U.S. Marine Corps S&T Stategic Plan

Leading Edge Technology for the Marines of Tomorrow

UNITED STATES MARINE CORPS

Report Documentation Page

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MARINE CORPS SCIENCE AND TECHNOLOGY STRATEGIC PLAN

August 2007

The *Marine Corps Science and Technology Strategic Plan* establishes the objectives and provides direction for science and technology investment to support the needs for our future Marine Corps. As you read this Plan, you will find that it addresses capability needs for all the elements of our Marine Air-Ground Task Force.

The Plan is designed to complement the *Naval S&T Strategic Plan*, approved by the Department of the Navy Corporate Board. It focuses specifically on defining the technology needs of our POM 10 *Marine Air-Ground Task Force Capability List* by identifying as science and technology objectives - STOs - the technology enhancements most needed to enable the warfighting capabilities of our future Marine operating forces. The STOs are not intended to be all-inclusive. Instead, they define the priority technology objectives that when met will implement our future vision for the Marine Corps.

This Plan is focused on STOs articulated by warfighting function. However, in recognition of the importance of the individual Marine, in Annex A we describe STOs in Human Performance, Training & Education that cross all the functions. In the past four years we have had an unprecedented influx of technology and new equipment added to our operating forces – focused specifically on our Ground Combat Element – in order to make us the best armed and equipped fighting force in the history of the world. Now we need to ensure that we capitalize on the best capabilities of our commercial game industry and simulation technologies to produce a coherent training and education system that will help our commanders prepare their Marines to employ these technologies at maximum effectiveness. At a minimum we need to be able to use simulation to prepare our Marines at home stations on techniques and procedures so that they can be more productive and efficient in training exercises such as *Mojave Viper.* Our aviators have used simulations for years; now we need provide the same for the rest of the force.

Of special note is the emphasis throughout the Plan on lightening the load of our dismounted Marines and sailors. This is of special concern as we add to the personal protection equipment and added technological advanced equipment to make our Marines more effective in a distributed battlespace.

Our definition of needs by warfighting function is augmented by two Annexes focused on specific technology areas of need that are not Marine specific. In Annexes B and C we highlight the capability needs we wish to emphasize to the Navy for Naval science and technology investment on behalf of future Naval aviation and the seabased, power projection Navy-Marine Corps team capable of implementing distributed operations

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Marine Corps Science and Technology Strategic Plan

Ref: (a) Naval S&T Strategic Plan: Defining the Strategic Direction for Tomorrow, dated 19 January 2007
(b) DC CD&I ltr 3500 C39 of 5 Feb 2007, Approved Program Objective Memorandum (POM)-10 MAGTF Capability List (MCL)
(c) MCO 3900.15A

Annexes: (A) Human Performance and Training Science & Technology Objectives
(B) Seabasing Science & Technology Objectives
(C) Aviation Science & Technology Objectives

1. **Purpose**. To provide a strategic plan for the Marine Corps Science and Technology (S&T) enterprise. The Plan focuses Marine Corps S&T efforts to pursue S&T initiatives and support experimentation of concept-based requirements to achieve future Marine Corps capabilities.

2. **Background**

a. The Marine Corps S&T Enterprise is an integral part of the larger Naval Research Enterprise (NRE). It is a collaborative effort between the Marine Corps Combat Development Command under the staff cognizance of the Deputy Commandant, Combat Development and Integration, (DC, CD&I); the Marine Corps Systems Command (MCSC); and the Office of Naval Research (ONR). This relationship is depicted in Figure 1.

b. The Commandant of the Marine Corps provides the future vision for the Marine Corps based on strategic guidance. The DC, CD&I expands on CMC's vision by developing Marine Corps warfighting concepts and determining required capabilities in Doctrine, Organization, Training, Materiel, Leadership and Education, Personnel, and Facilities to enable the Marine Corps to field combat-ready forces.

c. The Marine Corps Combat Development Command (MCCDC) serves as the combat developer for the Marine Corps in the same way that the Marine Corps Systems Command serves as the materiel developer and the Office of Naval Research is technology developer for the Department of the Navy (Navy and Marine Corps). Coalescing these responsibilities requires a synergistic partnership with a common vision, a strategy, and an implementing plan. Staff responsibility for coordinating Marine Corps S&T combat development efforts is assigned by DC CD&I to the Commanding General, Marine Corps Warfighting Laboratory under the title of Executive Agent for Marine Corps S&T. An S&T Integrated Product Team with a broad membership across the community of interest reflected in Figure 1 supports the EA for S&T in this coordination role as needed.

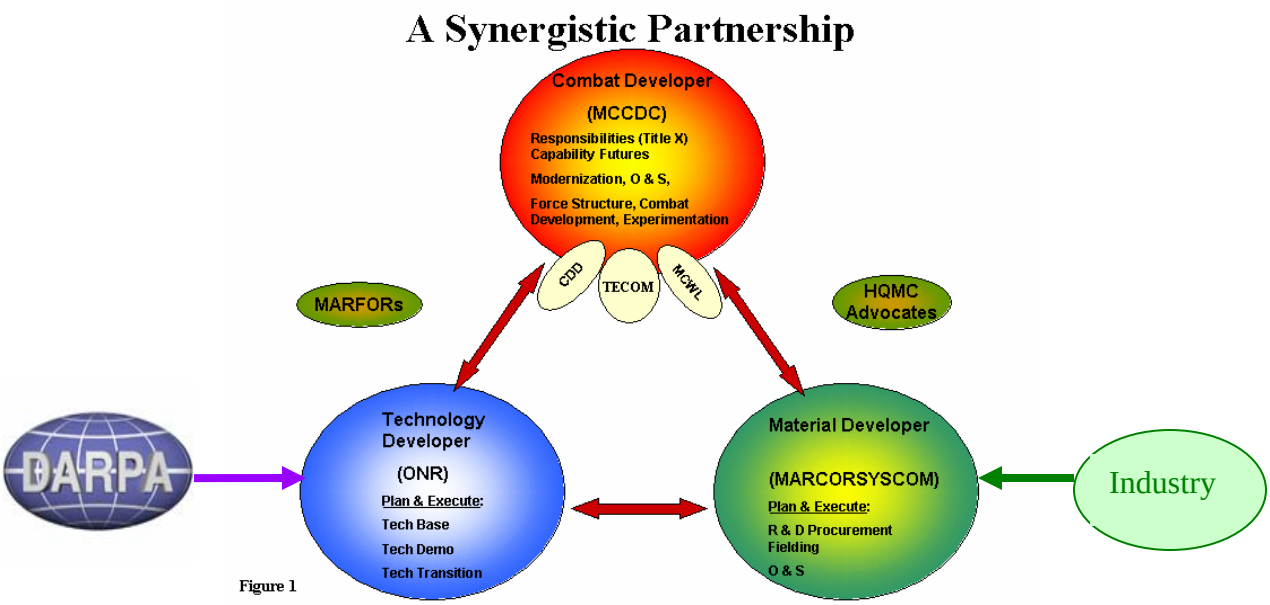

Figure 1

d. The Marine Corps Warfighting Laboratory supports combat development as a subordinate command of MCCDC. The Marine Corps Warfighting Lab develops the family of concepts that help articulate the future vision of the Marine Corps. Additionally, it conducts wargaming and experimentation that support emerging concepts, adapts and assesses selected technologies, and explores improvements in tactics, techniques, and procedures (TTP).

e. The *Marine Corps S&T Strategic Plan* is based on the S&T guidance of the Office of the Secretary of Defense and that of the Department of the Navy in reference (a) as approved by the Naval S&T Corporate Board. In addition, the Strategic Plan is derived from a Marine Corps capability gap analysis that results from Phase I of the Functional Solutions Analysis as refined via the Front End Assessment for POM-10 as promulgated in reference (b) and as depicted in Figure 2 below.

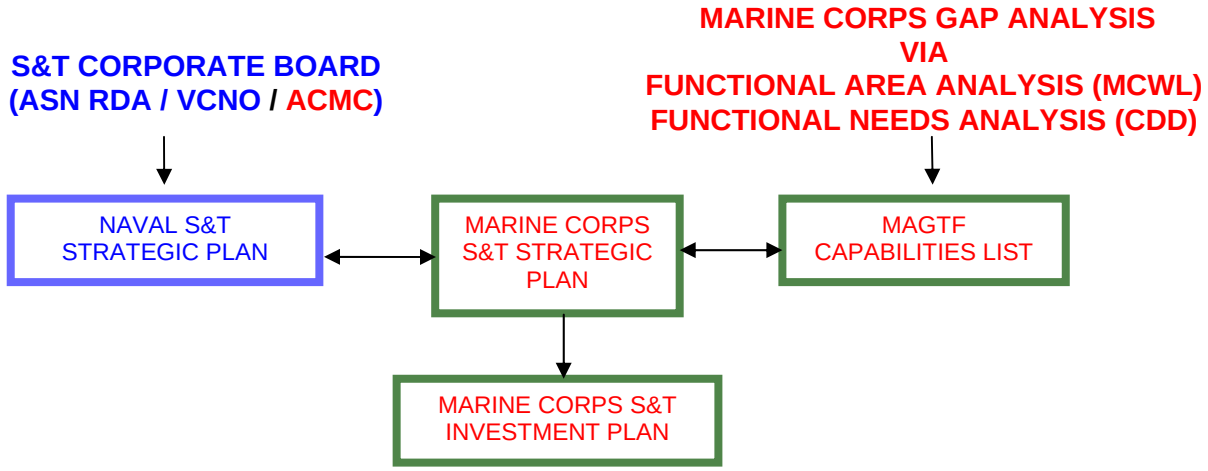

Figure 2

f. The Marine Corps leverages the investment of ONR, the NRE, Defense Advanced Research Projects Agency (DARPA), other Services—specifically that of the Army[1] -- and industry while focusing our Marine Corps unique investment to support Marine Corps combat development and future materiel needs. This approach must ensure that we are meeting our near-term needs focused primarily on those of the current operating forces; our mid-range needs – primarily those of the materiel developer in technology enhancements to acquisition programs for the next Marine Corps; and the far-term needs of the Marine Corps after next as articulated in our future concepts by the combat developer.

3. **Capability Needs**

a. The Marine Corps capability needs are determined as a result of the process contained in reference (c) and are articulated principally through the MAGTF Capability List (MCL) promulgated by reference (b), and as contained in Universal Needs Statements (UNS), Initial Capability Documents, Capability Development Documents, and Capability Production Documents. In addition, Marine Corps S&T capability needs are shaped by the Advocates Requirements List.

b. Marine Corps S&T capability gaps are integrated into the Navy's gap analysis process. The Navy has established an operational gap analysis process that supports specifically the ONR Future Naval Capability (FNC) program. The goal of the FNC is to ensure that at least a portion of the S&T investment ongoing at ONR is focused specifically on transitioning technologies into Naval acquisition programs targeted at priority warfighting capability gaps. The Navy gap analysis process consists of wargaming multiple scenarios, developing Mission Capability Packages (MCPs), and then defining the capability gaps within each MCP.

c. The Marine Corps participates in the Navy process to develop Naval S&T gaps. Marine Corps representatives will use the MCL during both the Marine Corps S&T gap analysis and Navy gap analysis to identify our Service-specific capability gaps.

4. **Assumptions**

a. Marine Corps-unique expeditionary maneuver warfare capabilities and naval character remain relevant and essential.

b. Marine Corps core competencies as contained in *Marine Corps Strategy 21* and principal warfighting concepts remain unchanged.

c. S&T resources available to the Marine Corps remain stable based on the PR09 profile. Department of the Navy S&T resources remain at approximately 0% real growth across the FYDP

d. Marine Corps warfighting functions will remain unchanged.

e. Emerging concepts in support of Distributed Operations, Urban Operations, Irregular Warfare, or Fourth Generation (asymmetric) Warfare will be addressed by S&T in the mid- and long-range planning process.

5. **S&T Budget Categories**

a. The Department of Defense delineates budget activities with specific funding categories for science and technology known as: basic research, applied research, and advanced technology development.

(1) **Basic Research (6.1)** includes scientific study and research to increase knowledge and understanding in the physical, engineering, environmental and life sciences related to long-term naval needs. Its focus is knowledge of scientific phenomena. Discovery and invention is the responsibility of ONR and current research areas of primary interest to the Marine Corps are:

- Autonomous Systems
- Communications
- Lightweight Power Sources
- Information Efficiency
- Sensing
- Human Performance
- Landmine and Improvised Explosive Device (IED) countermeasures (to include both detection, induced pre-detonation, and survivability)
- Energetic Materials
- Urban/Asymmetric Warfare
- Small Unit Excellence

(2) **Applied Research (6.2)** is the systematic study to understand the means to meet recognized and specific naval needs. Applied research translates promising basic research into solutions for broadly defined military needs, short of system development projects. Its focus is proving technology feasibility when applied to solving military problems.

(3) **Advanced Technology Development (6.3)** includes the development of subsystems and components and the efforts to integrate subsystems and components into system prototypes for field experiments and/or tests in a simulated environment. The focus is on demonstrating the military utility of technologies and applying them to acquisition programs. It supports the FNC program, as well as the warfighting experimentation conducted by the Marine Corps Warfighting Laboratory.

6. **Science & Technology Objectives**

a. STOs are established to provide combat development guidance to the S&T community, primarily to the Naval Research Enterprise but also other Services, defense agencies, industry, and academia. A STO states a major technological advancement to be achieved and is in support

of a capability need identified and prioritized during S&T gap analysis. STOs must be consistent with the funding available in the Future–Years Defense Plan. The Marine Corps S&T budget submission is developed to support this Marine Corps S&T Strategic Plan.

b. The STOs are also the principal driver for Navy S&T investment in the land warfare component of Naval expeditionary warfare as articulated in reference (a).

c. The organization of this Plan mirrors the six-warfighting functions inherent to the framework of the MCL as contained in reference (b). Warfighting functions assist commanders in achieving unity of effort to build and sustain combat power when used in concert, and should not be viewed independently but as inseparable parts of a whole. Each warfighting function is designed to depict the linkage of the general statement, vision, and goal to the individual STOs.

d. The “maneuver” functional area specifically addresses the area of “mine countermeasures” which includes technology responses to the threat of improvised explosive devices (IED) and unexploded ordnance in keeping with the emphasis that is currently placed on this warfighting gap through extensive investment outside of the Navy. Two interconnected combat development working groups (Mine Counter Measures under the lead of DC, PP&O and IED Working Group under the lead of the EA for S&T) are focused on closing this significant warfighting gap.

e. In recognition of the significance of training and human performance to the ability of Marines to operate across all warfighting functions, we address ” Human Performance, Training, and Education as a discrete focus area in Annex A, in keeping with its importance to the successful preparation of the individual Marine for combat and in achieving optimum unit operational performance.

f. Expenditures for seabasing and aviation STOs are Navy "blue" dollars and capability gaps are developed via the Navy capability gap process. However, both seabasing and aviation capabilities are essential to the realization of MAGTF power projection capabilities even though resourced by the Navy on behalf of the Marine Corps. Accordingly, seabasing and aviation STOs are both embedded in the warfighting functions and broken out separately in Annexes B and C respectively. The purpose of these annexes is to document the S&T priorities of the Marine Corps for use in Navy gap analyses and to assist Marines in representing Service combat development interests in Naval S&T functional working groups.

g. The sequence of the warfighting functions within the Plan that follows: Command and Control; Intelligence; Maneuver (to include Mine Countermeasures); Fires; Force Protection; and Logistics.

Command and Control

The S&T investment in Command and Control is focused on three areas required to implement the FORCEnet concept and its Marine Corps instantiation, Marine Air-Ground Task Force Command and Control (MAGTF C2): (1) communications and networking systems to enable data exchange with and among distributed tactical forces; (2) decision support systems; and (3) effective combat identification of enemy combatants, friendly forces, and non-combatants.

***The Vision*: Through seamless information architecture, future comprehensive command and coordination will be characterized by increased freedom of action and enhanced access to all elements of national power through comprehensive interconnected networks.**[2]

Goal: The focus is directly associated with the Naval Concept of FORCEnet and MAGTF C2. Integration of all force elements throughout the battlespace, including: satellites; manned aircraft;, ships, submarines;, Unmanned Combat Vehicles; Unmanned Ground Vehicles; Unmanned Aerial Vehicles[3]*; Unmanned Underwater Vehicles; unattended space, air, ground and sea sensors; and warfighter afloat and ashore.*[4] *Forces, activities and platforms are interconnected in this networked, collaborative command and control environment, thereby benefiting from the advantages of decentralization (e.g. initiative, adaptability, and increased tempo) without sacrificing the coordination or unity of effort typically associated with centralization. The system will provide a shared understanding of position location information (PLI) on friendly forces, and will incorporate combat identification technology to facilitate distinguishing combatant forces. Commanders will be able to gain and maintain situational awareness, make better decisions, and exercise authority and direction over assigned forces via an adaptable, distributive, and seamless system.*[5]

-- C2 STO-1: Converged services networks with assured, robust communications linking all echelons of the MAGTF

Develop network centric warfare technologies that enable early entry forces to communicate over the horizon and on the move (OTH/OTM)[6] with each other, and interoperate with other naval, joint, and coalition forces to enable distributed maneuver, and to leverage joint fires and logistics on the future battlefield.

-- C2 STO-2: Multilevel information security and information assurance

Develop technologies that facilitate information sharing (down to the platform level) and enable the integration of unclassified and classified systems for joint and coalition operations. Provide intra-, cross-, and inter-domain authentication, encryption, and information assurance/integrity services in conditions typical to Marine Corps distributed operations, such as intermittent connectivity and limited throughput in restricted and hostile environments.

-- C2 STO-3: Intelligent network monitoring, maintenance, and mobility

Develop intelligent network management technologies to enable the real time monitoring, maintenance, and distribution of the network status. Provide technologies that enable automatic

recovery, alerting, and net intrusion countermeasures; and graceful network reconfiguration and/or degradation as nodes are lost and recovered.

-- C2 STO-4: Improved situational awareness for warfighters at all echelons

Develop improved situational awareness capabilities that operate with high levels of automation to provide Marines (across all echelons and elements of the MAGTF) intelligent access to digital information. Enable near-real time distribution of tailored information using cognitive tools, intelligent agents, tailored services, and other relevant technologies.

-- C2 STO-5: Blue Force Tracking/PLI/Combat ID

Develop passive and active methods for timely determination of location and identity of battlespace entities. Provide tools for discovery, retrieval and presentation of most relevant/highest quality location and identification data regardless of source.

-- C2 STO-6: Collaborative Planning and Synchronized Execution

Develop intuitive non-user-intensive decision aids and collaborative planning tools tailored for mission, location and echelon appropriate for the distributed Battlespace. Facilitate dynamic and rapid mission adaptation through transparent user information pull and automated information push**.**

Intelligence

The S&T investment in intelligence also includes surveillance and reconnaissance constituting a complete ISR capability set which is focused on three specific areas: (1) intelligence collection, (2) signal exploitation technologies, and (3) intelligence analysis, fusion, and dissemination. In addition, we need technologies to deny selective spectra from the enemy.

The Vision: Commanders at all levels have both the capability to leverage the Joint ISR architecture, and to conduct reconnaissance, surveillance, and target acquisition functions commensurate with their mission, with assets that they control.[7]

Goal: The focus is on data collection, intelligence fusion into usable products, and distribution of relevant information across the network to all authorized users. Using the network, relevant intelligence is available in near-real time to all authorized users globally. In addition, to "top-down intelligence," commanders at all levels require the collection tools to actively conduct reconnaissance, surveillance, and target acquisition in areas that support their own assigned missions. The results of this "bottom-up" tactical intelligence collection is then entered into the network and adds granularity to the shared situational awareness available to decision makers at all echelons of command via the shared data that underpins the common relevant tactical picture. Recent world events and analysis of likely futures have resulted in focusing efforts on urban and asymmetric warfare capabilities as well as Distributed Operations.

-- Intel STO-1: Tactical Quality Sensing in Denied Areas

Develop small, light-weight, low-power autonomous sensors that can covertly collect relevant tactical information in denied areas. Develop low probability intercept communication capabilities to quickly extract large amounts of data from tens of kilometers.

-- Intel STO-2: **Exposing hidden enemy networks, anticipating and influencing behavior**

Develop techniques to expose hidden enemy networks by establishing causality between entities, taking into consideration geocultural influences. Develop technology to model decisions and behaviors of interest allowing for their stimulation and manipulation. Utilize probabilistic methods to develop techniques to anticipate the actions of irregular actors using statistically derived patterns.

-- Intel STO-3: **Urban-specific situational awareness**

Develop urban structure-penetrating sensors capable of detecting and classifying personnel (moving and stationary), detecting firearms, explosives, and identifying construction features from standoff range. Urban structures include buildings, basements, sewers and subterranean complexes. Determine if buildings are occupied without having to enter the building. Determine orientation and intent of personnel/behavior located within the urban infrastructure prior to engagement. Processes raw data from penetrating sensors and all Intel sources into optimum own-course-of-action decisions enabled by data mining and visualization. Develop ISR sensors that operate reliably within high multi-path environments to include technologies associated with the Tactical Exploitation of National Capabilities (TENCAP) and their capability in urban restricted, and denied space.

-- Intel STO-4: **All source level 1, 2, and 3 data fusion relevant to irregular warfare and combating terrorism**

Develop algorithms that can queue sensors, translate useful tactical sensor data across all nodes/INTs and security domains in an AOR to tactical understanding (unusual, interesting) and generate automated indications and warnings. Depict normal tactical activity and perform statistical determination of entity to event relationships. Create algorithms to relate data and entities to aggregates. Facilitate integration of data and ontology development to understand entity and aggregate activity. Continually assess the relative suspicion level associated with data, entities and entity aggregates**.** Identify technology research requirements supporting distribution requirements, including video streaming to tactical level required to support Distributed Operations.

-- Intel STO-5: Sensor field planning and management

Develop tools that enable the design of multi-INT sensor systems that are optimized against specific mission requirements. Automate sensor field designs that specify the sensor modalities & densities needed to counter a specific threat against a specified unit and place. Develop tools that can dynamically and autonomously manage/task large numbers of netted sensors.

-- Intel STO-6: Generation of actionable intelligence enabled by small unit situational awareness

Develop an intelligent, scalable and non-intrusive tactical user knowledge discovery interface that allows an individual warfighter to harness the power of the local mission aware tactical sensor field. Provide models of cooperative behavior between sensors that provide situational awareness (visualization within a grid). Develop technology to enable tactical ISR to support current operations in near real time.

-- Intel STO-7: Specific entity awareness (TTL/biometrics/witness materials)

Develop tools, sensors and materials to tag any object or person of interest. Sense the presence of unique elements in an environment. Develop tools for discriminating and enhancing the taggants or sensor signals and tools/tags that influence one another based on proximity. Develop tag/material standoff interrogators and develop algorithms to translate objects or tracks to actionable intelligence. Develop technologies that enable the ability to positively identify, tag, and track individual persons of interest. In addition, develop technologies that provide a means to positively identify bomb makers and bad actors and then disseminate information to all echelons of command.

-- Intel STO-8: **High information content tactical sensors**

Develop smart sensors able to process algorithms and data on-board that leads to actionable intelligence by sensing unique features of entities or their behaviors. Sensors are unattended, low size weight and power (SWAP); capable of storing and processing data, cueing other air or ground sensors, and providing alerts. Sensors are ground, hand-emplaced, UAV-mounted, vehicle/boat mounted; enabling the widest range of collection opportunities and flexibility in emplacement. Sensors are employed at the lowest tactical level for wide area tactical persistent surveillance. Develop sensor technologies that are specifically applicable to unmanned aerial systems that can be either lighter-than-air[8] or air-breathing UAVs.

-- Intel STO-9: Algorithms capable of translating data to information at point of collection

Develop mature algorithms that can translate raw tactical intelligence to useful information at the point of collection in order to conserve bandwidth. Develop agents that can maintain overall sensor field situational awareness and provide individual sensor nodes with context needed to optimize the translation of raw data to useful information.

-- Intel STO-10: Agile sensor fields relevant to distributed operations

Develop rapidly forming and mobile networks to support empowered and agile distributed tactical operations. Enable tactical decision making by providing gateways to net agile warfighters, mobile sensors and distributed data/analysis nodes.

-- Intel STO-11: Wide Area Persistent Surveillance

Coordinate efforts with the Joint IED Defeat Organization's emerging family of systems technology development efforts for wide area persistent surveillance.

-- Intel STO-12: Communications and network denial

Develop technologies that enable the denial of selective communications spectra to the enemy. Denial can be through jamming or through the insertion of deceptive or misleading data. In addition, develop technologies that counter attempts to deny our use of the RF spectrum for communications and network operations.

Maneuver

The S&T investment in maneuver is primarily focused in five areas: (1) increasing the air-mobility of vehicles either through making them internally aircraft transportable or through development of a means to transport them externally from aircraft at high speeds, (2) survivable and fuel-efficient family of vehicles, (3) more survivable aviation connectors and ability to protect and insert capabilities at greater distances in reduced times[9], (4) improved mobility for the dismounted Marine, and (5) enabling unrestricted maneuver across the littoral battlespace to include at sea, in the surf zone, over the beach, and ashore.[10] IEDs pose a related threat with many of the same requirements as mines. The mine countermeasures S&T investment of interest to the Marine Corps is focused in three specific areas: (1) detection, (2) neutralization, and (3) investigative technologies to track mines/IEDs to their source.

***The Vision*: Marines will maneuver from the seabase in a family of high-speed connectors that include amphibious vehicles, tilt-rotor and rotary bladed aircraft, and high-speed surface craft. Once ashore, Marines will maneuver utilizing a family of highly mobile and survivable combat vehicles. Marines maneuvering from the seabase will be able to conduct assault breaching of complex obstacles (including minefields) and follow assigned tracks through the shallow water, the surf zone, over the beach, and inland without impediment to maneuver.**

Goal: The focus is to achieve needed operational and tactical mobility in support of EMW Distributed Operations. This includes projecting forces from the seabase, and once ashore, employing vehicles that are significantly more sustainable through Autonomic Logistics and survivable with alternative power systems, a reduced requirement for fuel, along with crew and manpower reductions. Mobility systems will be more reliable with a reduced requirement for routine maintenance and employ autonomic features to integrate functions of crew, vehicle, and weapon system. Dismounted Marines will employ technologies that enhance their performance: in speed, range, and in load bearing capacity. The maneuvering forces will have the ability to detect and neutralize mines and IEDs from sufficient stand-off distance that they do not put the maneuvering force at risk with minimal impact to rate of advance. Once established ashore, MAGTF elements will have the ability to continue to detect, avoid, and neutralize mines in complex terrain including urban environments. Where mines and/or IEDs are detected, the MAGTF commander will have the ability to rapidly apply investigative methodologies to determine source of devices.

-- MVR STO-1: Advanced power plants, drive trains, and suspensions

Develop technologies to improve current vehicle and support a new family of vehicles that are lighter in weight and thus more fuel efficient, and more capable of being more effectively transported by air from the seabase ashore. Advanced propulsion, drive trains, and suspensions

to improve performance over rough terrain are required to enable greater agility enhanced by speed and mobility.

-- MVR STO-2: Advanced materials and survivability technology to enhance the performance and survivability of combat vehicles

Develop technologies to improve the survivability of both current and future tactical and combat vehicles through the use of innovative passive and active technologies. Develop technologies that have better blast and ballistic protection qualities while reducing the overall weight to the vehicle or platform in order to decrease the impact on performance. Where applicable develop technologies that enable threat-specific protection to be readily added to vehicles and platforms as needed for a specific mission or to counter an emerging threat.

-- MVR STO-3: Augmented cognition for combat vehicle crews and operators of maneuver systems

Develop technologies to assess cognitive state and workload of human operators non-invasively and to manage workload of the combat vehicle crew, the vehicle weapon system, and the vehicle IT infrastructure to improve man/machine performance while moving, shooting, and communicating.

-- MVR STO-4: Aviation technologies that increase the capacity of aviation assets

Develop technologies for rotary wing and heavy-lift applications to increase survivability and decrease the weight of aircraft in order to increase performance of rotary wing transport aircraft. Development of unmanned alternatives to manned helicopters for the delivery of logistics support with reduced risk to manned aircraft is also desired.

-- MVR STO-5: Dismounted Marine performance enhancements

Develop technologies that provide protective equipment, communications equipment, weapons, ammunition, sensors, and optics for the dismounted Marine that are multifunctional, lighter, and provide greater capability. Technologies, such as exo-skeletons[11] will enhance the performance of the Marine by improving load carrying capacity and speed and distance of movement.

-- MVR STO-6: Advanced robotic systems for ground combat

Develop technologies for robotics, teleoperation, autonomous operation, machine vision, and related means for taking the human out of direct involvement in hazardous and exceptionally arduous missions and reduce the Marines' mental and physical burden.

-- MVR STO-7: Mine detection from the surf zone to inland objectives

Develop the technologies to enable the detection of mines and minefields from the surf zone through to inland objectives[12] for sustained operations ashore. Detection technologies must encompass a variety of threats including surface laid and fully buried mines as well as both near-field/far-field detection and include multi-spectral approaches with particular emphasis on detecting low-metallic and non-metallic mines.

-- MVR STO-8: IED detection technology

Develop technologies enabling the standoff detection of IEDs and precursor materials and activities. Detection technologies that address detectable signatures and events across the entire IED kill chain.[13]

-- MVR STO-9: Mine and IED neutralization

Develop technologies to either neutralize mines and IED's from a safe distance or induce a pre-detonation/deflagration in order to remove the threat from maneuvering forces. These technologies include active and passive countermeasures to devices, energetic neutralization methods to kill devices (ignitor blasting caps), and mechanical methods to rapidly clear devices.[14]

-- MVR STO-10: Investigative technologies and methodologies

Develop the technology to permit the operating forces to perform and apply investigative forensic and pattern analysis techniques in order to track back IED to their source.

Fires

The S&T investment in fires is focused in four areas: (1) target detection, (2) advanced weapons systems, (3) munitions and fuses, and (4) the development of directed-energy weapons.[15]

The Vision: ***Marines of the future will be focused on seamlessly applying Naval and Joint fires using a universal spotter concept enabled by the shared situational awareness afforded by the netted battlespace. They will also have an enhanced capability to apply scalable lethal and non-lethal effects with great precision, resulting in less collateral damage and less fratricide.***

Goal: The focus is to streamline the fires process network and the network-wide sharing of position location information to enable improved target detection, location, and clearance. Weapons systems will be reduced in weigh and size, and capable of mobility equal to that of the force they are designed to support. Responsiveness will be enhanced by greater reliance on loitering munitions. Fires will be increasingly discriminate through precise target location, highly accurate weapons, all weather standoff, and scalable weapons effects. Concurrently, multispectral sensing, automated target recognition, and other advances will enhance the

detectability of targets throughout the battlespace, improving detection ranges, turning night into day, reducing fratricide and accelerating the tempo of operations. A range of weapons effects will be available to the commander from electronic attack against systems, to kinetic weapons against personnel, vehicles, and facilities, to scalable weapons effects through multiple means including directed energy. Expeditionary forces will employ weapons that are designed to reduce the logistical demands and take maximum advantage of seabased logistics support systems.[16] *The ability to produce a broad range of weapon effects, from non-lethal to hard-target kill, from sensor-fused to directed-energy weapons will enhance our capability.*[17]

-- Fires STO-1: Lightweight, all weather, precision targeting technologies to include automated fire control for infantry weapons

Develop technologies that enable mounted and dismounted maneuvering forces and the Distributed Operations (DO) Marine to locate, discriminate, and provide target location information in order to facilitate immediate target engagement by either direct or indirect fires. Specifically, develop target acquisition technologies that will provide for 360 degree long range, radar coverage enabling effective target acquisition in all-weather conditions.[18] Develop technologies for use with infantry weapons, technologies that provide ranging, target location, ballistic compensation and target data handoff. Develop hand-held, target location technology designed for dismounted forces capable of defining targets within 10m of accuracy at night and in adverse weather conditions at extended ranges.

-- Fires STO-2: Highly responsive loitering munitions

Develop technologies that permit on-call immediately responsive fire support to the warfighter in support of either ground or aviation borne maneuver through loitering or persistently available munitions.[19] The munitions may be independently deployed and individually targeted or multiple-deployed aboard a UAV with individually targetable munitions. The munitions must be capable of being individually targeted by forces on the ground, in the air during aviation-borne maneuver, or by airborne forward air controllers.[20]

-- Fires STO-3: Pulsed and continuous wave High Energy Laser (HEL) weapons

Develop technologies that generate optical, infrared, and other appropriate wavelengths of coherent energy. Focus is high-energy laser technologies, as well as explosively driven isotropic radiators and other appropriate technologies that can produce both high average and high peak power. HEL sources should be made frequency agile whenever possible and should strive for compactness, energy efficiency, and effective thermal management.[21]

-- Fires STO-4: Low-cost scaleable, modular, and enhanced-effects munitions

Develop technologies that enable design of munitions that closely match terminal effects to the target. The emphasis is to affordably decrease the circular error probable (CEP) while tailoring the effective casualty radius (ECR) in order to enhance effects on target and decrease collateral damage.

-- Fires STO-5: Advanced gun and propulsion technologies

Develop technologies, e.g., electric magnetic, electric thermal etc…[22] that will increase capabilities of direct and indirect fire weapons (small arms through major caliber). These will enhance weapon performance and decrease weight, as well as logistics loads.

-- Fires STO-6: Integrated Lightweight Optics

Develop for use on infantry weapons technologies for durable, lightweight optics (including single integrated day/night scopes) that are quiet, easy to use, and operable in all environments.

Technologies would provide low-power generation requirements, day-night use, and possess target detection and discrimination capabilities.

Force Protection

The S&T investment in Force Protection is focused in four areas: (1) individual protection, (2) platform protection, (3) autonomous systems, and (4) non-lethal effects. The investment in individual and platform protection is intended to provide increased survivability across the spectrum of conflict. Force protection technologies are needed to reduce the weight while increasing the levels of protection of armor for individuals and platforms (vehicles as well as aircraft). In addition, technologies are needed that can protect individuals in chemical, biological, and radiological environments with increased mission effectiveness. This focus on the individual and platform protection should not be construed as negating interest in protecting the MAGTF as a whole from a variety of network attacks and kinetic attacks either ashore or afloat. Rather limiting the discussion to individual and platform protection issues, acknowledges the larger investment in joint and naval protection systems. The inclusion of autonomous systems under force protection recognizes that one major advantage of autonomous systems is the performance of dangerous, dirty, and distant activities formerly performed by Marines.

***The Vision*: Future protection for the Marine and the Force will rely on various technological protective systems countering the most likely threats.**

Goal: The focus is on individual Marine's equipment, platforms and vehicles, and autonomous systems. Marines are equipped with protective clothing and equipment that reduces the individual's optical and heat signature, and improves survivability against the most common threats while minimizing impact on mission accomplishment. Vehicles and platforms are designed to minimize the effects of blast – specifically from mines detonating in the vicinity of wheel wells – and with the capability to readily adapt to threat-specific armor additions as needed. Active defense systems counter the most common threats to vehicles and platforms. Autonomous systems provide tools that reduce the risk to Marines conducting specific tasks to include but not limited to reconnaissance, local security, mine clearing, and EOD.

-- FP STO-1: Technology that provides improved protection for the individual against fragments, projectiles, blast effects, fire, and lasers with reduced weight and impact on ability to perform required functions

Develop technologies that improve the helmet, body armor, and eye protection for the combat Marine against a variety of threats improving comfort and ease of employment while performing combat functions such as using the service weapon in a prone position or with the gas mask. Eye protection – to include optics – is needed to counter the emerging threat of multi-spectral battlefield lasers.

-- FP STO-2: Technologies for improved protection for individuals and vehicles in a chemical, radiological, and biological environment

Develop full body suits and collective protection systems, as well as threat detection and warning systems that provide increased protection[23] while reducing the limitation that environmental

factors such as heat, have on mission accomplishment. In addition, develop technologies that enable decontamination with reduced – or ideally without – the requirement for water.[24]

- FP STO-3: Active protection system for vehicles against rocket propelled grenades and missiles

Develop technologies that provide active protection but without unacceptable threat to supporting dismounted forces or non-combatants in the proximity of the vehicle.

-- FP STO-4: Develop technologies to impede movement (counter-personnel) when unable to adequately deny/defend area or delay personnel using NL means.

Develop the capability to use non-lethal counter-personnel means to warn, deter and/or incapacitate individuals or multiple personnel at range when the threat is unconventional and ambiguous and potential for collateral damage is high. The need is to warn, distract, and/or determine intent of potential threats using NL visual means. Develop the means to incapacitate and/or deter personnel with non-lethal point-target weapons.[25]

-- FP STO-5: Develop non-lethal technologies to disable (counter-materiel), rendering vehicles inoperable using non-lethal non-kinetic means

Develop the capability to render vehicles inoperable using non-lethal, non-kinetic means, when the threat is ambiguous and unconventional and the risk of collateral damage is high. Must render vehicles inoperable using non-kinetic means at standoff ranges greater than 100m by disabling the power train of a moving vehicle, regardless of weight, size, engine type (fuel injection, carburetor, gasoline, diesel, etc.), so that the only remaining forward motion is from existing momentum. Must permit selectivity of vehicles to be stopped, provide near instantaneous and remote activation/employment, and require little or no time between subsequent activations, in order to engage multiple targets. The capability must function day and night, in all weather and environments.[26]

-- FP STO-6: Fires detection and engagement systems against incoming direct and indirect fires

Develop technologies that enable near-real time detection of incoming fires and position location of the source to facilitate engagement. Technologies that detect incoming rockets, mortars, artillery, cruise missiles, UAV's, other low Radar Cross-Section (RCS) targets**,** and direct fire weapons – specifically snipers in urban terrain – are desired.[27]

-- FP STO-7: Directed energy for non-lethal applications and lethal applications[28]

Develop technologies that provide a less lethal alternative to kinetic/blast weapons for employment in urban operations to clear facilities, disrupt crowds, and reduce the risk to ground forces involved in urban clearing.[29] In addition, *[30]* develop technologies that enable scalable directed-energy effects[31] that can provide weapon systems that can deliver non-lethal or lethal effects (scaleable from lethal to less than lethal).[32] Develop directed energy technologies that generate terahertz, millimeter, and microwave electromagnetic radiation at high average and/or

peak power. RF sources should be made frequency agile and should strive for compactness, energy efficiency, and effective thermal management. Develop technologies that utilize low energy Directed Energy techniques, and coherent and incoherent light at various optical frequencies for degrading enemy personnel techniques. Both technology development and bio-effects research are required concurrently.[33]

Logistics

The S&T investment in logistics is primarily focused on four areas: (1) logistics tracking and en route visibility, (2) packaging, (3) reduction in battlefield consumption of major consumables, and (4) dense power generation and storage.

The Vision: ***Marines of the future, operating as distributed forces and supported from the seabase, will demand a tailored level of sustainment that must be transported from the seabase and then accompany the force ashore. Logistics systems of the future will be more effective, more flexible, and provide better support.***

Goal: The focus is to provide support from a seabase to the operational echelons ashore down to the tactical level of operations adaptive to the needs of dispersed and highly mobile forces. The inventory of theater-wide sustainment will be continuously updated to support a dynamic distribution system empowered by automated logistics decision support system. Logistics will be provided to the warfighter as needed from the seabase by leveraging theater stocks, tracking and shifting assets even while en route, delivering tailored logistics sustainment packages with minimum development of rear areas, and dumps and marshalling areas ashore.

-- Log STO-1: Logistic commodity tracking

Develop novel cost-effective identification/tagging technologies that facilitate comprehensive visibility of assets as they flow throughout the entire logistics chain.

-- Log STO-2: Vehicle readiness tracking

Develop novel sensing technologies that permit individual vehicles to receive the timely logistic support and maintenance necessary to assure operational readiness and prevent mechanical failure.[34]

-- Log STO-3: Optimized delivery planning tools

Develop logistic planning tools that permit new missions to be rapidly planned and ongoing missions to receive flexible logistic support in response to unanticipated changes in the operational tempo.

-- Log STO-4: Logistic delivery/retrieval technologies for dispersed units

Develop cost effective delivery technologies for providing necessary logistic support to highly mobile small units operating across hostile terrain. Develop packaging technologies that both reduce the cube and square of sustainment and facilitate unit distribution from the seabase to the

individual user or weapons system. Develop composite, collapsible intermodal packaging for use within the twenty-foot equivalent units.

-- Log STO-5: Small unit transport of organic logistics

Develop novel weight-effective approaches for small, dispersed, and specifically dismounted units to more effectively transport their own logistic supplies. Develop technologies to improve accuracy of aerial deliveries and providing a capability that integrates global positioning satellite technology for a precision aerial delivery system and multiple supply loads to multiple locations.

-- Log STO-6: Enhanced self sufficiency for fuel

Develop ways to reduce the Marine Corps dependency on fossil fuels with new technologies that support warfighting and at the same time reduce the MAGTF's footprint ashore.[35] Develop the portable means to assess the suitability of locally available fuel sources or captured fuel. Technologies must be capable of assessing both the chemical composition of the fuel as well as detecting the presence of the most likely adulterants.

-- Log STO-7: Enhanced self-sufficiency for water

Develop weight-effective technologies for small mounted and dismounted units to safely utilize locally available water sources or to scavenge drinking water from environmental sources. Develop technologies for water purification and for the production of water from air and vehicle exhaust. In addition, develop the concept and technology for a new system of seabased water packaging and delivery systems.[36]

-- Log STO-8: Enhanced self-sufficiency for electric energy

Develop weight effective technologies for providing small units with alternative tactical mobile electric power sources necessary to support an increasing supply of electronic devices. Provide small units with lightweight technologies for providing low level emergency back-up electric energy. Improve power management, generation, and storage technologies, replacing current batteries with alternatives that are cheaper, environmentally friendly, more compact, and with a longer service life such as fuel cells, micro-turbines for tactical generators, and other relevant technologies.

-- Log STO-9: Improve life-support for casualties at point injury through evacuation

Develop technologies to improve life expectancy at time of injury until evacuated to a medical facility. Technology is needed to reduce the immediate effects of shock and blood loss, but also to provide effective life saving agents/devices which are lighter, smaller, more durable and versatile, to include the ability to treat and move casualties. This includes items such as the oxygen concentrator, mobile ventilator, and multifunctional monitoring devices that are man-portable and support air and ground vehicle patient movement.

ANNEX A: Human Performance Training and Education

HPT&E seeks to enhance the combat effectiveness of the U.S. Marine Corps through the development of technology enablers. The DoD Training Transformation Implementation (T2I) Plan and the DoD Training Capabilities Analysis of Alternatives (TC AoA) address the strategic and tactical needs of future training capabilities by OSD, DoD, and Joint Staff. The Technology Division of the Marine Corps Training and Education Command is responsible for identification of the Marine Corps -specific technology needs to enable T2. The Marine Corps Warfighting Laboratory acts as the S&T lead to focus the HPT&E development efforts to address USMC training technology gaps. Program Manager for Training Systems is the transition pathway for acquisition of mature technologies developed through S&T. The HPT&E S&T efforts are an integral part of the process to develop training technologies which will be force multipliers for Marine Corps training events which prepare Marines to win wars in the future.

The Vision. ***The S&T investment in Human Performance Training and Education (HPT&E) is intended to enhance future Marine Corps capabilities by developing technical solutions which seek to close human performance gaps utilizing training and education technologies as well as physiological and nutritional solutions. The desired end state is improved technology enablers to prepare Marines to win on the battlefield of the future. Specifically, these technologies shall address the mandates of DoD Training Transformation (T2) to develop Joint integration of live, virtual, and constructive training events.***

Goal: The training technology focus of the Human Performance (HP) is optimization of individual and team performance across the full range of military operations HP training technology must support Marine Corps capability developer's efforts to mitigate T2 needs, capabilities, and gaps which have no other DOTMLPF solutions.

-- HPT&E STO-1: Warfighter Cognition.

Develop tools, systems and training environments/domains which inculcate and reinforce cognitive and kinetic skills necessary to fight on the battlefields of the future. Technology enablers will be provided at all levels from the individual to the MEF Staff. We can reduce stress, fatigue, while increasing combat effectiveness by ensuring Warfighters have access to training opportunities to train to the skills necessary to operate and employ these complex tools 24/7.

-- HPT&E STO-2: Learning Thinking OPFOR.

Develop technologies that address the warfighter's need to train against an adaptive enemy. Develop AI tools that utilize dynamic tactics and reasoning to observe friendly force tactics, exploit weaknesses/repetition and casualties and sway public opinion against friendly force training audience.

-- HPT&E STO-3: Physics Based Library for Battlefield Effects.

Develop accurate and appropriate models of the effects of all Marine Corps ordnance and weapons systems against various weapons platforms, man made features, individuals, crowds, mass formations, and terrain. The goal is to develop a universal library that permits the Marine Corps to model and assess weapons systems effects (catastrophic, social, and political) prior to initiation of hostilities. This will enable both realistic training of Marines and incorporation of Collateral Damage Estimate (CDE) into mission rehearsal.

-- HPT&E STO-4: Warrior Technology Training.

Develop flexible, adaptive training technologies that permit Marines to understand the nomenclature, operation, functioning, and tactical employment of new information technologies. At a minimum, these new technologies must address training requirements associated with the employment of Blue Force Tracker/FBCB2, Digital Automated Command and Control Terminal, target designators, and Command Post of the Future (CPOF).

-- HPT&E STO-5: Warfighter Physiology.

Develop technologies that will reduce fatigue by reinforcing planning/training that eliminates unnecessary actions, helps dissipate the fog of war (trains to anticipate the enemy and local populace reactions), ensures re-supply, reinforcements, and rest are anticipated and planned for in order to eliminate fatigue.

-- HPT&E STO-6: **Experiential Learning Technologies and Pedagogy.**

Develop tools and technologies to enable Marines to train the way they fight. This includes engaging the senses in realistic, challenging, and rapidly reconfigurable scenarios that allow both training and mission rehearsal. The goal is to optimize the application of simulation training across the Live, Virtual, and Constructive (LVC) training and education continuum.

-- HPT&E STO-7: **High Fidelity Virtual Environment.**

Develop technologies that address the warfighter's need to train in a high fidelity physically accurate Synthetic Natural Environment to include accurate geo-specific terrain as well as realistic, culturally accurate and AI-driven entities (friendly, enemy, and civilians).

-- HPT&E STO-8: **Automated Performance Assessment.**

Develop technologies which allow a user to semi-autonomously create tailored training scenarios based on selected training standards from which the performance is automatically evaluated based on the provided metrics and results are exported to a Marine wide learning management system.

ANNEX B: SEABASING

1. **Sea Base Overview**

a. The sea base – particularly the Maritime Prepositioning Group (MPG) and/or an Amphibious Force (AF) – must be able to sustain select Joint ground force operations, with minimum supplies held ashore, until the objectives are achieved or until the situation provides for secure movement of selected support functions ashore (e.g. the transition of operational capability from Seabasing to shore basing) Operations supporting daily presence of deterrence and crisis response forces in a forward theater, or for Joint operations short of defeating the military efforts of an adversary state, often lack sufficient regional support to permit establishment of a U.S. in-theater footprint. For these cases, the sea base must be able to sustain and support a Joint forcible entry capable force from the sea for an extended or indefinite period of time.

b. Seabasing enables persistent combat operations by sustaining selected Joint forces ashore through multiple entry points. Tactical distribution directly from the sea base reduces the need for the build-up of large supply bases ashore. Once Joint ground forces have been projected ashore, they will be continually sustained by a combination of intra-theater and tactical air and surface connectors from the sea base and Advanced Base. The primary sea base assets that will support and sustain Joint ground forces include the MPG, Expeditionary Strike Group (ESG), and AF.

2. **Sea Base Logistics Challenges**

a. Adverse weather conditions and sea state directly impact the ability of logistics platforms to provide timely sustainment and throughput (i.e. transfer cargo, fuel, passengers, and other supplies) to seabased assets. Sea base platforms will require the capability to perform operations in all weather, 24/7, through sea state 4 and potentially 5.

b. Sea base platforms will require the capability to interface with other sealift ships to conduct equipment and cargo transfer in the open ocean.

c. The quantity of intra-theater connectors (shuttles) required to support a sea base from an Advanced Base has yet to be determined.

d. A robust Joint logistics command and control system must be established to ensure sustainment reaches the right units in a timely, efficient manner.

e. The need for a high-speed surface connector (shuttle) to move time critical equipment, personnel, and supplies to the sea base from an Advanced Base located 2000nm distant is a significant challenge.

f. The ability of the sea base and MPF(F) ships to sustain all of the demands of two Joint brigades ashore is limited by the vertical and surface connector capabilities that move the sustainment ashore, Landing Craft Assault Craft (LCAC), Landing Craft Utility (LCU)).

g. Adverse weather, legacy ship designs and limited cargo movement automation directly impact the ability of sea base platforms to conduct efficient and time effective Strike-Up and Strike Down (SUSD) cargo operations and potentially achieve the desired throughput to forces ashore.

3. **Essential Sea Base Logistics Capabilities**

a. The Seabasing Logistics network that supports the sea base will require an aggregation of many different capabilities, systems, and processes. For example, sustaining Joint operations from the sea base will require joint Total Asset Visibility (TAV) and responsive delivery systems. The sea base must also be a flexible and integrated transshipment point that sustains Joint Force momentum. The aggregation of these logistics capabilities provides a robust capability for the sea base and its operations. The logistics capabilities include:

- o Underway Replenishment,
- o Improved Internal Cargo Handling
- o Enhanced Prepositioning Afloat with Selective Offload
- o Joint In-transit Visibility/Total Asset Visibility
- o Logistics Command and Control (C2)
- o Seabased Maintenance
- o Joint Intermodal Packaging
- o Time Critical Resupply
- o Open Ocean Interface and Transfer

4. **Seabase Priority of Focus**. Seabasing enables scalable power projection through the sequential and concurrent integration of expeditionary forces through five lines of operation: *Close, Assemble, Employ, Sustain, and Reconstitute (CAESR).* Marine Corps seabasing capability development will utilize these lines of operation as the framework for a comprehensive process that integrates and validates Science and Technology (S&T), Experimentation and the Seabasing JIC. The focus of effort and priorities for Marine Corps Seabasing capability development are:

a. Arrival and Assembly. Refine TTP's and develop systems or processes that support the rapid and seamless integration of Flow-in-Echelon (FIE) forces with forward deployed assets and conduct Reception, Marshalling, and Staging for onward movement of the 2015 MEB. This focus area encompasses the functions required to facilitate: (a) the reception, integration and movement (inter/intra-ship) of forces, (b) the at-sea transfer of a MAGTF in various sea-states, and (c) preparation of force assets for onward movement.

b. Sustainment Capability. Develop capabilities to sustain the 2015 MEB. Included in this focus area are asset visibility, automated and manual material handling, advanced packaging methods, and the selective offload of supplies and equipment.

c. Personnel and Equipment Transfer. Develop a common interface allowing at-sea transfers of MAGTF personnel and equipment between MPF(F) platforms, ships of the ESG and CLF, lighterage and connectors. Concepts to explore include Interface Ramp Technologies (IRT), Mobile Landing Platforms (MLP), lightweight modular causeways, and passenger transfer systems. Specific emphasis will be placed on MPF(F) and JHSV interfaces.

d. Cargo/Vehicle Handling Stowage. Develop systems that enhance the movement, stowage (indexing) and restraint of cargo, vehicles and equipment. Near term emphasis will be placed of Cargo/Vehicle Restraint systems, and container handling technologies.

5. **Seabase Tasks (CAESR)**

a. **Closing the Force.** Seabasing will provide the Joint Force Commander with significantly expanded options for rapidly bringing significant force to bear in support of his operational and strategic objective.

b. **At-Sea Arrival and Assembly.** The at-sea arrival and assembly capability provided by the sea base will give naval and joint forces transformational options for rapidly assembling a significant force.

c. **Employing Forces.** The capability to rapidly employ elements of a MEB-sized force and sustain that force indefinitely from the sea base is a transformational warfighting capability.

d. **Sustaining Forces.** Near-term experimentation and investments in science and technology, combined with the introduction of new air and surface platforms and the ability to maintain total asset visibility, will improve sustainment at sea, minimize or eliminate time off-station for replenishment, and decrease the time required to flow sustainment to forces operating ashore.

e. **Reconstituting and Redeploying Forces.** Sea Base capabilities will also dramatically expand the options of the Joint Force Commander by enabling forces to reconstitute at sea, restore combat power and re-deploy.

6. **Critical Sea Base Technology Development**

The following technology based advancements are critical to executing our **Seabasing Tasks**.

a. Selective offload / access

b. Joint command and control

c. Integration of naval logistics

d. Joint in-transit visibility

e. At-sea transfer of personnel, inter-modal containers, out-sized equipment, and bulk liquid

f. Improved Internal Cargo Handling

-- SEA-STO 1: Underway Replenishment

Develop the Underway Replenishment (UNREP) system forms the foundation of a Seabasing Logistics capability by providing the means for logistics shuttle ships to transfer fuel, ammunition, spare parts and other heavy bulk sustainment supplies required by forces and ships at-sea. Without this capability, the sea base and naval ships would not be able to maintain a continuous forward presence at-sea. Alongside Connected Replenishment (CONREP) and Vertical Replenishment (VERTREP) are the **critical capabilities** that support the transfer of high volumes of cargo between logistics shuttle ships and Seabased assets.

-- SEA –STO 2: Improved Internal Cargo Handling

Develop future Strike-Up/Strike-Down (SUSD) techniques and systems should automate the movement of cargo and weapons from the shipboard onload point to stowage spaces (strike-down), and from stowage to the offload point for transfer to another ship or to shore (strike-up). The future sea base will be able to receive, store, track, retrieve, and transport more dense loads and potential advanced packaged loads and reconfigure those loads for deployment within the sea base or to the shore in manageable configurations. Methods for selective retrieval of materiel today present equally significant challenges.

-- SEA-STO 3: Enhanced Prepositioning Afloat with Selective Offload

Develop an enhanced afloat prepositioning and selective offload capability allows operations afloat and ashore independent of APODs and SPODs within the JOA. In these anti-access situations, the sea base must be able to provide support for up to two Joint brigades ashore for an extended or indefinite period of time. A critical sub-capability of enhanced prepositioning afloat is selective offload. In addition to the selective offload of rolling stock, the sea base must be capable of **selectively accessing, retrieving, and offloading cargo sustainment to Joint forces**, as they require it.

-- SEA-STO 4: Joint Logistics In-transit Visibility/Total Asset Visibility

Develop sea base logistics data systems must be able to provide users – afloat and ashore – with timely and accurate information on the location, movement, status, and identity of units, personnel, equipment, materiel, and supplies. The ability to locate, move, track, and transship a variety of cargo from CONUS through an Advanced Base, to a sea base, between ships at-sea, and on to forces ashore will mitigate risk and prevent operational pauses in theater. Total asset visibility (TAV) and In-transit visibility (ITV) will be critically needed capabilities to effective logistics C2.

-- SEA-STO 5: Seabased Maintenance

Develop technologies enabling a seabased maintenance capability for both aviation and ground combat equipment will be critical to maintain a high operational tempo while also supporting the ability to regenerate combat power for reemployment.

-- SEA-STO 6: Joint Intermodal Packaging

Develop Joint Intermodal Packaging, utilizing standardized packaging concepts and containers, will ensure that goods will not have to be repackaged as they travel through commercial or Government transportation networks by ship, rail, aircraft, or truck across the logistics continuum to the sea base and potentially to the end users ashore. This will aid in ensuring more rapid delivery and reduce retrograde packaging.

-- SEA-STO 7: Time Critical Resupply

Develop technologies to adequately support and sustain all sea base requirements, the JFC must have the ability to move high priority cargo and passengers between the Advanced Base and sea base. This requires a robust and highly effective transport capability via either surface and/or air means. This capability will ensure critical sustainment reaches the right forces at the right time.

-- SEA-STO 8: Open Ocean Interface and Transfer

Develop an open ocean interface and transfer capability provides a Joint throughput capacity that will serve as a sea base's at-sea interface platform for surface sealift vessels when a port is unavailable. One such open ocean interface and transfer capability is **skin-to-skin transfer**. Skin-to-skin transfer allows very heavy and oversized equipment and cargo such as vehicles to move between ships in higher sea-states. Potential technology investment areas that will support open ocean interface and transfer include:

(1) dynamic positioning systems,
(2) advanced fendering or mooring techniques and approaches,
(3) advances in ship heading control systems,
(4) side-port ship-to-ship vehicle ramps and
(5) small ship to large ship interface methods.

Annex C: Aviation Science & Technology Objectives

1. Aviation S&T Strategic Guidance. These are Aviation focal points in terms of (a) S&T Program Opportunities and (b) Legacy S&T Investment Category Priorities. This Annex serves to articulate Marine Corps unique S&T needs to those agencies devoted to Aviation S&T priorities.

a. Key Program Challenges. These are the major Aviation program areas that have opportunity for high-payoff S&T investments:

(1) Heavy Lift Replacement (HLR)
(2) Airborne Electronic Attack (AEA) follow-on
(3) Tiltrotor UAV

b. Legacy (rotorcraft) Investment Category Priorities. These are prioritized categories in terms of current rotorcraft force S&T technology modernization/transition/insertion as well as future rotorcraft programs. These areas directly correspond to Marine Corps priorities to the US Army S&T Strategic Planning document and are emphasized due to a historical minimal investment in rotorcraft S&T.

(1) Affordability: Reduction in Development, Acquisition, Operating and Support Cost While Maintaining or Increasing Capability.

(2) Supportability/Maintainability: Improvement in Reliability, Availability and Maintainability.

(3) Footprint: Reduction in the weight and volume of the personnel, materiel, equipment and supplies that support an aerial system and must be moved.

(4) Survivability/Safety: Improvement in the ability to avoid detection, tracking and engagement in a complex threat environment and survive hit/crash.

(5) Deployability: Reduction in the time, effort, and support systems to prepare, transport, and restore a force capability.

(6) Battlefield situational awareness: Improvement in the ability to know and comprehend the location, intent, and actions of blue/red forces, non-combatants, environment condition, terrain, and obstacles in the area of operational responsibility.

(7) Training: The efficiency with which commanders/staff, pilots, operators and maintainers are initially and continuously trained to proficiency.

(8) Lethality: Improvement in the ability to precisely deliver a spectrum of intended effects (lethal or non-lethal).

(9) Mobility: The ability to responsively maneuver and transport troops, supplies and equipment on the battlefield in complex terrains/sea states.

(10) Battle Command: Improvement in the ability of the commander to decide on a course of action and execute command measured in response time.

2. Aviation S&T Relationships. Relationships with the following agencies are essential in order for the Marine Corps S&T IPT to ensure visibility on adequate Aviation leverages, sharing unique leverage opportunities, and ensuring an overall balanced Marine Corps Aviation S&T investment.

a. ARMDEC. U.S. Army Research, Development and Engineering Command: responsible, by charter, for Rotorcraft S&T. This is a key relationship as Rotorcraft S&T investment has been minimal for over a decade.

b. Office of Naval Research. Achieved primarily via the Marine Corps S&T IPT, but also through a direct relationship with ONR.

c. Air Force Research Lab. In particular, the Technology Transition Office: a key S&T partner for development of a Marine Corps EW follow-on platform.

d. DARPA. In particular, ultra-wideband transmitter technologies for EA follow-on and advanced computing applications.

3. S&T in support of Aviation

-- AVN STO 1: Standardized force tracking system

Technologies that provide 100% assured, covert, real-time identification of friendly forces for fratricide avoidance as well as battlefield coordination, maneuver deconfliction, command SA, future resupply/CASEVAC etc during future distributed operations. Tracking technologies may be applicable for red-force/HVT (classified).

-- AVN STO 2: **Advanced multi-function electronic warfare transceiver**

Leverage ONR NEXGEN jammer. Technologies must be compatible with Marine Corps follow-on EA platform (i.e. Low-observable) as the platform requirements are refined. Multi-function transceiver array potentially enables future Electronic Warfare as well as bandwidth, SIGINT and ISR

-- AVN STO 3: Advanced rotor/prop technologies for performance across wider envelope[37]

Rotor/Prop as a component of assault support propulsion as well as tactical UAVs will continue for the foreseeable future. As rotorcraft/helicopters (MV-22/VUAV) requirements grow in terms of hover load and harsh environments (heat), as well as top-end speed (i.e. MV-22 escort), advanced rotor performance enhancement (dynamic blade shaping) will garner performance as well as efficiency (fuel/load savings).

-- AVN STO 4: **Variable-speed air refueling drogue**

Technologies that enable refueling drogues to refuel fast tactical aircraft as well as slower rotorcraft enable the entire aviation force.

-- AVN STO 5: Active kinetic and non-kinetic A/C self-protection

Technologies such as High Energy Liquid Laser Area Defense System (to leverage the Advanced Tactical Laser ACTD for USMC benefit employing all-electric high energy laser technologies at DARPA) and continued investment in technologies which enabled systems such as Tactical Aircraft Directable Infrared Countermeasures: technologies must enable "unlimited magazine" self-protect capabilities against both IR SAMs and RPGs while reducing requirement for magazine (i.e. flares).

-- AVN STO 6: **Sand and dust penetrating radar providing precision (landing quality) navigation video in brownout, dust-out visibility areas**.

Includes technologies that enable passive obstacle detection at range (i.e. uncharted wires/ables) and enables precision support of distributed operations in unprepared landing zones from future UAV tiltrotor, as well as possible technology transition into legacy rotorcraft.

-- AVN STO 7: Scalable, light weight, interference cancellation system for co-situated RF emitters to eliminate VHF and UHF RF interference between multiple radio systems.

Includes low-cost interference cancellation technologies for potential EA UAV as well as technology transition for legacy platforms that suffer communications degradation with multiple communications systems or jamming.

-- AVN STO 8: Cost effective Mass Memory (hundreds of gigabytes)

Improvements for Digital Map and other avionics systems capable of higher speed data transfer, compatible with helicopter airborne environmental conditions. Enable autonomous operations with comprehensive information onboard. Information storage requirements onboard autonomous platforms reduce risk in distributed and net-centric operations against an EW-capable adversary where link information is potentially denied.

-- AVN STO 9: Helo-mode, low airspeed indication system

Complementary technologies to precision quality navigation in brown-out/dust-out that enables precise, landing quality, non-visual air and groundspeed reference.

-- AVN STO 10: **Multi-function, low-drag VHF, UHF, and UHF SATCOM antenna**

Enables reduced airframe antennae. Reduces airframe signature as communications requirements grow. Allows communications growth without additional apertures.

End Notes

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[11] UNS for "Exoskeleton" Aug 2004.
[12] USMC "MAGTF Mine Countermeasures Master Plan" Aug 2004, Appendices E & F.
[13] Distributed Operations Architecture Study, 26 March 2007, pg. 13.
[14] USMC "MAGTF Mine Countermeasures Master Plan" Aug 2004, Appendix G.
[15] USMC Ground Combat Element Campaign Plan 2004, Science and Technology Addendum.
[16] USMC Logistics Campaign Plan 2002, pg.17.
[17] UNS for "Non-Lethal Weapon (ADS)" Dec 2001, UNS for "Gunship Advanced Combined Arms Weapon Suite" May 2002, and UNS for "Full Spectrum Effects Battle Weapon" Oct 2004.
[18] Distributed Operations Architecture Study, 26 March 2007, pg. 12.
[19] UNS for "Multi-mission Expeditionary Persistent Overhead Platform" Nov 2004.
[20] Distributed Operations Architecture Study, 26 March 2007, pg. 12.
[21] There are a number of promising high and directed energy technologies of interest to the Marine Corps to include Electromagnetic Pulse (EMP) Hardening; DC and AC LINAC-Driven Charged Particle Beam (CPB); Directional Acoustic Weaponry; and, Pulsed and CW Terahertz High Power Microwave (HPM) and Millimeter Wave Weapons Technologies.
[22] UNS for "Transformational Mass Acceleration Capability" Dec 2004.
[23] UNS for "Protection from Environment Stressors" Oct 2004.
[24] In accordance with the National Defense Authorization act for 1994 and subsequent provisions of 50 U.S.C. 1522, all CBRN efforts and funding for those efforts are Joint. All S&T for CBRN is done by the Defense Threat Reduction Agency, Joint Science and Technology Office. There is a single program element for each of categories of R&D, T&E, acquisition, and military construction. As Executive Agent for the program, the Army has responsibility for reviewing all funding requirements for the chemical biological defense programs.
[25] The following Urgent UNS documents refer: "Non-Lethal Tube Launched Munition (VENOM)," "Long Range Non-Kinetic Non-Lethal Weapons," "Laser Dazzlers," and "Long Range Acoustic Devices." In addition, the Draft Mission Payload Module (MPM) CDD and Joint Non-Lethal Weapons Directorate CBA consistently reflect these standards of need.
[26] The Urgent UNS for "Vehicle Stopping," the "Portable Vehicle Arresting Barrier "ORD, and USMC NLW Strategy, and USMC NLW Annual NL Requirements are consistent with this technology need.
[27] Distributed Operations Architecture Study, 26 March 2007, pg. 13.
[28] CG 1st MarDiv letter 5000 SSEC/dwa of 29 Aug 04, "Urgent Need for Vehicle-Mobile Active Denial Technology Enabled Capability" in Support of OIF-2.
[29] UNS for "Visual Marking System for Urban CAS" Sep 2004.
[30] USMC NLW Strategy dated 2005
[31] UNS for "Gunship Advanced Combined Arms Weapon Suite" May 02.
[32] Hoke, Jeff, USMC Non-Lethal Weapons PSO, Slide Brief "Advanced Technology Projects," 14 Jul 2004, pg. 10.
[33] DoD Dir 3000.3 Policy for NLW
[34] UNS for "Predictive Readiness" Mar 2004
[35] USMC Logistics Campaign Plan 2002, pg 9.
[36] Draft UNS for "Water Packaging and Distribution Technologies," DC I&L, May 2007
[37] Director, CDD "Letter of Interest in Continuation of the Joint Heavy Lift (JHL) Concept of Refinement and Solution Development," 22 June 2007