Flight Performance of an Airborne Minefield Detection and Reconnaissance System

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ABSTRACT: The Airborne Minefield Detection and Reconnaissance System (AMIDARS) was developed in response to the U.S. Army's problem of identifying minefields, vehicles, troop concentrations, bridges, railways, and buildings from an unmanned reconnaissance system. A potentially operational sensor and aircraft system has been developed, and flight tests have demonstrated system capabilities. Selected imagery is presented and evaluated to describe in general terms the performance of the system.

INTRODUCTION

CAI DESIGNED, FABRICATED, AND ASSEMBLED the Airborne Minefield Detection and Reconnaissance System (AMIDARS) under an Advanced Development program. The program was a joint effort between the U.S. Army's Center for Night Vision and Electro-Optics (CNVEO) and Belvoir Research, Development and Engineering Center (BRDEC) at Ft. Belvoir, Virginia starting in 1984. State-of-the-art technology has been integrated, including a passive thermal IR (8 to 12 μm) SPRITE detector, two-axis active stabilization, electronic roll stabilization, and unmanned vehicle technologies.

Data from the sensor were recorded directly on an Ampex 1700i 28-track recorder. Simultaneous data link of selected resolution and field-of-view (FOV) imagery to a local ground station for real-time display was also achieved. After a period of engineering "debugging" and system calibration, the sensor produced outstanding IR imagery, and proved its usefulness for both mine detection and general reconnaissance.

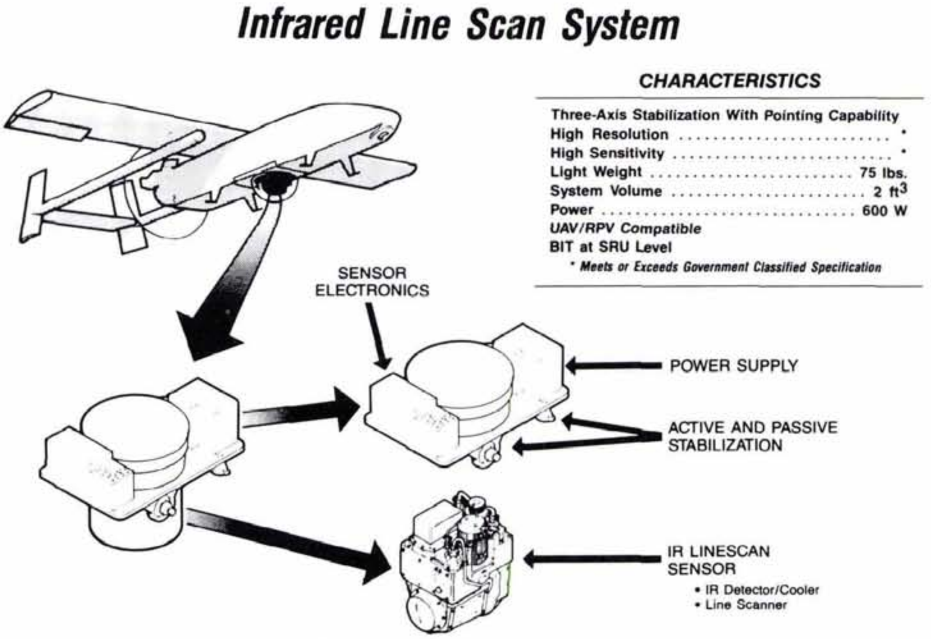
The AMIDARS components are shown in Figure 1. The hardware is shown mounted under the wing of the Cessna O2-A test platform in Figure 2. Table 1 lists the IR Line Scanner (IRLS) parameters.

The AMIDARS program has now progressed from design and laboratory tests to field tests. Data from the engineering flight tests completed at CAI have demonstrated that the AMIDARS does achieve the U.S. Army specifications for resolution and sensitivity. To date, 34 missions have been flown over simulated minefields and a thermal tri-bar target. Eight of the flights were taken at night. Imaging conditions ranged from full daylight with good visibility to complete darkness, no moon, and overcast sky.

FLIGHT TEST CONFIGURATION

The AMIDARS sensor was integrated into a flight test system for performance evaluations. Figure 3 shows a block diagram of the flight test configuration. The sensor, cabin equipment, hand-held terminal, display monitor, and flight instrumentation were installed in a Cessna O2-A. Figure 4 shows the placement of the equipment in the Cessna, and Figure 5 shows the test platform with the equipment installed.

The cabin equipment was designed to provide on-board sen-



CHARACTERISTICS

Three-Axis Stabilization With Pointing Capability	
High Resolution	*
High Sensitivity	*
Light Weight	75 lbs.
System Volume	2 ft^3
Power	600 W
UAV/RPV Compatible	
BIT at SRU Level	

** Meets or Exceeds Government Classified Specification*

FIG. 1. AMIDARS components.

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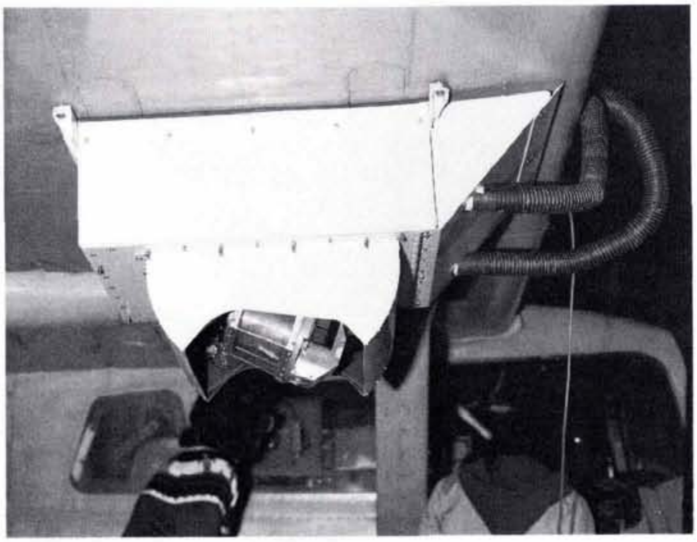


FIG. 2. AMIDARS sensor mounted on Cessna 02-A test platform.

TABLE 1. IRLS PARAMETERS

Scan mechanism	Oblique scanner
Detector type	HgCdTe SPRITE
Spectral region	8 - 12 μm
Detectors in parallel	8
Equivalent detectors in series	11.85
$D^*\lambda_p$ equivalent detector	12.6×10^{10} cm $Hz^{1/2}/W$
NFOV	60° (within ±40° of nadir)
WFOV	120° (within ±10° of nadir)
Scan rate	85.73 lines/s
f/no.	3.33
Optical transmission	0.8
Size (inches)	7.63 W × 10.94 L × 14.09 H
Weight	12.34 kg
Power	173 W

sor display and control to facilitate the engineering tests. Included in the cabin equipment were a control panel, Ampex 1700i recorder unit, heading indicator, display electronics, and power supplies. These are shown in a rack-mounted configuration in Figure 6. Control panel functions include sensor status, sensor pointing, FOV selection, Built-in Test (BIT), and video monitor control.

The heading indicator was the AIM 400 series directional gyro system. The Ampex 1700i tape transport and its Digital Processing Unit (DPU) were employed because of its high bit rate digital recording system. Sixteen digital data tracks were recorded and supported by two master tracks and two error correction tracks. One auxiliary track record was recorded from the aircraft intercom. Data were recorded at 3.5 Mbytes/s, resulting in a record time of over 30 min for a 2926-m (9600-ft) tape reel with bit error rates better than 1 in 10^7.

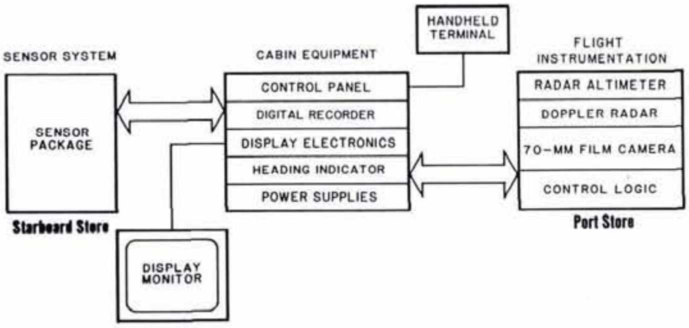


FIG. 3. AMIDARS flight test configuration.

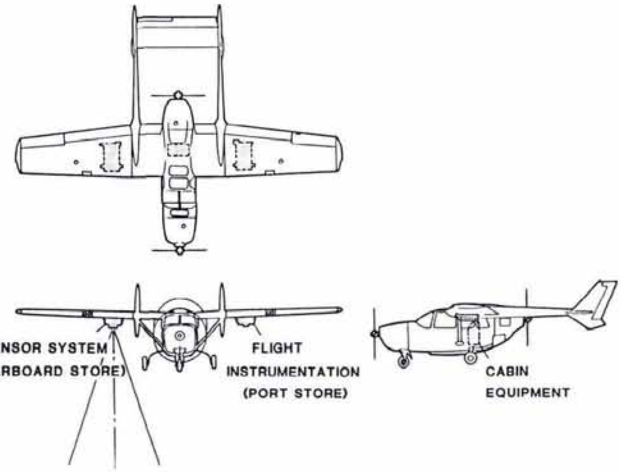


FIG. 4. AMIDARS equipment placement in Cessna 02-A.

The display system can provide real-time imagery to the operator during flight, or playback the stored imagery with an optional playback unit on the ground. Three display modes allow for "waterfall," "freeze frame," and "inverse" methods of making image presentations. A scan converter is incorpo-

FIG. 5. Cessna 02-A test platform with AMIDARS installed.

FIG. 6. AMIDARS cabin equipment.

rated to drive a 512- by 480-pixel RS-170 display. The monitor used for the flight test was a Sekai RSM-91. During these flights, imagery was recorded at full resolution on the Ampex recorder for later playback and evaluation. In the evaluation procedure, video from the cabin equipment display was simultaneously data linked to a ground station in a test tower located in close proximity to the simulated minefield and resolution targets.

The data link used a UHF 2235-MHz analog video link, and voice communication was maintained over VHF and FM radio channels. The down-linked video allowed test personnel to monitor airborne status and image quality. Command decisions concerning sensor performance, weather, flight profile, test targets, and targets of opportunity could therefore be made in "real time." With the exception of the heading indicator located in the cabin equipment rack, the flight instrumentation equipment was mounted in a store under the port wing. This included a Honeywell HG7508 radar altimeter and a Marconi Avionics AD-600 doppler velocity sensor to allow accurate determination of image velocity independent of aircraft instrumentation. Also included was a Hasselblad SWC EL/M wide-angle flight camera to provide a visible spectrum film record for correlation with the recorded IR imagery.

TEST METHODOLOGY

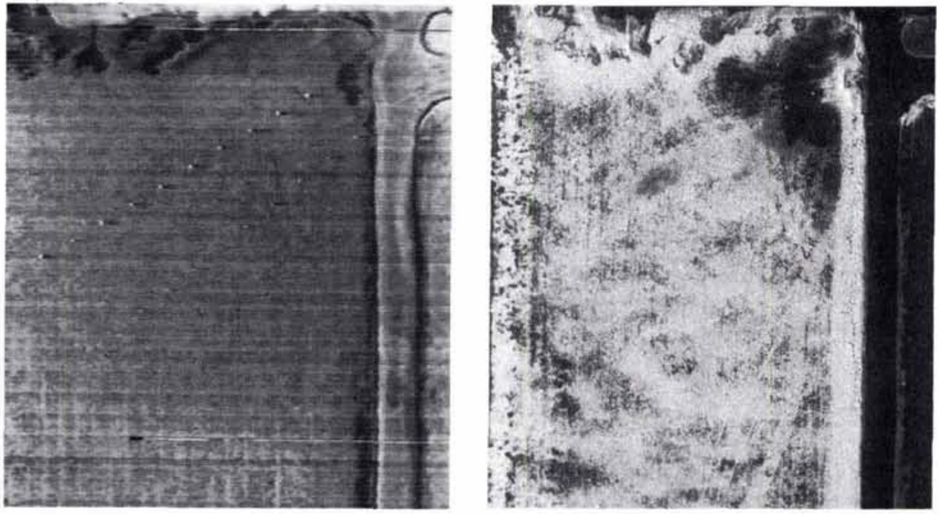
These flight tests were performed to build engineering confidence that the system was performing as designed. A simulated minefield was designed to provide targets of various sizes and temperatures. The mines were simulated by cookie tins which were painted and heated to provide only a known thermal signature. The covers of the mines were painted white while snow covered the minefield, and olive drab after the snow had melted. Target sizes included 12-, 8-, and 6-inch versions. Mine temperatures were measured with an IR pyrometer before and after tests. System performance was evaluated by the ability of the operator to resolve the size and pattern of the mines placed in the field.

Other targets of opportunity were also used to evaluate performance. Roads and railroad tracks were particularly useful in determining the degree to which the stabilization system was operational. Building roof lines provided excellent indications of proper sensor alignment. Other indicators used were fences, power lines, vehicles, personnel, creeks, rivers, and lakes.

The BRDEC thermal target board was used as a final measure of resolution. The target is configured in a three-bar pattern, bidirectional, $\sqrt[4]{2}$ progression. The bars consisted of cutout areas on an insulated metal panel. The cutouts exposed an electrically heated thermal blanket powered by a gasoline generator. Again, a pyrometer was used to determine the ΔT of the target board.

TEST RESULTS

Specific resolution and performance data cannot be presented due to their classified nature. However, hard copy images, without reference to altitude or geometry, do yield a good qualitative measure of performance. Because the system was specifically designed for mine detection, evaluation against the simulated minefield was critically important. Mines were indeed detected on both day and night flights during the initial week of flight tests. Imagery from the video band link was recorded on U-matic tape and converted to film on a Fire 240 laser beam recorder. The left side of Figure 7 shows the result-



IR Visible

FIG. 7. AMIDARS flight test imagery showing snow-covered minefield.

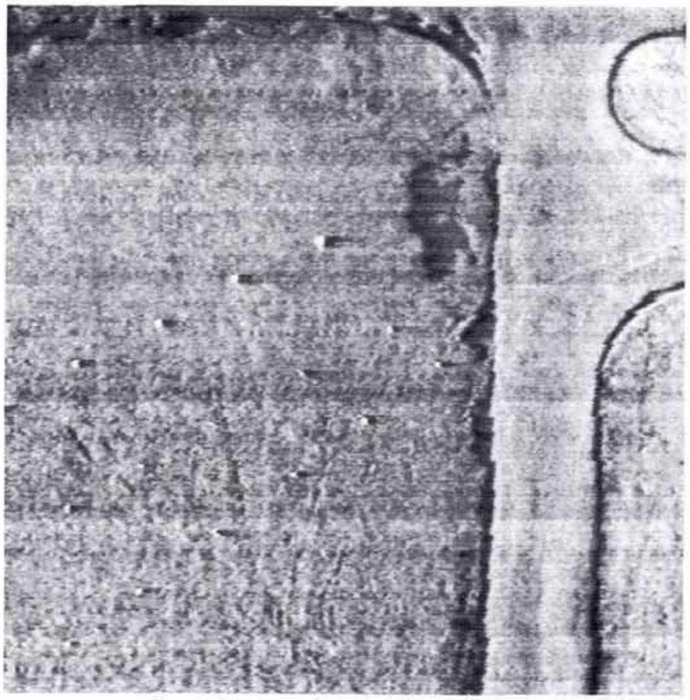


FIG. 8. Closeup of downlinked IR imagery.

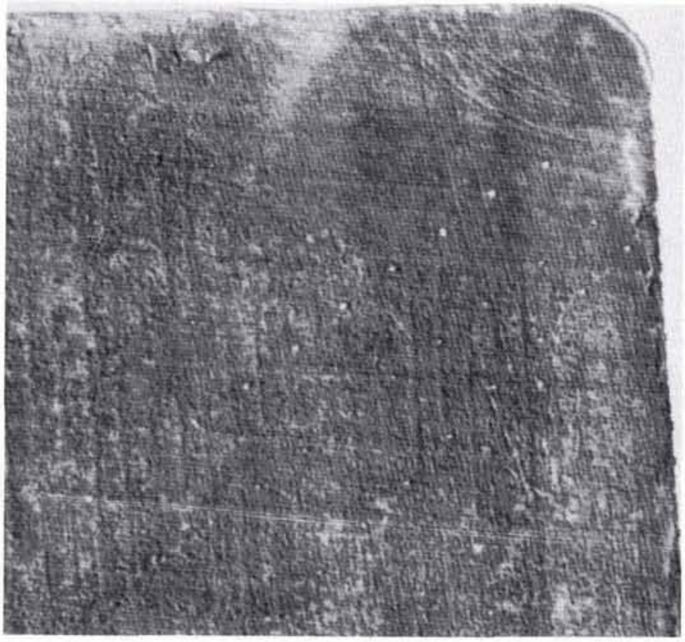


FIG. 10. Closeup of minefield shown in Figure 9.

FIG. 9. Wide FOV IR image of minefield and CAI facility.

FIG. 11. Residual thermal signature of cars in parking lot.

FIG. 12. Powerlines, railroad tracks, and vehicles.

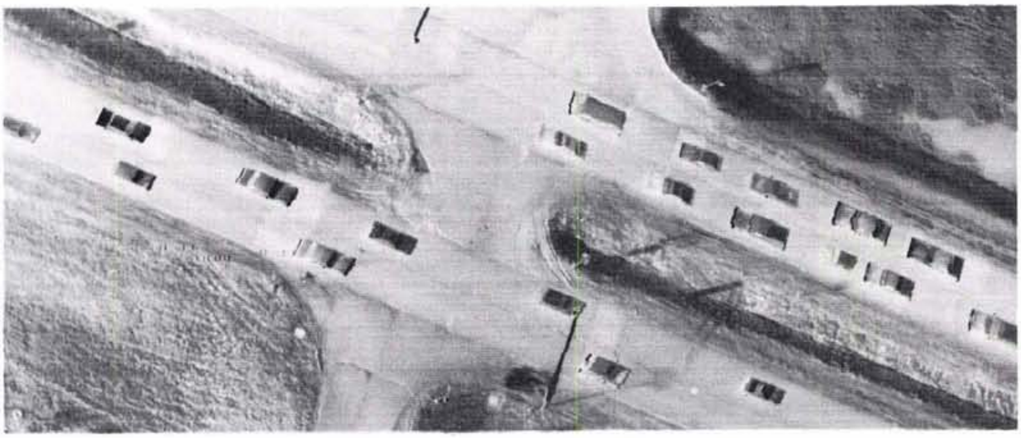


FIG. 13. Vehicles along U.S. Rt. 14.

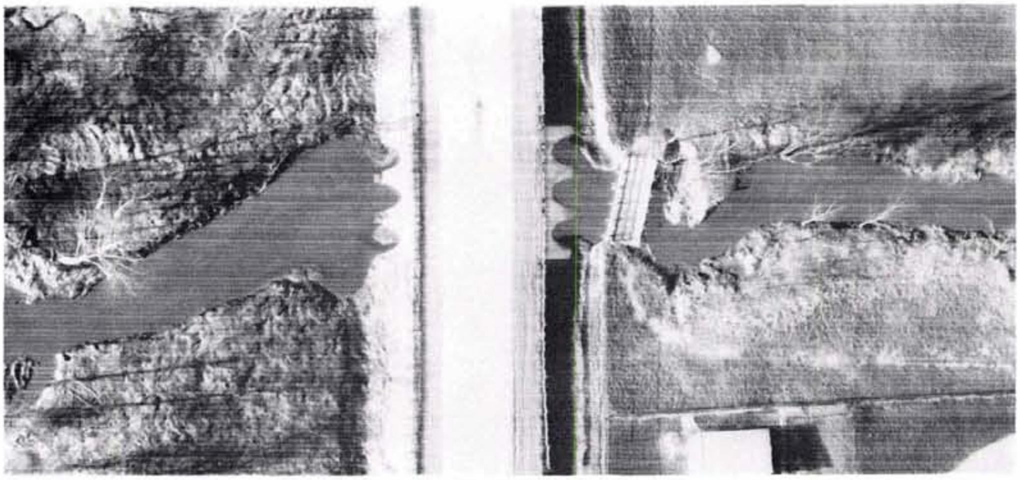


FIG. 14. Automotive and pedestrian bridge over Flint Creek.

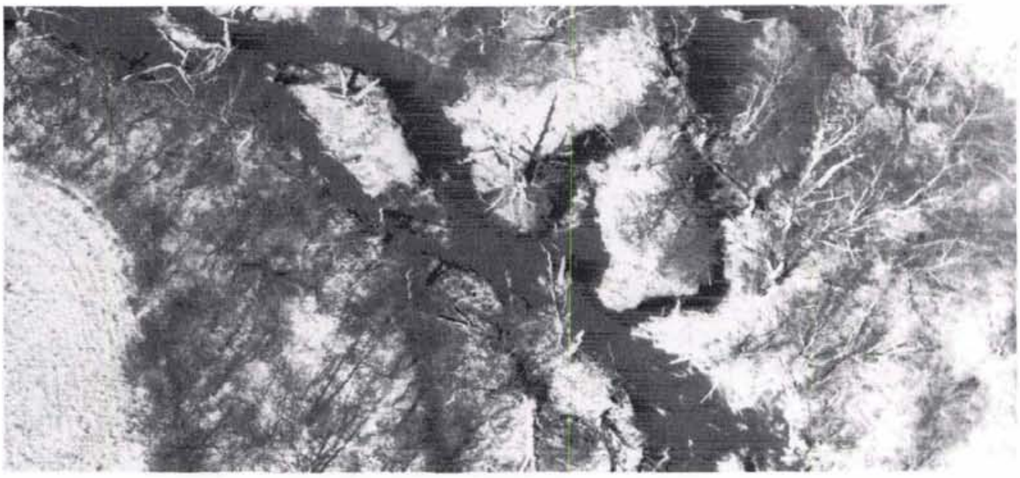


FIG. 15. Flint Creek waterway.

ing IR imagery; the right side of Figure 7 shows the striking comparison with visible spectrum film of the same minefield taken with the Hasselblad flight camera on board the Cessna. The painted mines are undetectable in the snow-covered field. Figure 8 shows a closeup of the mines from the IR image. Clearly, three diagonal rows of mines are detectable. The different mine sizes are also apparent.

Figures 9 and 10 show a full-resolution, wide FOV image and closeup of the minefield after the snow had melted and the olive drab covers were installed. Figure 11 shows the residual thermal signature of cars in a parking lot after most of the cars had left. Other images of interest show power lines, railroad tracks, vehicles, bridges, and waterways, as shown in Figures 12 through 15. These demonstrate the sensor's ability to resolve spatial frequencies near its limit.

CONCLUSIONS

The AMIDARS's ability to provide passive day or night reconnaissance of minefields, vehicles, railways, and buildings has been demonstrated. It is ready to do the job of remote mine detection and reconnaissance for which it was designed.

ACKNOWLEDGMENTS

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