23rd ICCRTS Program
Track 5: Highly Connected, Automated and Autonomous Forces

Command and Control Mobility Nodes Beyond the Tactical Edge - Unmanned Force Protection

Joint Service Concept for Counter Area Denial Systems

Unmanned Force Protection Concept of Operation

by

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Abstract

Command and Control (C2) methods which provide Tactical Agility for Commanders are critical for mission success. Situational Awareness (SA) as a Capability provides decision makers critical information. Inserting technology into combined arms missions to obtain Battle space awareness allows dynamic retasking to shape the engagement as needed. This proposed Joint Concept describes how to optimize planning, project and synchronize Force Application (FA) with autonomous platforms while Countering Area Denial Methods[1].

This Multi-Domain Capability shall simultaneously create new C2 Mobility Nodes (MDC2), Movement and Maneuver (M2), Force Protection (FP), synchronize Amphibious Landing capabilities, fill requirements for SA and reduce breaching delays. This Operations Research identifies new MAGTF, NATO and SOF Joint Service Material Solution Capabilities to achieve mission objectives, remove dangerous obstacles, make landings, fill breaching requirement gaps and Lines of Departure (LODs) for Cross-Domain Collaborative Operations.

This combined new Capability extends to Reconnaissance, Route Sweep, DTE and other missions to fulfill Operational Needs for IED/Mine Breaching with Mine Counter-Measures (MCM) methods synchronizing FA for operational tempo and mobility capabilities. A robust autonomous unmanned platform with scalable modular technology provides CCMDs Capabilities to enable mobility from the water to beyond the tactical edge synergizing SA with dynamic retasking of Dismounted Warfighters where IED/mines exist for On-the-Move Tactical Agility. This same operational concept applies for Humanitarian Efforts and departure activities.

Synchronizing Joint Operations

A Course of Action COA which allows dynamic, flexible Lines of Effort (LOE) to advance with new ISR Capabilities and extend AO Tactical Edge boundaries is advantageous for any deep GCE. In order to enable MEB and SOF CCMDs C2, Tempo and Mobility of troops for maneuver warfare, functional steady state communications SADL must extend operations BLOS.

In turn, platform mobility delivers SA for C2 decision making via multiple view streaming in austere settings to deliver ISR and Battlespace Awareness (BA) for a Common Operating Picture (COP) between command staff and Joint services and coalition forces. Tactical performance for MAGTF and SOF Forces shall overcome significant stop and delay due to the presence of mines in the water and land IED/Mines with autonomous platforms. These New MAGTF and SOF Capabilities for frequent breaching tasks shall lead to future mission success.

Existing operational strategy relies on maneuver warfare combining ISR directly interfaced with the soldier advancing to perform for the highest level for mission success. IED/mine is the prevalent weapon that halts warfighter advance including the capabilities of the ISR system in use. These delays cause significant risk to mission success and casualty increase.

The case is presented for minefield breach requirements as a CONOP with an effective tactic using technology solutions to address these persistent issues. The functionality of this proposed Tactic can be thought of as Technology and platoon Mechanization paired for the objective of mine breaching lane operations with benefit of Force Protection during any activity.

The integration of human abilities is closely matched with mechanical engineering technology to survive within blast exposure environments. This can be thought of as a continuous process with multiple procedures performed concurrently by either a UGV or likewise fashioned robot platform. At present many agile moving UGS robots exist being over 600 lbs in weight. Both lightweight materials and technology exist to form a mobile robotic solution to defeat IED/mines in water and on land. This Joint Concept combines the C2 SA process with UGV ability to breach while preventing fragmentation forming a hybrid chassis Material Solution. This complements Navy EOD Teams functioning concurrently. The existing definition for useful operations for Combat Engineers is:

> "(1) **Mobility.** Combat engineering mobility capabilities and activities assure the ability of land combat forces to maneuver. They only include tasks that meet the definition of combat engineering, and they typically include tasks associated with conducting **combined arms breaching operations**, **clearing operations**, and **gap crossing operations**; constructing and maintaining **combat roads and trails"** additionally:
> "Joint forces should be prepared to encounter obstacles (including IEDs, mines, and other UXO) across the range of military operations."
> and:
> "breaching, neutralization, or large-scale clearing of land-based mine hazards is the responsibility primarily of combat engineer units and special units of the Navy."[5]

This Joint Capability Concept and CONOP supports robust technology development to achieve tactical gain using feasible, affordable and scalable material solutions for SOCOM, PACOM and MAGTF User operational needs for MCM and land IED/Mine breaching.

As a further level of operational control, C2 On-the-Move C2OTM (as defined by Tidwell and Teske, JFCOM 2011) provides a strategy for improving control over missions particularly at the Tactical Edge. The present CONOP provides a new Course of Action COA for dynamic, flexible Lines of Effort LOE to advance and extend AO boundaries for any deep GCE.

In order to enable and enhance MEB commander's control over troops for maneuver warfare with quickness, functional steady state communications that extend operations BLOS are needed.

A robust UGV platform delivering ISR SADL to the tactical edge for BA shall synchronize dismounted warfighters' advances which contain mitigating blast countermeasures for on the move retasking agility. In turn, platform mobility delivers Situational Awareness SA for C2 decision making via multiple view streaming in hostile settings able to perform breaching tasks in austere environments saturated with IED/Mines synergistically. This performance solution for MAGTF MEB and Joint Service forces shall overcome significant stop and delay existing due to frequent breaching requirements and lead to leading to higher mission success.

Fulfilling Requirements for Joint Capabilities

The present Technology Development Strategy (TDS) concurrently builds prototype modules to optimize funds by transitioning Technology for key Capability Needs. The Capability Gaps identified follow Tier II UGV ICD, Expeditionary Force 21 and Marine Corps Operating Concepts MCOC JCAs and Requirements. This Joint Concept provides several Capabilities in one Platform while allowing the modules to be developed and designed scalable.

Capabilities Required by the Joint Operational Access Concept (JOAC) include;
For Movement and Maneuver:
JOA-017. The ability to mask the approach of joint maneuver elements to enable those forces to penetrate sophisticated anti-access systems and close within striking range with acceptable risk.
and
For Protection:
JOA-021. The ability to protect forces and supplies deploying by sea and air.

Within the Joint Concept for Entry Operations (JCEO), the following Required Capabilities are provided for through use of this CONOP with the individual and combined features from the proposed Technology;
For Movement and Maneuver:
Required Capability 12: The ability of Initial Entry Forces (IEF) to conduct the initial entry into an operational area. Generally, initial entry forces will value strategic, operational, and tactical mobility and require specialized training, organization, and equipment:

e. The ability to identify and clear mines and obstacles in littoral and riverine approaches sufficient to support amphibious operations.
For Protection:
Required Capability 14: The ability to mitigate the effects of threats and hazards to personnel, equipment, and facilities while maintaining initial entry operations.

Required Capability 16: The ability to provide sufficient air and maritime advantage necessary to insert entry forces and sustain littoral and vertical maneuver during entry operations.
a. Ensure that sufficient counter-mine capacity exists to clear areas and lanes in coastal areas in support of littoral maneuver during entry operations.

Naval S&T Focus and Research Areas;

Current ONR FNC Investment Concept for Pillar and S&T Gap Program includes the following prioritization of Technology objectives with overlapping MCCDI MCWL objectives;

Expeditionary & Irregular Warfare Objectives:
Modular, scalable, and autonomous ground platforms and capabilities.
Focus Area Expeditionary and Irregular Warfare Counter asymmetric weapons and explosive hazards afloat and ashore.
• Explosive Hazard Defeat
• Personal Survivability
• Vehicle Survivability

Platform Design and Survivability Objectives:
• Platform Design focused on efficiency, agility, and affordability
• Autonomous and Unmanned Vehicle Mobility
• Vehicle Structures and Materials
• Low Observable (LO) and Counter LO Technologies
• Modular/Affordable Platforms

Autonomy and Unmanned Systems:
Novel Platforms and Integration.
• Intelligent and Autonomous Systems
• Unmanned Sea Vehicle Technology
• Unmanned Ground Vehicles

Power Projection and Integrated Defense:
Integrated Layered Defense Across the Entire Detect-to-Engage Continuum.
Extended Threat Neutralization Capabilities.
• Expeditionary Force Protection

The Office of Secretary of Defense has the following current applicable Focus Areas:
Asymmetric Force Application.
• Use of non-traditional technologies, tactics, and weapons to provide a clear military advantage to our forces during maneuver and engagement operations.

Autonomous Systems.
• Capability that enables a particular action of a system to be automatic or within programmed boundaries, or 'self-governing'.

From Expeditionary 21 Capstone Concept:
The Capability Development Focus Areas for Combined Integration of Combat Power by this UGV/USV Platform are:
Force Protection - Detecting and neutralizing explosive hazards, including mines, improvised explosive devices, unexploded ordnance, and explosive remnants of war.

Expeditionary Force 21 Focus Areas:
These objectives are further supported in MCOC and EW21 for Maneuver. Surface littoral maneuver capability where Area Denial Threats are present:

Force Protection

- Detecting and neutralizing explosive hazards, including mines, improvised explosive devices, unexploded ordnance, and explosive remnants of war.

Maneuver:

- The ability to overcome ground obstacles (explosive and non-explosive) from the seaward approach when they cannot be by-passed during an assault.

Joint Requirements also extend from UGV ICD:
Required Capabilities are provided for through use of this CONOP with features from technology Transitioned for Force transformation along the intent of "The Unmanned Imperative".
c. Recommended prioritization of the gaps.
"Unmanned Systems can support future forces within the expanded battlespace by serving as economy of force assets with intelligence collection and area security and by enhancing force protection by providing standoff operational capabilities."

b. "The recommended approach is interoperable Unmanned Systems and their modular payloads that will cover the following desired capabilities; Battlespace Awareness, Force Application, Protection, Command and Control, Logistics, Force Support and Net-Centric."

User Capability Needs to overcome Tactical Variables and Risks

The threat environment and countermeasure capability present in today's battlespace has a direct relationship with mission success most often due to the use of IED/Mine threats. Warfare with minefields has imposed conditions with considerable effects onto both offensive and defensive tactics during Dismounted Warfighter's missions. Filling these capability gaps shall significantly reduce delays, risks to IED/Mine threats and mobilize technology to OPNAV95 for assets bearing SA M2 and FP for use benefiting CCMD's C2 and Dismounted Warfighters.

In this analysis, the case for time spent for forensics collection as well as international law and treaty administration is not the focus. Present and future conditions have caused the requirement for evaluation of means and methods to achieve Force Protection to further improve the order of battle for Tactical Agility involving Ship to Objective Missions (STOM) with IED obstacles as the enemy has achieved conditions which include force mission execution from the dismounted state of advance.

To greatly improve the success percentages, the nominal speed and momentum of missions must be improved. Technology development in the way of combined arms shall establish mobility allowing for ISR sensors to be positioned. The aspect of planning and actual task execution shall be greatly improved through the use of dynamic positioning of Situational Awareness nodes. This is warranted as the enemy has succeeded in producing numerous mission delays, reduced mobility and increased casualties. It follows technology can improve offensive maneuvers and should be developed to provide the means of carrying out those missions against IED/Mine threats within the environment set by those enemy weapons.

> "Clearing operations involving explosive obstacles are especially difficult because the detection systems employed are imperfect and available neutralization systems are only partially effective."[6]
> and
> "Engineers must discern and identify patterns and plan specific detection strategies based on the threat. The proliferation of mines and IEDs requires engineers to continuously develop new counter procedures. The tactical integration of EOD capabilities has become an increasing requirement."[5]

These required operations represent the standard from history and are employed today for ground forces to advance.

> "The goal of breaching operations is the continued, uninterrupted momentum of ground forces to the objective; therefore, these operations should be planned and executed in support of the ground forces' needs to ensure that actions at the objective are supported by actions at the breach."[6]

A feasibility assessment for this capability shall exhibit both utility and be deemed an enduring requirement. The potential for this concept to be gap prioritized exists and the capability can move as a rapidly fielded capability solution for all existing Minefield Breaching Operations to improve Mobility and Safety. “the assessment may address refinements to the original capability requirements as needed to reflect lessons learned from operating the rapidly fielded capability solution.”[7] These types of technologies shall improve tactical mission effectiveness for WAS and CAM operational strategy.

> “(6) Providing adequate engineer capabilities to facilitate survivability for combat maneuver forces as a part of combat engineering.
>
> c. **EOD.** EOD augmentation to the engineer force is not only essential, but critical. The speed and efficiency with which UXO hazards, weapons caches, and IEDs are eliminated directly impacts overall mission success, both militarily and politically.”[8]

Additionally:

> **“2. Mobility Considerations**
>
> a. **General.** Mobility operations include five functional areas, three of which are designed directly to meet challenges from barriers, obstacles, land mines, and other (EHs). These three (breaching operations, clearing operations, and gap crossing operations) are discussed further in paragraphs b through d below. The five functional areas of mobility operations for Army units and Marine air-ground task forces (MAGTFs) are covered in detail in FM 3-90.4/MCWP 3-17.8, *Combined Arms Mobility Operations*.
>
> (1) **Conduct Combined Arms Breaching Operations:** detect, breach or bypass, mark, and proof mined areas and obstacles. Combined arms breaching operations are typically performed in a close combat environment.
>
> (2) **Conduct Clearing Operations:** employ tactics and equipment to detect and eliminate obstacles, mines, and other EHs. While this is not always part of a combined arms breaching operation and is typically not performed in a close combat environment, it will still generally include the task of breach.
>
> (3) **Conduct Gap Crossing Operations:** fill/cross gaps in the terrain/man-made structures to allow personnel and equipment to pass.”[9]

Advance of GFEs through minefields with a medium sized robot shall produce the Tactical Gain of uninterrupted mobility improving speed and surprise for tasks to achieve mission objectives.

New Tactical Solutions

From a tactical performance standpoint each obstacle in the CLZ and IED/Mine inland has an effect on movement and maneuver warfighter functions by reducing the mobility of assets and dismounts during missions. This proposed Operational approach harnesses new technology to

reduce mission delay and increase area stability. This Joint Concept offers Material Solutions for increased mobility while simultaneously providing multiple node Situational Awareness. In light of advances in technology, new tactics are presented to fulfill Force Protection, Mobility, robot survivability to fulfill several current Operational Gaps.

The design of scalable modules for Fast Attack Mine Destroyer Robots is presented for minefield breaching CONOPS. Research and development of fragmentation barriers and simultaneous safe zone detection systems for regular field use are high important capabilities. Alternative technology use is a necessity due to the statistical mission failure and effects when not employing available technology capabilities providing options for Command and Control.

Multiple Terrain MOB Versions are able to traverse several environments, inclinations and reduce obstacles. Multiple terrain maneuverability is a desirable transport capability for tactical communications TDL in DIL. Simultaneous breach capability at the tactical edge provides means to intercept enemy and achieve mission success without delay or Stop.

> "(c) **Hasty Breach.** A hasty breach is an adaptation to the deliberate breach conducted when less time is available. It may be conducted during either a deliberate or hasty attack due to lack of clarity on enemy obstacles or changing enemy situations to include the emplacement of scatterable mines and/or networked munitions.[10]

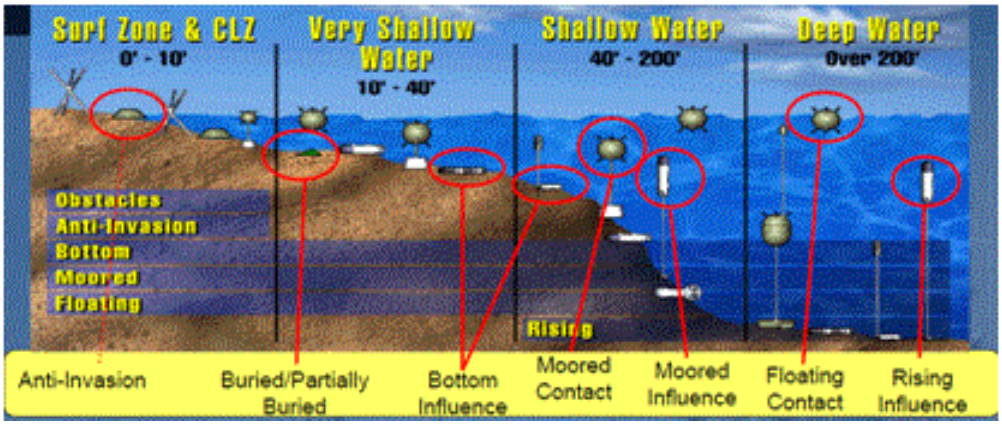
The offensive and defensive maneuvers as detailed in Chapter 7 & 8 of MCDP-1 are afforded greater operational effectiveness due to individual mission speed increase and with the ability to gain surprise. JCA, KPP & KSA Tables exist to define objective thresholds for this capability solution in AOs with mine obstacles. This Technology applies to most dismounted missions and tactical tasks which have factors of METT-T containing exposure and intensive use of IEDs and AP Mines. These threat conditions shall exist as persistent threats and for the future creating an enduring requirement for the technology as a C-IED MCM countermeasure asset. This shall increase the speed and reliability filling Breaching Requirements to improve CONOP.

The modular robotic concept addresses the enemy countermobility tactic issues of delay, deter and psych effects caused by IEDs. Conventional engine powered platforms are larger, use louder equipment, are less able to move in tight spaces and do not possess the scalable size and modular functionality to serve either remotely or autonomously. From a Psych standpoint, when the enemy sees new tactical missions in place and the regularly used capability to quickly detect and detonate AP Mines, the value to use them in the future will be reduced.

Evaluating several years of Lessons Learned and forming a new UGS protection robot system establishes a capability for tactical maneuvers fulfilling the "optimum means available to support the JFC's CONOPS"[11], an operational use for critical lethal MTs allowing for "tailorable" assessment to "refine capability requirements"[12]. The Assessment designates priority ranking based on tactical advantage and force protection benefits. KPP thresholds for MoP and MoE may show tactical M2 and protection performance benefits reflecting JCAs for solutions to these gaps. Technology may then provide realistic cost effective solutions integrating TDL communications for BA & SA Capabilities through M2 enabled with breaching capability. This in turn provides agility to respond effectively and timely with C2 FMV TDL and OPINT at the tactical edge fulfilling a C2OTM gap concern.

Defensive Maneuver Capabilities

Each mission has the potential to make landings and continue inland through minefields exists. This enemy land area-denial method is created as an Anti-Invasion Defensive Strategy. Additionally, the goal of a water minefield is Sea Denial, not the damage and destruction of a specific ship. With the Sea being a maneuver area, the Navy's goal is to assure Access, clear dangers and to achieve landing and area access, MCM use must be able to detect and neutralize mines in the CLZ while allowing the amphibious maneuver in the CLZ to come out of the water.



Amphibious Landing – Mine Threat Obstacles and Hazards.

It follows that as the Robots are assigned into EOD team units, that the additional capabilities be simply designated and assigned to those same units providing a fast attack, variable terrain and barrier protection Increment. As well, the EOD team captain being skilled as a field tactician delivering the ISR reviewed instructions to the Robot. This real-time logistical manner to enable and meet the needs of Commander's mission needs allows the tactical maneuvering to be performed successfully. This allows for immediate defense of the ground the enemy is attempting to take.

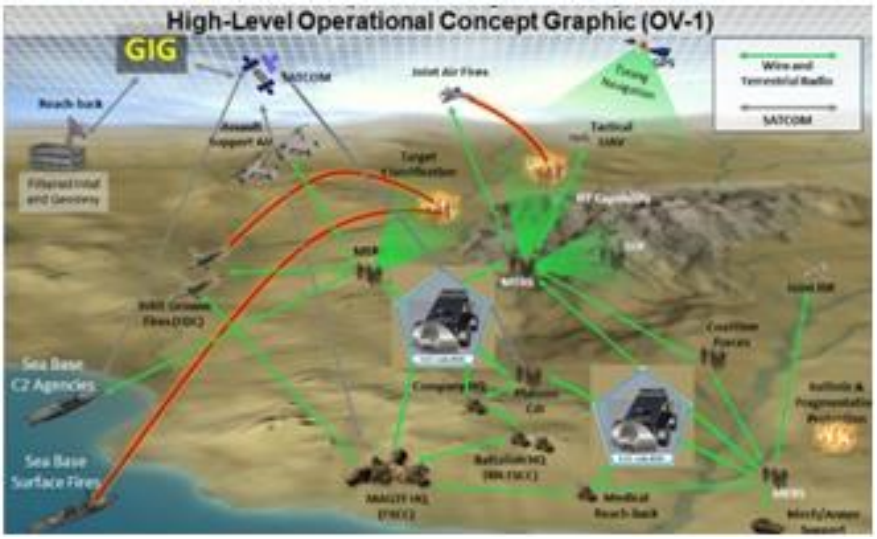
As the warfighter has received his instructions each component of his mission relies on his ability to maintain Tempo, a primary element. An AP Landmine eliminates the possibility of having Tempo. In addition, today's search for target missions many times require tracking and search only a few enemies. This involves traveling to and striking a Focal Point which has a limited window of success due to few fixed command centers or posts with enemy leaders constantly moving about or able to retreat quickly. Use of AP Mines eliminates Surprise to Focal Point for obvious reasons. Therefore it is necessary to concurrently defend against the mine in a manner that does so by removing the need to Stop Advance causing Reduced Mobility allowing for enemy retreat. Providing the Technology presented allows for the Tactical Gain to achieve the advantage of not Stopping upon detection of an AP Mine(s) and IEDs.

Advanced robot reconnaissance prevents separation providing eyes forward and fast attack over AP Mines. This prevents enemy's intention to delay and split line formation. In this way the enemy can cause the place where it is best for him to cause the maximum damage using surrounding of his choice. The first casualty causes the other unit members to stay close to him to save him performing first aid. In the moments after detection or detonation, enemy communications notify whether our troops were injured or killed or had stopped for neutralization procedure. Line of sight disruption after IED effects occur with the enemy utilizing fixed position fires or movement often resulting in further casualties. Intervisibility further delays and disrupts unit cohesion during crossfire. Further development of the situation by the enemy allows for a critical fish in the barrel situation to be established. Technology allows a team to be properly equipped to perform the defensive tactical maneuver preventing this event.

As the enemy inhabits an area, they are present as soldiers, locals or insurgents. When sweeps are eminent in those particular areas, the enemy has spent great effort evaluating our dismounted forces' likely pathways for movement. These include both natural obstacles and manmade structures. As the potential for a sweep mission is to be completed, the enemy has carefully selected and positioned IEDs in the areas where he believes the soldier must move on his route between turning points and possibly needing to maintain cover at corners. It is this method of pinpointing HE threats that causes delay and optimizes effects for casualties of dismounted advancing during their missions.

> Mines and "Minefields are used to:
> (1) Produce a vulnerability to enemy maneuver that can be exploited by friendly forces.
> (2) Cause the enemy to piecemeal his forces.
> (3) Interfere with enemy C2.
> (4) Inflict damage to enemy personnel and equipment.
> (5) Exploit the capabilities of other weapon systems by delaying enemy forces in an engagement area.
> (6) Protect friendly forces from enemy maneuver and infiltration."[13]

For tactical mission tasks involving IED obstacles, the mission statement follows as:
Theater commanders need a means to obtain responsive intelligence, surveillance, HE detection, capability to breach lanes, force protection and BDA information from within each asset. The system should be usable in multiple scenarios and terrain and be reliable over the mission providing limited risk to dismounted personnel from fragmentation. It should provide reasonable coverage, have multi-spectral capability with near real-time information supplied to the Joint Force Component Commander via SADL, enabling C2 automation for prediction and retasking between MAGTF HQs and platoon CDR for critical mission element integration to increase mobility and synchronized ISR capability (see OV-1).



COA using UGVs/USVs for mobility nodes for C2 SA at Tactical Edge BLOS.

Legend for UGV/USV SADL Connectivity

DODAF OV-1

Having Mobility is central to success in the strategic aim of operations containing Defensive Counterattack missions where tactical speed and surprise are required to achieve objectives. These missions are crucial in tracing back enemy forces as part of WAS.

Offensive Tactical Land Maneuver Capabilities and Operational Need for DTE STOM

The proposed Material Solution provides Tactical Maneuvers for Amphibious and Land Missions. Platforms capable of this agility in the CLZ crossover areas provide insurance against Asset and Dismounted Warfighter losses. Thrust to Traction transition of Metacenter to Center of Gravity allows for simultaneous physical movement for coming out of the water for beach landings. The Tactical Gain is provided by better Mobility and Mission Speed for any Mission providing the highest advantage with a combined arms approach. This sequence creates mission

tempo, agility and dynamic retasking for successful deliberate and hasty troop movements approaching and breaching minefields. Tactical mobility means ease of maneuvering in varied topography to achieve mission objectives which require speed, surprise and safety.

Using a platoon lead robot gives the detachment leader a "terrain risk grade" in order to judge the potential for ambush complexity to pass under fire with the ability clear the path before the first warfighter breaches a minefield or an enemy ambush setting. Part of autonomous sensor use allows for a near real-time continuous assessment of situational risk. The successful implementation of this equipment establishes a much higher order of reliability for non-delay in missions and assuring tactical unity – a high priority.

As the Navy delivers Marine Expeditionary forces either by sea or air, the potential drop off location may be in a minefield. This has major consequences as most marine and air landings are of a one-way nature. The trip time to target is a priority KPP as the element of surprise with speed being necessary. Any hesitations, Stop, Pause and reduced Mobility result in loss of speed to target even if the detachment does not know they are about to have contact by chance. Advancing MCM technology in the CLZ is imperative as "mining the coast"[14] is frequent and "make the success in landing for potential invasion scenarios"[14] a high-risk mission.

To get to this level-of-agility at the tactical edge the platform must be able to breach so as to maintain and close distance to target. Maintaining C2 at the tactical edge shall also present for those DIL environments. As sweep operations continue into smaller and smaller subareas the enemy will be forced to retreat into the mountainous topography for their greatest degree of safety. As sweep missions occur and carried out closer to the AO mountainsides, mission success requires Mobility without delay and is a critical KPP, as to close the loop and complete envelopment is required for tactical success. The METT-T factors of many missions carry the required objective of capturing the "logistical Tail" of the enemy. The COG is the focus of the commander's intent for operation. More than one relevant COG may be relevant in a particular region and the need of ISR to be net-centric between UGVs and UAVs is of benefit in order to reduce overall costs performing reconnaissance, route sweep, DTE and other USMC mission.

Battlefield missions require an adaptable robot chassis able to perform amphibious missions, come out of the water and traverse various terrain in the same theatre of operation with physical characteristics able to withstand HE blasts. The combined flexibility and strength to simultaneously advance links mission objective success with Force Protection. This suite of performance metrics allows for tactical mission mobility for CONOPS.

Entry points may many times be decided upon based upon the shoreline location and beach section. Any location may have land transect constructed with extended bathymetry with various tidal ranges. The important features of tide lines and cross-shore current may be detailed as well. These elements of relief detail allow for simulation and statistical results for risks to amphibious maneuver from VSW and CLZ drift, time dependent littoral drift for sediment, seaweed and rock exposure change in bottom conditions and storm related issues which change the fixed tides schedule from known to unknown or variable. Each location shall then have a set of circumstances assessed according to these factors which are dramatically different for various latitudes. Of course SME's are very focused on any waterline area where the boundary is awash and the sediment and bearing stability is questionable.

"The VSW zone, defined as depths between 10 to 40 feet of water, exhibits unique environmental characteristics to Underwater Mine Countermeasures (UMCM) that are not as easily overcome as in other operational depth areas. Underwater visibility is very limited; murky sea floors contribute to turbid underwater environments with low light conditions at depth, making it difficult for divers to operate, even during daylight. These environmental aspects are compounded by the confined nature of the VSW zone; consisting of inlets, berthing areas, dock and bridge pillars, and confined channels that only increase the DTE timeline by significantly limiting mobility" (from NPS-SE-11-004).

In the CCMD's order of battle, the sequence and timing of landings shall be planned. Before lanes on land are created, the ability to make rapid landing is of high value and desired in order to reduce risk on the open shore. Cast against this, the preferred time of landing must be evaluated with the best information of present bottom topography, tides and any storm related

effects on the sea. Additionally, each forward position and COG may be best approached from more than one point of entry. An affordable streamlined failsafe detection approach is possible.

"c) The Marine Corps requires that MCM must provide the capability to clear a minimum of 12 boat lanes to land 2 Marine Expeditionary Brigades (MEBs) of 29,000 Marines and Sailors (Trickey, February 2010). The requirement is for the lanes to be cleared covertly within the objective of 72 hours. There appears to be a lack of planning for the number of assets required by the MCM force to facilitate the clearance of those lanes or a timeline for conducting clearance operations. The MCM community does not accurately address the amount of time it will take to collect the data, recover the data, and perform the clearance supporting an amphibious force." (from NPS-SE-12-001).

Within the VSW and CLZ zone may range from approximately 8 feet wide to over a hundred spanning along the coast. The available detection technology has a relative accuracy or degree of precision that is lost as the intertidal depth increases. This edge of zone may use the Scout & JABS option. This may be compromised by in between placement of additional mines for highly protected sites. Additionally, if the landing mission is to have any degree of surprise or employ stealth technology, the meaningful effect of silence is lost. Further, "execution of real world events [MCM Tasks], the mission is often cut short and a full DTE is not always complete." (from NPS-SE-12-001).

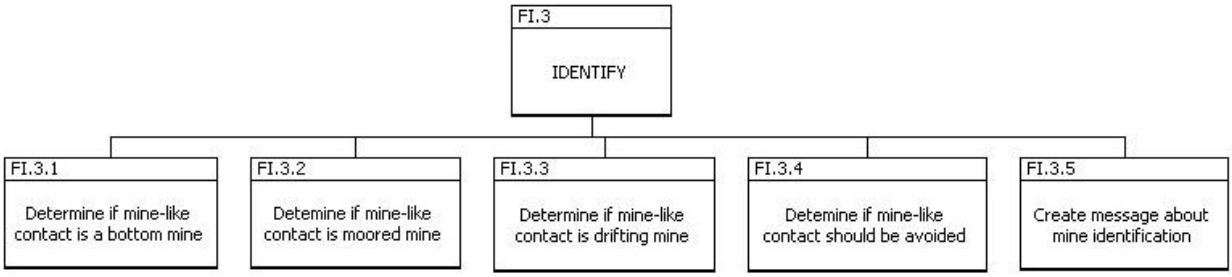


Figure 25. Identify Function Hierarchy, from NPS-SE-12-001.

For each environmental state and Mine Threat condition, the proposed Material Solution is presented as an affordable modular scalable and feasible Mobility Solution for Amphibious Landings in these tidal zones or river edge situations providing for detection in the VSW & CLZ.

This On-the-Move decision condition is an Autonomous or manned control step for successful clearing of lanes for littoral penetration sites (LPS). This relates to both scales of operations where the DTE is simply to make it ashore or for the larger objective of synchronizing operations where the massing or stealth mission demands an advance without significant Stop or Delay. This also plays well for minimizing critical vulnerability being open on the beach or river edge. Validation Testing of Competitive Prototypes is in these Operational Settings.

Autonomous platforms can offer several unique innovative features with measureable MoEs providing mandatory FP KPP & SS KPP to execute EOD and MCM missions for maneuverability and mobility on land (UGV) and water (USV). Five threats involved in VSW and CLZ are as follows: Anti-Invasion, Buried, Bottom, Moored and Floating. The scalable and modular Technology which provides significant additional MCM Capabilities in the VSW and CLZ shall add to mission successful mission outcomes. It is noted that the Hybrid MOB Module travels through the Shallow Water Zone where additional Mines may be detected. This maneuver shall support operational needs for the strategy of Offshore Balancing through a Cost Calculus.

To establish and maintain maneuver for this geographical band of VSW to CLZ, MAGTF MCO and SOF stealth landings have the operational need of rapid MCM implementation to advance inland. This scalable methodology for the littorals is to safely & rapidly conduct 1.12.1 Conduct Amphibious Ops, 1.12.5 Conduct Seabasing Ops with 1.5.2 Conduct Amphibious Ops and shall synchronize operations for the following limits of environmental conditions.

Detail of Statistical Landing Risk Evaluation including Detect-to-Engage missions

The following statistical assessment for landings in Austere Littoral Environments. The benefits contained in this Capabilities Document provide Seabasing required. This initial landing of assets allows for an initial surge to allow for detection of mine density in the beach area and before in the VSW. Each node is for attack and reconnaissance and for withdrawal as well. These aspects of maneuvers are provided for with the Capabilities proposed by Mission Modules forming new organic force mobility assets with Fulltime SA for moving targets and target confirmation. The study assesses the CONOP for MCO, COIN SOF Missions.

This Joint Capability forms a Joint Program tailored for C2 (SA BLOS) and FP (Standoff/Freedom-to-Maneuver enabling M2) and for Amphibious Capability Needs. MCM and EOD capabilities review for Operational Requirements may be used for technology development and validation testing. The Regression analysis includes the relevant technology Requirements for performance, Expected Missions, Threat Assessment, Net-Centric Data Strategy, Operational View and proposed Reference Design Concept. The Combined Arms Equipment with Mission Modules are needed to succeed in these proposed missions requiring Joint Maneuver and Force Protection Capability Attributes. The Capabilities analyzed allow freedom to maneuver without APOBS straight line technology for village approach and for uneven terrain. The tasks to which the mission modules are utilized and contribute to are:

NTA 1.1.2.5-Employ Remote Vehicles
NTA 1.5-Dominate the Operational Area
NTA 1.5.2-Conduct Amphibious Operations
NTA 1.5.2.1-Conduct Ship-to-Shore or Ship-to-Objective Maneuver
NTA 1.5.2.2.3-Buildup the Force
NTA 3-Employ Firepower
NTA 3.2-Attack Targets
NTA 5-Exercise Command and Control
NTA 6-Protect the Force
and
MCT 1.6-Dominate the Area of Operations
MCT 1.12.1-Conduct Amphibious Operations
MCT 1.12.3-Conduct Prepositioning Operations
MCT 1.12.5-Conduct Seabasing Operations
MCT 3-Employ Firepower
MCT 3.2-Attack Targets
MCT 3.2.5.3-Control Naval Surface Fire Support (NSFS)

The following Map depicts the number LPPs and size of area that MCM assets will need to clear.

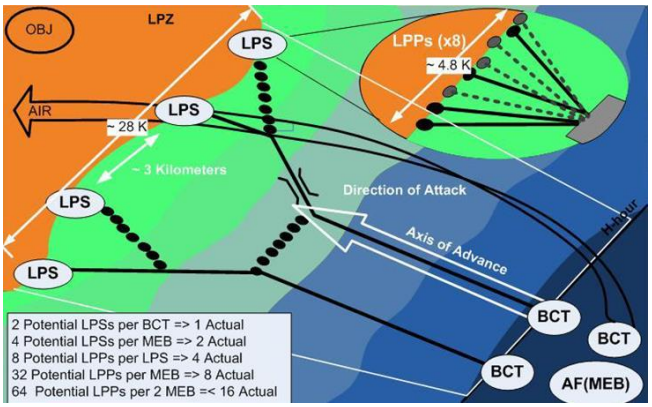


Figure 8. Amphibious Landing Site Dimensions
(Neller, 2005), From NPS-SE-12-001.

First, the beachfront and inland COG are evaluated for risk and cost effectiveness from the MAGTF perspective. A Long-shore Grid Analysis shall assess the cost of assets with risk of advance and loss of force strength per ft^2/Cost of MCM Operations. The SW line offset from the coast where UUV MCM cannot detect and the CLZ line where the Scout has lower detection reliability shall be investigated for the optimized areas. When planning for clearing areas suspected of containing sea mines or other ordnance, there may be time constraints or other significant pressures posed on those performing the operation. Underwater cables or sonar balls may be used for where it has been determined mines may exist at entry points and the confidence level is uncertain. When mine marking is not possible and all locations are unknown, the BCAM offers safe boat and HCBS lanes for landings in the littoral zones. Layout of both low tide and high tide relief with known and worst case scenario for entry.

Second, percentage air to sea deployment is initially decided and updated on in-progress success. Air and marine deployment risk assessment including weapons to be encountered, third, the counterattack to be defended against is evaluated including land, air and cyber efforts; Strength of forces needed to seize given enemy's defenses encountered and fourth, all selected tasks are simulated for a synchronized operation and evaluated for time to finish, cost and risk of mission failure. This forms a moving vector algorithm and is spatially and time dependent with variables characterized as follows:

I = Insertion-deployment = risk of travel in, on water or by air.
A = Make landing = difficulty due to wave height and bottom conditions.
W = Fixed threat = saturation of weapons likely to be present, kinetic and non-kinetic.
L = Traverse terrain = a combination of path impasses and percent-incline.
V = Platforms used = derivation of quotient of costs for platforms and VSL.
T = Platforms with ISR = Joint FA with SA BLOS downrange for COP.

Where BLOS = beyond line of sight, COP = common operating picture, FA = force application
ISR = intelligence surveillance and reconnaissance, SA = situational awareness
VSL = Value of a Statistical Life

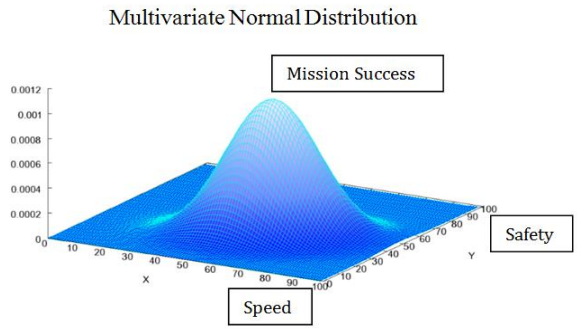
Each has low range and high range values collected from prior histories and current information from which an analysis can be performed to reduce risk.

Summation: $\sum = I + A + W + T + V + T$

From the equation it is seen the mission success is high related to the Maneuver Mission Module selected and to the ISR package used for identification and signature recognition. Distributions and regression analysis are calculated for each variable with respect to each Route.

Notes
1. These variables are properly set so as to adversely affect the mission outcome.
2. Any tradeoffs made must be noted.
3. Parameters are established with bias for highest % of likelihood to control outcome.
4. A linear or nonlinear regression approach may be used where appropriate including time varying coefficients.

Each variable may be further utilized in a broader statistical evaluation. WF = weighted Factor coefficients may be used based upon causality, time exposure vulnerability and with likeliness of occurring. The resultant variables may be further developed and formulated into a larger algorithm such as a Multivariate normal distribution.



The algorithm is adjustable for each phase in the operation.

To isolate the risks into a set of most likely events, alternatives are defined for a useful assessment. The CCMD shall then have the analyzed data with assumed risks for any suggested mission changes providing reduced risk evaluation while moving for assets in-transit on water and on land. The autonomous platform approach has the unique benefit for determining CLZ obstacles, mines, armed pillars and tunnels from which the enemy may launch attacks with a high degree of success including ambush tactics. The actual information is then used in the GIG for the real-time information from sensors of each platform which establishes higher confidence in the initial mission plan as it progresses through each phase in the operation.

Commanders conduct significant planning for each of these tasks. In order to establish the highest percentage of success for mission objectives, the objectives for Technology as Material Solutions has a critical role in establishing new Capabilities to succeed in those missions. The following table represents an overall multiple Capabilities Summary of associated Joint Capability Attributes. This Table applies to autonomous platform use.

Joint Capability Area - CV-2 Diagram(s)			(other JCAs apply but are not included here)		
JCA Number	Battlespace Awareness	Force Application	Command and Control	Net-Centric	Protection
2.2 Problem Solution	Collection of Information No SA SA Provided				
3.1 Problem Solution		Maneuver to Position Delay and Stop Hasty Breach Provided			
5.3.1.1 Problem Solution			Ability to Analyze Situational Awareness No real-time C2 Dynamic re-tasking		
6.1.2.2 Problem Solution				Ability to transport and transfer data BLOS Data not sent SADL Net-Centric use for C2	
7.2.1 Problem Solution					Mitigate Lethal effects FP w/ Stop Full-time FP

Note: Respective UJTL, UNTL, METL and MCTL Numbers are available.

The combination of these capabilities benefits the assessment of all tasks and allows for material solutions analysis and material development decisions to be made from a high qualitative standpoint.

The Benefit Matrix on the following page summarizes Technology Utilization during Marine and Joint Force amphibious landing, offensive and defensive land missions. The respective tactical task details are listed from the perspective of having to reduce obstacles and breach lanes. The Tier 1 JCAs which enable Command and Control with Situational Awareness have overlapping benefits for Force Application, Force Protection and Net-Centric BA.

Tactical Marine Tasks*	Delay Scenario IED Presence	Troop/Unit Response	Potential Risk w/o	KPP Solution KSA Function	JCA Tier 2 w/MoEs&MoPs
Enemy-Oriented Tactical Tasks:					
Ambush	Observe/detect/trip	Bypass	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Attack by Fire	Observe/detect/trip	Bypass	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Block	NA			Advanced Recon	2.4.4, 5.2.3 & 6.1.2
Breach	Reduce	Pause	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Bypass	Observe/detect/trip	Bypass	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Canalize	Observe/detect/trip	Stop & 5c's	Mine Casualty	Neutralize	3.1.1,3.1.4,7.1.2&7.2.1
Contain	NA			Surveillance	3.1.1,3.1.4,7.1.2&7.2.1
Defeat	Observe/detect/trip	Stop & 5c's	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Destroy	Observe/detect/trip	Stop & 5c's	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Disrupt	Observe/detect/trip	Stop & 5c's	Lost Mobility	Mark&Movew/ISR	3.1.1,3.1.4,7.1.2&7.2.1
Exploit	Observe/detect/trip	Stop & 5c's	Lost Mobility	Route Sweep	3.1.1,3.1.4,7.1.2&7.2.1
Feint	Observe/detect/trip	Stop & 5c's	Lost Mobility	Neutralize	3.1.1,3.1.4,7.1.2&7.2.1
Fix	NA			Advanced Recon	2.4.4, 5.2.3 & 6.1.2
Interdict	Observe/detect/trip	Stop & 5c's	Lost Mobility	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Neutralize	Observe/detect/trip	Stop & 5c's	Lost Mobility	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Penetrate	Observe/detect/trip	Bypass	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Reconnoiter	Observe/detect/trip	Stop & 5c's	Lost Mobility	Advanced Recon	2.4.4, 5.2.3 & 6.1.2
Rupture	Reduce	Pause	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Supportby Fire	Observe/detect/trip	Stop & 5c's	Lost Mobility	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Terrain-Oriented Tactical Tasks:					
Clear	Observe/detect/trip	Bypass	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Control	Observe/detect/trip	Stop & 5c's	Mine Casualty	Surveillance	3.1.1,3.1.4,7.1.2&7.2.1
Occupy	Observe/detect/trip	Stop & 5c's	Mine Casualty	Neutralize	3.1.1,3.1.4,7.1.2&7.2.1
Reconnoiter	NA			Advanced Recon	2.4.4, 5.2.3 & 6.1.2
Retain	Observe/detect/trip	Stop & 5c's	Mine Casualty	Neutralize	3.1.1,3.1.4,7.1.2&7.2.1
Secure	Observe/detect/trip	Stop & 5c's	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Seize	Observe/detect/trip	Stop & 5c's	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Friendly Force-Oriented Tactical Tasks:					
Breach	Reduce	Pause	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Cover	Observe/detect/trip	Bypass	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Disengage	Observe/detect/trip	Bypass	Mine Casualty	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Displace	Observe/detect/trip	Stop & 5c's	Lost Mobility	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Exfiltrate	Observe/detect/trip	Bypass	Mine Casualty	Mark&Movew/ISR	3.1.1,3.1.4,7.1.2&7.2.1
Follow	Observe/detect/trip	Stop & 5c's	Delayed trigger	Route Sweep	3.1.1,3.1.4,7.1.2&7.2.1
Guard	Observe/detect/trip	Stop & 5c's	Lost Mobility	Immediate Breach	3.1.1,3.1.4,7.1.2&7.2.1
Protect	Observe/detect/trip	Stop & 5c's	Lost Mobility	Surveillance	2.4.4, 5.2.3 & 6.1.2
Screen	NA			Advanced Recon	2.4.4, 5.2.3 & 6.1.2

*Notes: Reference MCDP 1-0. The Joint definition of each technique must be interpreted. JCA Numbers are for MCT capability gap solutions: Mobility for Advance and Breaching, Protection for Dismounted Warfighters & ISR synchronization.

This matrix is devised to include the portion of tactical mission tasks entering into zones with IED obstacles with *immediacy of time to advance* analyzed. This becomes relevant for COA in assigning priority required by the Commander to achieve each objective. Each of the Tier 2 JCA numbers corresponds to the descriptions defined in the 2010 JCA refinement (BEA) as shown on CV-2 Diagrams. With consideration of unknown obstacle locations, technology use provides M2 capability to contact allowing fast lanes for mobility in areas with IED/mines.

Measures of Performance and Effectiveness (MOP & MOE)

For initial capability development planning purposes, it is expected that, at a minimum, the measures listed in table below will be applicable to these capabilities, as operational requirements for HCBS are further decomposed to technical and functional requirements, other detailed measures of performance and effectiveness will be developed.

Hybrid Chassis Breaching System MoP and MoE Table

(See Joint Task List and Joint Capability Area List)

ID	Measure	Description	Threshold	Objective
MoP 1.0	Ability to resist Overturning	Synergy of Hasty and Deliberate Breaching Modules has effect to dissipate upward, overturning Forces	Remain within 6 inches of ground with rearward translational movement	Not lose ground contact
1.1	Ability to form FP OTM for Freedom-to-Maneuver Breaching Lanes.	Breaching Modules detect, neutralize and protect Dismounted Warfighters.	Ballistic projectile pattern is blocked by barrier with 135 and 360 degrees of low cast projectiles.	Subsume Kinetic threats on land and Neutralize in CLZ.
1.2	Survive fragmentation and shock effects (Asset).	The MOB Module has simultaneous load transfer Shock Cage Chassis dissipating energy w/shell absorption	Five events before major service	Five months before major service
1.3	Ability to send information after g-force.	Mounted COTS and GOTS equipment is field tested for ability to send and receive information.	Five events before major service	Five months before major service
1.4	Ability to deploy, make way & navigate, maritime	Propulsion and Metacenter has direction and depth control.	Five events before major service	Five months before major service
1.5	Achieve Situational Awareness BLOS for decision making MCCL 5.2	The means of Data Transfer for Net-Centric Operations is achieved with a specialized morph turret antenna.	Five events before major service	Five months before major service
MoE 1.0	The ability to perform nuetralization events in a repeated, rapid manner.	Breach with Standoff for M2 and FP; 3.1.1.3, 3.1.2.3, 3.1.2.4, 7.1.2, 7.2.1.	Five events before major service	Five months before major service
2	Deliver SA BA NC for C2.	Provide real-time SA for dynamic re-tasking of assets and personnel in austere environments.	DISA has at least two Bandwidths and data transfer speed failsafeSADL	Two Optics Systems Shell density change for stealth.
3	DTE from Maritime to Land 3.1.2.3/3.1.2.4	Ability to make Amphibious landing and maintain tempo at the tactical edge while providing SA.	Perform STOM in SS-4, OMFTS DTE Missions. CLZ incline <15% no seaweed.	Incline<30% with medium rock cover, 50% drift seaweed.

Maneuver and Breaching Technology significantly increases User Capabilities. Operational SA feeding C2 with Net-Centric Data Sharing shall provide information at the tactical edge BLOS for CCMDs to the forward position dismounted detachment leader. As the advance continues, platforms form nodes for a COP continuously along the length with sensors, cameras and artificial intelligence feeding realtime ISR to CCMDs.

Breaching IED/Mines at CLZ and inland to the tactical edge shall have a Joint Operation for Breaching Requirements for successful mission outcomes especially those with CBRN. The Ability to Breach Lanes as needed for reconnaissance, sweep, LOEs, DTE Missions for Hasty Advance and Deliberate Triggering Tasks shall be performed synchronized maintaining Tempo.

Initial Entry Forces conducting entry can typically range from as small as a company to as large as a brigade. Given this and the wide variety of scenarios in which entry operations may be conducted, for conventional and SOF Forces, the size could be the smallest creating and maintaining lanes by breaching with SA and node positioning.

A Joint Concept for modular technology for Breaching and Mobility can easily be adapted into MAGTF, SOF and platoon size operations such as those in MARFORSOC Core Activities.

Insertion and Deployment Scenarios and Methods of Delivery

Typical topography and terrain to be encountered for SOF and NEMW MAGTF Missions. These Capabilities allow for Joint Operations Planning, Reverse Planning and COA for CCMDs to deliver MCM capability near-shore able to come out of the water allowing for continuous mission tempo providing breaching.

Direct Roll-Off from manned Fleet vehicle

Air Delivery

Mission and Maneuver readiness for CONOPS;

As the Commander evaluates and selects his COA, Support, Breach and Assault Forces are arranged into situational templates using a reverse planning sequence based on OBSTINTEL. Amphibious Landing Capability to come out of the water and make landing shall allow stealth, surprise and overall mission speed. Execution of deliberate and hasty breaching operations is by

combat breach forces adapting for METT-TC factors. With sufficient reduction assets, lanes and corridors are created through the obstacle for platoon and company advance and attack without Delay or Reduced Mobility. The effect integrates team unity for delivering maximum combat power forward. Mass, speed and reliability to create lanes are achieved as a MOP for the Breaching Force when implementing the Technology for Capability. For breaching operations, combined arms synchronization is essential to provide speed through engagement zone. The capability to advance over distances without Stop provides flexibility to execute dismounted maneuvers due to changing Battlespace conditions with unknown obstacles. The survivable aspect of the Technology allows for continuation of capability with detection to reduction solution of IED/mines with Force Protection and ISR Mobility for follow-on obstacles and enemy surveillance.

The Common Operational Picture desired by leadership has increased confidence with increased SA and the number of nodes available for ISR. Of course, budget constraint limits the number of fixed points for security. The addition of streaming real-time video allows for confidence in target recognition. These affordable assets may come into range and can provide SA BLOS at the Tactical Edge and deliver with Datalink and control systems. This form of simultaneous delivery of shared awareness with AI allows for Unmanned Autonomous Assets to provide CCMDs Capabilities for the Tactical Advance and for Security while on land and from the water when necessary.

Use of the Technology in Tactical missions improves the commander's strategic movement for any tactical mission following C2OTM's RCs. This Joint Concept combined arms approach with MOB, M2 and FP Capability Modules provides advantages for defensive and offensive tactical maneuvers relevant to today's in-demand CONOPs. Technology insertion allows Tactical Edge advance BLOS and Joint Force mission success maintaining tempo.

Conclusion

The common thread sought in each war is the capability of Freedom-to-Maneuver without Stop and Delay due to Area Denial defensive strategies. This problem exists for land and Amphibious Missions and is a Technology Focus Area. In order to conduct successful military operations in the A2/AD environment, U.S. leadership must address A2/AD as a new way of war".[18] CCMDs desire affordable robust Material Solutions to overcome these A2/AD methods. Specifically stated, "The ability to identify, classify, bypass, and when necessary breach obstacles within the littoral." and "The ability to overcome ground obstacles (explosive and non-explosive) from the seaward approach when they cannot be by-passed during an assault."[19]

This operational need identifies Capability Gaps where Technology development programs exist for prototyping competitive Material Solutions. It is possible to address this operational gap through existing Requirement documents to reflect lessons learned. A Material Solution Program to develop Technologies should follow a Material Development Decision (MDD) prioritizing these Capability Gaps which exist in the ICD, Unmanned Ground vehicles validated by the Defense Acquisition Executive, the milestone decision authority. Existing UGVs are found within OSD's FY2009-2034 Report without these stated Capabilities presented.

Common tactical picture - BA w/ M2 – Full Dimensional Protection

Utilizing Research and Development Programs for new UGV/USV Platforms with SA Modules allows for rapid dynamic retasking. With Mobility, CCMDs are capable of maintaining operational tempo and to achieve mission objectives for a broader Ground Force Strategy.

Operational Planning – OPLAN Capability for OPORD & FRAGORD

Achieving mobility, Freedom-to-Maneuver, enhancing Force Protection, synchronizing coming out of the water with dynamic retasking and breaching capability to continue overland to objectives are future capabilities for amphibious systems. This allows tempo, speed and surprise for CCMD's FA while providing BA for forward movement and real-time SA/ISR for defensive capabilities. A plan of action has been suggested presenting details to improve tactical missions with CONOPS. This provides a suggested scheme of field logistics to deploy C2 with mobility. This Analytic Basis demonstrates M2 Capabilities enabling C2 at the tactical edge.

Affordability of Modular Technology for Modern Warfare

Future Naval Capabilities continue to expand operational capabilities and seek to continue to transition USMC technology. Autonomous Platforms shall yield many times the Power Projection Capabilities compared to other focus areas priorities for platoon uses for MAGTF MEB Operations. A new User Capability Opportunity for MAGTF and SOF Operational Effectiveness is provided in the VSW and inland for DTE missions. This capability readily applies to exoskeleton and AEODRS platforms and vehicles. The Evolution of these Material Solution Programs to resolve Anti-Access/Area Denial methods with lightweight modular solutions shall provide landing, mobility, breaching and Situational Awareness where C2, M2 and FP capabilities may be extended into any expeditionary geographic environment.

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