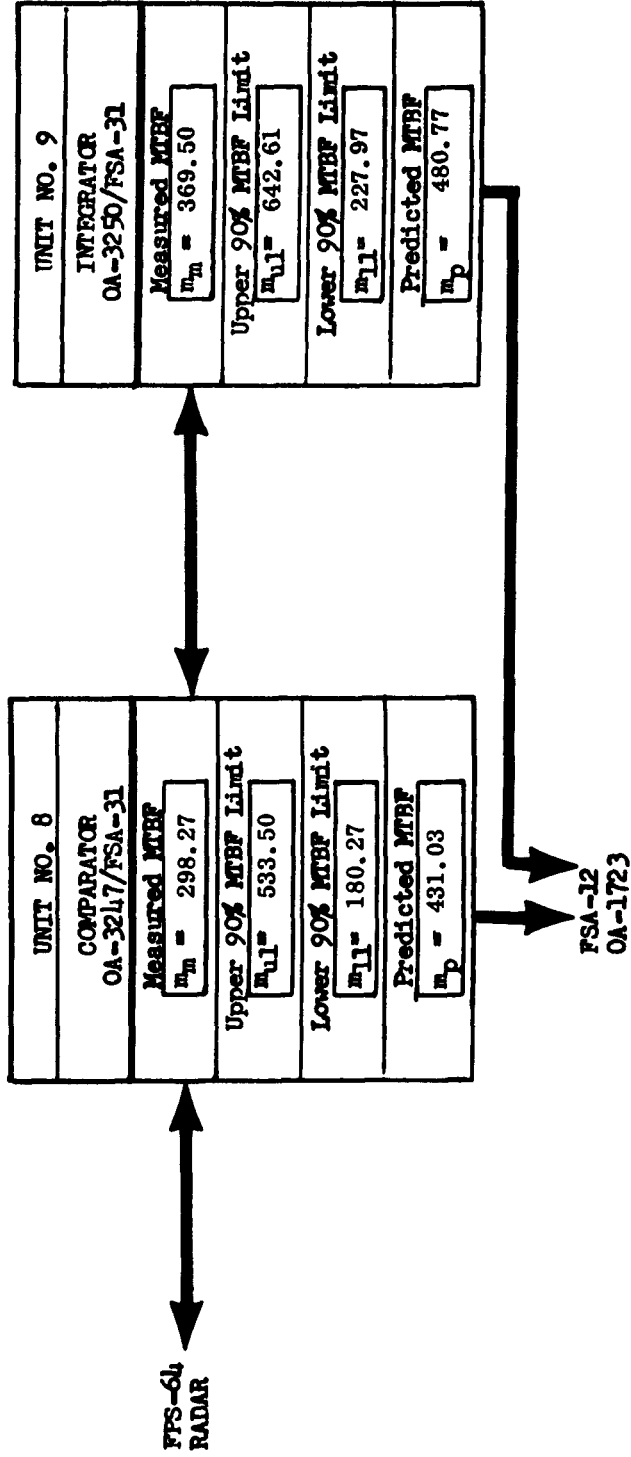
VERONA TEST SITE

RADAR SIGNAL PROCESSOR AN/FSA-31
Measured MTBF $\bar{M}_m = 165.02$
Predicted MTBF $\bar{M}_p = 227.27$

Figure 13. Radar Signal Processor Group, AN/FSA-31 (Data Acquisition Portion) MTBF Data

RADAR SIGNAL PROCESSOR GROUP
AN/FSA-31

VERONA TEST SITE



N.A. = Not Available

Figure 14. Radar Signal Processor Group, AN/FSA-31, MTBF Data

DATA PROCESSING AND DISPLAY SUBSYSTEM
AR/OPA-73

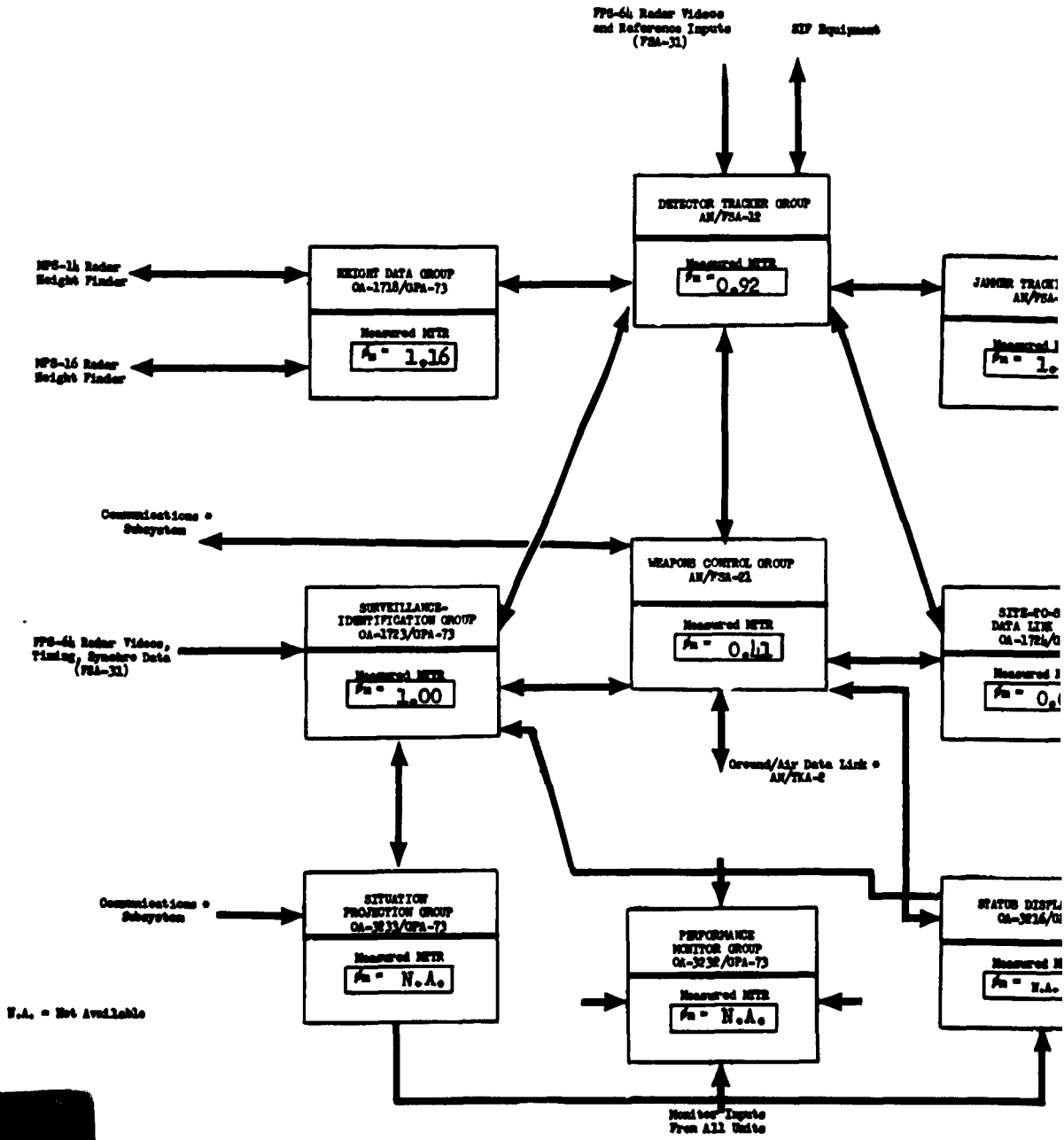


Figure 15. Data Processing and Display

DATA PROCESSING AND DISPLAY SUBSYSTEM
AN/GPA-73

VERONA TEST SITE

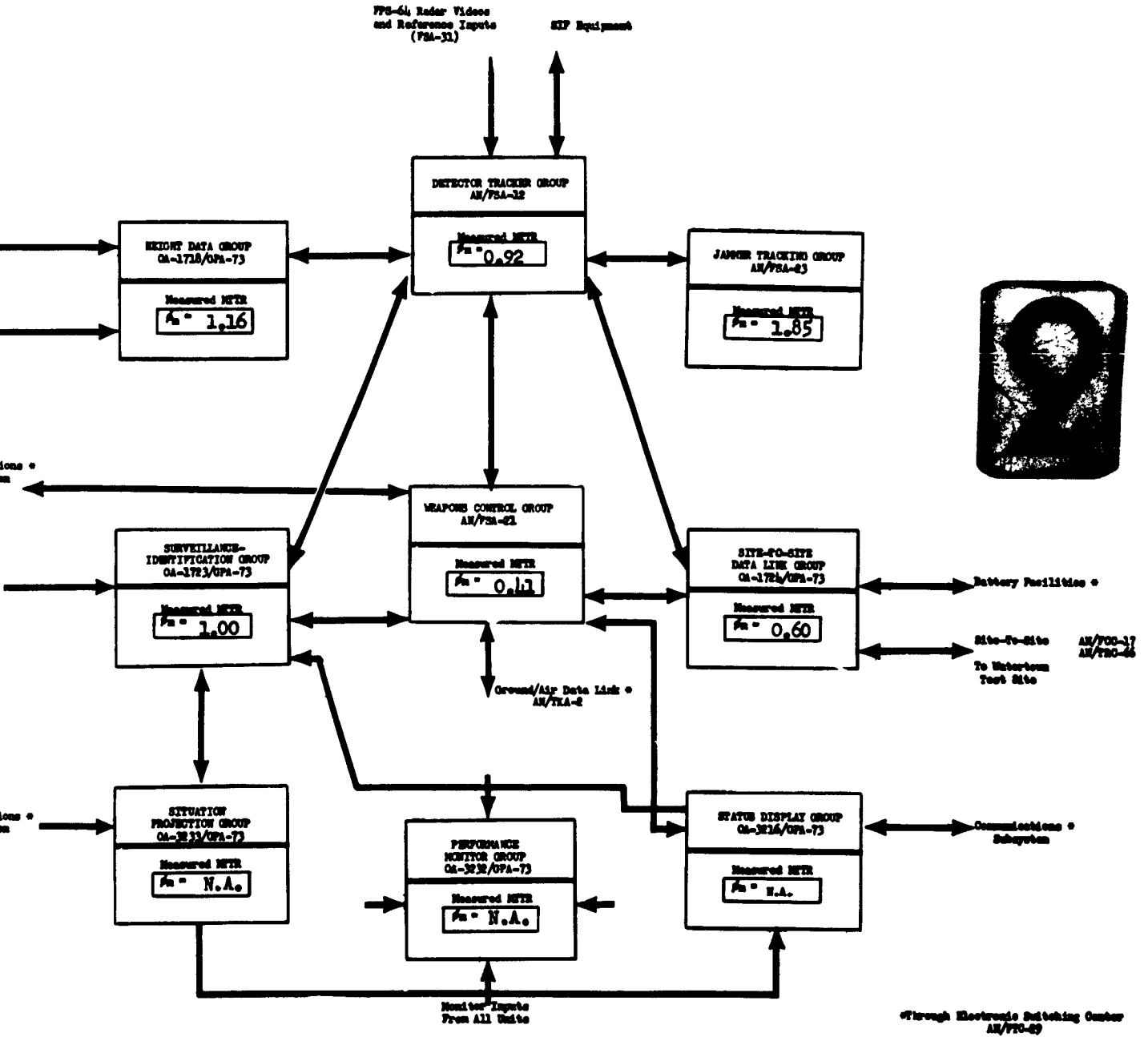
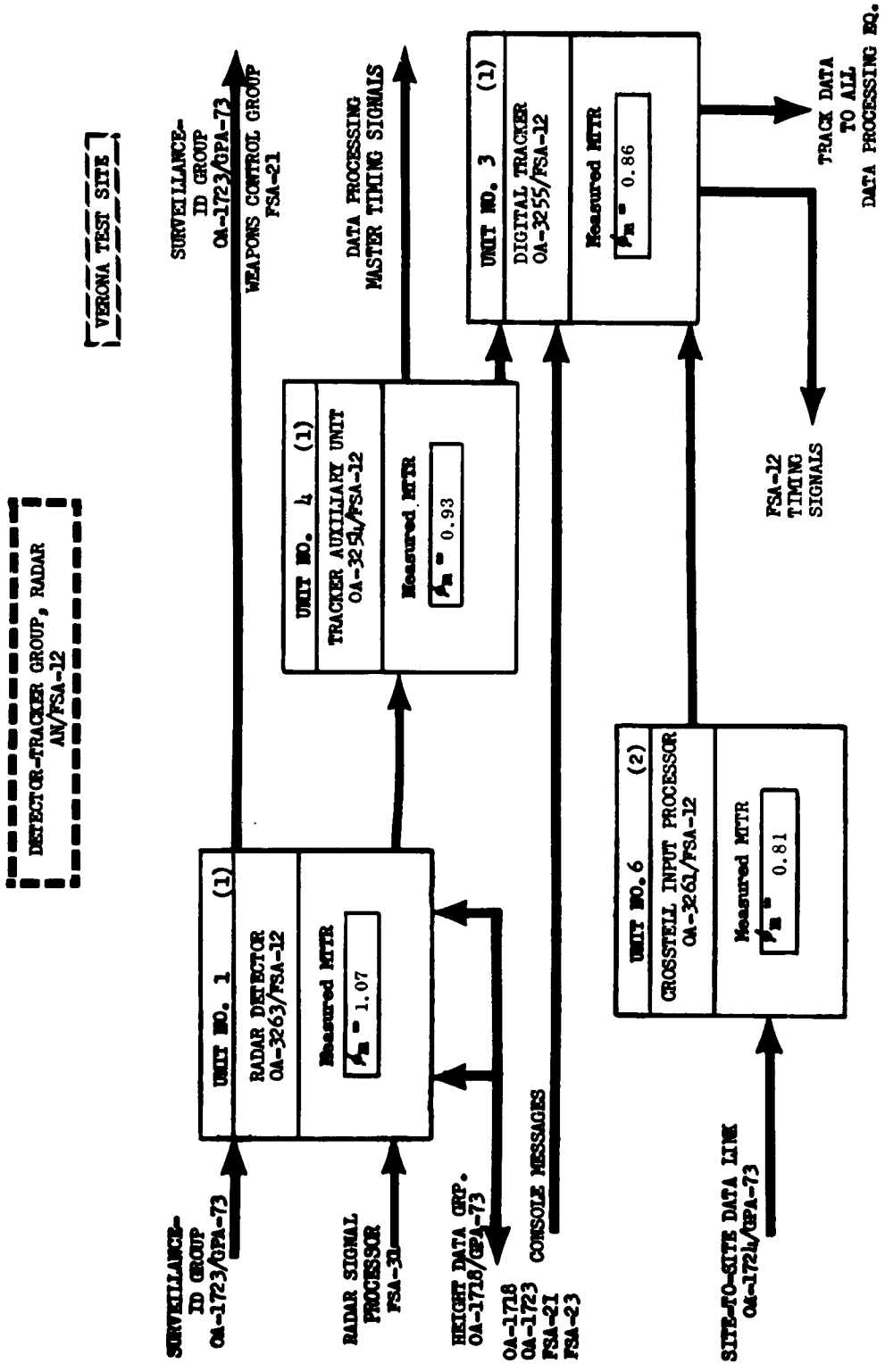


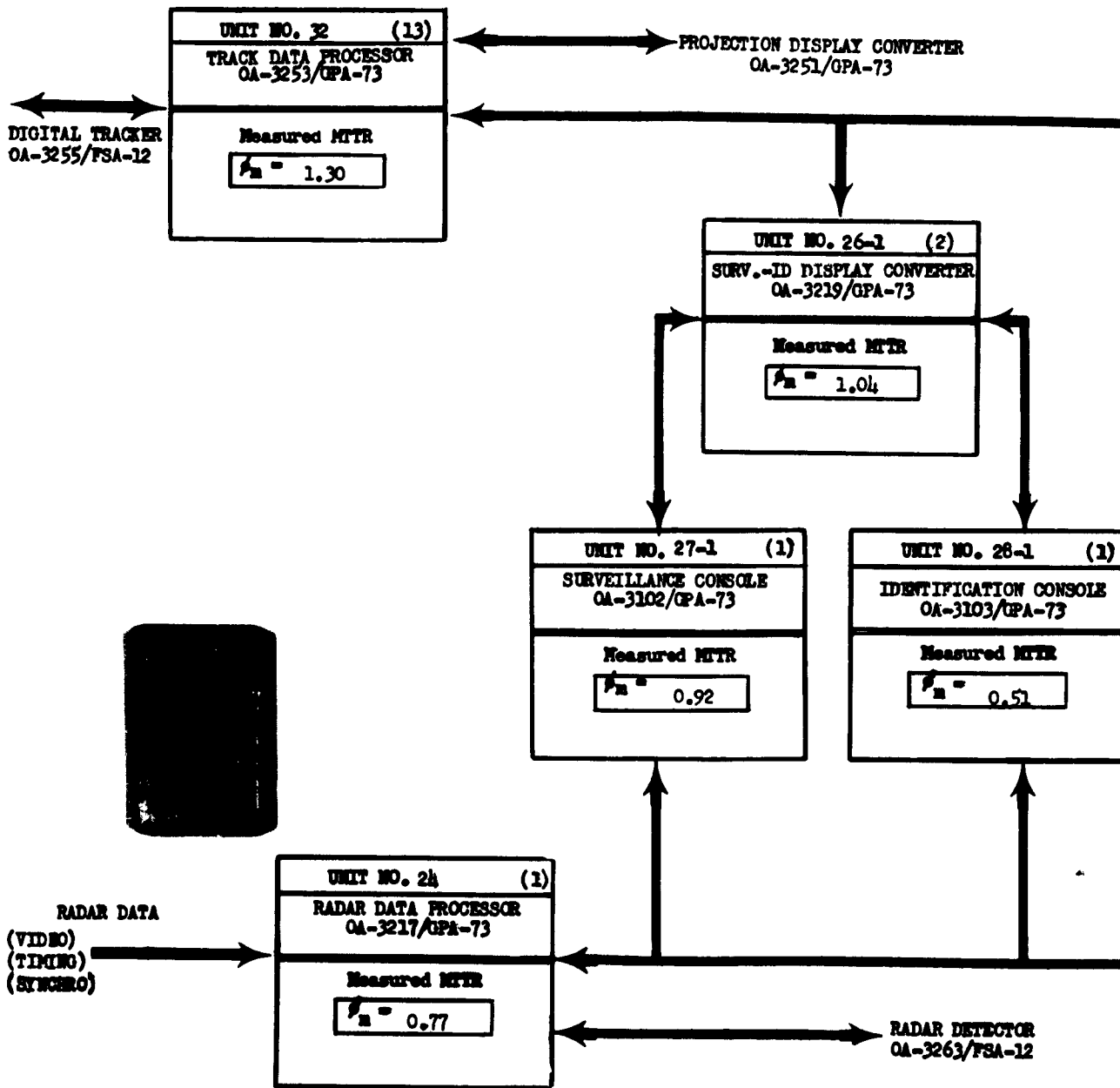
Figure 15. Data Processing and Display Subsystem MTTR Data



N.A. - Not Available

Figure 16. Detector-Tracker Group, Radar AN/FSA-12 MTTR Data

SURVEILLANCE - IDENTIFICATION GROUP
OA-1723/GPA-73



N.A. - Not Available

Figure 17. Survei

SURVEILLANCE - IDENTIFICATION GROUP
OA-1723/GPA-73

VERONA TEST SITE

PROJECTION DISPLAY CONVERTER
OA-3251/GPA-73

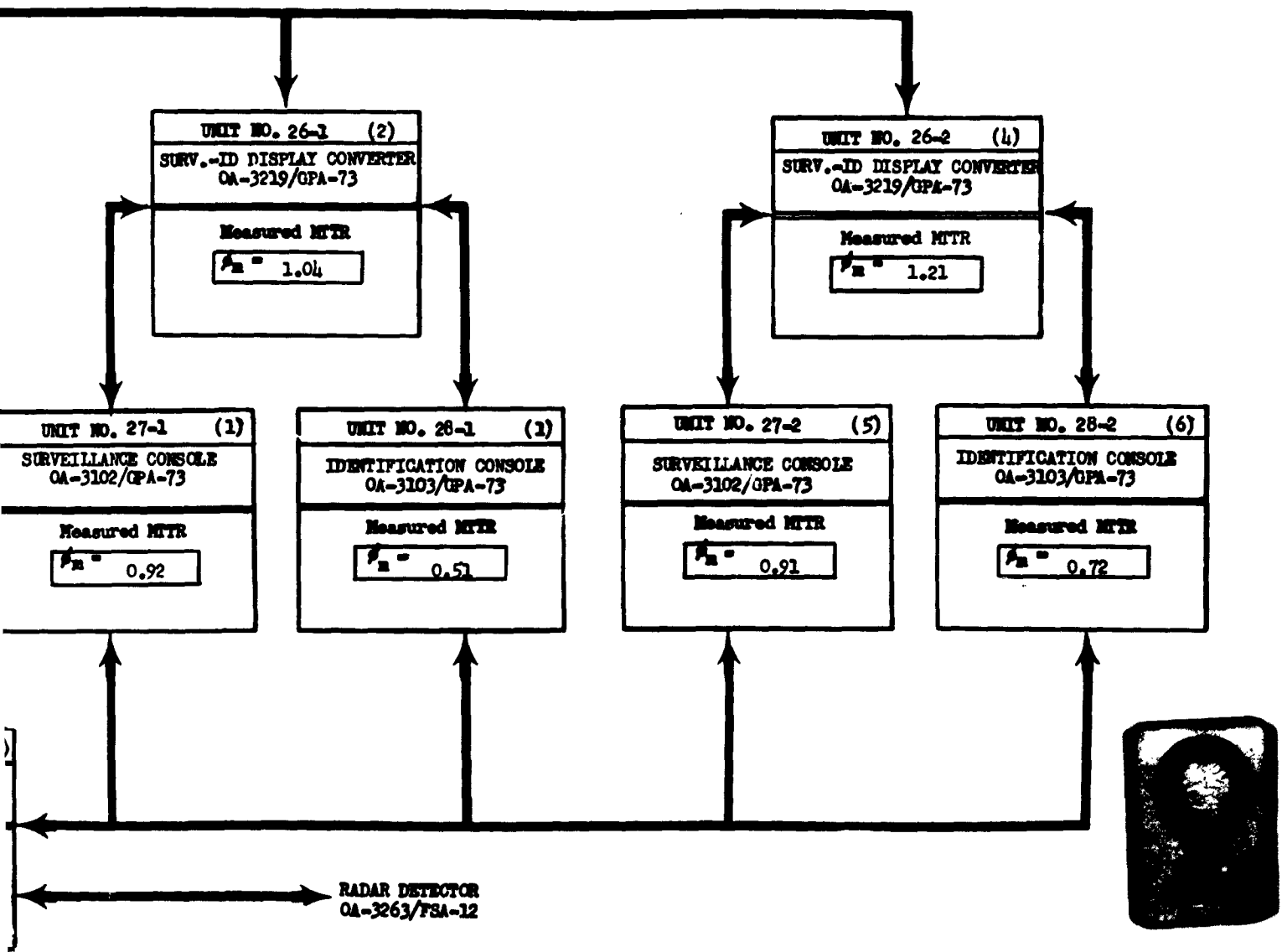
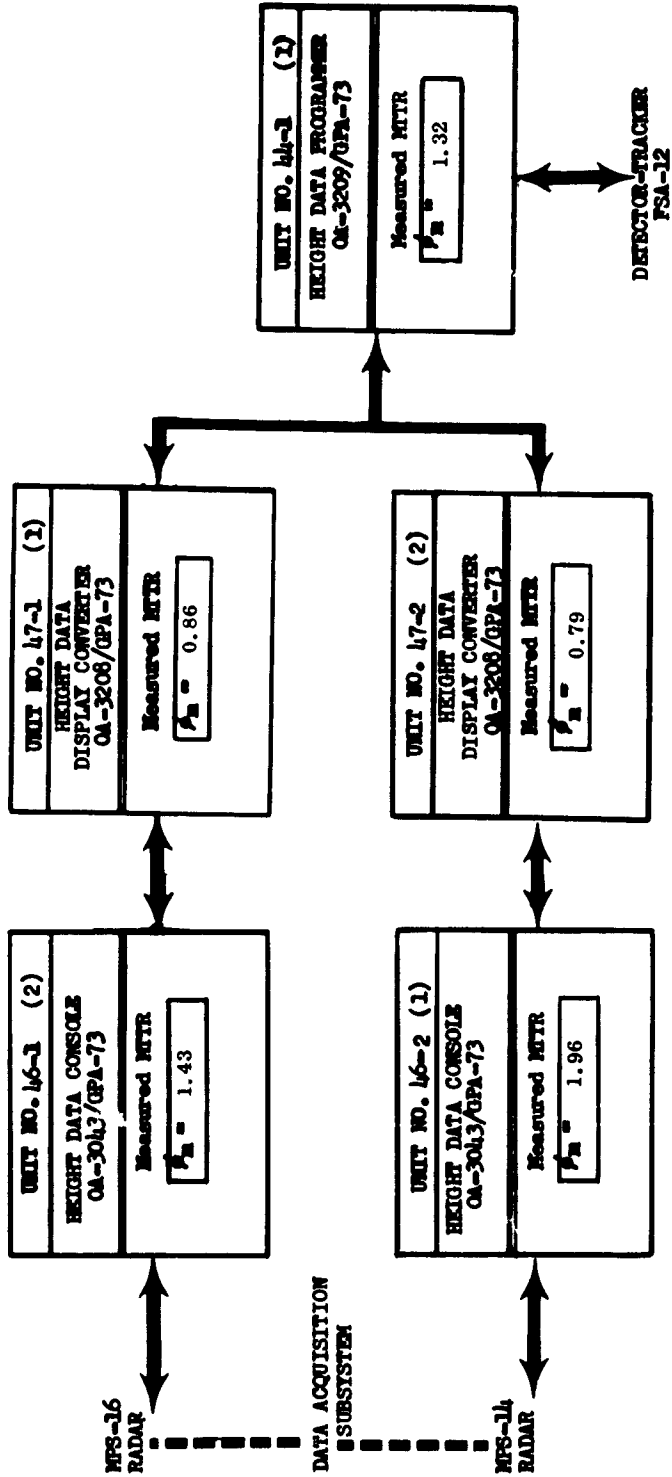


Figure 17. Surveillance Identification Group, OA-1723/GPA-73 MTTR Data

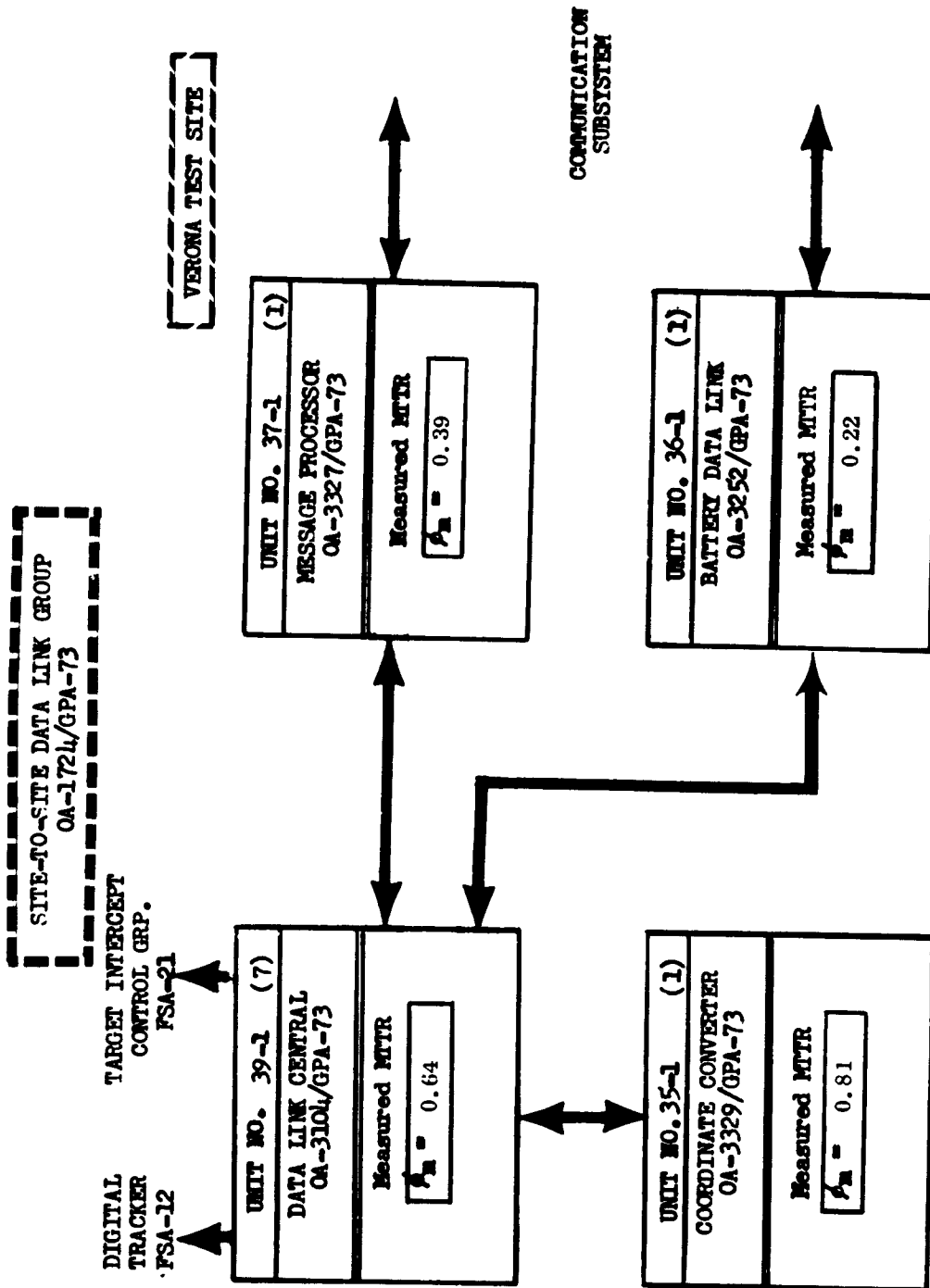
HEIGHT DATA GROUP
OA-1718/GPA-73

VERONA TEST SITE



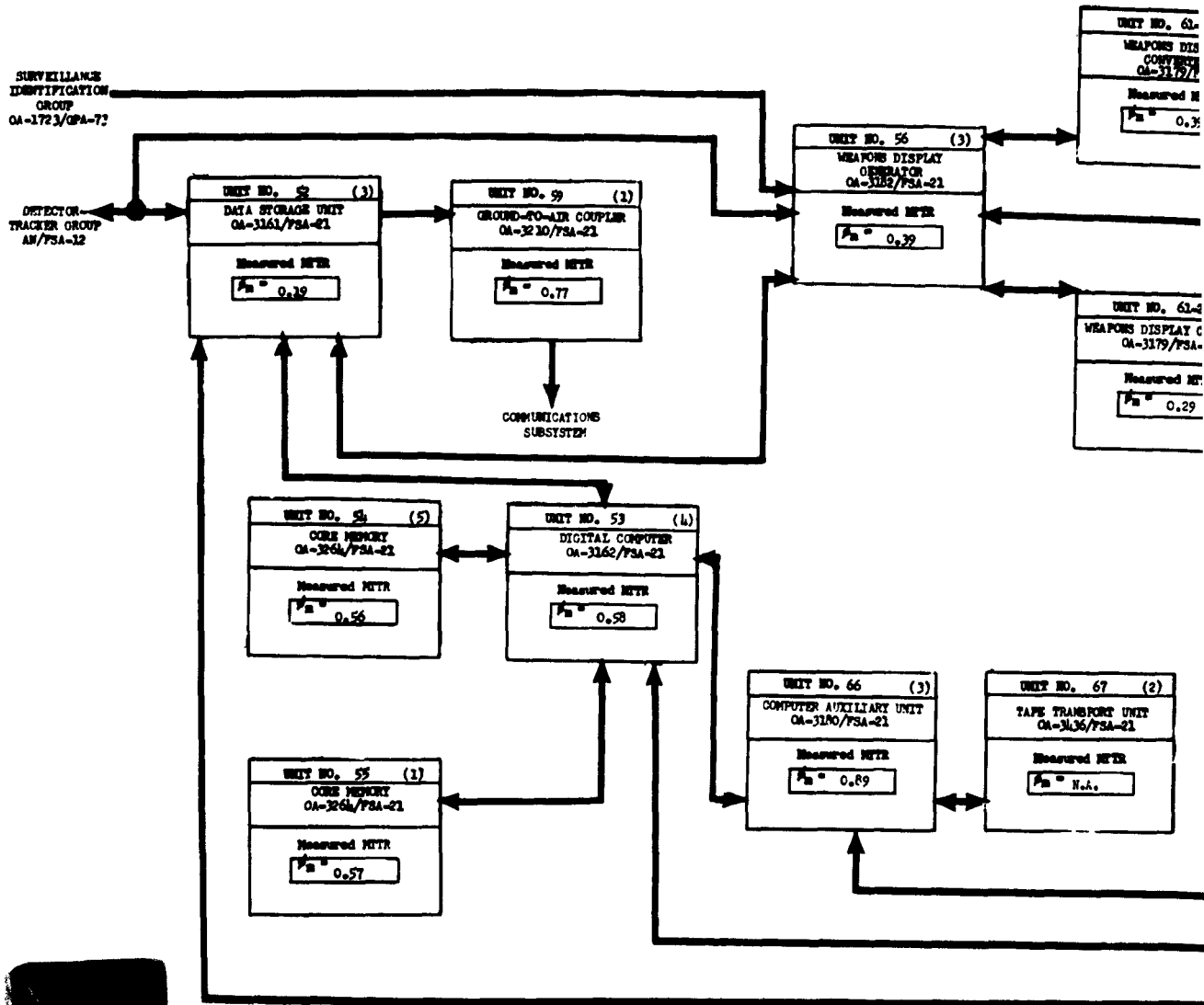
N.A. = Not Available

Figure 18. Height Data Group, OA-1718/GPA-73 MTTR Data



N. A. = Not Available
 Figure 19. Site-to-Site Data Link Group, OA-1724/GPA-73 MTTR Data

WEAPONS CONTROL GROUP
AN/P3A-21



N.A. = Not Available

Figure 20. We

WEAPONS CONTROL GROUP
AN/FSA-21

VERONA TEST SITE

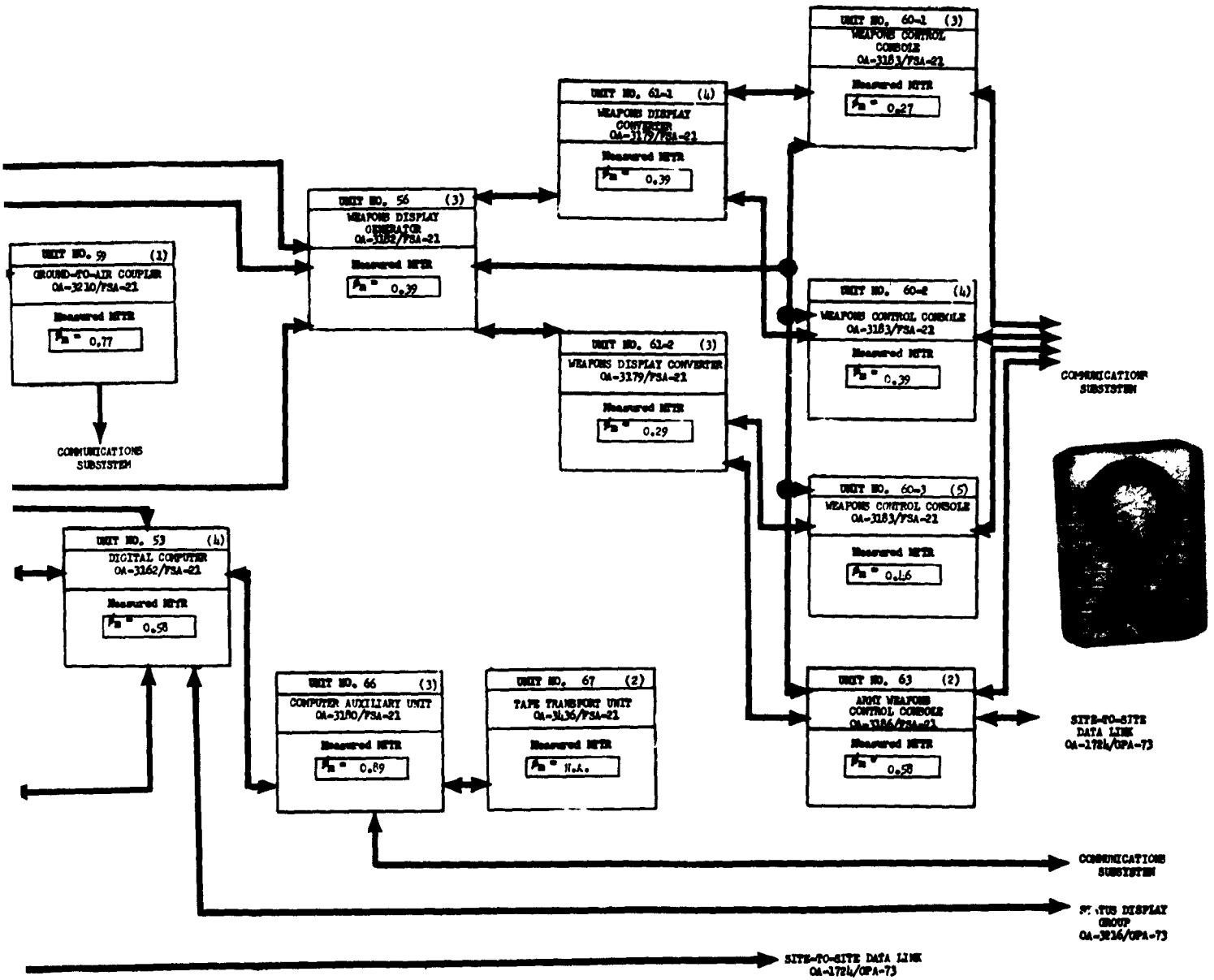
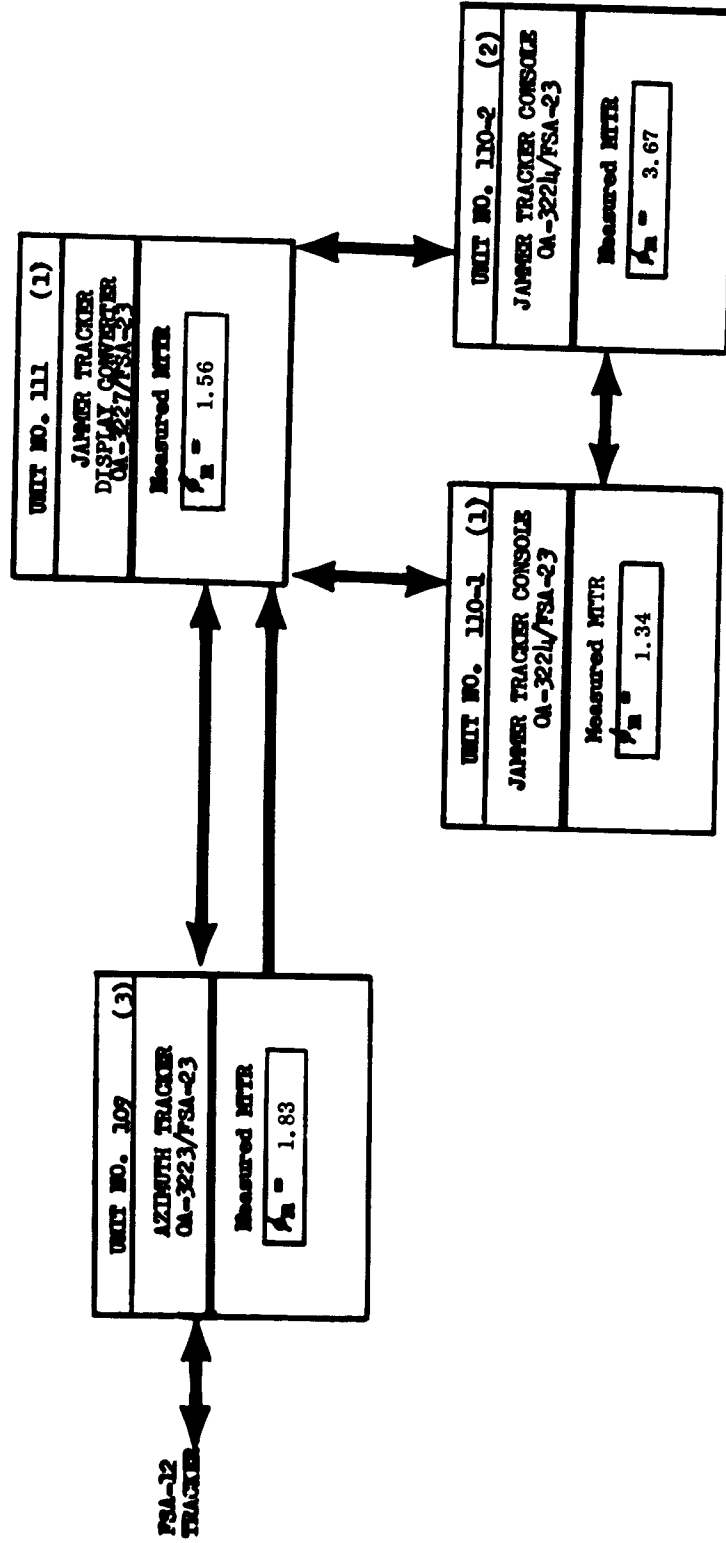


Figure 20. Weapons Control Group, AN/FSA-21 MTTR Data

JAMMER TRACKING GROUP
AN/FSA-23

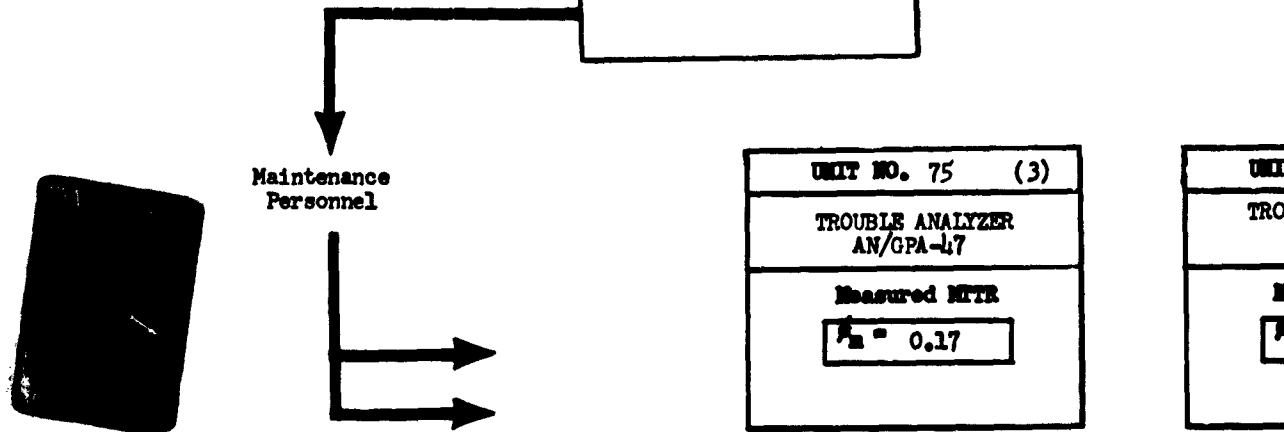
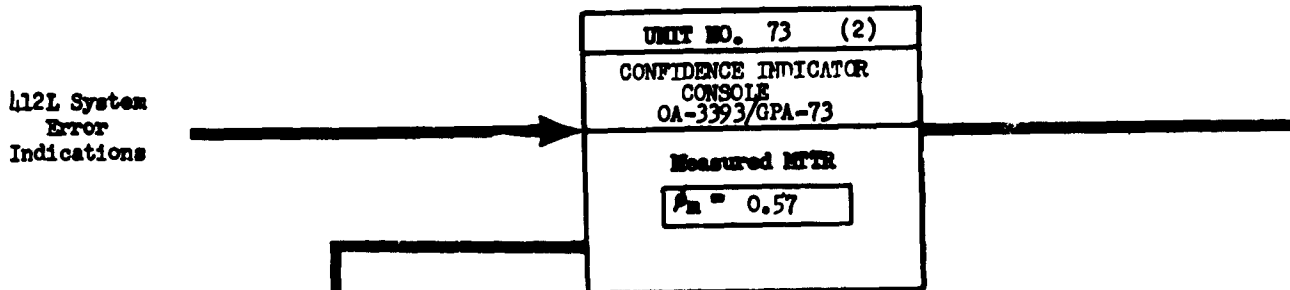
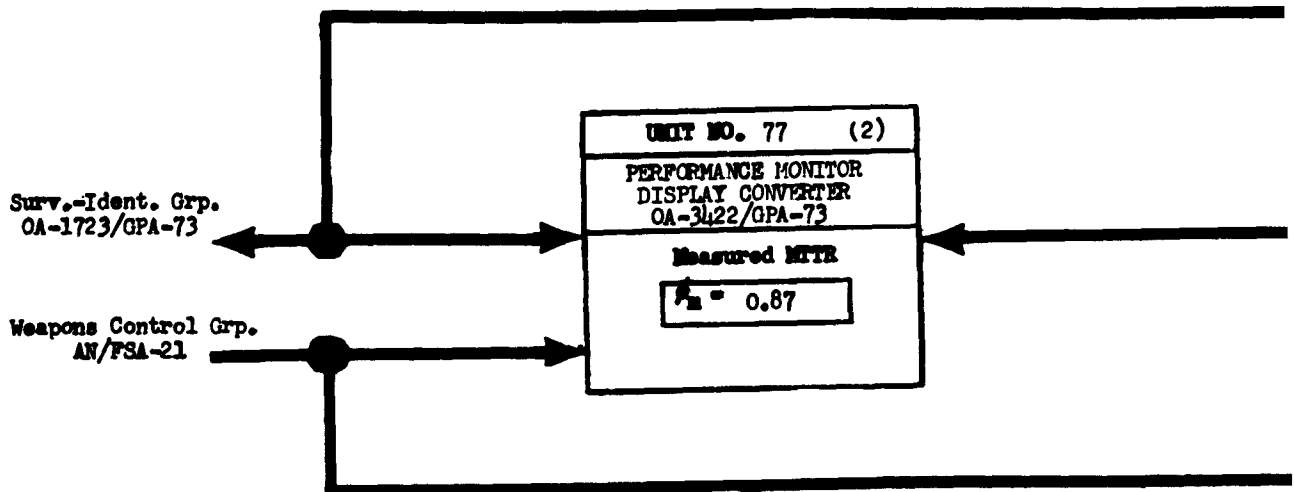
VERONA TEST SITE



M.A. - Not Available

Figure 21. Jammer Tracking Group, AN/FSA-23 MTTR Data

PERFORMANCE MONITOR GROUP
 OA-3232/GPA-73



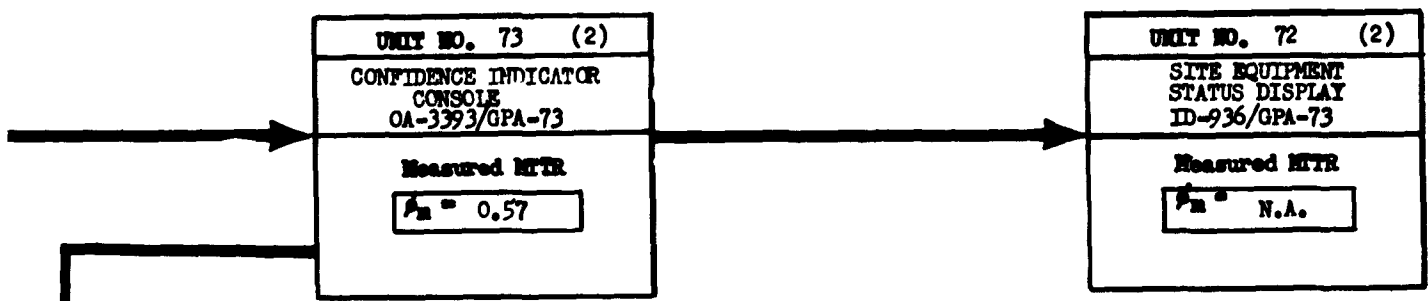
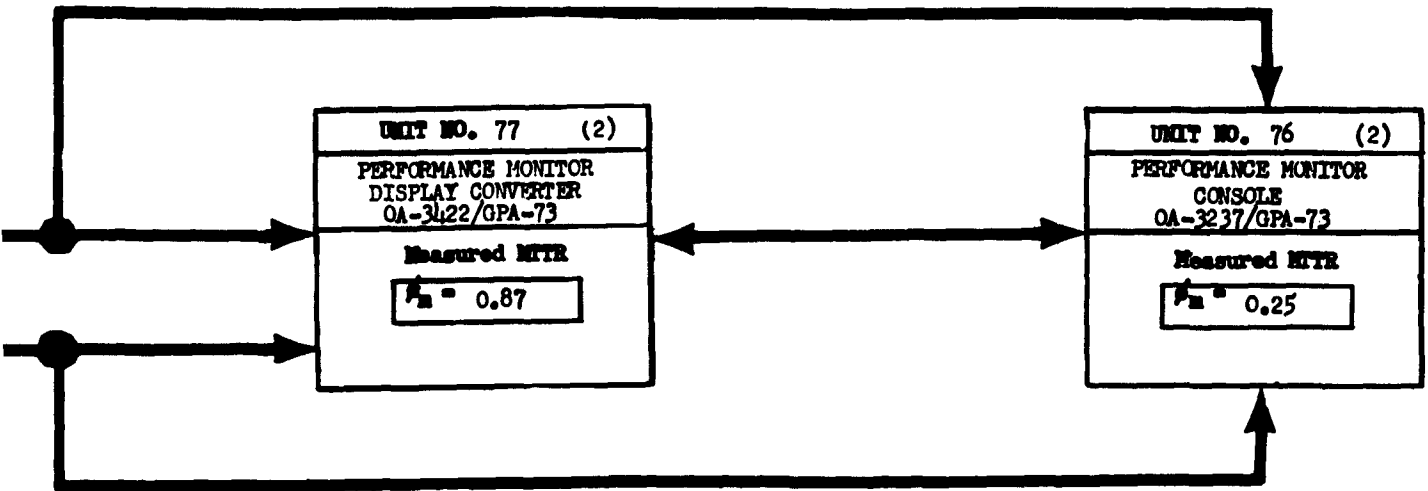
(Portable)

N.A. = Not Available

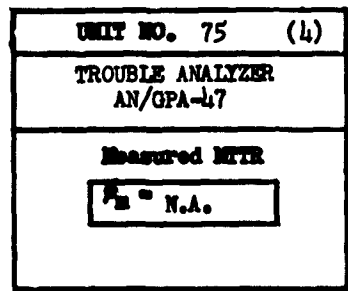
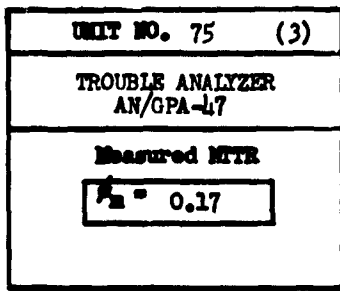
Figure 22. Performance Monitor Group

PERFORMANCE MONITOR GROUP
OA-3232/GPA-73

VERONA TEST SITE



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ersonnel



(Portable)

(Portable)

lable

Figure 22. Performance Monitor Group, OA-3232/GPA-73 MTTR Data

RADAR SIGNAL PROCESSOR GROUP
AN/FSA-31
(Part of Data Acquisition Subsystem)

VERONA TEST SITE

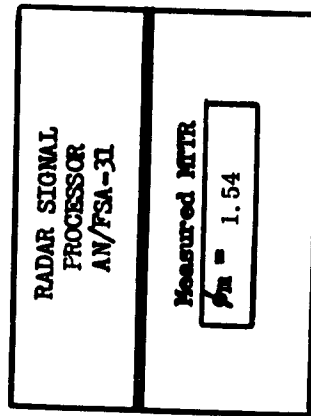
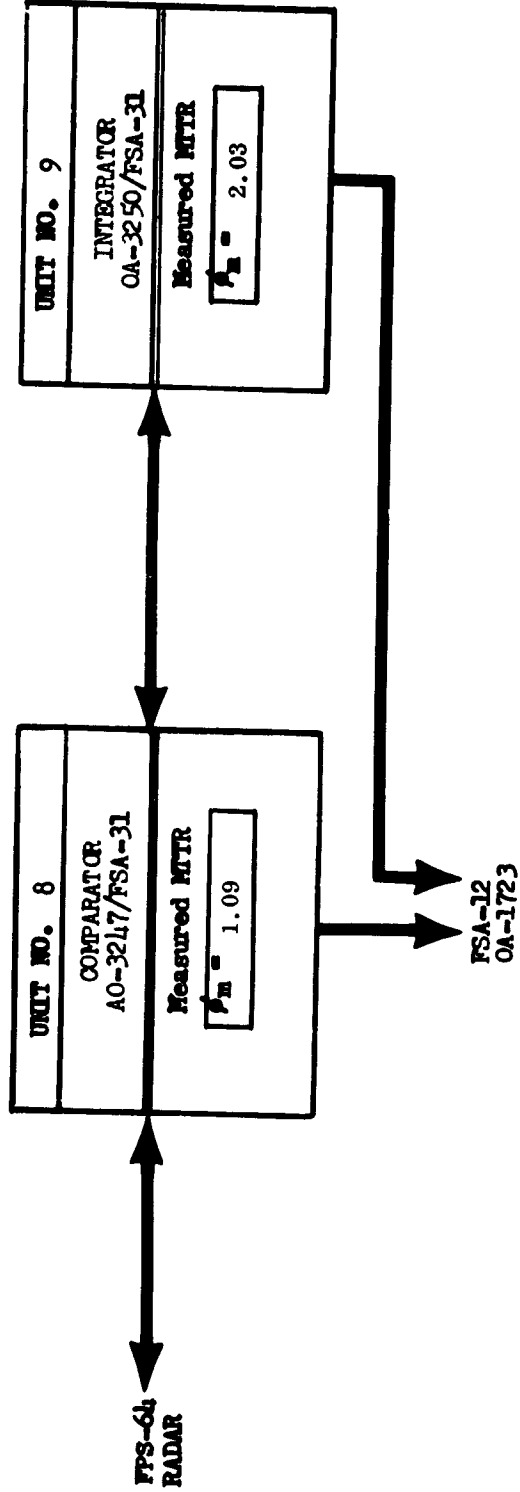


Figure 23. Radar Signal Processor Group, AN/FSA-31 (Data Acquisition Portion) MTTR Data

RADAR SIGNAL PROCESSOR GROUP
 AN/FSA-31

VERONA TEST SITE



N.A. - Not Available

Figure 24. Radar Signal Processor Group, AN/FSA-31 MTTR Data

b. Category II Test Reliability Data

No Category II reliability data is available for this report, although, the Category II reliability test program is discussed in Part I, paragraph E. 1 of this report.

c. Category III Test Reliability Data

No Category III reliability data is available for this report.

4. Failure Investigations (See table 23)

a. FF-1 Printed Wire Boards

Analysis of the two FF-1 boards returned from Site F in the European environment has been completed. As mentioned in AWCS-SQR-7, Part II, paragraph 4. e, no failure has been observed but a deposit had formed on the component leads. The deposit was determined to be lead carbonate and is not a conductor nor is it corrosive in nature. The material can be cleaned off and it is not expected that the deposit on the component leads will cause any failures.

b. Synchro No. 7727736P5

Four units which were returned from the European environment were opened for inspection to determine the cause of failures. The investigation showed that the rotor windings had failed and were open. The general appearance would indicate that the windings had carried excessive current prior to opening. The general condition seemed to indicate that the units had overheated. The investigation did not show the cause of failure. Investigation by Display Engineering showed that a new unit supplied by the same vendor overheated at equipment operating voltage limits. The problem is still being investigated but, it appears that the vendor's unit meets the purchase part drawings but will not operate satisfactorily in this application. Results of the investigation will be included in future reports.

c. Printed Wire Board Failures

A relatively high number of wire board failures in the European environment, which were rejected at sites and returned to the depot for repair, were tested and no defects

Table 23. Failure Investigation Corrective Action Table

Item	Description Of Problem	Corrective Action	Investigation Status
1	Deposit on FF-1 printed wire board reference Part II, paragraph C. 4a of this report.	No changes in equipment cleaning method sent to European Environment.	Completed
2	7727736P5 Synchro Failures - Reference Part II, paragraph C. 4b of this report.	Review application and drawing specifications consider vendor approval.	Incomplete
3	Printed wire board testing in European Environment Ref. Part II, paragraph C. 4c of this report.	Systems support trip to European Environment to verify operation of GPM-50 and tape usage.	Completed
4	Cabinet temperature - high temperature thermal cutout reference Part II, paragraph C. 4d.	Installation of ECR-22D change thermostatic part number and add air deflectors ECR972.	Completed
5	ZA-1 and OPA-1 printed wire board failures reference Part II, paragraph C. 4c of this report.	None	Incomplete - Circuit Design Engineering is investigating.
6	7496045 Motor Failure due to grease breakdown in gear reduction unit reference Part II, paragraph C. 4d of this report.	Recommendations for different lubricant to prolong life of motor design engineering considering pump system redesign.	Failure Investigation Complete.
7	1N231 diode rejections at unit test reference chart C3 of this report.	Pending	Incomplete
8	1N458 diode rejections at unit test reference chart C3 of this report.	Pending	Incomplete

were found when checked at the depot. An investigation was started to correlate this data with that from Category I testing and repair data from the Syracuse depot. The data from Europe indicated that more than one-third of the boards returned to the depot had no defects reported. Less than one-fifth of the boards tested at the Syracuse depot showed defects. Information on boards which were tested on the GPM-50 in Syracuse showed that the AN/GPM-50 is very reliable in its ability to detect faulty components on printed wire boards. A check of which tapes were available in the European environment and of AN/GPM-50 usage in that area, showed that the GPM-50 was not being used for testing boards in most cases prior to November 1962. The data for the investigation was gathered prior to that time. Prior to November, testing was done on a machine which did not have the capabilities of the AN/GPM-50. This lack of capability resulted in failure to test all the input diodes on printed wire boards. A visit to the European depot by AN/GPM-50 design engineering and systems engineering during the quarter to instruct depot personnel in the use of the AN/GPM-50 should correct the problem.

d. Cabinet Cooling Problems

Reports from the European environment indicated that excessive temperature in some cabinets was causing printed wire board failures. A check of the modifications performed in the European environment by configuration control showed that no sites had taken action on ECT No. 220. This ECR indicates that the fine wire screen on the air flow baffle in the base of the cabinets should be removed. Failure to remove the screen restricts chiller base air flow. This was brought to the attention of the Quality Control and Reliability group in Europe. The completion of this ECR should solve the overheating problem provided the cooling system is functioning properly.

e. ZA-1 and OPA-1 Printed Wire Boards

Reports from Europe and from Category I test sites showed that failures in excess of the expected number were being experienced. A study is being made to determine the cause. To date, no conclusive results have been found.

f. Motor 7496045

Failure of this motor in the Situation Display Projection Set led to an investigation of the lubricant used in the reduction gears. The grease had hardened and caused the motor to stall. Laboratory investigation of the grease had indicated that a more suitable lubricant could be used. The motor supplier has recommended that the gears be repacked with type Shell SG6120 per MIL-G-7118. The change in the lubricant should prolong the life of the motor thus increasing the reliability of the Display Projector.

5. Failure Data and Reliability Measurement

A special printed wiring-board life test was constructed and put into operation during the past year; the previous quarterly report mentioned the life test in Part II, paragraph C.6. Table 24 lists the board types and the quantity being using in the tests. Table 25 lists the components, their drawing numbers, and the quantity being energized in the life test. Table 26 is a listing of the failure rates as based on data from Board Life Test.

The components were grouped into the "Component Groupings" as listed in Table 26. The "Component Hours" column is the product of the number of components in that grouping and the hours of operation. There have been no failures so the "Number of Failures" column and "Actual Failure Rate" column have all zero entries. The "Predicted Failure Rate" column contains the failure rates used for the prediction of reliability of the AN/GPA-73 equipment.

Since there have been no failures the actual failure rates are zero. To make the data more meaningful, the failure rates were calculated by assuming a failure at 4180 hours. These calculations of the failure rates are shown in the column labeled "Failure Rate Assuming One Failure."

The column "Upper 90% Confidence Limit" gives the statistical calculation of the failure rates with a probability of 95 percent that the actual failure rate is less than the value indicated. Although the values do not approach the predicted failure rates at this time, it is expected that the two values will approach each other as more operating hours are logged on the test.

Table 24. Board Types Used in Board Life Test

Board Type	Quantity Used
BP-2	1
BP-3	2
CA-1	4
CA-2	1
CG-1	1
CL-1	2
DR-3	1
DR-4	1
FF-2	2
HL-3	1
HL-5	3
LT-4	1
ND-1	1
RD-1	1
SC-1	3
WC-1	4
WC-2	1
WM-1	1
WP-1	1

Table 25. Component Types Used in Board Life Test

Component Type	Component Drawing No.	Number Used
Diode	1N198B	371
Diode	1N2032-2	5
Diode	1N277	177
Diode	1N457	26
Diode	1N538	9
Diode	1N691	10
Diode	1N645	1
Diode	1N746A	1
Diode	1N751A	21
Diode	1N752A	4
Transistor	2N1301	6
Transistor	2N1039	6
Transistor	2N1403	1
Transistor	2N1450	46
Transistor	2N1646	67
Transistor	2N388	1
Transistor	2N396A	2
Transistor	2N599	24
Transistor	2N604	53
Transistor	2N697	25
Resistor	RC20GF	612
Resistor	RC32GF	40
Resistor	RC42GF	25
Resistor	RN65B	39
Resistor	3R153P	8
Resistor	7717791	8
Capacitor	CL25	24
Capacitor	CC36C	8
Capacitor	CM20C	10
Capacitor	7713040	115
Capacitor	7203760	2
Capacitor	7741850	153
Capacitor	7742510	4

Table 25. Component Types Used in Board Life Test (Cont.)

Component Type	Component Drawing No.	Number Used
Relay	7747913	1
Crystal	7747388	1
Delay Line	7747946P1	7
Coil	7722350P14	5
Coil	7724181P19	2
Coil	7747952	16
Coil	7748576	8
Transformer	7742843	17
Transformer	7745709	6
Transformer	7748567	18
Switch	7745171	3

Table 26. Failure Rates as Based on Data from Board Life Test (11, 302 Hours)

Component Grouping	Number of Components	Component Hours	Number of Failures	Actual Failure Rate	Predicted Failure Rate %/1000 HRS	Failure Rate Assuming One Failure %/1000 HRS	Upper 90% Confidence Limit * %/1000 HRS
<u>Diodes</u>							
Germanium (Signal)	371	4,193,042	0	0	0.02	0.02	0.07
Silicon (Signal)	223	2,520,346	0	0	0.02	0.04	0.12
Silicon (Zener)	31	350,362	0	0	0.02	0.29	0.86
<u>Transistors</u>							
Germanium (Power)	6	67,812	0	0	0.20	1.47	4.41
Germanium (Signal)	68	768,536	0	0	0.05	0.15	0.39
Mesa	99	1,118,898	0	0	0.10	0.09	0.27
Drift	27	305,154	0	0	0.07	0.33	0.98
Others	25	282,550	0	0	0.05	0.35	1.06
Silicon							
<u>Resistors</u>							
Fixed (Composition)	677	7,651,454	0	0	0.03	0.01	0.04
Fixed (Wirewound Precision)	8	90,416	0	0	0.10	1.11	3.33
Fixed (Carbon Film)	39	440,778	0	0	0.04	0.23	0.68
Variable (Wirewound)	8	90,416	0	0	0.15	1.11	3.33
<u>Capacitors</u>							
Ceramic	8	90,416	0	0	0.04	1.11	3.33
Mica	125	1,412,750	0	0	0.04	0.07	0.21
Mylar	159	1,797,018	0	0	0.06	0.06	0.17
Tantalum	24	271,248	0	0	0.20	0.37	1.11
Transformers (Pulse)	41	463,382	0	0	0.05	0.22	0.65
Delay Line (Lumped Constant)	7	79,114	0	0	0.30	1.27	3.80
Coils (R. F.)	31	350,362	0	0	0.09	0.29	0.86
Switches	3	33,906	0	0	0.20	2.94	8.82
Crystals (Quartz)	1	11,302	0	0	0.02	9.09	27.27
Relays (Miniature)	1	11,302	0	0	0.30	9.09	27.27

*Probability is 0.95 that the true failure rate is less than the value shown in this column.

The boards are mounted in a manner similar to that which would be used in the AN/GPA-73 equipment. One chassis of boards has the same logic diagrams as a clock-chassis used in the AN/GPA-73. The additional boards are used as a self-checking circuit which gives a visual indication of failure on any board. The environmental conditions of operation are that of a normal air-conditioned laboratory which has an ambient temperature of 25°C. There are no efforts to house the boards or have forced air-circulation. The only air-circulation is from convection currents.

D. PRODUCTION RELIABILITY

1. Reliability Indoctrination of Factory Personnel

Indoctrination of factory personnel was handled by manufacturing supervision.

2. Failure Rate Studies Associated With The Manufacturing Process

As reported in the last quarter, the contact finger resistance study was up-dated to cover the effects of aging. After three months aging, no significant difference between gold thickness on the sample boards that had twenty-five connector insertions has been detected.

A laboratory study was instituted to determine the cause of the white residue found on the tin-lead coated components after the ten-day cabinet humidity test. The residue was analyzed as lead carborate. The exact cause for this residue is still under study.

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