Standoff Systems and Technologies for Near Shore Mine Countermeasures (MCM)

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Abstract - **The Office of Naval Research (ONR) published a Broad Agency Announcement (BAA) to solicit concepts that would lead to the development of technologies for the rapid, organic, standoff breaching of surf zone (SZ) and beach zone (BZ) mines and obstacles. The BAA solicitation resulted in three concepts that are currently funded by ONR and are referred to as the Future Countermine Counter-Obstacle (CMCO) Systems. Two are aircraft deployed and one is naval gun fired; they are HYDRA-7/Lockheed Martin, Missiles and Fire Control, Advanced Projects; Mine Obstacle Defeat System (MODS)/The Boeing Company, Phantom Works, Advanced Aircraft and Missiles Systems; and the Naval Gun Fired System (NGFS)/Science Applications International Corporation (SAIC). The Future CMCO Systems are focused on the ability to hit and destroy mines and obstacles. All three systems are developing new warhead technology. The Naval Surface Warfare Center, Indian Head Division (NSWC/IHDIV) is teamed with Lockheed Martin to develop reactive darts for mine clearance and with Boeing and SAIC to develop chemical darts for mine clearance and a continuous rod warhead (CRW) for BZ obstacle clearance. The goal of these systems is to destroy surface and buried mines, mines in the SZ, and obstacles on the beach. In addition, ONR is continuing to evaluate the use of unitary/blast warheads for effectiveness against obstacles on land and in the water. Estimates of lift for the three Future CMCO Systems are scenario dependent and are provided for a "high level" threat laydown. This paper discusses the emerging systems under development for breaching mines and obstacles in the SZ and BZ. A brief discussion of other approaches to obstacle clearance is also provided.**

INTRODUCTION

Naval Forces have a mission requirement to conduct rapid breaching of mine and obstacle fields to support amphibious landings on defended beaches by U.S. Marine Corps forces. The objective is to produce clear "lanes" through which the landing forces can move safely and rapidly. Current breaching capabilities are limited and extremely dangerous, requiring slow deliberate human intensive operations. Also, current capabilities significantly fail to satisfy the operational requirements of the more demanding future battle-space where the operational tempo will be much higher, the environmental conditions will remain just as challenging, and operations will be conducted under hostile conditions.

The Organic Mine Countermeasures (OMCM) Future Naval Capability (FNC) consists of three enabling capability priorities (ECP). The first, Enabling Capability Priority 1, is to provide organic mine countermeasures from the very shallow water (VSW), to the craft landing zone (CLZ), and then to the beach exit zone (BEZ) to enable Ship to Objective Maneuver (STOM). The vision for STOM is the seamless transition of MCM operations from deep water through to the objective inland by significantly shortening the MCM timeline and eliminating the

requirement for manned operations in minefields. The sub-capabilities associated with ECP 1 are arranged below from an operational perspective beginning with wide area surveillance to enable maneuver and concluding with rapid follow-on clearance.

- Wide area surveillance to enable maneuver
- Clandestine reconnaissance to prepare the battle-space
- Rapid overt VSW/SZ/BZ/CLZ/BEZ mine and obstacle reconnaissance
- Data fusion to accelerate the amphibious planning process
- Timely MCM Common Tactical Picture to enable maneuver
- Standoff precision neutralization of individual mines in VSW
- Autonomous, high speed compact influence sweep
- Lane marking and precision navigation from VSW to BEZ
- Standoff breaching of mines and obstacles in the SZ/BZ/CLZ/BEZ
- Rapid follow-on clearance

The current discussion will focus on standoff breaching of mines and obstacles in the surf zone, beach zone, craft landing zone, and the beach exit zone. It is important to recognize that success requires extensive knowledge of the battle-space and successful technology developments in the other sub-capabilities. As an example, the Airborne Remote Optical Spotlighting System (AROSS) demonstrated an improved capability for rapid overt reconnaissance during Fleet Battle Experiment (FBE) Hotel. AROSS provided bathymetric data and was able to determine the location of mine belts on the beach.

The Office of Naval Research published a Broad Agency Announcement in December 1999 to solicit concepts that would lead to the development of technologies for the rapid, organic, standoff breaching of SZ and BZ mines and obstacles. The BAA focuses on the development and demonstration of technologies and systems that can be "organic" to the forward deployed fleet, meaning they are to be deployed with the Carrier Battle Group (CVBG) or the Amphibious Ready Group (ARG). The breaching is to be conducted rapidly and from extended ranges to support the operational tempo of the assault and to overcome the threat of enemy defenses. This is a significant departure from traditional MCM operations in that the breaching becomes part of the air and surface strike mission. The BAA solicitation resulted in three concepts that are currently funded by ONR and are referred to as Future Countermine Counter-Obstacle Systems.

FUTURE CMCO SYSTEMS OVERVIEW

The Future CMCO Systems are focused on warhead effectiveness and the development of dispensing mechanisms, or in other words the ability to hit and destroy mines and obstacles. The goal is to target mine belts not individual mines. The systems utilize existing or emerging fleet assets for both deployment and employment. The systems are developing new warhead technology. There are three Future CMCO Systems (Table 1), two are aircraft deployed and one is naval gun fired. They are HYDRA-7 being developed by Lockheed Martin, Missiles and Fire Control; Mine Obstacle Defeat System being developed by The Boeing Company, Phantom Works, and the Naval Gun-Fired System being developed by the Science Applications International Corporation. HYDRA-7 uses darts filled with a reactive material to clear mines on the beach and in the water. The MODS and the NGFS use darts filled with a contact chemical for mine clearance on the beach and in the water, and a continuous rod warhead to clear obstacles on the beach. The Naval Surface Warfare

Center, Indian Head Division is teamed with Lockheed Martin to develop the reactive-material filled darts and with both The Boeing Company and SAIC to develop the chemical darts and CRW. In addition, ONR continues to evaluate the use of unitary/blast warheads for effectiveness against obstacles on land and in the water.

LM	HYDRA-7	Reactive Darts	BZ/SZ Mines
Boeing	MODS	Chemical Darts CRW	BZ/SZ Mines BZ Obstacles
SAIC	Naval Gun	Chemical Darts CRW	BZ/SZ Mines BZ Obstacles

Table 1

HYDRA-7. The HYDRA-7 mine clearing system is aircraft (F/A-18) deployed. A tactical munitions dispenser (TMD) is employed to deliver sub-munitions to the target area. Each TMD carried by the F/A-18 delivers five sub-munitions and each of these sub-munitions carries approximately 1,000 reactive material filled darts. The total number of darts delivered to the targeted area for each TMD employed is about 5,000. Furthermore, each of the sub-munitions has a guidance system and propulsion system to accurately guide it to the targeted area. The propulsion system is used to achieve and maintain an optimal path to the targeted area and to increase the velocity of the sub-munitions during the terminal phase of their flight. The sub-munitions initiate a terminal maneuver upon reaching the targeted area that results in each being oriented nearly vertical with respect to the ground target. The propulsion system then increases the velocity and the darts are dispensed from the sub-munitions. The increase in velocity is required in order for the darts to be dispensed with sufficient kinetic energy to destroy the mines.

The HYDRA-7 team members and their roles are identified below:

- Lockheed Martin Advanced Projects; *System Integration/Guidance and Control, Warhead and Dispense Design*
- NSWC/IHDIV; *Warhead and Dispense Design and Testing, WESERB*
- General Sciences Inc. (GSI); *Dart Design*
- Coastal Systems Station (CSS); *System Engineering*
- Naval Air Weapons Center (NAWC); *Aircraft Integration, Dispenser Sled Test*

The baseline HYDRA-7 dart (Figure 1) is made of steel and is 4.5” long, 0.35” in diameter along its shaft, and weighs 27 grams. The goal is to destroy surface and buried mines and mines in the SZ. The reactive material is carried within the body of the dart. A reactive material is a material that when subjected to a mechanical or thermal stimulus will react generating intense heat and pressure. This technology is similar to what has been successfully demonstrated for the Rapid Airborne Mine Clearance System (RAMICS). The HYDRA-7 program has successfully demonstrated the feasibility of using this dart concept to clear BZ mines using plastic and steel cased surrogate mines. The dart is designed to ignite the reactive material contained inside its body as it penetrates the mine. The reaction of the reactive material causes the high explosive within the mine (TNT) to burn or detonate. This is accomplished when the dart impacts the mine case, penetrating it and causing the TNT to fracture. The fractured TNT provides additional surface area for the reactive material to interact with the TNT promoting a spontaneous and continuous reaction.

Figure 1

Mine Obstacle Defeat System. The MODS is another aircraft (F/A-18) deployed concept. It employs the production Joint Direct Attack Munition (JDAM) BLU-109 guided vehicle kit to deliver the two new warheads to the targeted area. The JDAM tail kit provides Global Positioning System and Inertial Navigation System (GPS/INS) capability for accurate guidance. The standoff is consistent with the current JDAM BLU-109 mission and is about 7 miles. The MODS is launched from the aircraft and guided to the targeted area where it performs a terminal maneuver that results in it being oriented in a vertical position relative to the ground. The chemical darts or the CRW are then dispensed from the MODS.

There are two variants to the MODS. The MODS-P is equipped with the chemical darts for mine clearance and the MODS-C carries a continuous rod warhead for obstacle clearance. The MODS-P is being configured to carry 6,320 chemical darts and the MODS-C is configured to carry a single CRW. The MODS team members and their roles are shown below.

- Boeing Phantom Works; *Air Vehicles/ Guidance and Control*
- NSWC/IHDIV; *Design of Warheads (chemical darts, CRW) and Testing*
- Talley Defense Systems; *Dispense Systems*

Naval Gun-Fired System. The NGFS employs the Best Buy Projectile to deliver the same two warheads being developed for the MODS. The Best Buy Projectile is being used to demonstrate the CMCO technology in a 5-inch gun configuration. However, this technology is scaleable to the 155-millimeter guns and therefore, the transition target is the Long Range Land Attack Projectile (LRLAP) being developed for the Advanced Gun System (AGS). The warheads are smaller than those used in the MODS in order to accommodate the 5" diameter of the Best Buy Projectile, but it is the same technology, namely, the chemical darts for mine clearance and the CRW for obstacle clearance on the beach. There are two variants, one projectile configured to deliver the chemical darts and another to deliver a single CRW. The Best Buy Projectile (5") can deliver 612 chemical darts and a 155-mm projectile is projected to be able to deliver 1,120 chemical darts. The projectiles can be launched from the ship at a standoff of at least 30 miles. The flight trajectory consists of a ballistic phase and a range extended glide phase. As the projectile approaches the targeted area it performs a terminal maneuver that gives the projectile a vertical orientation with respect the ground. At this point the payload is dispensed from the projectile. The NGFS team members and their roles are identified below:

- SAIC; *Systems Integration, Delivery Vehicle*
- NSWC/IHDIV; *Design of Warheads (chemical darts, CRW) and Testing*
- Custom Analytical Engineering Systems (CAES); *Hardware and Integration for Delivery Vehicle*
- Alliant Allegheny Ballistic Laboratory (Alliant ABL); *Rocket Motors*
- NAVSYS; *Guidance and Control*

The Best Buy Projectile represents mature technology and was designed for future production in large quantities at a low cost. It is a double-ram design weighing 165 pounds and is 111 inches tall. The Best Buy Advanced Technology Demonstration (ATD) was started in FY 1997 and was completed in FY 2000. The ATD successfully developed and flight tested high performance composite jointed projectiles that maximize projectile payload and range performance for the improved Navy Mk 45 gun (MOD 4 5"/62). The Best Buy Projectile has already been tested in various short-range and extended

range gun tests to assess performance. The NGFS is leveraging the successes of the ATD by adapting the Best Buy Projectile design to meet the CMCO mission requirements. The Best Buy ATD primarily addressed the composite airframe, rocket motor, and long-range, aerodynamic and mechanical aspects of the projectile. As part of the NGFS development, SAIC will conduct a flight test program to demonstrate improved guidance, control, and accuracy. During these tests the projectiles will be equipped with a GPS-aided-INS guidance system. SAIC will use the same GN&C components that they are developing for the Advanced Gun System Land Attack Projectile.

Warhead Technology. The MODS and the NGFS use the same warhead technology to destroy surface and buried mines, mines in the SZ, and obstacles on the beach. The chemical darts are used to destroy the mines and the continuous rod warhead is used to clear obstacles on the beach. The chemical dart (Figure 2) has four main components, solid nose, housing assembly, surface contact chemical, and fins. It is designed to penetrate various combinations of air, water, and sand, as well as the material used to construct the mine (plastic, metal). As the penetrator punches through the case of the mine breaking up its explosive fill, additional surface area is created and the penetrator deposits the surface contact chemical, Diethylenetriamine or DETA. This chemical reacts on contact with the mine's explosive fill causing an exothermic reaction that results in the consumption of the explosive fill and destruction of the mine. DETA has been shown to be effective against TNT, Comp B, and RDX-based explosives. A reaction can occur without the presence of air since the explosive materials found in mines contain sufficient oxygen within their molecules. Thus, effectiveness is not expected to degrade when mines are buried or underwater. The final design of the chemical dart is yet to be determined, but the baseline configuration weighs 38 grams and contains 7.5 milliliters of DETA. This approach represents proven technology. The U.S. Army has demonstrated the use of chemicals to initiate anti-personnel mines and more recently NSWC/IHDIV has demonstrated that DETA can be used to destroy mines.

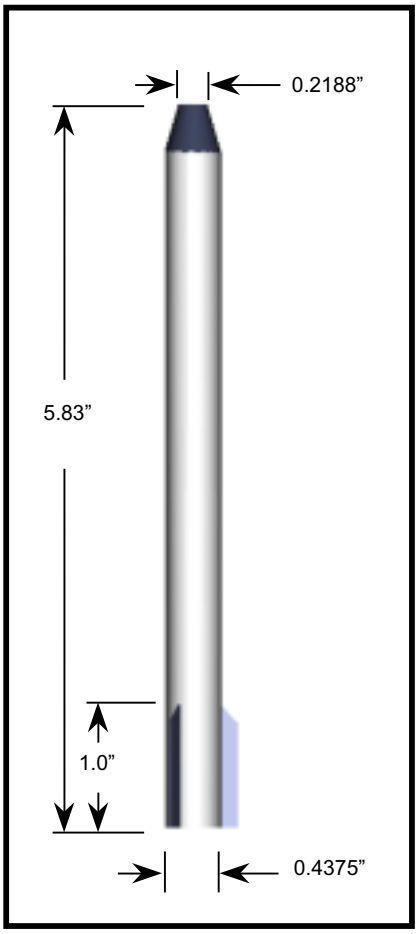

Figure 2

The continuous rod warhead is a special purpose warhead used in air-to-air missiles, such as the Phoenix, to attack enemy aircraft and is being adapted for obstacle clearance. It is composed of an explosive charge surrounded by steel rods. The rods are positioned next to each other forming a circle around the charge and welded at alternating ends. When the explosive charge is detonated

the rods are propelled outward forming a ring that expands as it is propelled parallel to the ground. The expanding ring of rod material will destroy obstacles, such as tetrahedrons, concrete cubes, and hedgehogs that are in its path. Therefore, effectiveness of the CRW is determined by the diameter of the circle created which is referred to as the "lethal diameter". The CRW provides an increase over unitary/blast warheads against obstacles on land since its lethal diameter is expected to be twice as large. However, its lethality is severely reduced in water thus offering only a very limited capability against surf zone obstacles.

UNITARY/BLAST WARHEADS

The first point regarding the use of unitary/blast warheads or any of the CMCO Future Systems is that they must be guided in order to be effective. This point has been reiterated in a number of previous studies. ONR is continuing to evaluate the use of unitary/blast warheads for BZ and SZ obstacle clearance. This will provide risk mitigation in the event the CRW does not provide the expected capability against BZ obstacles, and provide some capability against obstacles in the SZ where the lethality of the CRW is severely reduced.

Mine Clearance. The U.S. Air Force and the U.S. Army have evaluated the use of unitary/blast warheads for mine clearance. After reviewing the data, it has been concluded that unitary/blast warheads are ineffective against blast-hardened mines.

Obstacle Clearance. The CRW currently under development is effective for clearing obstacles in the BZ but offers very limited capability against obstacles in the SZ. ONR has been evaluating the effectiveness of unitary/blast warheads for obstacle clearance as part of the 6.2 Breaching Applied Research Program. Arena type testing has been conducted using MK 80 series bombs. The results indicate that bombs provide some capability to destroy obstacles on land (Figure 3). Arena type tests have been conducted against obstacles in water yielding similar results. The in-water tests show that some obstacles are destroyed while others are moved from their original position. The formation of craters on the beach and the sea bottom can be avoided. The sequential detonation of multiple bombs to create a wave that sweeps the obstacles from the lane has been evaluated.

Figure 3

The lethal diameter provided by bombs used for BZ obstacle clearance is half the size considered achievable by special purpose warheads such as the CRW. The weapon's lethal diameter directly influences the number of weapons required and therefore, the lift associated with its employment. Since the lethal diameter of the CRW is twice that for

bombs, less CRW weapons are needed to clear a given lane.

Channeling. The use of unitary/blast warheads to create a channel through the SZ and BZ has been shown to be technically feasible. A channel can be created in the SZ perpendicular to the water line by simultaneously detonating a line of air dropped bombs. The blast from the bombs ejects the sea-bottom material as well as mines and obstacles from the channel. Small-scale tests conducted as part of the ONR 6.2 Breaching Applied Research Program have shown that effective channeling requires precision guidance, very large bombs (at least 4,000 pounds), an explosive possessing high bubble energy for use in water, and special purpose fuzing. It is estimated to require 100 pounds of explosive per linear foot to clear a channel 50 yards wide. For example, to create a channel in the SZ (0-10-foot water depth) using a threat scenario that includes a beach gradient of 1:99 would require nearly 100,000 pounds of explosive. Channeling is explosive intensive and estimates suggest it would require significant amount of ordnance.

LIFT ESTIMATES

Estimates of lift are scenario dependent. They are determined by evaluating the performance of the systems against mines and obstacles in a realistic threat environment. The ultimate goal is to determine the number of weapons needed to clear a lane. The threat laydown used is a lane that is 50 yards wide and contains belts of mines and medium obstacles. The Marine Corps Intelligence Agency (MCIA) has assessed this scenario as a "high level" scenario, therefore, it represents the worst case. The threat encountered during Desert Storm was less severe. The threat laydown was provided to all three vendors and the Coastal Systems Station to determine lift estimates for the three Future CMCO Systems. The systems are targeting the mine belts and not individual mines. A circular error probable (CEP) of three meters is used for all estimates. The estimates provided are preliminary.

Mine Obstacle Defeat System. Using the threat laydown described, it is estimated that 48 MODS (36 for mines and 12 for obstacles) are required to clear a single lane that is 50 yards wide. This represents 12 aircraft sorties. These estimates address a worst case scenario. A less severe threat laydown would require significantly fewer weapons. These estimates are representative of aircraft deployed systems. Therefore, the HYDRA-7 estimates for mine clearance are similar.

Naval Gun Fire. Estimates for the NGFS have been provided by the CSS for both the 5-inch and 155-mm naval guns. To clear a single lane that is 50 yards wide of both mines and obstacles, it is estimated to require 582 5-inch rounds and 246 155-mm rounds. These are preliminary estimates. Using the magazine space allocated to the Extended Range Gun Munition (ERGM), SAIC projected the number of weapons that could be carried on ships. The employment of the 5-inch weapon is prohibitive, assuming these estimates remain constant, however, employment of the 155-mm weapon is more realistic. Again, these estimates are for a worst case scenario. A less severe threat laydown would require significantly fewer weapons.

CONCLUSION

The Future CMCO Systems will enable STOM by significantly shortening the MCM timeline and eliminating the requirement for manned operations in minefields. The systems are envisioned to be "organic" to the forward-deployed fleet enabling breaching to be conducted rapidly and from extended ranges.

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