Project CHLOE: High Altitude Defense Against Anti-Aircraft Missiles

R.M. Mabe,[1] K.A. Sarkady,[1] and B.A. Nichols[2]
[1]*Optical Sciences Division*
[2]*Alaire Inc.*

Introduction: NRL is conducting research to mitigate the threat posed by Man-Portable Air Defense Systems (MANPADS) to civilian aviation. Since the 1970s, the International Civil Aviation Organization has documented at least 42 civilian aircraft attacked with these systems. Twenty-nine of these attacks have resulted in loss of the aircraft and life. Attempts as recent as the Mombasa attack of an Israeli airliner in 2002, the attack of a DHL cargo plane in Iraq in 2003, and the arrest of an arms dealer attempting to smuggle MANPADS into the United States in 2003 are evidence of the continued threat posed to civilian aviation by these weapons.

Project CHLOE: Project CHLOE is a Department of Homeland Security (DHS) Homeland Innovative Prototypical Solutions (HIPS) project intended to demonstrate game-changing leaps in payload technologies at the prototype level that can enable the defeat of MANPADS from a persistent, high-altitude orbit. Project CHLOE is determining the system-level operational effectiveness, maturity of components, subsystems, software, system approach, and suitability for employing Counter-MANPADS (C-MANPADS) technologies from High Altitude Endurance Unmanned Aerial Systems (HAE UAS). The intent of CHLOE is to provide persistent, broad-area protection of commercial aviation from altitudes above the National Airspace System (NAS), that is, above 18 km mean sea level (MSL). The first stage of CHLOE was to determine the viability of MANPAD launch detection with existing technologies. To that end, NRL was tasked to conduct a rapid modification and prototyping of existing Tactical Aircraft Directed Infra-Red Countermeasure (TADIRCM) two-color infrared (IR) missile warning system (MWS) components to support a high-altitude flight demonstration and evaluation.

Technical Challenges: DHS desired the CHLOE flight demonstration be conducted from altitudes above the NAS and selected the National Aeronautics and Space Administration's (NASA) ER-2 as the test platform. The ER-2 is capable of achieving altitudes in excess of 21 km MSL. Standoff detection from these altitudes required an order of magnitude improvement in sensitivity over the current TADIRCM sensor design. The TADIRCM two-color missile warning sensors were designed to counter MANPADS at tactical ranges less than 10 km. NRL and DRS Technologies redesigned the missile warning sensor optics and electronics, achieving the required performance for the flight demonstration.

Additionally, most of the other components were only certified to maximum altitudes of 30,000 ft. This precluded a direct mounting of the TADIRCM Early Operational Assessment (EOA) pod on the ER-2. With the assistance of NRL's Spacecraft Engineering Department, the MWS was redesigned to fit in the ER-2's experimental Q-bay. Since this was a test of the missile warning function only, the laser-based directed infrared countermeasure was not installed. The repackaged MWS was integrated into NASA's Dryden Flight Research Center and flight tests were conducted there. Figure 1 shows the MWS installed in the upper portion of the ER-2 Q-bay, and Fig. 2 shows the MWS sensor installation in the lower Q-bay hatch. The design provided for a system field of regard of 360° in azimuth from an elevation of 40° to 90° below the horizon.

Demonstration Results: Initial flight operations were conducted in the areas surrounding Edwards AFB, California, to check MWS operability and measure urban clutter levels at various altitudes. The flights confirmed operation throughout the ER-2 operational envelope. During these flights, MWS operability was validated at various altitudes using a missile simulator. The simulator comprised a set of propane burners designed to generate infrared signatures with spectral characteristics similar to those of a threat missile at broad aspect. The MWS was able to detect and declare as a threat the simulator at slant ranges up to 30 km. The system was also able to geo-locate the simulator position with an average error of 50 m. The flights also measured urban clutter at various altitudes up to the maximum altitude of the ER-2. The data collected provide valuable insight into the effect of background clutter on MANPAD detection from high altitude.

Following the local flight operations, the ER-2 and support crew were moved to Kirtland AFB in Albuquerque, New Mexico, to support flight operations over the White Sands Missile Range during DHS C-MANPADS live fire tests. Five MANPAD launches were observed from altitudes in excess of 21 km MSL. The MWS detected, tracked, and declared all five of the launches. Figure 3 is a single sensor frame showing the declaration of two launch events. The red boxes declare as threats the near-simultaneous launch of two MANPADs toward targets near the end of the valley at the upper left. The data were obtained from 20 km MSL. The results were similar for the other observed events.

The MWS demonstration portion of Project CHLOE was successful in demonstrating the efficacy of MANPAD detection from altitudes above the NAS. During the demonstration, all observed MANPAD

FIGURE 1
CHLOE processing equipment mounted in upper ER-2 Q-bay.

FIGURE 2
CHLOE sensors mounted in lower ER-2 Q-bay hatch.

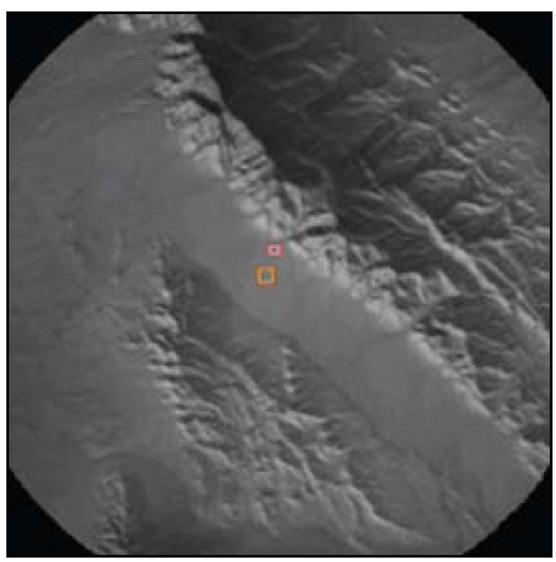

FIGURE 3
Detection and declaration of near-simultaneous MANPAD launches, from 65,000 feet.

launches were detected and declared as threats. The demonstration also provided valuable insight into the background clutter levels to be expected at these altitudes. Based on post-demonstration analysis, the higher clutter levels observed over urban areas will require a sensor with a higher resolution than the redesigned MWS sensor to provide adequate threat declaration probability with a reasonable false cue rate. This higher resolution sensor will provide additional benefits in a greatly reduced pointing error for handoff to a MANPAD countermeasure. Additionally, higher resolution will result in reduced geo-location errors and provide more accurate launch position reports to the nation's law enforcement agencies.

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