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The United States has faced the challenges of mine warfare since the American Revolution. One would assume that the Armed Services' long-standing experience of conducting countermine warfare would have yielded many lessons learned and improvements in countermine measures. After all, advancements in ships, weaponry, and aircraft all occurred rapidly during and after each war. However, this not is the case with mine-counter measures (MCM). These articles will look at the historic context of MCM, frame the problem of MCM today, and offer solutions for tomorrow's force against the backdrop of the Marine Operating Concept (MOC) and Littoral Operations in a Contest Environment (LOCE).

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Executive Summary

Part One: Those Who Cannot Remember the Past are Condemned to Repeat It MCM Lessons from Wonsan. The *Marine Corps Operating Concept* concludes conducting littoral operations in a contested environment in order to conduct littoral maneuver is important for future battles. A critical enabling factor for projection of naval power in the world's littorals is Mine Counter Measures (MCM). Before the next conflict, the services must learn from the past in order to minimize the risk to forces while conducting MCM during joint forcible entry operations. The Battle of Wonsan offers many MCM lessons that the Navy and Marine Corps may use to improve MCM mission for future wars. For example, the Battle of Wonsan demonstrated that in order to conduct successful MCM operations the service must have appropriate intelligence, adequate equipment, and properly trained personnel. While the technology has changed, the experiences at Wonsan can provide useful tactics, techniques, and procedures to conduct future MCM operations.

Part Two: Amphibious MCM: The Problem the MOC Forget About: For the last decade and a half, the Navy and Marine Corps have become increasingly concerned with littoral operations; both the Navy and Marine Corps must renew their proficiency in fighting for and gaining sea control in order to employ forces ashore. A type of Joint Forcible Entry Operation (JFEO), the amphibious assault, is perhaps the most complex type of JFEO requiring well-coordinate command and control and synchronized support from each of the services. In order to create sea lanes for the amphibious assault, the Navy and Marine Corps each have specific responsibilities for clearing mines and obstacles from the deep water to the beach. The Marine Corps lacks the capability to conduct breaching and proofing operations due to significant gaps

in the Marine Corps systems of systems created by budget constraints and minimal interest in MCM.

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Part One: Those Who Cannot Remember the Past are Condemned to Repeat It:[1] **MCM Lessons from Wonsan**

…when you can't go where you want to, when you want to, you haven't got command of the sea. And command of the sea is a rock-bottom foundation for all our war plans. We've been plenty submarine-conscious and air-conscious. Now we're going to start getting mine- conscious—beginning last week.

-Admiral Forrest Sherman, USN Chief of Naval Operations, October 1950

Mine countermeasures (MCM) date back to the American Civil War when Union Rear Admiral Farragut led his ships into Mobile Bay on 6 August 1864. Many only remember the Admiral "damning the torpedoes," and boldly maneuvering through the minefield, and do not remember the detection, marking, and neutralizing of the mines that occurred several nights before. About a week before the Union entered Mobile Bay, Lieutenant John Crittenden Watson led a mine-hunting expedition. Unobserved by Confederate forces, Lieutenant Watson quietly rowed into the bay and sunk mines by cutting holes in the buoys that held them afloat. He next marked the locations of the cleared lanes and took notes of mines not yet sunk. Watson's mine-hunting mission was so extensive that many believed Admiral Farragut was "well informed as to the location of [all] torpedoes planted,"[1] which enabled him to steer confidently into the bay. Many historical examples of MCM provide valuable lessons that can be applied to the future of warfare.

Littoral Operations in a Contested Environment concludes conducting littoral maneuver in a contested environment is important to fighting future battles. A critical enabling factor for projection of naval power in the world's littorals is MCM. Before the next conflict, the services must learn from the past in order to minimize the risk to forces while conducting MCM during joint forcible entry operations. The Battle of Wonsan offers many MCM lessons that the Navy

[1] George Santayana, *The Life of Reason: Reason in Common Sense* (Scribner's, 1905), 284.

and Marine Corps may use to improve MCM mission for future wars. For example, the Battle of Wonsan demonstrated that in order to conduct successful MCM operations the service must have appropriate intelligence, adequate equipment, and properly trained personnel. While the technology has changed, the experiences at Wonsan can provide useful tactics, techniques, and procedures (TTP) to conduct future MCM operations.

In September of 1950, General Douglas MacArthur decided to conduct an amphibious landing at Wonsan harbor in order to shorten lines of supply for units operating on the Korean peninsula and to "bring pressure upon Pyongyang should the attack upon [the] enemy capital result in a long, drawn-out siege."[2] The Tenth Corps Commander, General Edward Almond, wanted forces to land at Wonsan by 15 October to allow the Eighth Army enough time to pass through his Corps and start receiving supplies from the ships at the port. However, Wonsan harbor was not cleared of mines until 25 October due to a deficiency of intelligence, inadequate equipment and absence of trained personnel. Naval planners estimated clearing of the mines would only take five days; however, it took the Navy fifteen days to clear Wonsan bay.[3] By the end of the operation, Naval leadership learned many lessons in MCM operations.

The first valuable lesson learned from Wonsan that may be used for today's MCM operations is ensuring the appropriate intelligence is utilized when conducting planning. While useful intelligence may seem obvious, there are several types of detailed intelligence that are not usually considered for other operations. Detailed maps of the Wonsan harbor, including the location of potential mines were not available. To make up for this deficiency, the Navy began to use helicopters for locating mines. The use of helicopters became a TTP for the Navy after Wonsan. Today, the services have experimented with aircraft to locate both proud and buried

mines with varying degrees of success[2]. In addition to manned or unmanned aircraft, the joint services are also using unmanned underwater vehicles to providing the types and locations of mines. The joint services must continue to improve ground penetrating radar systems from different platforms to better detect mines in the water. The location of mines will assist the planning of where to clear and mark lanes for the Air Cushion Landing Zone (CLZ). Additional intelligence that is important for MCM planning are hydrographic surveys. Water level, tides, and currents all play an essential role in clearing mines. Additionally, the bathymetry of the Korean peninsula was not understood during the Korean War. Both tides and depth of water is critically important in MCM because of the different types of mines that can be laid in the surf zone (SZ), very shallow water (VSW), shallow water (SW), and deep water.[3] Only after the battle did leaders understand how ideal North Korea's hydrography was for the use of mines. Wonsan, in particular, had a large shelf of shallow water with muddy bottoms[4] that made mine laying very effective.[4] However, even the opposite shore of North Korea favored the defender: the west coast was a honeycomb of shallows, ideal for mine laying. Furthermore, the tidal range around the peninsula was 21', meaning the location of the SZ, VSW, and SW could be different on any given day. Not only did the shifting zones make command and control difficult, but it also may have changed the method of marking and neutralization of the mines. The Koreans used the tides to their advantage: a floating mine dropped from any port could transverse the peninsula with fifteen days because of the strong currents.[5] Finally, hydrographic after-action

[2] The four primary types of mines include bottom or "proud" mines that target submarines or ships in shallow water; moored mines held in place by anchors; floating mines assembled in buoyant cases and anchored; or buoyant drifting mines carried by currents and tide (http://mil-embedded.com/articles/unmanned-navys-sea-mine-hunting-capabilities/).
[3] Water depth classifications: SZ is 0-10', VSW is 10' to 40', SW is 40'-300' and deep water is 300'-1000'.
[4] Research did not uncover if the muddy bottoms had any effect on the actual landing forces. However, this is another intelligence consideration for today's forces: soil composition and trafficability of the coastline for assault breacher vehicles and amphibious assault vehicles to maneuver through.

reports showed nearly all suitable landing beaches in Korea were ideal for mining operations.[6] All of these factors led to casualties and loss of essential MCM equipment, as well as a delay in minesweeping operations.

Prior to conducting MCM in joint forcible entry operations, naval planners must insist on obtaining all appropriate data. Only if the underwater terrain is understood can leaders know how the defender can use it to their advantage and reinforce it with mines. Wonsan planners did not have the appropriate intelligence, as a result nearly half the MCM ships were destroyed, over 200 men became casualties, and the amphibious landing lost the element of surprise due to the lengthy clearing operation.[7] Admiral Sherman summarized the debacle at Wonsan: “Let's admit it, they caught us with our pants down. Those damn mines cost us eight days' delay in getting the troops ashore and more than two hundred casualties. That's bad enough. But I can all-too-easy think of circumstances when eight days' delay offshore could mean losing a war.”[8] Sherman’s comment reflects the importance of MCM today: a delay in projecting power ashore could mean losing a war. During the planning phases of a joint forcible entry operation, leaders must consider hydrographic data to include bathymetry in order to understand the potential location and types of mines present in the water leading up to the beachhead. Had planners known that the 400 square miles of water surrounding Wonsan harbor contained more than 3,000 mines, they might have been able to allocate suitable equipment and personnel.[9]

Perhaps just as obvious of an after-action bullet, although also very important, is ensuring appropriate MCM equipment is available to counter the technology of old and new mines. From the beginning of the operation, not only were amphibious craft limited in availability, but also the amount of MCM ships were limited. For the amphibious assault, the Navy only dedicated six minesweepers to the operation. In comparison, the invasion of Okinawa “had been preceded by

more than 100 sweepers; at the invasion of Normandy, by 300."[10] The 3,000 mines in Wonsan were comparable to the number of mines during World War II amphibious assaults, yet the amount of equipment available was almost none. MCM equipment shortfalls occurred because of budget cuts after World War II. Although successful mine-hunting sonar was developed in 1944, not much other new technology was invented to defeat minefields. Additionally, the amount of MCM ships was reduced from 374 to 37.[11] Today, the Navy only has eleven MCM ships.[12] If the United States were to conduct an amphibious assault on Wonsan today, the current number of MCM ships would be insufficient to combat the mine threat.

Furthermore, the United States was not prepared to combat the different types of mines during the Korean War. The North Koreans laid magnetic, pressure, and acoustic mines inside Wonsan harbor. In addition to these older variants of mines, the North Koreans also laid the newest type of mine: the combination mine.[5] The US Navy struggled to defeat the older mines and did not have technology to combat the combination mine.[13] Naval leadership created ad-hoc solutions on mine neutralization as they conducted sweeping operations. Lack of adequate equipment for emerging explosive obstacle technology was a problem for forces in the 1950s and continues to be problem for forces operating today in the Middle East. For example, ground forces were forced to change TTPs and create "on the fly" solutions for combating IEDs. Just as the adversaries in Iraq and Afghanistan were able to delay ground movements and cause causalities with crude, homemade IEDs, leaders at Wonsan observed that "simple application of extensive fields of…mines, many of them antiques laid by small native vessels, could hold up a

[5] Magnetic mines are seafloor mines which are detonated when the Earth's magnetic field is disrupted by a passing ship. Acoustic mines (also seafloor mines) are detonated by the machinery or propeller noise of a passing ship. Pressure mines are anchored mines and detonate when the negative pressure of a passing ship sucks a diaphragm upward, closing the firing switch. A combination mine is an anchored mine that combines the above: magnetic acoustic or pressure magnetic (Malcolm Cagle and Frank Manson, *The Sea War in Korea* (Annapolis, Maryland: United States Naval Institute, 1957), 124.

superior naval force with inadequate MCM capabilities."[14] After Wonsan, the Navy and Marine Corps began researching more effective MCM equipment but, like before, funding was soon cut to all MCM developments and forgotten about until the Gulf War. Today, the United States still cannot combat either unsophisticated or sophisticated mines laid in the VSW, SW, and SZ.

The adversaries' littorals of tomorrow will be covered with simple to complex mines from the deep water to the SZ. The Naval team must learn from Wonsan that control of the littorals will be much easier to obtain if adequate mine sweeping forces and experienced people are ready before the next war.[15] The joint force today must modernize its MCM equipment and train personnel to meet today's explosive hazards. Naval leaders at Wonsan recognized that a system of systems (SoS) must be utilized in order to combat the variety of mines. By the end of the ten-day sweep of the waters, the Navy utilized small boat sweepers, Navy Explosive Ordnance personnel, detection equipment, direct path markers, counter-mine bombing, and helicopters for detection as their SoS.[16] Today, the Navy-Marine Corps team has a modern MCM SoS known as the Assault Breaching System (ABS)[6]. Yet, significant gaps exist in the ABS due to lack of funding and technological advancements. Even with the ABS today, Naval leaders would still face difficultly in breaching the minefield at Wonsan. The joint force cannot fall back on old habits; relying on "quick-fix solutions" [17] for combating naval mines. Not only do the services need more MCM equipment, but also an advanced MCM SoS that can defeat belts of simple and complex mines. With the improvement of equipment, trained personnel are also required in order to operate the equipment to defeat the minefields.

[6] The current SoS refers to Coastal Battlefield Reconnaissance and Analysis (COBRA), C4I (MINEnet tactical), Counter-Mine Counter-Obstacle (JABS), and Precision Navigation and Marking (PN&M). These systems will provide targeting data, mission data, breaching, and navigation of the landing force (Lieutenant Colonel Michelle Macander (I Marine Expeditionary Force Engineer) email to author, 27 November 2017).

The last major lesson learned from Wonsan was the "considerable lack of minesweeping forces and experienced personnel available."[18] Prior to the Korean War, the training of amphibious forces did not include the sweeping of live-contact or dummy mines. Thus, not only were there not enough personnel to conduct the mission, the few minesweeping personnel were not properly trained.[19] This compounded the previously mentioned problems at Wonsan. With inadequately trained personnel, the minefields were not properly swept, which led to several of the MCM ships running into mines. Additionally, the SoS that became required to sweep the minefield required ships operating in close sweep formation, landing crafts able to conduct precision navigation, and Navy EOD personnel able to neutralize the identified mines.[20] None of these forces had previously worked together, creating communication and command and control issues. After Wonsan, the training of personnel to become MCM experts increased exponentially. Educational programs from career professional military education to annual training and even master degree programs were established in order to create a cadre of subject matter experts (SMEs).[21] These educational opportunities allowed the SMEs to innovate and create new methods of defeating the minefields.

Unfortunately, much like the equipment, the MCM educational programs were cut a few years after the Korean War ended.[22] Additionally, today's Navy and Marine Corps only has very few mine warfare qualified personnel. Marine Corps engineers have insufficient exposure to training and employment of MCM equipment aboard ship-to-shore connections and limited ability to proof assault lanes and CLZ during amphibious operations.[23] In order to conduct amphibious operations in the future, the Navy and Marine Corps must train their personnel in MCM operations. Marine Corps engineers have journeymen schools at the non-commissioned officer, staff non-commissioned officer, and senior staff non-commissioned officer levels. The

officers can receive basic MCM training at their basic engineer officer course and refresher training during the Occupational Field Expansion Course weeks during Expeditionary Warfare School. If the services wait until the next major conflict to start training their personnel, it will be too late. The joint forces cannot afford the casualties experienced at Wonsan where minesweeping personnel made up only 2% of the force, but mines accounted for 20% of casualties.[24]

The MCM operations conducted at Wonsan provided several lessons learned that could be applied to today's United States military. Proper intelligence, equipment, and personnel are all important when planning a joint forcible entry operation. Detailed consideration must go into the planning for the clearing of obstacles in the water. Vice Admiral Charles Turner Joy, who observed the Wonsan MCM operation, summarized the problem best: "…no so-called subsidiary branch of the naval service, such as mine warfare, should ever be neglected or relegated to a minor role in the future. Wonsan…taught us that we can be denied freedom of movement to an enemy objective through the intelligent use of mines by an alert foe."[25] Knowledge, funding, and training for MCM over the last half century displays a distinct pattern: during conflict "quick-fix" solutions and hasty SMEs are created, post-conflict concern and budgeting for MCM increases exponentially, then once the military budget shrinks, "MCM is the first thing to go."[26] With high likelihood that the next conflict will be near the littorals, the United States military cannot afford to react to enemy minefields. There are simply too many lessons learned from previous MCM operations to ignore. Until the joint services "learn more about the reality and potential of mines and their counter-measures, MCM will no longer be called the Cinderella of the service and considered a subject about which much is written and less is done."[27] History highlights the problems associated with MCM; unfortunately, many of the same problems exist

today. The Naval Services must make MCM their priority or face the same consequences experienced during previous battles.

Part Two: Amphibious Breaching: The Problem the MOC Forget About

For the last decade and a half, the Navy and Marine Corps have become increasingly concerned with littoral operations. Several publications from *Operational Maneuver from the Sea, Ship-to-Objective Maneuver, Seabasing, and Expeditionary Force 21* to the current *Marine Corps Operating Concept* (MOC) and *Littoral Operations in a Contested Environment* (LOCE) all point to the same problem: the Navy and Marine Corps must renew their proficiency in fighting for and gaining sea control in order to employ forces ashore. The one mission that remains consistent amongst all these documents is Joint Forcible Entry Operations (JFEO). One of the more challenging operations, JFEO is "a joint military operation conducted against armed opposition to gain entry into the territory of an adversary by seizing a lodgment as rapidly as possible in order to enable the conduct of follow-on operations or conduct a singular operation."[28] One type of JFEO is the amphibious assault. The amphibious assault is perhaps the most complex type of JFEO requiring well-coordinated command and control and synchronized support from each of the services. As the United States amphibious force-in-readiness, the Marine Corps executes amphibious assault operations. In order to create sea lanes for the amphibious assault, the Navy and Marine Corps each have specific responsibilities for clearing mines and obstacles from the deep water to the beach. The Marine Corps lacks the capability to conduct breaching and proofing operations due to significant gaps in the Marine Corps systems of systems created by budget constraints and minimal interest in MCM.

Amphibious assault operations are operations that are conducted from the water by an amphibious force (AF) to conduct landing force (LF) operations within the littorals.[29] Composed of an amphibious task force and landing force, the AF mission is to secure critical objectives that will enable the establishment of a lodgment. Part of the difficulty of amphibious operations is

command and control between key leaders. While each commander has defined responsibilities, often these duties overlap and become complex when conducting mine countermeasures (MCM). The commander, amphibious force (CAF) is the overall responsible officer for the amphibious operation. Subordinate to CAF is the commander, amphibious task force (CATF) and the commander, landing force (CLF). The CATF is responsible for debarkation and ship-to-shore movement until termination of the amphibious operation; additionally, the CATF is also responsible for mine clearance in the maritime areas of the amphibious objective area (AOA) (from the shallow water through the SZ).[30] The CATF is also responsible for conducting assault breaching operations from the shallow water through the SZ and up to the agreed upon line of demarcation. This line of demarcation is determined during the amphibious planning process and mutually agreed upon by the CLF and the CATF. The mine countermeasure commander (MCMC), who is the supporting commander to the supported CATF, conducts MCM operations from deep water to through the beach exit/line of demarcation. The relationship between all these key leaders is important because of the changing nature of the littoral environment. Generally, the littorals are categorized as deep ocean waters (200-feet or greater); shallow water (SW) from 200-feet to 40-feet; very shallow water (VSW) from 40-feet to 10-feet; the surf zone (SZ) and the craft landing zone (CLZ) from 10-feet to the high-water mark (HWM); the beach zone (BZ); and in-land through the beach exit.[31] The changing nature of tides can create additional friction because the location of the zones can change several times throughout the day. Shifting tidal ranges may affect the MCMC and CLF because, doctrinally, the MCMC responsibility of clearing mines ends at the SZ and the CLF is responsible for clearing the obstacles inland of the SZ. Command and control between the CATF and CLF can become further complicated, especially if the amphibious portion of the mission is still occurring. Therefore, it is imperative

that MCM and amphibious operations be synchronized and coordinated among the CATF, CLF, and MCMC.

Prior to the assault force maneuvering ashore, Navy and Marine Corps forces must clear the deep water through the BZ of all obstacles. MCM must occur during prelanding or supporting operations. MCM is a time-consuming mission and as a result the CLF must understand how MCM missions affect the planning for H-hour and/or L-hour. During the planning phases, the CATF and CLF must agree upon a line of demarcation that will delineate responsibility for clearing of obstacles. Generally, the CATF will execute MCM and assault breaching seawards of the SZ, while the CTF will execute obstacle clearing or removal from the SZ landward.[32] Not only will the waters have to be cleared of mines for amphibious vehicles to travel through, but also these cleared lanes will need to be marked and then communicated to the LF. Ashore, a CLZ of no less than 150' must be cleared for amphibious vehicles. Lastly, if any additional obstacles remain on the beach, a lane through those constructed obstacles or mines must also be reduced, proofed, and marked. Different categories of mines can be emplaced in deep and shallow waters, coastal areas, harbor entrances, and rivers, which makes clearing them exceptionally difficult. Therefore, in order to defeat the myriad of mines across bathymetric ranges a MCM system of systems (SoS) must be employed.

The Navy and Marine Corps have the assault breaching system of systems (ABS SoS) to defeat mines in the water and BZ. In order to defeat mines from the deep water inland, the SoS must be able to detect, classify, identify, and neutralize the mines. The SoS must also include a communications network between the Navy and Marine Corps amphibious crafts, and a navigation and marking system that will allow amphibious vehicles to stay within the designated cleared lanes. For the past decade and half, the Marine Corps has turned to the Costal Battlefield

Reconnaissance and Analysis (COBRA) for detection of mines in the SZ and BZ. The COBRA system is attached to an unmanned aerial vehicle (UAV) and is designed to detect and localize minefields and obstacles in the SZ and BZ. After the COBRA locates the mines, the "data from COBRA will be sent to the amphibious landing force through the Joint Direct Attack Munition (JDAM) Assault Breaching System (JABS), which could either direct a JDAM air assault on the beach to clear mines or could feed the location of mines to the precision navigation and lane marking systems on the amphibious vehicles coming ashore."[33] The initial system, COBRA I can only detect (surface-laid) mines in the BZ during the daytime. The next stage of development (COBRA II) includes full detection of mines in the SZ and at night. The final stage (COBRA III) includes nighttime detection of buried mines in the SZ and BZ. The problem with the COBRA is the slow development of technology and cost associated with procurement. Only COBRA I is operational, which means that the US military cannot detect buried mines, or mines in darkness. This gap in MCM capabilities is not anticipated to be fulfilled until 2022 when COBRA III is expected to be made available, meaning if an amphibious assault needs to occur in the near future, buried mines in the littorals will not be able to be found. Either a cheaper solution must be found or more money must be provided to the COBRA program in order to quickly improve the intelligence, surveillance, reconnaissance, and targeting of mines in the SZ and BZ.

As stated earlier, the COBRA will feed information about the location of the mines to the JABS. Without precise targeting data from the COBRA, "the JABS could still be employed, but more weapons would be required to cover the uncertainty."[34] The JABS is the only capability currently available for breaching mines and obstacles in the SZ to the BZ. While the JABS is effective against proud mines, there is uncertainty about the JABS effectiveness against buried mines. An additional problem the JABS presents is the delivery by aircraft in that the maximum

number of aircraft that the USAF can provide in support of an amphibious assault effectively sets the maximum number of concurrent lanes that can be breached. Currently, the Armed Services do not have enough platforms to create the required lanes for a MEB-sized amphibious assault. Furthermore, in a dynamic environment it is unreasonable to assume USAF strategic aircraft will abandon all other national missions to only support the breach. This is problematic if the amphibious force faces significant obstacle belts as only so many lanes may be cleared. Another layer of friction is the shock effect of hundreds of 2000 pound bombs exploding within a short period of time. Besides synchronizing the end of the JABS dropping and the arrival of the AF, the effects of the bombs on the sandy soil is unknown. Furthermore, each weapon produces approximately 1100 pounds of scrap iron that can scatter over a 400-yard radius, which means a typical mission could produce about 100,000 pounds of frag.[35] The amount of scrap metal might affect rubber-tired vehicles and follow-on mine detection efforts that use ground penetrating radar and metal detectors. Because of the metal, current mine and metal detection systems will produce many false positives. Another concern is that doctrine does not allow for post-mission analysis of the effectiveness of the JABS, meaning the AF will assault the BZ with an unknown number of mines, unexploded ordnance, and obstacles and might have to breach, proof, and mark new lanes which will slow down the assault. Finally, there are currently no JABS ranges that have a beach available for amphibious operations. While one beach on San Clemente island has some restrictions, proper environmental clearance still needs to occur and the beach is only suitable for one lane. While the JABS has several capabilities, it is still limited, and additional testing and training needs to occur.

The next capability in the ABS is the Precision navigation and marking system (PN&MS). The PN&MS visually and/or electronically marks the breached lanes and provides

electronic aids to facilitate following a precise track through danger areas. Once the lanes have been cleared of mines, it's important for the amphibious vehicles to stay inside the cleared lanes. The nature of the environment (water) does not allow for conventional marking systems such as stakes or markers; therefore, the lanes would be marked using a navigation system that navigates landing crafts air cushioned (LCAC), landing craft utilities (LCU), and amphibious assault vehicles (AAV). This system would fulfill navigation requirements; however, the technology is not available yet to USMC forces. During the December 2017 STEEL KNIGHT (SK18) exercise, First Combat Engineer Battalion (1st CEB) conducted a live fire amphibious breaching operation on San Clemente island. The after-action report from SK18 concluded that "AAVs and LCUs cannot currently identify clear lanes in the water."[36] The Navy's LCUs employ a Voyage Management System capable of achieving a navigation accuracy of 16.3 yards, while the Marine Corps' AAVs use the DAGR navigation system, which has been shown to be unreliable.[37] In fact, during the 2015 MCM demonstration at Camp Lejeune Marines had to use personal devices and visual markers to navigate through the lanes to the beach.[38] If a reliable navigation and marking system is unavailable during an amphibious breach, the Naval services must rely on additional JABS to create more lanes. Yet, as mentioned previously the level of USAF bomber support availability establishes the maximum number of concurrent lanes that can be breached. One success of marking occurred during SK18 when 1st CEB developed and validated methods for marking beach lanes. Engineers refined the previous marking methods that only accounted for "left," "center," or "right," by constructing 3'x 3' colored panels (which match the beach color) and a 2'x3' naval signal flag below that indicating location of the lane.[39] While the Navy and Marine units were able to understand this new marking system, it is not doctrine. Still, this marking requirement is necessary to facilitate assault waves coming ashore ahead of the Beach

Operations Group and Landing Support Marines. Until technology is able to meet the requirements, Navy and Marine Corps personnel must continue to develop solutions to navigate and mark breached lanes from the water to the shore. Unless amphibious vehicles can properly navigate through cleared lanes, clearing the minefield becomes a wasted effort.

The last requirement for a successful MCM mission is effective command, control, communications, computers and intelligence (C4I). As with any amphibious operation it is important that the key leaders establish efficient command relationships early on during the planning stages. However, once the mission commander shifts from CATF to CLF (generally at the SZ) the CLF must still be prepared to conduct breaching operations with JABS, M58 Mine Clearing Line Charge (MICLIC), or mechanical measures. Beyond control concerns, is also communication between the Naval ships and amphibious craft. During SK18, 1st CEB noted a deficiency in communication abilities between the *USS RUSHMORE* and breach forces. The ship was not able to use crypto, which meant the forces could only communicate with one single channel plain text net. Not only is this not realistic, but it also makes C2 much more difficult for the commander. Both intra and inter-communication assets must be made available for the AF and LF, thereby allowing communication flow between the CATF, CLF, MCMC, and breach force commander. Finally, intelligence gathering is a deficiency in MCM for the Marine Corps. Currently, Marines do not possess hydrographic survey materiel compatible with Common Operator Interface –Navy (COIN) or Mine Warfare and Environmental Decision Aids Library (MEDAL); requiring Navy assets to conduct hydrographic surveys.[40] The Navy's MEDAL is able to catalogue environmental data, store the data, and then promulgate the information to its forces. However, the "level of effort for populating this mine-environment data system has been kept low by a lack of funding and a lack of collection priority"[41] which renders the data base

useless with lack of information. While the Marine Corps is developing INTELINK to gather information from MEDAL, again lack of interest and funding makes this another ineffective program. While both systems, MEDAL and INTELINK have potential for providing important intelligence for situational awareness of the littorals, the funding for the technology need to be advocated and supported.[42] C4I is an important part of any mission; however, numerous shortfalls are apparent in the C4I of MCM and must be fixed in order to conduct a successful amphibious landing in a mined environment.

While the potential of the ABS SoS shows promise, the technology still needs to be created and implemented. Beyond the ABS SoS, ships and ship to shore connectors remain a shortfall. One Marine Expeditionary Brigade requires 15 L-Class assault ships, 26 LCACs, 6 LCUs, and 109 AAVs to conduct a surface assault. The United States possesses only eight LHDs and one LHA, meaning even with enough LCACs, LCUs and AAVs, there is not enough ship space to transport a MEB.[43] Besides equipment, training and doctrine shortfalls also exist.

The Navy and Marine Corps must continue training for amphibious operations in order to develop TTPs for MCM, validate or change doctrine and equipment, train with emerging technology, and develop solutions for existing problems. Bold Alligator 2015 (BA15), Bold Alligator 2017 (BA17), and SK18 focused on MCM, with the latter being a live fire exercise. Each exercise refined or re-established MCM TTPs. The previously discussed new beach lane marking method established by 1st CEB is an excellent example of creating a new TTP. However, this new marking method needs to be tested by other Marine engineers and the Navy to validate or improve this technique. Another TTP identified by both BA15 and SK18 was combat engineers' limited ability to train for embark and employment of MCM equipment. Both after action reports mentioned the difficult of embarking and debarking ABVs from an LCU. The

clearance from the ABV turret is minimal and the distance between the LCU gate and ABV frame is less than one foot.[44] The lack of space to maneuver off the LCU forced the ABV's debarkation to be slow, and caused minor damage to the LCU. During real world operations, ABV operators need to be able to operate efficiently in order to clear obstacles and establish combat power ashore. Slow offloads delay this process and cause additional risk. The after-action reports recommended the ABV turrets remained free from any additional equipment and combat engineers need to maximize opportunities to train in loading and off-loading ABVs in landing craft. While the ABV width problem was not fully solved, some issues were fixed between the two exercises.

Bold Alligator 15 identified that the ABV with a Full Width Mine Plow (FWMP) could not be embarked in a LCU.[45] The ABV with FWMP is designed for breaching and proofing assault lanes through obstacles at beach landing sites, and should be the first breaching asset ashore. Only because of a training exercise was this discrepancy identified. Since BA15, the FWMP has been modified and then tested at SK18. This modification was a success story but the initial problem was only identified because units took the time to conduct an MCM exercise. Another change to equipment and doctrine that has garnered concern from both MCM demonstrations is the AAV's lack of ability to accurately navigate through cleared sea lanes. During both exercises, Marines had to use personal GPSs in order to navigate properly through the lanes. Recommendations from both demonstrations include using the LCAC and LCU virtual navigation systems to traverse cleared sea lanes to the shore. While a similar navigation is scheduled for install in the AAV, (the Augmented Reality Visualization for the Common Operational Picture (ARVCOP)) the upgrade will not occur until at least 2023.[46] Until the AAV receives the upgrade, Marines will have to be creative in maneuvering through the lanes. This

type of innovative problem solving can only occur if the Marine Corps continues to conduct MCM exercises. Then, once the training becomes consistent and regular TTPs are established, doctrine can be established and written.

The current MCM doctrine publications are old, outdated, and are missing procedural information. The doctrine that focuses exclusively on MCM is *NTTP 3-15.24: Mine Countermeasures in support of Amphibious Operations*. Updated in 2008, the NTTP favors the Expeditionary Fighting Vehicle (EFV) as the ship to shore connector. The EFV will be able to "eliminate the requirement to clear ship approach and retirement lanes as narrower EFV transit lanes will be required in their place."[47] The NTTP late explains how the EFV will also receive a rapid mine clearance system for neutralizing mines. While the doctrine could not predict less than two years later the EFV program would be cancelled, the Navy or Marine Corps should have updated this publication within the past eight years. The TTPs in this doctrine need to be re-written to reflect the current equipment. Furthermore, NTTP3-15.24, JP 3-18 *Joint Forcible Entry Operations,* and JP 3-05 *Amphibious Operation* do not codify assault breaching procedures and responsibilities in support of Marine expeditionary brigade (MEB) and Marine Expeditionary Force (MEF) operations. Perhaps the information is incomplete because there have been no amphibious breaching exercises since 1999. Additionally, SK18 was the only time amphibious breaching had been attempted with current breaching capabilities.[48] Quite simply: the Navy and Marine Corps has not invested in training to these abilities. Therefore, without training to confirm TPPs, doctrine will continue to remain stale.

With several gaps across the ABS SoS, the Navy-Marine Corps team still needs to prioritize MCM and allocate funding towards research and design. Much of MCM equipment has been programmed for almost a decade; however, MCM funding has continued to be cut

regardless of the fiscal environment. This creates a delay in MCM programs to become further behind schedule, which means a delay in capability to defeat the minefields in the water. The Navy-Marine Corps team will not be adequately equipped or trained if funding continues to get cut for MCM programs. Additionally, if newer, cheaper technology emerges, leaders must be able to pivot and acquire what is available. For example, during the latest MCM demonstration the newer UAS detection system, Sandfly, could identify multiple types of proud and buried mines. With other swarm technology on the horizon, the Marine Corps must take advantage of the new systems in order to keep up with the ever-changing minefield. Leaders must look at the art of the possible when defeating the minefield; whether it is incorporating new technology within the ABS SoS or improving TTPs to minimize risk and keep Marines out of the minefield.

Finally, training needs to continue. Conducting amphibious breaching exercises once every two decades should be an embarrassment to the organizations who consider themselves amphibious. Training also needs to be realistic and conducted from the deep water to inland. There has never been an MCM exercise in which JABS was part of the evolution. Moreover, the JABs effectiveness in VSW still needs to be tested and it is unknown if the CLF has to proof the VSW and inland. Proven TTPs need to be in place before the next war, and they cannot come to fruition without consistent, realistic training.

The joint services know the next battle will occur along the littorals: it's written in the *Marine Operating Concept*, *Littoral Operations in a Contested Environment*, and *Expeditionary Force 21*. Freedom of maneuver in the littorals can only occur with MCM missions, yet the MOC does not mention amphibious breaching, and the other two documents give MCM only a few short sentence considerations. [7] Ship-to-objective-maneuver (STOM) may be one solution to

[7] LOCE mentions using small unit warfare and submarine warfare as expeditionary MCM capabilities but does not provide any additional MCM consideration. EF21 recommends the Marine Corps finds mechanisms to "identify,

going over the minefield, but what happens when the minefield is so large it exceeds the services' ability to go over the minefield? MCM has been a problem for Naval forces since the Civil War and has played a factor in almost every single major war since. Yet, despite MCM being one of the most needed missions, it has been the first program to be underfunded, cut, and ignored. Navy and Marine Corps leaders must ensure that its personnel have the proper equipment to conduct amphibious breaching *today.*

bypass, and if required breach shore-laid obstacle belts (explosive and non-explosive) to secure entry points," but does not provide any additional recommendations or concerns.

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Notes

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[3] *Ibid*., 142.
[4] *Ibid.*, 122.
[5] *Ibid.*, 130.
[6] *Ibid.*, 122.
[7] *Ibid.*, 142.
[8] *Ibid.*
[9] *Ibid.*, 134.
[10] *Ibid.*, 134.
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[18] *Ibid.*, 121.
[19] *Ibid.*, 129.
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[21] *Ibid.*, 88.
[22] *Ibid.*, 88.
[23] MCM Gap Matrix, 1.
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