

GAO

Report to the Chairman, Legislation and
National Security Subcommittee,
Committee on Government Operations,
House of Representatives

April 1992

ELECTRONIC WARFARE

Faulty Test Equipment Impairs Readiness of Army Helicopters



146657

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Washington, D.C. 20548

**National Security and
International Affairs Division**

B-247503

April 17, 1992

The Honorable John Conyers, Jr.
Chairman, Legislation and National
Security Subcommittee
Committee on Government Operations
House of Representatives

Dear Mr. Chairman:

This report, prepared at the request of your Subcommittee, discusses problems that the Army has encountered in maintaining electronic warfare systems. It recommends that the Secretary of Defense take steps to ensure that the Army deploys proven test equipment with electronic warfare systems so that they can be effectively maintained.

As arranged with your office, unless you publicly announce this report's contents earlier, we plan no further distribution of it until 30 days from this date. At that time, we will send copies to other interested congressional committees; the Secretaries of Defense and the Army; and the Director, Office of Management and Budget. Copies will be made available to other interested parties upon request.

Please contact me at (202) 275-4841 if you or your staff have any questions concerning the report. Other major contributors are listed in appendix III.

Sincerely yours,

Louis J. Rodrigues
Director, Command, Control, Communications,
and Intelligence Issues

Executive Summary

Purpose

To protect its helicopters against enemy weapons, the Army equips them with electronic warfare systems, including radar warning receivers, missile warning systems, and jammers. Radar warning receivers alert a pilot that the helicopter is being tracked by radar, while missile warning systems alert a pilot that a missile has been launched at the helicopter. Jammers disrupt the guidance systems of threat weapons. The Army considers these systems to be important to the survivability of its helicopters during combat. Thus, the Army must be able to effectively maintain the systems and assure that they are operating properly.

The Chairman, Legislation and National Security Subcommittee, House Committee on Government Operations, asked GAO to evaluate the adequacy of test equipment used by the services in maintaining electronic warfare systems. This report, the third in a series, addresses problems with Army systems. GAO reported on Air Force and Navy test equipment inadequacies in August 1989 and July 1991, respectively.¹ In addition, GAO reported in July 1991 that the Department of Defense had not corrected the problems cited in an August 1989 report on Air Force test equipment.²

Background

To assure that its helicopters are ready to perform combat missions, the Army must be able to verify that electronic warfare systems are functioning properly. When malfunctions occur, the Army must also be able to quickly diagnose the problem and make repairs because spare systems may not be available and the Army may require its helicopters to fly one or more combat missions daily. Because of the technical complexity of electronic warfare systems, the Army uses test equipment that is built into the system and other more sophisticated test equipment to detect system malfunctions and defective components and verify proper system operation.

Results in Brief

Inadequate test equipment is impairing the Army's capability to conduct and sustain air combat with operable electronic warfare systems, and it could jeopardize pilots and aircraft because it often indicates inaccurately the combat readiness of the systems and does not enable the timely diagnosis and repair of system malfunctions. These consequences resulted from the Army's failure to demonstrate the adequacy of test equipment in

¹Reliable Equipment Needed to Test Air Force's Electronic Warfare Systems (GAO/NSIAD-89-137, Aug. 11, 1989) and Faulty Test Equipment Impairs Navy Readiness (GAO/NSIAD-91-205, July 8, 1991).

²No Air Force Follow-Up on Test Equipment Inadequacies (GAO/NSIAD-91-207, July 17, 1991).

realistic operational testing before producing and deploying the electronic warfare systems, as required by Department of Defense and Army policies. The consequences could recur on new systems being acquired unless the Army changes its acquisition process.

Principal Findings

Test Equipment Inaccurately Indicates Combat Readiness

Test equipment built into the Army's electronic warfare systems and intended to verify system readiness before or during combat missions often erroneously indicated whether systems were functioning properly. For example, GAO found that the rate at which built-in test equipment erroneously showed operable APR-39 radar warning receivers to be faulty was 32 percent. Army program officials attributed this deficiency to faulty system wiring, not to the test equipment. Nevertheless, the test equipment falsely indicated system problems that resulted in unnecessary maintenance trying to fix nonexistent problems.

Also, 43 percent of ALQ-144 jammers shown by built-in test equipment to be operable actually had undetected defects. This inadequacy could cause pilots to fly missions with undetected faults in electronic warfare systems.

Test Equipment Inadequacies Prevent Timely Repairs

Other more sophisticated test equipment used to identify defective system components and malfunctions often misdiagnosed or failed to detect problems, forcing maintenance personnel to resort to time-consuming trial and error techniques to repair systems. These inadequacies contributed to repair times far longer than allowed to sustain combat operations. For example, electronic warfare systems on key Army helicopters that participated in Operation Desert Storm required several days to repair. In a prolonged conflict, these helicopters would have been unable to sustain combat operations with operable electronic warfare systems.

Army program officials attributed lengthy repair times to the lack of training and experience of maintenance personnel and not to inadequate test equipment. GAO believes that test equipment must have characteristics that permit it to be used effectively by typical military personnel.

Army Has Not Complied With Acquisition Policies

Department of Defense and Army policies require that the effectiveness of test equipment be verified in realistic operational testing before full-rate production and deployment of electronic systems. However, the Army generally did not evaluate the adequacy of the test equipment during operational testing or conducted such limited tests that no valid conclusions on the adequacy of the equipment could be drawn.

Recommendation

GAO recommends that the Secretary of Defense ensure that the Army deploys proven test equipment with electronic warfare systems so that they can be effectively maintained. In implementing this recommendation, the Secretary should require that controls be established over the Army's electronic warfare system operational test programs to assure that tests are valid demonstrations of system test equipment performance.

Agency Comments

As requested, GAO did not obtain written agency comments on this report. However, GAO discussed the information in the report with responsible agency officials and incorporated their views as appropriate.

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Abbreviations

GAO General Accounting Office

Introduction

The Army equips its helicopters with electronic warfare systems to protect them from threat missiles and guns. These systems include a radar warning receiver, which alerts a pilot that the aircraft is being tracked by a radar used to guide and control threat weapons, and a missile warning system, which alerts a pilot that a threat missile has been launched at the helicopter. Another key system is a jammer, which protects aircraft by disrupting the guidance systems of threat weapons.

The Army considers these electronic warfare systems to be important to the survivability of its helicopters. Accordingly, aircraft without properly functioning electronic warfare systems are considered to be less than fully mission capable.

During an intense conflict, Army helicopters may be required to fly one or more combat missions daily. Because of this requirement and because the Army may not have spare electronic warfare systems,¹ the Army must be capable of quickly diagnosing system problems and repairing the system for the next mission. Otherwise, helicopters could be prevented from performing missions or could attempt missions without the protection of electronic warfare systems.

Army Maintenance Concept and Equipment Used

The Army's concept for maintaining most of its electronic warfare systems includes three levels. The first, called unit level maintenance, is performed while electronic warfare systems are in the aircraft. The second, or intermediate level, refers to maintenance that must be done in a repair shop. This shop is a part of each Army division and is usually separated from, but as close to, the flight line as the combat situation will allow. The third, called the depot level, refers to maintenance that is beyond the capability of the first two levels and is performed at a central facility located farther away from tactical units. Army personnel use sophisticated test equipment at each level to diagnose system malfunctions, identify faulty components, and verify that systems are operating properly.

At the unit level, the primary test equipment is built into the electronic warfare systems. Unit maintenance technicians use the built-in test equipment to verify that systems are operating properly while they are in the helicopters. Pilots also use the equipment to verify system readiness before and during combat missions.

¹The Army's policy is to procure only one system per helicopter. Thus, spare systems could be made available only by removing systems from nondeployed helicopters.

If a system defect is identified and cannot be repaired at the unit level, the faulty component is removed and sent to the intermediate level repair shop. The repair shop has more sophisticated test equipment that can diagnose faults at a more detailed component level.

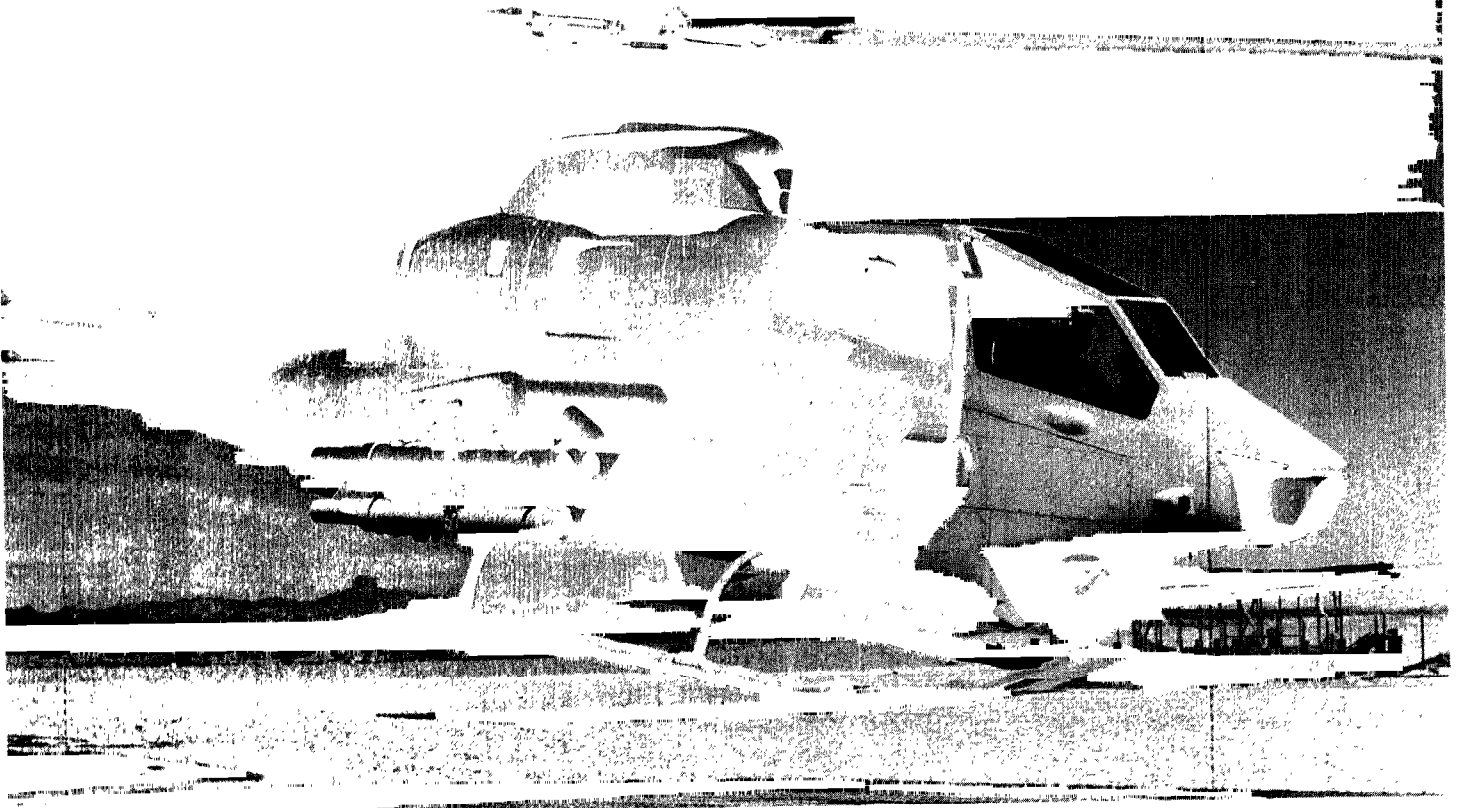
Faulty components that cannot be repaired at the intermediate level repair shop are shipped to a remotely located depot. Thus, the Army's capability to sustain combat operations with operable electronic warfare systems depends primarily on the effectiveness of maintenance at the first two levels.

Objective, Scope, and Methodology

The Chairman of the Legislation and National Security Subcommittee, House Committee on Government Operations, asked us to evaluate the adequacy of test equipment used by the services in maintaining electronic warfare systems. This report, the third in a series, addresses problems with Army systems. We reported on Air Force and Navy test equipment inadequacies in August 1989 and July 1991, respectively. We also reported in July 1991 that the Department of Defense had not taken action to correct problems cited in the August 1989 report on Air Force test equipment.

In response to the Chairman's request, we reviewed the test equipment used in maintaining the electronic warfare systems for the Army's primary aircraft, such as the AH-1 Cobra, AH-64 Apache, and UH-60 Blackhawk helicopters (see figs. 1.1 through 1.3).

Figure 1.1: AH-1 Cobra Attack Helicopter



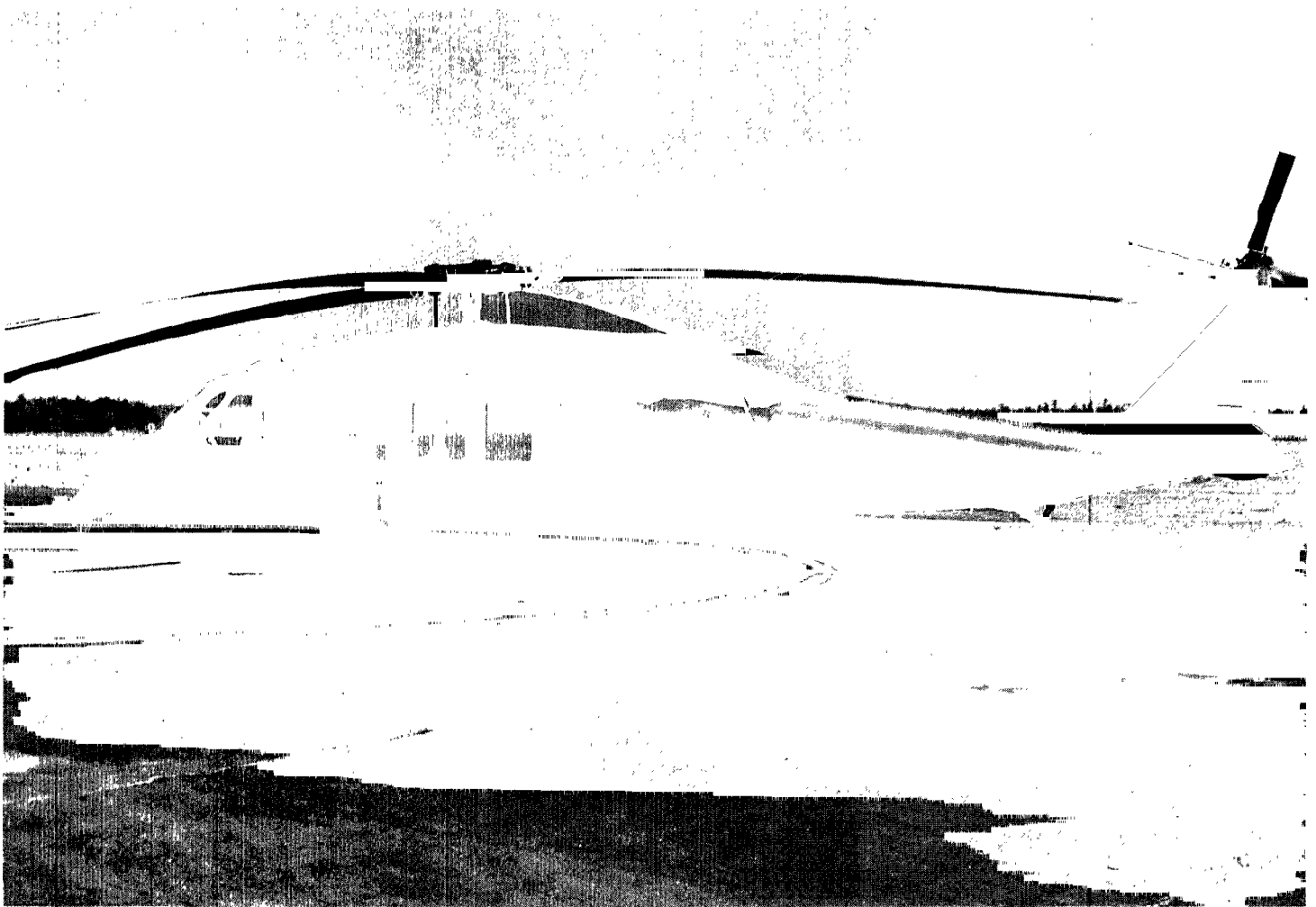
Source : U.S. Army

Figure 1.2: AH-64 Apache Attack
Helicopter



Source: U.S. Army

Figure 1.3: UH-60 Blackhawk Utility Helicopter



Source: U.S. Army

The specific systems and test equipment reviewed are listed in table 1.1. Photographs of some of the systems and test equipment are included as appendix I.

Table 1.1: Electronic Warfare Systems and Test Equipment Reviewed

System	Test equipment
APR-39(V)1 radar warning receiver	SM-674, MX-9848
APR-39A(V)1 radar warning receiver	SM-674A, MX-9848A
ALQ-136(V)1 and (V)5 jammer	TS-3614, TS-3615
ALQ-144(V)1 and (V)3 jammer	ALM-178
ALQ-144A(V)1 and (V)3 jammer	ALM-178
ALQ-156(V)1 missile warning system	TS-3609
ALQ-156(V)2 missile warning system	TS-3609

We conducted our review at Army headquarters and various subordinate organizations responsible for acquiring, testing, and maintaining electronic warfare systems and related test equipment. We reviewed program documents, test reports, acquisition schedules, and other records dealing with the acquisition, test, and maintenance of electronic warfare systems and test equipment and discussed these matters with responsible Army officials. We also reviewed Department of Defense and Army policy directives bearing on our objective.

We visited three active Army divisions in the United States and two divisions and one regiment in Germany that were equipped with the Apache, Blackhawk, Cobra, and Scout helicopters. At the time of our review, there were 16 active Army divisions. We selected these units because they were equipped with the Army's primary electronic warfare systems, had the highest number of electronic warfare systems installed in their aircraft, and in the case of the units stationed in Germany, trained with the systems regularly. In addition, three of the five divisions had recently returned from Operations Desert Shield and Desert Storm. The primary organizations where our review was done are listed in appendix II.

At the regiment and divisions' aviation units and intermediate level repair shops, we reviewed maintenance records for a current 3-month period² to determine if the test equipment enabled the Army to identify defective electronic warfare systems and repair them quickly enough to sustain combat operations. To do this, we first established the amount of time the systems spent in repair less any time waiting for spare parts. For the regiment and two divisions in Germany, we also deducted times in which

²Our review was limited to a 3-month period because the Army destroys maintenance records more than 3 months old. For the units in Germany, records were available for January to April 1991. For units that participated in Operations Desert Shield and Desert Storm units, the period was from December 1990 to March 1991.

the repair shops were not operating, such as holidays. For the three divisions that participated in Operation Desert Storm, such deductions were not required since repair shops operated 24 hours a day, 7 days a week. To supplement our review of maintenance records, we interviewed aviation unit commanders, pilots, and maintenance personnel.

As requested, we did not obtain written agency comments on this report. However, we discussed our work with responsible Army officials and included their comments as appropriate. Our review was performed from April 1991 to September 1991 in accordance with generally accepted government auditing standards.

Faulty Electronic Warfare Test Equipment Impairs Combat Readiness of Army Helicopters

The Army's capability to conduct and sustain helicopter combat operations with properly functioning electronic warfare systems has been impaired because of faulty test equipment used in maintaining the systems. Test equipment built into the electronic warfare systems and used to verify system readiness prior to and during combat missions often inaccurately indicated the status of systems. These inadequacies resulted in unnecessary maintenance and could cause pilots to fly missions with undetected faults in electronic warfare systems, thereby jeopardizing pilots and helicopters. Test equipment at the intermediate level often misdiagnosed or failed to isolate system defects, contributing to repair times far in excess of those needed to sustain combat operations.

These consequences resulted from the Army's failure to comply with acquisition policies requiring that the adequacy of test equipment be demonstrated in realistic operational testing before producing and deploying electronic warfare systems. The situation could recur unless the Army's acquisition process is strengthened.

Unit Level Test Equipment Is Faulty

Adequate built-in test equipment is fundamental to the effective maintenance of electronic warfare systems and their use during combat operations. If the equipment falsely indicates that a properly functioning system is defective, needless and time-consuming maintenance can result trying to diagnose and repair nonexistent problems. Such false indications can also delay combat operations and unnecessarily increase spare parts requirements. If the false indications occur during flight operations, a pilot could refrain from using a properly functioning system. If, on the other hand, the equipment shows a faulty system to be operating properly, a pilot and aircraft could be jeopardized.

Table 2.1 shows the rates at which built-in test equipment erroneously indicated operable systems to be faulty, based on maintenance records at the six tactical units we visited. Army requirements do not specify an acceptable error rate for such equipment. However, for comparison, Air Force requirements specify a maximum allowable error rate of 10 percent.

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Faulty Electronic Warfare Test Equipment
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Table 2.1: Erroneous Indications of Electronic Warfare System Faults by Built-In Test Equipment

System	False Indications	Total Indications	Percent false
APR-39	42	133	31.5
ALQ-144	7	160	4.3
ALQ-136	6	16	37.5
ALQ-156	0	1	0.0
Overall	55	310	17.7

Note: Maintenance records did not consistently indicate the model of the electronic warfare system repaired. For example, the records did not consistently indicate whether the system repaired was the APR-39(V)1 or the APR-39A(V)1. We therefore combined the data for the various models.

The Army program manager for aircraft electronic warfare systems did not agree that built-in test equipment was faulty. He maintained that undetected problems in the wiring between the electronic warfare systems and the aircraft caused the equipment to falsely indicate system malfunctions.

The program manager's contention could not be verified through the maintenance records. Even so, regardless of the cause of the defect, the equipment falsely indicated problems with the electronic warfare system components, which resulted in unnecessary maintenance at the intermediate repair facilities. Redesigning the built-in test equipment or providing units with additional test equipment to distinguish between system component and wiring defects could overcome this maintenance weakness.

We also found that the built-in test equipment for the ALQ-144 jammer often failed to detect system defects. Of 254 jammers shown by the test equipment to be functioning properly, 108, or 43 percent, were determined through further tests to be defective.¹ Inadequate records precluded determining the seriousness of the defects; however, at least 17 of the 108 jammers required replacement of components to restore them to a fully operational condition.

¹Army maintenance records and related records did not permit this kind of analysis for other electronic warfare systems included in our review.

**Intermediate Level Test
 Equipment
 Inadequacies Prevent
 Timely Repairs**

Test equipment at the intermediate level has limited capability to identify defective components and malfunctions. As a result, Army technicians resort to trial and error troubleshooting methods in identifying the problem and making needed repairs. These test equipment limitations contributed to repair times that far exceeded those required by Army maintenance standards and needed to support wartime operations.

Army intermediate maintenance requirements for electronic warfare systems provide that technicians should require an average of 30 minutes to 2.5 hours, depending on the system, to identify faults and make needed repairs. Quick repairs are required because spare electronic warfare systems may not be available and the Army may require its helicopters to fly one or more combat missions each day. When a system malfunctions and spares are not available, the system must be repaired quickly for the helicopter's next combat mission.

Table 2.2 shows the average number of days required for the units we visited to return a system to an operable condition after it was received in the shop for repairs, less any time awaiting parts.

**Table 2.2: Average Number of Days
 Required to Repair Electronic Warfare
 Systems**

System	Number of maintenance actions	Average time (days)
APR-39	118	13.2
ALQ-136	16	13.1
ALQ-144	376	5.7
ALQ-156	6	13.8

Note: Maintenance records did not consistently indicate the model of the electronic warfare system repaired. For example, the records did not consistently indicate if the system repaired was the APR-39(V)1 or the APR-39A(V)1. We therefore combined the data for the various models.

The repair times shown in table 2.2 included those of three Army divisions that participated in Operations Desert Shield and Desert Storm. As shown in table 2.3, the repair times experienced by those units were comparable to or slightly higher than the overall averages shown in table 2.2.

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Table 2.3: Average Number of Days Required to Repair Electronic Warfare Systems During Operations Desert Shield and Desert Storm

System	Number of maintenance actions	Average time (days)
APR-39	100	14.6
ALQ-136	14	13.0
ALQ-144	358	5.5
ALQ-156	5	16.0

Note: Data for the various models were combined as in table 2.2.

Army maintenance personnel who participated with one Army unit in Operations Desert Shield and Desert Storm told us that they would have been unable to support combat missions with operable electronic warfare systems if the conflict had lasted much longer. Some Apache and Cobra helicopter pilots told us that near the end of the short ground war, they were flying combat missions with inoperable or partially inoperable electronic warfare systems because of the inability to quickly repair them.

Army maintenance personnel told us that the test equipment had only limited capability to isolate system faults and often misdiagnosed the problem. As a result, the technicians frequently isolated defects by substituting parts known to be free of defects—one at a time—until the problem was identified. Our review of maintenance records showed that in 89 of 192 repair actions involving replacement of parts, technicians had to replace more than one part before isolating the fault.

The Army program manager for aircraft electronic warfare systems did not agree that the lengthy repair times were caused by equipment limitations. He maintained that the equipment was adequate and attributed the lengthy repair times to the lack of training and experience of Army maintenance personnel.

However, to be suitable for military use, equipment must have the characteristics that permit it to be used effectively by typical military personnel in an operational environment. Accordingly, Defense and Army policies require that the adequacy of equipment be evaluated during operational testing by typical users under conditions that simulate a combat environment to the extent practical. Such testing, which was not conducted by the Army, might have revealed the inadequacy of the test equipment.

**Improvements Needed
in Acquiring Electronic
Warfare Test
Equipment**

Department of Defense and Army policies require that the ability of test equipment to support electronic warfare systems be verified in realistic operational testing before full-rate production and deployment. However, the Army generally did not evaluate the adequacy of the test equipment during operational testing. Instead, the Army conducted very limited tests and relied on technical testing by the contractor.

For a new system now being acquired, the enhanced version of the ALQ-136 jammer, the Army evaluated the test equipment during operational tests. However, testing of the intermediate test equipment was so limited that no valid conclusions on the adequacy of the test equipment could be drawn. As a result, problems may recur.

**Unit-Level Test Equipment
Generally Not Tested**

As indicated in table 2.4, the Army did not operationally test built-in test equipment for most of its electronic warfare systems.

**Table 2.4: Operational Testing of
Electronic Warfare System Built-In Test
Equipment**

System	Operationally tested
APR-39(V)1	No
APR-39A(V)1	No
ALQ-136(V)1 and (V)5	No
ALQ-144(V)1 and (V)3	Yes
ALQ-144A(V)1 and (V)3	No
ALQ-156(V)1	No
ALQ-156(V)2	No

Operational testing of the ALQ-144(V)3 jammer revealed that the built-in test equipment did not function properly. According to the test report, the equipment frequently indicated the jammer to have faults, although none existed. Army program officials told us that the equipment was modified to correct the problem. The adequacy of the modifications, however, was not verified in subsequent operational tests.

**Operational Testing of
Intermediate Test Equipment
Not Done or Not Realistic**

The Army also failed to conduct operational testing of intermediate level test equipment for most of its electronic warfare systems as indicated in table 2.5. For some systems on which operational testing was done, the testing was so limited that no valid conclusions of the adequacy of the test equipment could be drawn.

**Table 2.5: Operational Testing of
Electronic Warfare System Intermediate
Test Equipment**

System	Operationally tested
APR-39(V)1	No
APR-39A(V)1	Yes
ALQ-136(V)1 and (V)5	Yes
ALQ-144(V)1 and (V)3	No
ALQ-144A(V)1 and (V)3	No
ALQ-156(V)1	No
ALQ-156(V)2	Yes

The APR-39A(V)1 radar warning receiver underwent two phases of operational testing. The adequacy of the intermediate test equipment, however, was only evaluated during the second phase, and the tests included only five repair actions. Similarly, testing of the ALQ-156(V)2 and ALQ-136(V)1 and (V)5 intermediate test equipment included only 5 and 24 repair actions, respectively.

Such limited testing does not allow for a valid evaluation of the adequacy of test equipment. According to applicable military standards, evaluation of test equipment requires a minimum of 30 repair actions that include system faults of the types expected to occur in an operational environment.

Test Equipment Problems May Recur on New Systems Being Acquired

The Army may encounter similar problems with test equipment for its new electronic warfare systems unless the Army's procedures are strengthened. For example, the Army recently started production of an enhanced version of the ALQ-136 jammer without subjecting its intermediate test equipment to adequate test and evaluation.

The Army's operational test of the jammer's intermediate level test equipment was too limited to reach conclusions on the equipment's adequacy. According to the test report, the limited repair actions involved were insufficient to adequately evaluate the jammer's maintainability, and conclusions reached were speculative indications of what might be expected to occur when the jammer is deployed in an operational environment.

The testing limitation on the enhanced ALQ-136 jammer's intermediate level test equipment parallels that on earlier electronic warfare system acquisitions. The limitation occurred because during the short duration of the tests, the electronic warfare systems did not fail frequently enough to provide a representative number of repair actions. This limitation could be

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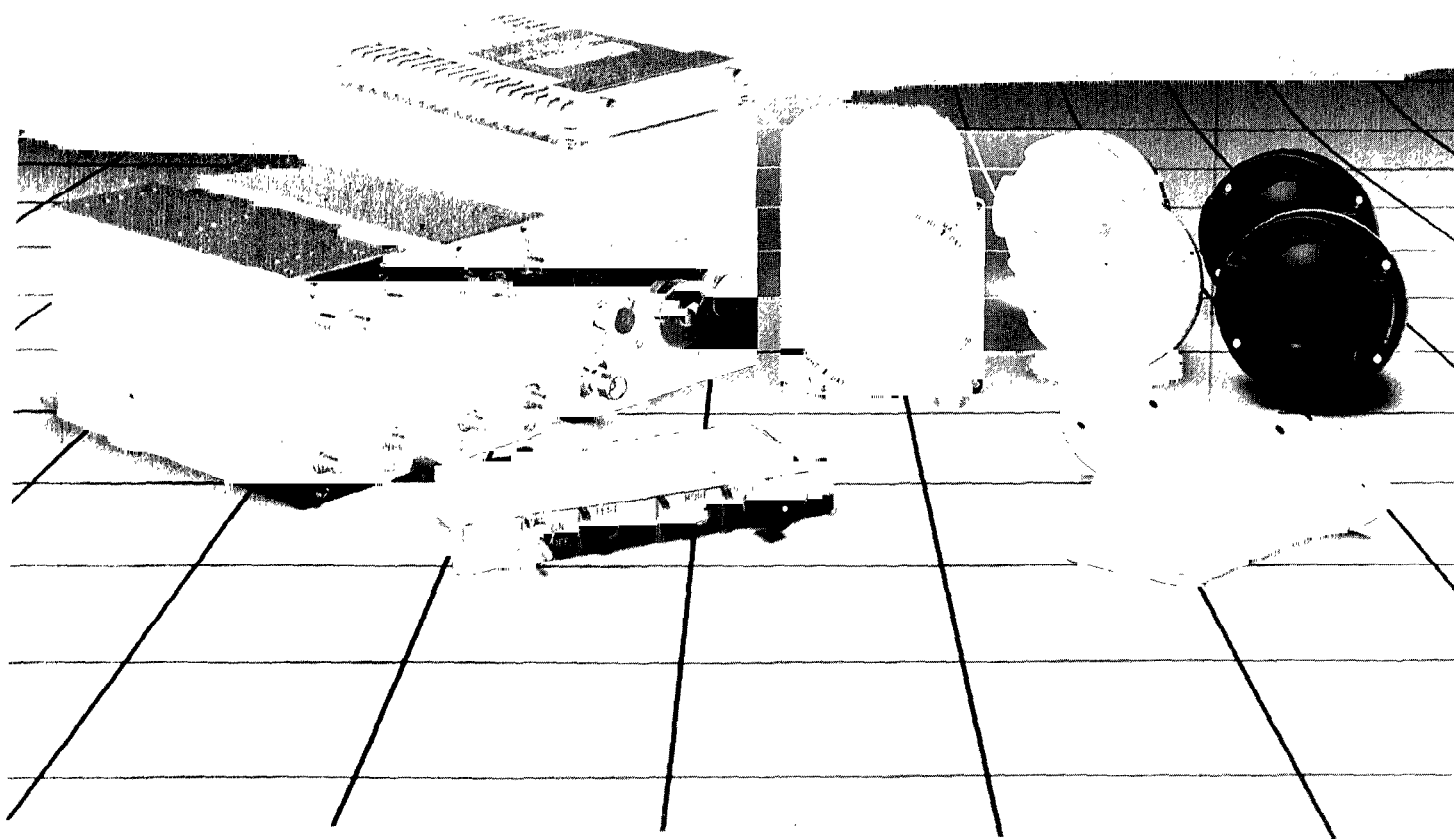
overcome by inducing faults into the electronic warfare systems as the Air Force and the Navy do when testing electronic warfare systems.

Recommendation

We recommend that the Secretary of Defense ensure that the Army deploys proven test equipment with electronic warfare systems so that they can be effectively maintained. In implementing this recommendation, the Secretary should require that controls be established over the Army's electronic warfare system operational test programs to assure that tests are valid demonstrations of system test equipment performance.

Photographs of Army Aircraft Electronic Warfare Systems and Test Equipment

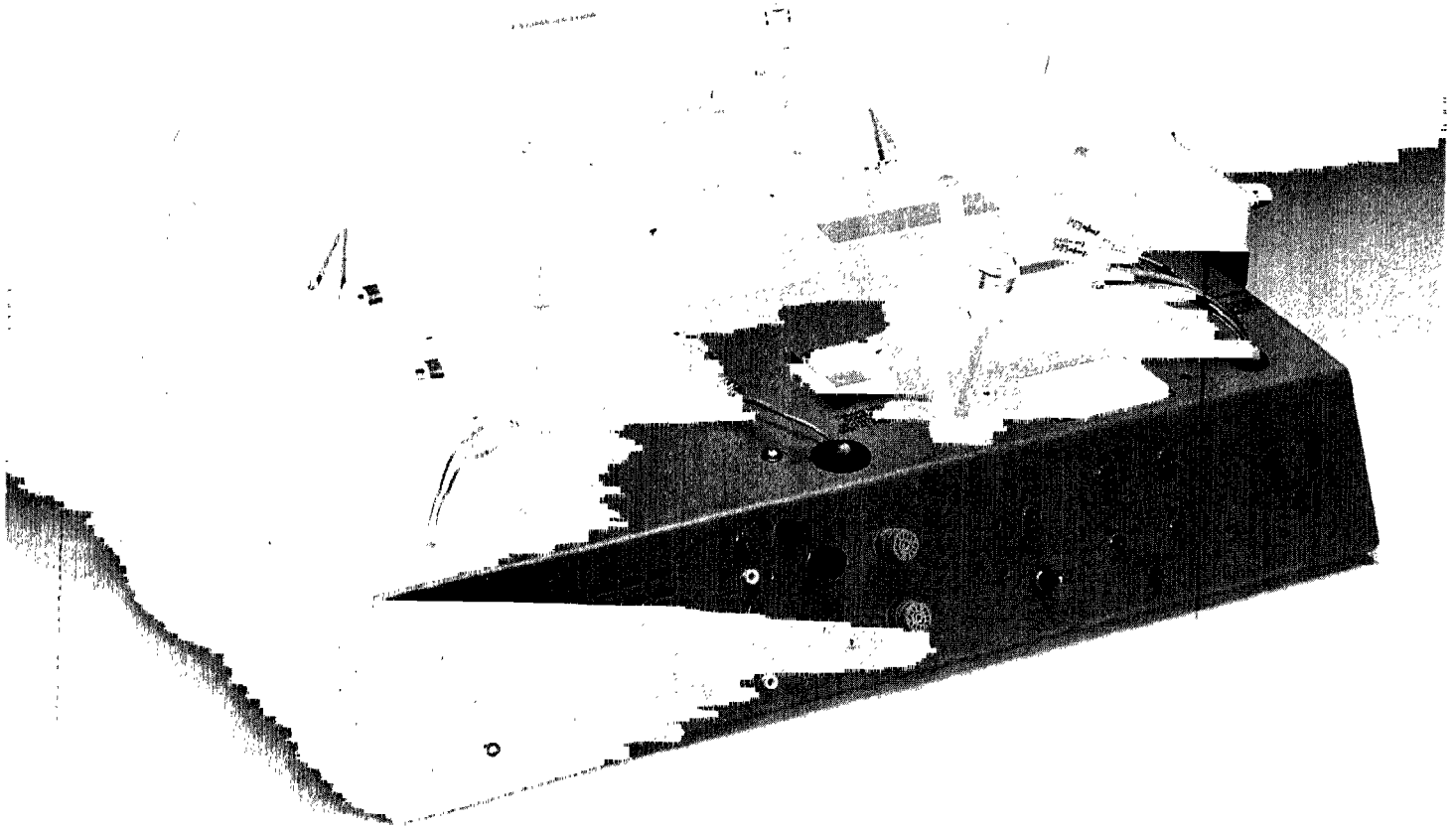
Figure I.1: APR-39 Radar Warning Receiver



Source: U.S. Army

Appendix I
Photographs of Army Aircraft Electronic
Warfare Systems and Test Equipment

Figure I.2: APR-39 Test Set



Source: U.S. Army

Appendix I
Photographs of Army Aircraft Electronic
Warfare Systems and Test Equipment

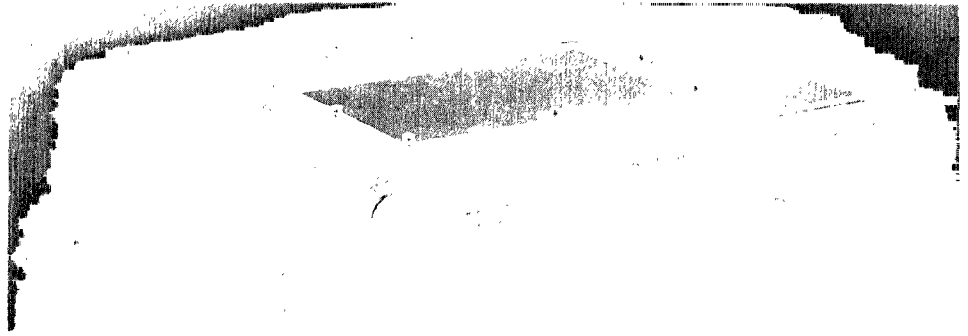
Figure I.3: ALQ-136 Radar Jammer



Source: U.S. Army

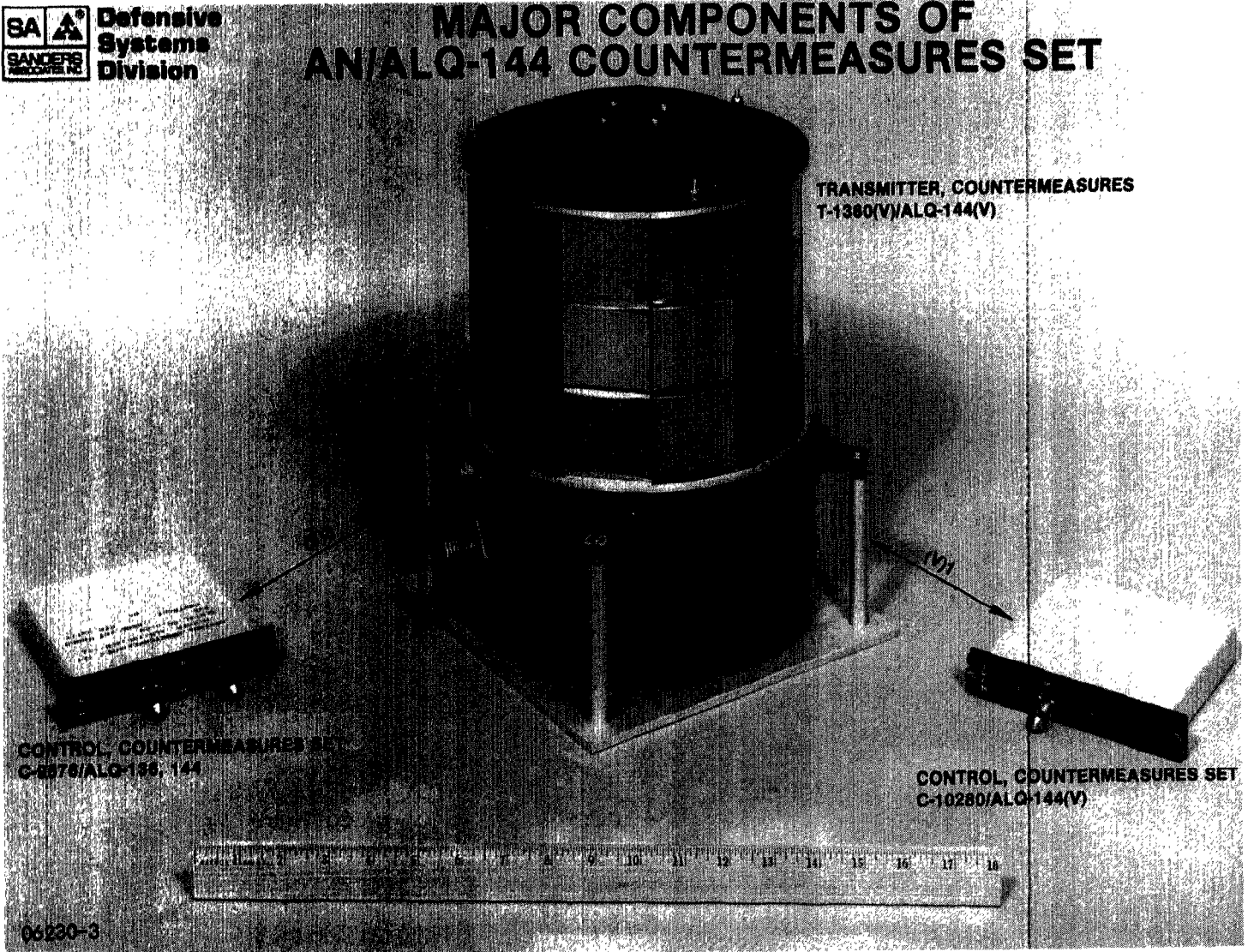
Appendix I
Photographs of Army Aircraft Electronic
Warfare Systems and Test Equipment

Figure I.4: ALQ-136 Test Sets



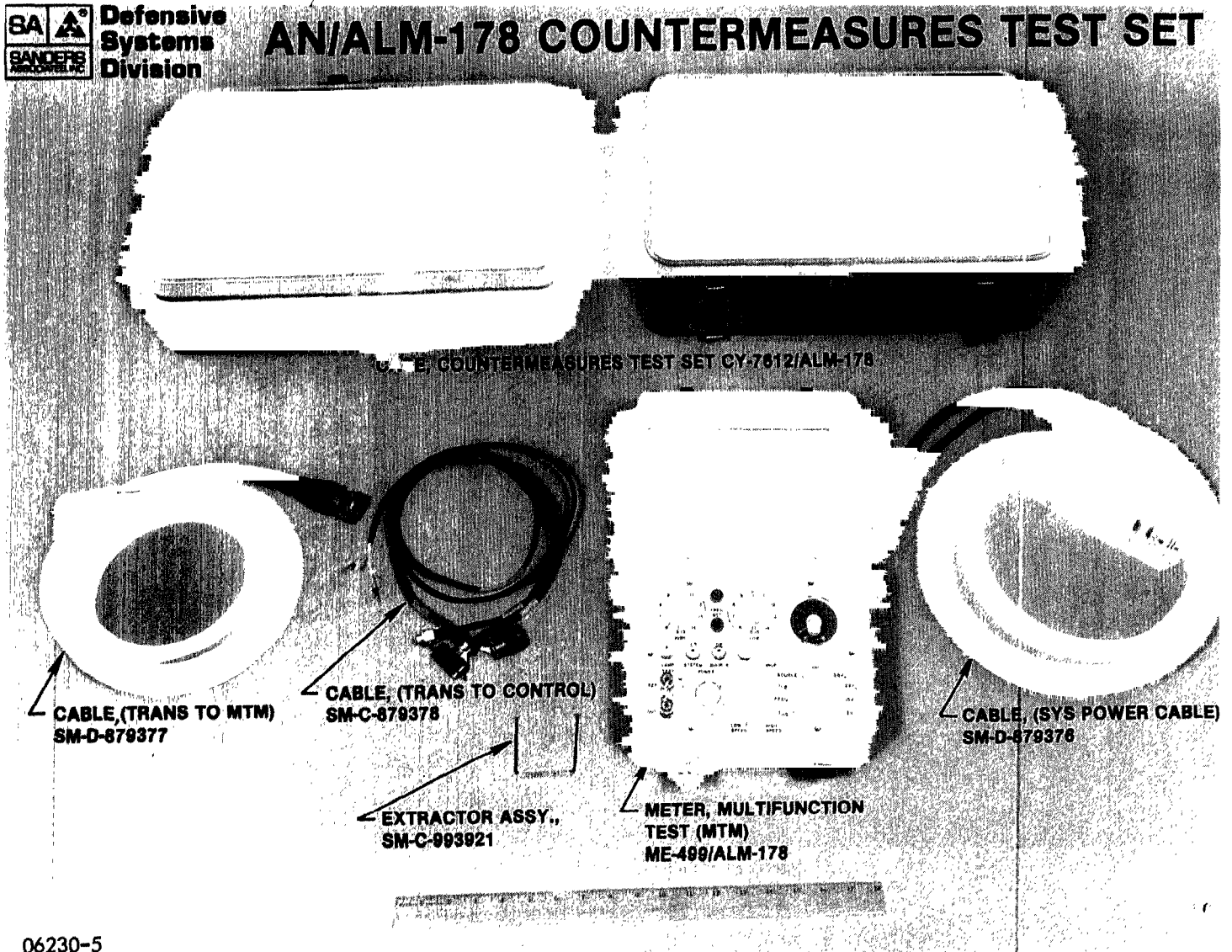
Source: U.S. Army

Figure 1.5: ALQ-144 Infrared Jammer



Source: Sanders Associates, Inc.

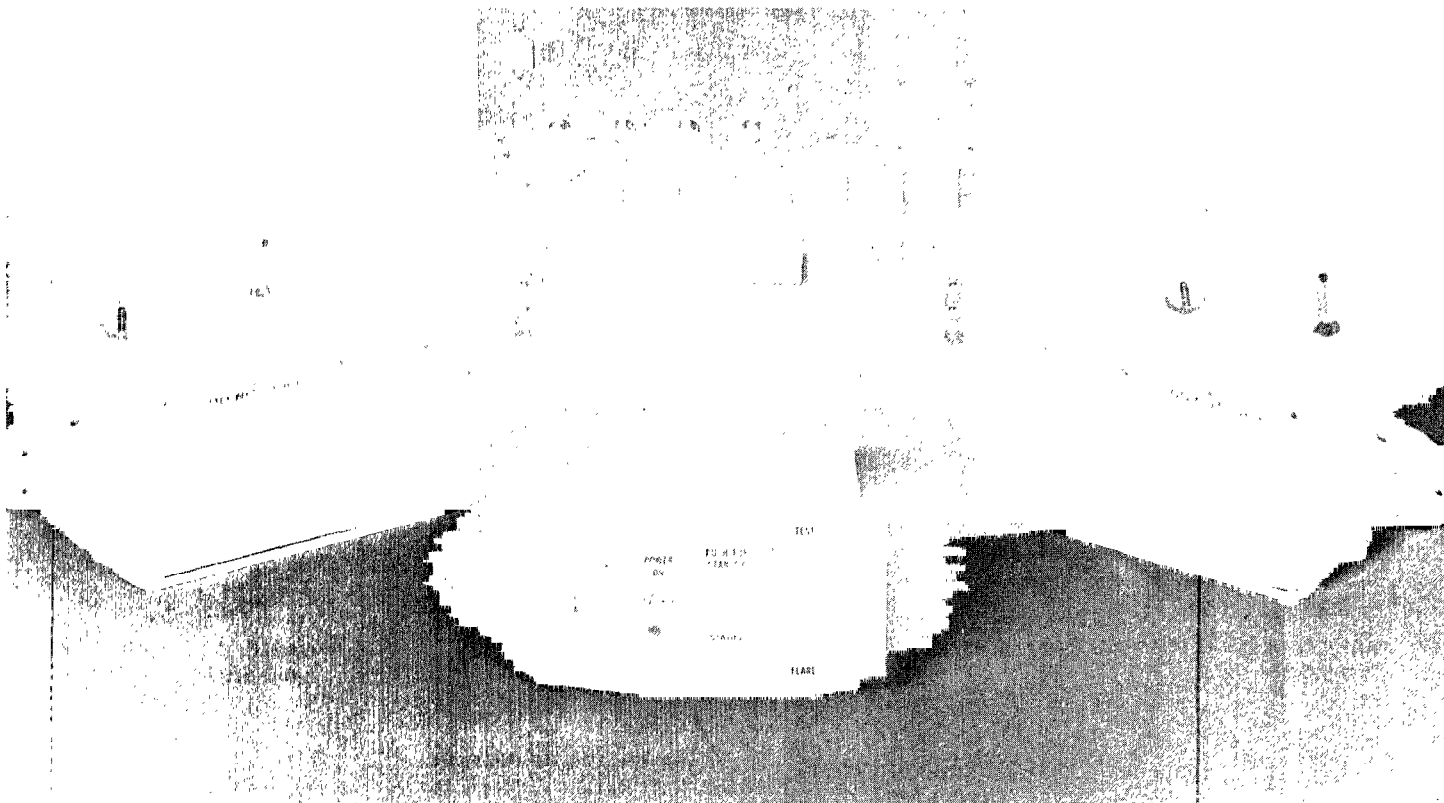
Figure I.6: ALM-178 Test Set for ALQ-144



Source: Sanders Associates, Inc.

Appendix I
Photographs of Army Aircraft Electronic
Warfare Systems and Test Equipment

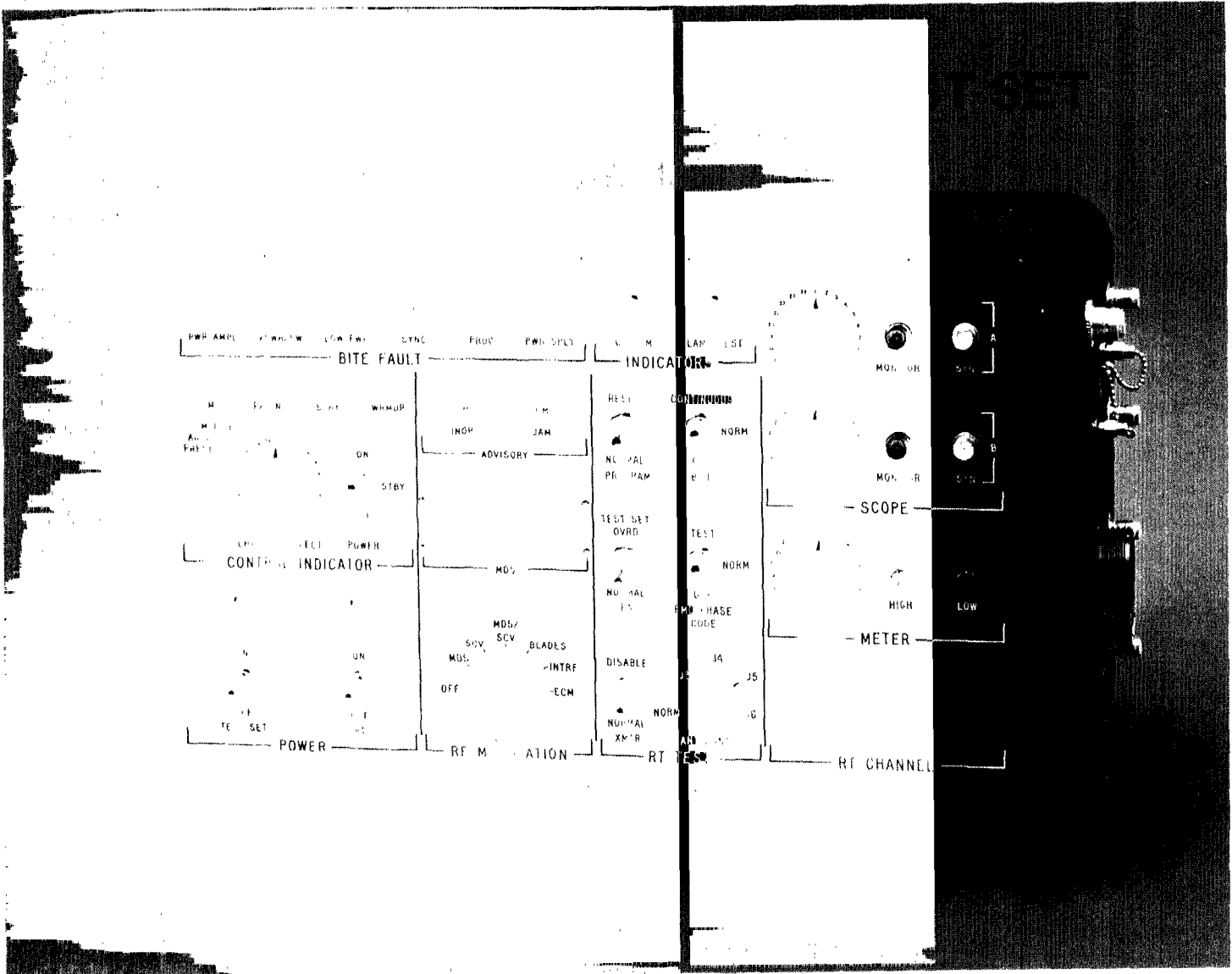
Figure I.7: ALQ-156 Missile Warning System



Source: Sanders Associates, Inc.

**Appendix I
Photographs of Army Aircraft Electronic
Warfare Systems and Test Equipment**

Figure I.8: ALQ-156 Test Set



Source: U.S. Army

U.S. Army Organizations Visited

- Headquarters, U.S. Army, Europe, Heidelberg, Germany
- V Corps, Frankfurt, Germany
- 3rd Infantry Division, Geibelstadt, Germany
- 8th Infantry Division, Mainz-Finthen, Germany
- 11th Armored Cavalry Regiment, Fulda, Germany
- 24th Infantry Division, Fort Stewart, Georgia
- 82nd Airborne Division, Fort Bragg, North Carolina
- 101st Air Assault Division, Fort Campbell, Kentucky

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