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AWS-2 RAMICS

Outlook

- RAMICS development was canceled May 2011 due to program delays resulting from hardware and software development issues.
- The forecast has been deleted
- This report will be archived next year, 2014

Orientation

Description. The AWS-2 Rapid Airborne Mine Clearance System (RAMICS) is a targeting, fire control, and gun system that fires a supercavitating projectile as a countermeasure against near-surface moored mines. The laser infrared detection and ranging instrument and gun system are mounted on the helicopter. The LIDAR directs the gunfire to the target mine. Mine deflagration is accomplished utilizing the reactive material and kinetic energy of the supercavitating projectile.

Sponsor

U.S. Navy
U.S. Office of Naval Research
Washington, DC

U.S. Naval Surface Weapons Center
Coastal Systems Station (NSWCCSS)
Panama City, FL
(Principal laboratory)

Status. Program canceled May 2011.

Total Produced. An advanced-technology demonstration prototype had been constructed (mainly subcomponent systems).

Application. As an airborne mine countermeasures (AMCM) system, RAMICS uses laser targeting to assist in the firing of supercavitating projectiles that penetrate and neutralize shallow-water sea mines. RAMICS was being designed to fly aboard the Navy's MH-53E MCM helicopter and possibly the SH-60 LAMPS helicopter.

Price Range. The unit cost of the RAMICS, including its sensors, was estimated to be $8.6 million based on existing financial projections. The cost of the cannon used for RAMICS was believed to be $93,000.

Contractors

Prime

Raytheon Co	http://www.raytheon.com, 870 Winter St, Waltham, MA 02451-1449 United States, Tel: + 1 (781) 522-3000, Fax: + 1 (781) 860-2520, Prime
Alliant Techsystems - Security and Sporting, Commercial	http://www.atk.com, 900 Ehlen Dr, Anoka, MN 55303 United States, Tel: + 1 (763) 323-2307, Fax: + 1 (763) 323-2506, Email: ammunition.group@atk.com,

AWS-2 RAMICS

Products - Federal Cartridge Co	Consortium Member
Kaman Aerospace Corp	http://www.kaman.com/aerospace/, Old Windsor Rd, PO Box 2, Bloomfield, CT 06002-0002 United States, Tel: + 1 (860) 242-4461, Fax: + 1 (860) 243-7514, Consortium Member

Subcontractor

CPI Aerostructures Inc	http://www.cpiaero.com, 60 Heartland Blvd, Edgewood, NY 11717 United States, Tel: + 1 (631) 586-5200, Fax: + 1 (631) 586-5840 (Pod Structures)
Lockheed Martin Mission Systems & Sensors, Syracuse Unit	http://www.lockheedmartin.com, 6417 Deere Rd, Syracuse, NY 13206-1304 United States, Tel: + 1 (315) 456-0123 (Test and Evaluation)
Northrop Grumman Aerospace Systems, Battle Management and Engagement Systems	http://www.as.northropgrumman.com, 2000 NASA Blvd, PO Box 9650, Melbourne, FL 32902-9650 United States, Tel: + 1 (321) 951-5000 (Test and Evaluation)

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Contractors are invited to submit updated information to Editor, International Contractors, Forecast International, 22 Commerce Road, Newtown, CT 06470, USA; rich.pettibone@forecast1.com

Technical Data

Design Features. RAMICS is a helicopter-borne MCM system that rapidly detects and destroys shallow-water naval mines. It was being developed by Raytheon, which acquired Hughes Electronics' Hughes Naval and Maritime Systems in 1997. The system's operation is based upon a supercavitating projectile that is fired in bursts from a 30mm gun. The projectile, which consists of Raytheon's proprietary active material, penetrates the mine's explosive core, causing immediate detonation or deflagration.

Five major components are integrated to perform the RAMICS mission. These are:

- Targeting Pod – Double blue-green laser
- Gun – Mk 44 Bushmaster II 30mm cannon
- Ammunition – Mk 258 Mod 1 hydroballistic armor-piercing long-rod projectile
- Common Console – Used by all five AMCM systems for control and display
- Aircraft – MH-60S multimission helicopter

RAMICS targeting is performed by an AES-1 LIDAR, a blue-green laser that penetrates the water column to locate and accurately target a shallow water mine. This laser, aboard the hovering, or circling, helicopter, "looks" at the mine from more than one direction, virtually eliminating false alarms. The laser-derived mine coordinates are provided to the RAMICS controller. The controller automatically directs and holds the stabilized rapid-fire gun on target, firing a burst of 20-50 rounds at the mine.

The supercavitating projectile is spin-stabilized in the air until the projectile enters the water at an oblique angle. The combination of its open-tubular shape and high velocity creates a cavitation "envelope" in the water. The projectile, which rides inside this envelope with very low drag, maintains high kinetic energy and is capable of high velocities traveling under water.

The program objective is to achieve an assured kill using 10 to 15 rounds per mine, with an estimated production cost of $30 per round. If such accuracy and low cost can be achieved, mine neutralization could cost only $300-$450 per mine.

Operational Characteristics. Threat mines are detected through a variety of methods, including the Airborne Laser Mine Detection System and the AQS-20 towed sonar, pilot reports (i.e., visual sightings), and intelligence reports. Those reports are entered into a shipboard processing system. This system is connected to the mission planning workstations the squadrons use to prepare for their sorties. Contact lists for RAMICS (and other systems depending on environment, location, and type) are generated. The sortie is planned and loaded in the aircraft.

The aircraft proceeds to the contact localization area and enters a hover at a safe distance. The targeting system scans the localization area and presents the contact(s) to the operator for reclassification. Once the operator

selects a contact, the system trains the gun to the correct azimuth and elevation. A boresight laser mounted on the gun subsystem illuminates the correct spot for the projectile to enter the water. Once the firing solution is complete, the gun fires a hydroballistic projectile.

On impact with a mine, the projectile penetrates the mine case and begins to break up. This process releases an oxidizing agent from within the projectile. The material is reactive with the mine's explosive filler and initiates deflagration (rapid burning) but not detonation. Energetic destruction of the mine results from the combined effects of the projectile's reactive material and its kinetic energy. Positive evidence of the reaction is visible at the surface, providing assurance that the mine has been destroyed. The projectile was developed by C-Tech Inc, with support from the Office of Naval Research, the Coastal Systems Station, and Raytheon.

Variants/Upgrades

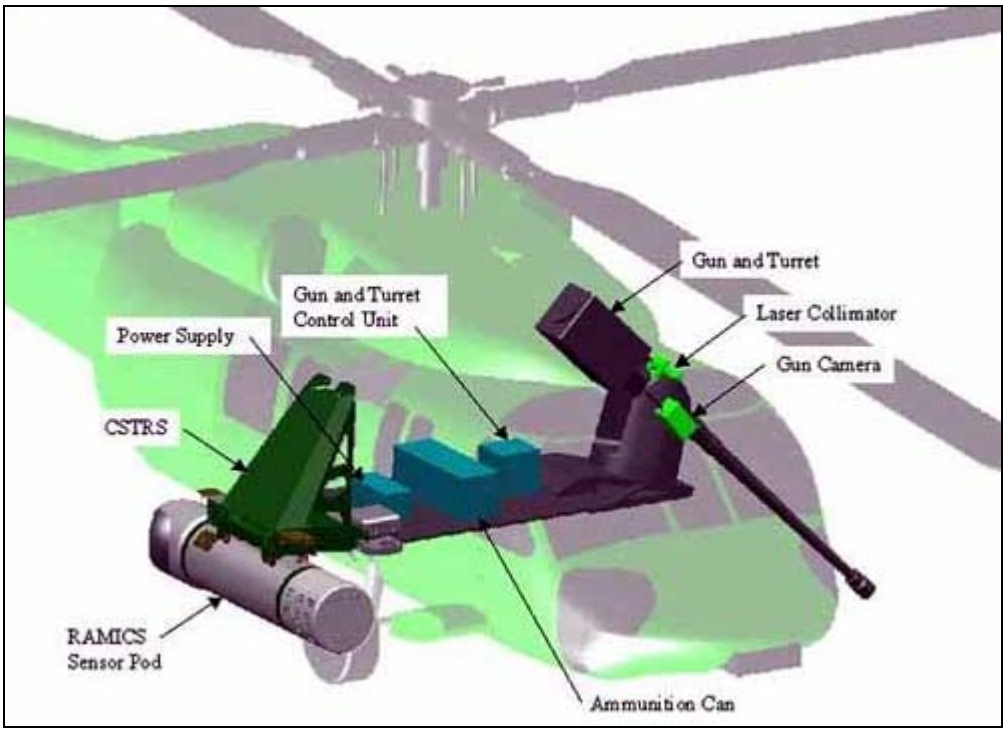
Mk 258 Mod 1. Designation for the complete cartridge including a Raufoss-designed long-rod penetrator with supercavitating nose and tapered fore body. The Mk 258 Mod 0 is a non-cavitating round used against surface targets.

Additional Applications. RAMICS had potential as a final, hard-kill defense against anti-ship torpedoes. Installed as a ship-mounted gun, RAMICS' fire control system would be directed by an acoustic detection and tracking computer monitoring for incoming torpedoes. The basic operating principle is similar to that of the U.S. Navy's Phalanx close-in anti-ship-missile weapons system, and the Goalkeeper system of the navies of the U.K. and the Netherlands. RAMICS would have had an effective defensive firing range of anywhere from a few hundred yards to within 100 feet of the ship under attack. Additionally, undisclosed Special Forces applications for RAMICS were added to the use portfolio. Interest in RAMICS had also been expressed for search-and-rescue and air-to-air operations, for protection/offense against small craft and vehicles, for very shallow water MCM, and for swimmer defense and use in anti-submarine warfare.

AWS-2 Rapid Airborne Mine Clearance System (RAMICS)

Source: U.S. DTIC

AWS-2 RAMICS



RAMICS Installation on MH-60

Source: United States Navy

Program Review

Background. The concept for RAMICS evolved in the early 1990s based on the hard lessons learned in dealing with mines during the Persian Gulf War. Government funding started around 1994 under PE#0602315N, Mine Countermeasures, Mining and Special Warfare Technology, which oversees the U.S. Navy's development of explosive ordnance for mine countermeasures (MCM). (This program also focuses on the Navy's Joint Littoral Warfare Mission area.) Prior to full government support, the original developer, Hughes, funded its own development of RAMICS.

The U.S. Navy awarded Hughes a $1.5 million contract in the spring of 1995 to develop RAMICS for deployment aboard the Navy's MH-53E and SH-60 helicopters. Under this contract, Raytheon was responsible for overall system integration and the laser targeting system. Raytheon acquired the Alliant Techsystems division through its purchase of Hughes, and assisted with the development and production of the mine-destructor 20mm munitions. C-Tech was responsible for technical support in developing the kill mechanisms and for hydrodynamic testing.

Transfer to Technology Development

In 1997, the RAMICS effort was transferred to the U.S. Navy's Advanced Technology Demonstration Project of the Advanced Technology Transition Program. The program was delayed by some four months following difficulties with the munitions, but successfully completed its first-year demonstration in November 1998. A total of five explosive targets were neutralized in the demonstration series. The target matrix included several mine shapes, including witness plates, surrogate mines, and two Mk 6 mines (300 lb of TNT). In each test, a single anti-mine projectile (AMP) effected target neutralization through a deflagration process, which resulted in case rupture. This series of tests validated the lethality of the supercavitating projectile design against submerged large explosive targets. The next goal was to integrate the AMP into a fully compatible ammunition for firing from the Mk 197 Gatling gun. This was completed by the end of 2000, with test firings being conducted from an AH-1 helicopter.

Additional work was undertaken to improve the mine detection and laser-ranging components of RAMICS. Errors in slope measurement significantly affected the accuracy of RAMICS. At the same time, a method for removing capillary wave distortions in the system was being evaluated. Work during 2000-2001 included fully integrating RAMICS' gun system with the H-60 family of helicopters, and the development of advanced supercavitating projectile and image restoration algorithms. The aim was to develop higher caliber rounds with decreased hydrodynamic drag.

Firing Trials Successful

The first live-fire tests of RAMICS, carried out in 2000, had two objectives. The first was to demonstrate that a mine could be successfully located under water. This objective was met when the AES-1 LIDAR successfully ranged and imaged both the reflection and the shadow of the target.

The second objective was to prove that the supercavitating projectile could successfully penetrate the mine at the intended range. In preliminary firing tests, rounds were fired single-shot from a Mann barrel, a test barrel that is standard for determining ammunition accuracy. Once the M197 Gatling gun was in place, burst firing was conducted against paper and aluminum targets to measure the total yaw, velocity, and in-flight dispersion of the gun's rounds in a simulated RAMICS engagement scenario. Following that, the mine targets were placed in the tank.

The Pacific Ranges and Facilities Department carried out the testing with support from Raytheon, the RAMICS prime contractor, along with the U.S. Naval Surface Weapons Center Coastal Systems Station and Kaman Aerospace Inc. The mine was successfully targeted and hit (simulating a mine neutralization), and the test was deemed a complete success.

These tests were conducted using an AH-1F helicopter mounted on a platform above a tank of water. They were followed by another series in September 2000 carried out in the Gulf of Mexico that successfully demonstrated the workability of the system under field conditions. The AH-1W Cobra helicopter used for the test was fleet-representative and equipped with the latest communication/navigation and airborne survivability equipment upgrades. The aircraft was extensively modified to integrate RAMICS for flight worthiness and effectiveness. Among the modifications, the night targeting system and components were removed and replaced with a contractor-supplied nose-mounted sensor/gimbal assembly, cockpit control/display unit, and laser and fire control system mounted on a specially designed ammunition bay pallet.

The system integration and ground test effort was conducted in June and July 2000, with integration flight-testing beginning in August. Local-area flight tests were conducted to evaluate the safety of the system, followed by system performance flights at the Hooper Target complex on the Chesapeake Test Range.

The test team evaluated the capability of the system to successfully track inert mines, both floating and submerged, and to recommend firing solutions for targeting the aircraft's 20mm cannon. More important, before conducting ATD Phases One and Two of the program, the test team required that RAMICS successfully demonstrate control of the cannon during full-up system operation. Prior to departing for the Aberdeen Test Center for Phase One of the ATD – a demonstration of the capability of RAMICS to destroy a submerged Mk 6 mine loaded with 300 pounds of TNT from an aircraft – the team conducted firing tests against the mines.

At Hooper Target, the test team used the Mk 149 armor-piercing discarding sabot 20mm Phalanx rounds as a precursor to firing the actual RAMICS projectile. The cannon was successfully controlled at this stage, meeting the test team objectives and paving the way to move the test to Aberdeen's Underwater Test Facility (UTF) for Phase One. At this point, the specially designed RAMICS projectiles were loaded and fired for the first time from an aircraft.

The RAMICS spin-stabilized discarding sabot rounds were designed to travel through the water column by creating an air pocket around the projectile, thereby maintaining a straight trajectory and high velocity to target impact. Two types of RAMICS rounds were used: some with salt-filled projectiles for boresighting and use against inert targets, and some with reactive projectiles designed to kinetically burn, or deflagrate, live targets.

A major milestone was passed at the UTF when the RAMICS team successfully targeted and destroyed three mines submerged in 15 feet of water from the Cobra. The first mine destroyed was inert, and the second and third destroyed were live, both loaded with 300 pounds of TNT. Each targeted mine was acquired, tracked, and destroyed in a quick and efficient manner.

Tracking System Tested

The RAMICS program then moved to the Coastal Systems Station for Phase Two. This was intended to demonstrate the system's capability to acquire, track, and engage mines at various depths in the open ocean environment. The system once again demonstrated the capability to acquire, track, target, and neutralize

floating and shallow moored mines, but this time in a more mission-representative environment.

Changing Caliber

Successful completion of this ATD represented a potential jump forward in the technology required to expeditiously clear shallow underwater minefields. The engineering and manufacturing development effort that followed this program was oriented toward the development of a removable RAMICS module, which would be integrated into the MH-60 helicopter. A key feature to be resolved was the caliber of the main gun; the tests had shown that 20mm was only marginally adequate and that a production system should use either a 25mm or 30mm cannon and projectile. By November 2002, tests had shown that the 30mm cannon had a marked superiority over other options. As a result, the final RAMICS configuration consisted of a 30mm Mk 44 Bushmaster cannon firing Mk 258 Mod 1 ammunition.

The RAMICS test and evaluation activities conducted under this contract generated significant data on RAMICS' lethality and host aircraft vulnerabilities. The results of the RAMICS Safe Standoff (SSO) tests conducted in Socorro, New Mexico, indicated that fragments from detonating a worst-case surface threat mine were more lethal than expected, with the implication being that a greater SSO distance from the mine than originally envisioned for the helicopter firing the RAMICS projectile might be required.

Phase I Lethality Tests, conducted at the West Freugh test facility in Scotland, showed that the RAMICS projectile was capable of penetrating the casing of a large near-surface mine, causing it to sink. Although the water characteristics (salinity and depth) and the target mine depths were considered mission-representative, the projectile travel distance was significantly limited by the range facilities, and the sensor and fire control components of the system were not tested.

Low-Rate Initial Production Begins

The systems development work was completed and the system certified over the period 2002-2005. This process ended with the Critical Design Review in May 2005. Under the RAMICS program acquisition strategy, mission capability was confirmed in FY05. As part of this effort, the advanced laser targeting and fire algorithms were developed for RAMICS under the Sea Mine Neutralization effort, with a focus on deeply submerged targets of interest. At one time, procurement of 44 systems was projected.

According to FY08 financial documentation, RAMICS procurement was to begin in FY09. RDT&E funding originally was to fall off significantly before then, but in subsequent years R&D funding was increased, probably due to the application of RAMICS to the Littoral Combat Ship project. In FY07, following alternate platform testing involving contractor evaluation of an MH-60S, the Navy exercised two LRIP options under the System Development and Demonstration (SDD) contract with Raytheon.

Technical evaluation (TECHEVAL) studies followed in 2008, including contractor testing, weapons systems integration trials, ground testing, delivery of an engineering development model, "captive carriage" analysis, and jettison testing on the MH-60S helicopter. A year later, an operational evaluation (OPEVAL) was scheduled to take place, but this was subsequently reprogrammed for FY11.

From FY09-FY11, this program developed logistics products, including training materials and an interactive technical manual. The program also provided engineering support, including reviews of product development and integration.

In May 2011, the AWS-2 RAMICS program was canceled, according to a report dated May 23, 2011 and published in *Jane's Defence Weekly*.

Funding

Program terminated in 2011.

Contracts/Orders & Options

Contractor	Award ($ millions)	Date/Description
Hughes	12.5	Sep 1997 – A not-to-exceed CPFF contract for the RAMICS ATD program. Completion date Sep 2000. (N61331-97-C-0046)
Northrop Grumman	36.9	Aug 2002 – A three-year contract to develop RAMICS for use by the U.S. Navy in protecting the Fleet from near-surface and floating mines.
CPI Aerostructures	0.5	Dec 2004 – RAMICS pod housings.
Northrop Grumman	2.03	Oct 2009 – Hardware and software development.
Northrop Grumman	0.532	Oct 2009 – Engineering services.
Northrop Grumman	3.103	Oct 2009 – Test and evaluation.
Raytheon	0.665	Nov 2009 – Engineering services.
Northrop Grumman	9.500	Dec 2010 – Post-delivery technical support of RAMICS units. Under this contract, delivered hardware would be modified or repaired; new RAMICS components would be modified or built to resolve productivity, obsolescence, and end-of-life issues; and the technical data package would be updated.

Timetable

Month	Year	Major Development
	1994	RAMICS concept design
Apr	1995	Initial development contract awarded
	1998	ATD (ran to 2001)
	2001	Engineering development
	2002	Evaluation and testing
	2004	Start of production system design
	2007	Prototypes delivered for testing
	2009	TECHEVAL completed
	2010	OPEVAL completed
	2011	Program canceled

Worldwide Distribution/Inventories

RAMICS was initially being developed for the **U.S. Navy** before reportedly being canceled. However, once the system was operational, select allied nations involved in airborne MCM, such as the various NATO nations, would likely have been allowed to acquire the system. Other potential customers included Japan (the only nation outside the U.S. to make extensive use of helicopter-borne MCM), a few Middle Eastern countries (Kuwait and Saudi Arabia, to start), and several countries in the Pacific Rim (South Korea, Taiwan, and Malaysia in particular).

AWS-2 RAMICS

Forecast Rationale

In May 2011, the AWS-2 RAMICS program was canceled, according to a report dated May 23, 2011 and published in *Jane's Defence Weekly*. The program reportedly ran into technical problems with the sensor and gun mountings which caused schedule delays and cost overruns. Eventually, the U.S. Department of Defense became fed up and canceled the remainder of the program and instructed the U.S. Navy to focus on developing other Airborne Mine Neutralization Systems.

This report will be archived next year, 2014.

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