ATIP

ADVANCED TECHNOLOGY INVESTMENT PLAN
2020 - VOLUME XI

PEO LAND SYSTEMS MARINE CORPS
IT'S ALL ABOUT THE WARFIGHTER

PROGRAM EXECUTIVE OFFICER
LAND SYSTEMS MARINE CORPS
ADVANCED TECHNOLOGY
INVESTMENT PLAN
2020

Executive Summary

This 2020 edition of the Program Executive Officer Land Systems (PEO LS) Advanced Technology Investment Plan (ATIP) provides an update of the Top Technical Issues across the PEO LS Portfolio. Each technical issue has been vetted through the program managers to ensure an accurate representation of their highest priority technology needs.

This update is consistent with previously published ATIPs and continues to emphasize our commitment to "Focusing the Future Faster" by leveraging available Science and Technology (S&T) venues to provide gap closing capabilities to the Warfighter. The process developed is designed to influence, inform, and align S&T investments and support effective technology insertion, demonstration, experimentation, and systems fielding efforts across PEO LS.

The 2020 ATIP is intended to be used as an informative resource that highlights the importance of collaboration and communication across the S&T Enterprise. Our shared efforts will ultimately result in our Warfighters being equipped with state-of-the-art technologies to better meet the challenges of the future evolving battlefield.

JOHN M. GARNER
Program Executive Officer
Land Systems Marine Corps

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PROGRAM EXECUTIVE OFFICER
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ADVANCED TECHNOLOGY
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Bottom Line Up Front

The PEO LS ATIP employs a focused, repeatable process, which informs all key stakeholders, industry, and academia of Top Technical Issues within PEO LS programs.

This document is designed to foster collaboration, align S&T investments, and support effective technology insertion within PEO LS Programs.

The ATIP identifies and prioritizes Top Technical Issues within PEO LS programs, with the goal of informing, influencing, and aligning S&T investments to resolve program technical issues and support transition of critical capabilities to the Warfighter. Each technical issue has been thoroughly vetted through the appropriate S&T representative, lead engineer, deputy program manager, and program manager to ensure an accurate representation of each program's highest priority technology needs.

The ATIP can also be accessed via the Office of the Secretary of Defense's Defense Innovation Marketplace website (www.defenseinnovationmarketplace.mil/ATIP.html). This site is a resource for information about Department of Defense investment priorities and capability needs.

In an environment of fiscal austerity, changing requirements, and rapid technical innovation, being engaged and knowing with whom to discuss new ideas is vital to fostering opportunities across the S&T Enterprise. With your participation, we can maximize ingenuity in a constrained environment and "Focus the Future Faster" for our warfighters.

As always, we welcome any comments or suggestions to improve the usefulness of this investment plan. Please forward any suggestions or comments to me at william.story@usmc.mil.

W. Scott Story
Lead, Advanced Technology
Program Executive Office
Land Systems Marine Corps

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PROGRAM EXECUTIVE OFFICER LAND SYSTEMS MARINE CORPS ADVANCED TECHNOLOGY INVESTMENT PLAN 2020

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Section 1.0

INTRODUCTION

"While we must accept an environment characterized by uncertainty, we cannot ignore strong signals of change nor be complacent when it comes to designing and preparing the force for the future."

-General David H. Berger, Commandant of the Marine Corps

In this 11th edition of the PEO LS ATIP, the Top Technical Issues for each PEO LS program are identified. The intent of the ATIP is to inform, influence, and align S&T investments to help resolve these technical issues, transition advanced technology, and deliver capability to the Warfighter. The development of the ATIP is accomplished by utilizing a repeatable, concept aligned, capability-based "Concept to Capability Process" that aligns PEO LS S&T investments with high priority capability gaps and top program technology needs (depicted in figure 2-1). This process is designed to encourage communication from the early stages of concept development, throughout the process, and culminating in delivered capability. The key to success is stakeholder engagement within the S&T enterprise, industry, and academia. By cultivating an understanding of the 'realm of the possible,' the concepts and requirements developers are able to articulate requirements that become the backbone of program capabilities. These capabilities, clearly and accurately communicated to the materiel developer support the development (and ultimate transition) of critical and affordable capabilities to the Warfighter.

This year's ATIP theme is **modernizing the force for the future** and aligns with the 38th Commandant's Planning Guidance which states, "...we must prioritize research, development, and fielding of emerging and advanced technologies that are applicable within the seaward and landward portions of the littorals. Technologies such as artificial intelligence, robotics, additive manufacturing, quantum computing, and nanotechnology will continue to change the world - **we must be positioned to capture the return on investment**."

Published annually, the PEO LS ATIP is a catalyst for opening communication and collaboration between the "3 Circle" partners (combat developer, materiel developer, and the S&T developer) and to other Department of Defense (DoD) and Non-DoD organizations. The ATIP is developed in collaboration with the Office of Naval Research (ONR), Defense Advanced Research Projects Agency (DARPA), Naval Surface Warfare Centers (NSWC), Naval Undersea Warfare Centers (NUWC), Naval Information Warfare Center (NIWC), and other government agencies. The ATIP is published as an open-source document to increase the probability that it is shared and to allow those outside the DoD to propose solutions that might otherwise be missed.

In today's fiscally austere budget environment, the Marine Corps must continue to find ways to procure the best equipment for the defense of our nation. The publication of the PEO LS ATIP is intended to find ways to enhance our

Warfighter's capabilities by:

1. **Identifying and defining the top technical challenges** that must be resolved within each program, some of which remain consistent from year to year. These challenges are vetted and published in the ATIP to alert and assist industry and government regarding the S&T needs of major Acquisition Category (ACAT) programs within PEO LS.
2. **Resolving capability gaps and technical issues** by identifying and publishing the technical challenges which require assistance from the S&T enterprise, industry, and academia.
3. **Informing, influencing, and aligning S&T investments** by identifying the S&T needs of PEO LS **and supporting the technology insertion and transition into Program of Record (POR).**

Section 1.1

PEO LS ORGANIZATION

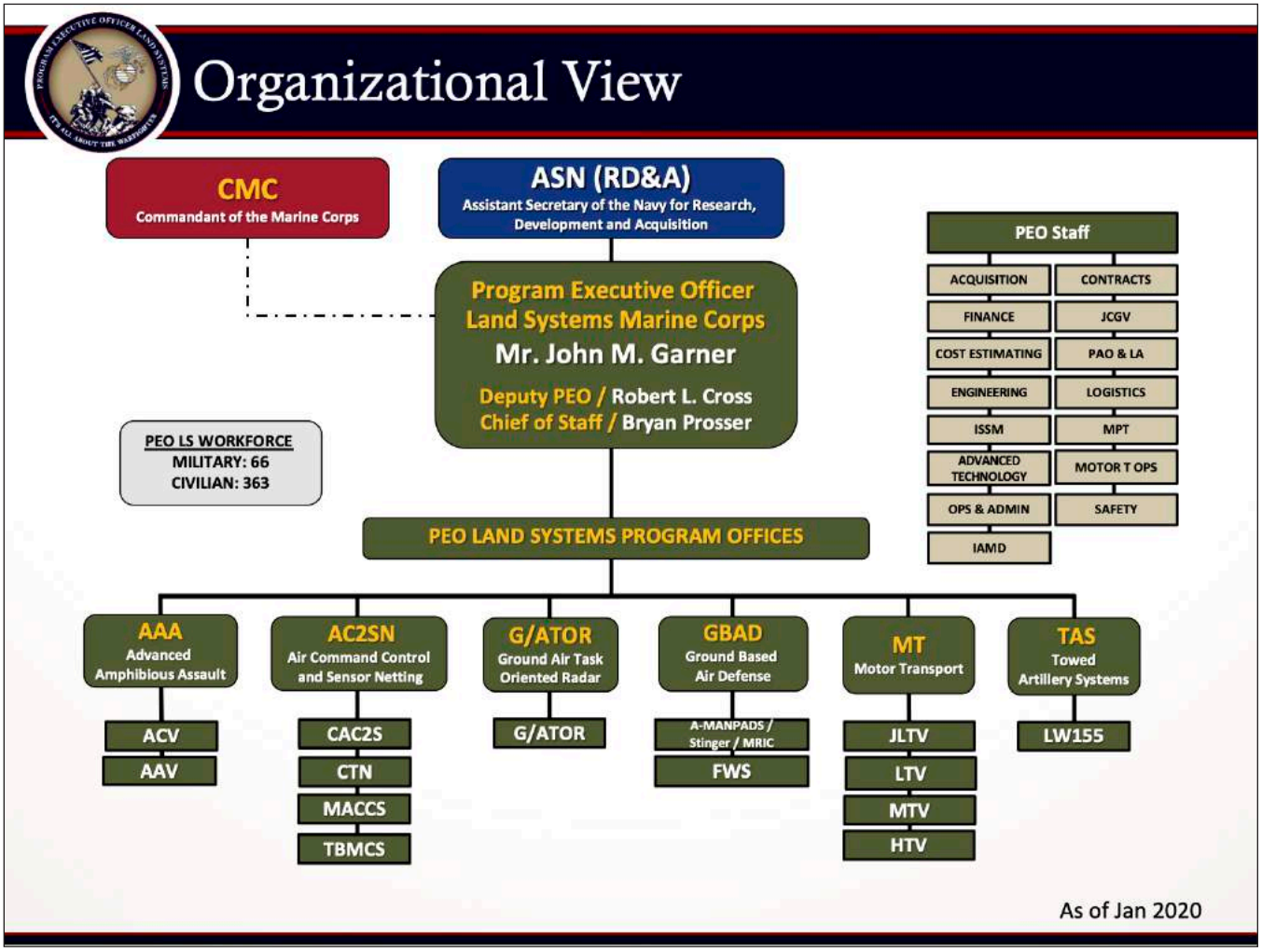

Figure 1.1-1. Program Executive Officer Land Systems Organization

The PEO LS, located at Marine Corps Base Quantico, Virginia, is the Corps' only PEO. PEO LS is led by Senior Executive Service John M. Garner, and is tasked with meeting the Warfighter's needs, while partnering with the Marine Corps Systems Command (MCSC), who is responsible for providing support services to include contracting and technical authorities in order to develop, deliver, and provide life-cycle planning for assigned programs. PEO LS reports directly to the Assistant Secretary of the Navy for Research, Development and Acquisition. PEO Land Systems' concentration of effort is on resources to balance Marine Corps modernization and sustainment of assigned programs. The monetary value of these programs across the Future Years Defense Program (FYDP) is approximately $8.5 billion.

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Section 2.0

S&T COLLABORATION AND ENGAGEMENT

Concept to Capability Process

The PEO LS S&T Concept to Capability Process, depicted in figure 2-1, provides the PEO LS with a focused and repeatable process that has proven essential for facilitating effective interaction with S&T stakeholders within the S&T community.

The PEO LS S&T Concept to Capability Process begins with an in-depth understanding of, and alignment to, the overarching concepts identified in **Expeditionary Force 21**, **Marine Corps Service Strategy**, **Marine Corps Service Campaign Plan**, and the **Commandant's Planning Guidance**, the capstone concepts for the future Marine Corps. The next step in the process entails developing an understanding of Warfighter concepts and the core capabilities required to enable those concepts. It is also critical to develop an understanding of the top-level strategic and operational service issues that rely on materiel solutions for resolution, such as re-honing the expeditionary edge, reducing the sustainment footprint, fuel saving across the Marine Air-Ground Task Force (MAGTF), lightening the MAGTF load, and reducing the MAGTF footprint.

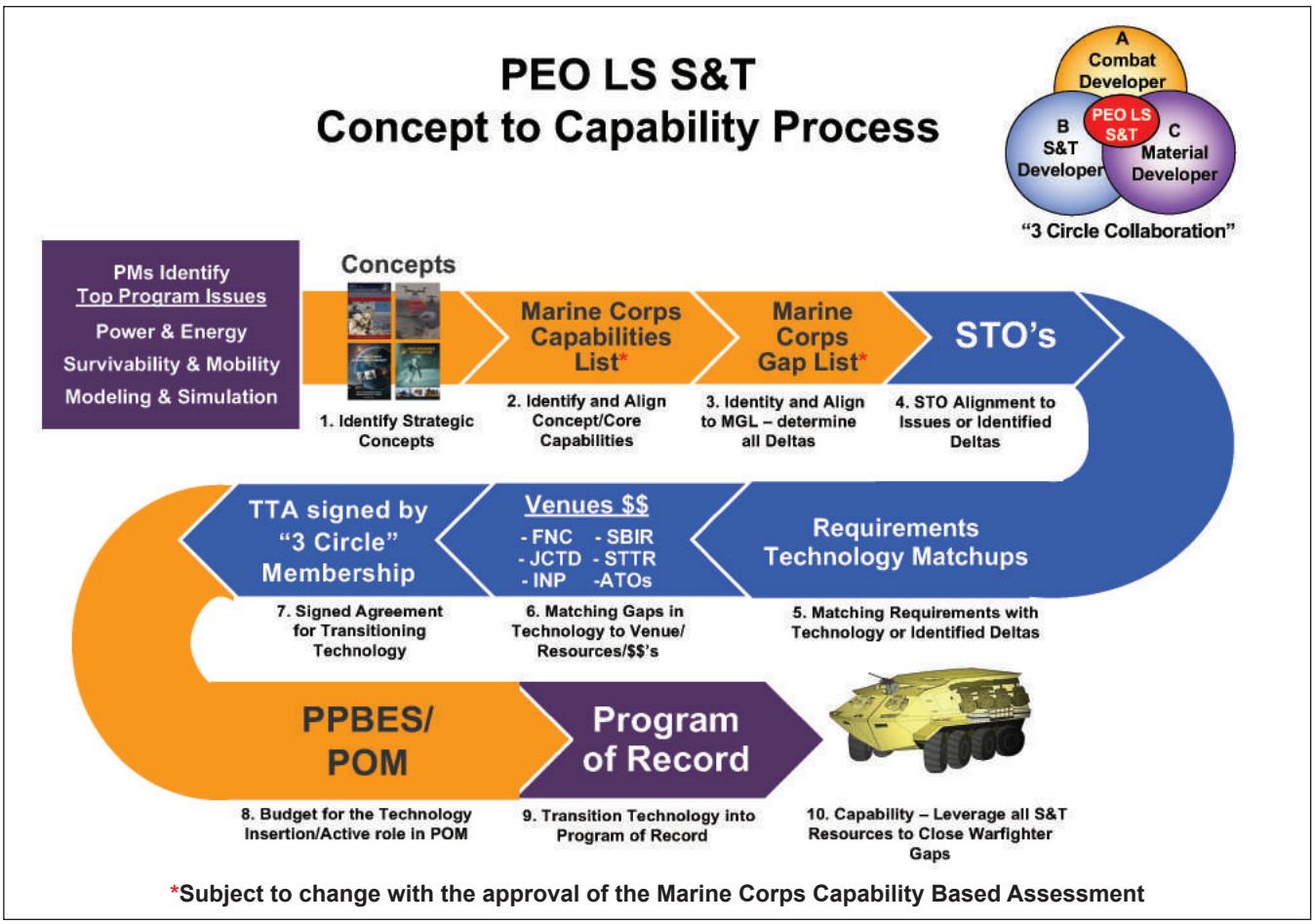

Figure 2-1. PEO LS S&T Concept to Capability Process

Once the operational concepts and capabilities are understood, an analysis is performed by each of the individual programs to identify the Marine Corps' capabilities and technology gaps. These capabilities and gaps are categorized in the Marine Corps Capabilities List (MCCL) and Marine Corps Gap List (MCGL), as well as in the **Marine Corps Solutions Planning Directive** and the **Capability Investment Plan.**

The S&T Objectives (STOs) are matched to the technology issue identified by the program office and the Marine Corps capability gap. This step is performed to ensure the traceability of S&T investments as well as enabling stronger support within the Program Objective Memorandum (POM)/Planning, Programming, Budgeting, and Execution process. Once a matching requirement/S&T initiative capable of lessening the effect on a Marine Corps gap is identified, S&T venues are examined to identify funding for the maturation of the technology.

Before resources are applied, a transition path must be identified. The Program Manager (PM) collaborates with the resource sponsor and the S&T developer to ensure a successful transition. This 'shared commitment' is usually documented in a Technology Transition Agreement (TTA) that is signed by all parties. After the TTA is signed by the appropriate level of 3 Circle leadership (explained further in the following sections), the S&T representative continues to work closely with the PM to ensure funding support is available (within the FYDP). POM funding is essential to integrate and transition the technology to the appropriate POR and to close the associated Warfighter gap. Currently, TTAs are only required for a specific venue, Future Naval Capability (FNC). All other venues and core funding initiatives do not require a TTA, but should have a transition path and an associated service requirement.

By working through the Concept to Capability Process, potential S&T opportunities and solutions are identified, enabling S&T representatives to better inform requirements and to provide the "best value" S&T investment and transition of gap-closing technologies to a POR.

S&T investment is one of the earliest steps in the process of properly equipping the future force. When applied correctly, it will result in a well-balanced Marine Corps, postured for the future with upgrades to their existing legacy systems, as well as new state-of-the-art equipment. This is developed through rigorous analysis, targeted investment, aggressive experimentation, and most importantly, through the active collaboration and engagement of all stakeholders.

S&T Objectives

The most important objective of S&T development is to ensure the Marine Corps always has an overmatching technological advantage. Preserving technological superiority continues to be at the cornerstone of our national military strategy and is critically important as advanced-technology weapons become less expensive and more readily available to traditional and non-traditional adversaries. In addition to preserving our technological advantage, Marine Corps S&T has the following specific goals:

- Inform the Marine Corps Combat Development Process;
- Encourage, promote, plan, initiate, execute, and coordinate research and technology development;
- Identify and assess technologies;
- Develop and demonstrate technologies;
- Reduce technical risks;
- Protect against technology surprise;
- Conduct warfighting experimentation; and
- Transition mature technology to acquisition PORs.

The Executive Agent for Unites States Marine Corps (USMC) S&T

The Commanding General (CG), Marine Corps Combat Development Command (MCCDC) tasked the Director, Futures Directorate/CG, Marine Corps Warfighting Lab (MCWL) to act as the Executive Agent (EA) for S&T, thereby consolidating responsibility for coordinating all aspects of Marine Corps S&T requirement generation through the Marine Corps EA. Inherent in this transfer of responsibility was the transfer of staff cognizance to the Office of Science and Technology Integration (OSTI) from MCCDC Headquarters to the Warfighting Lab. OSTI is responsible for providing policy, guidance, and strategy in the areas of scientific innovation, to include co-sponsoring annual round tables to identify Marine Corps S&T requirements.

Science and Technology

Within DoD, S&T includes the earliest forms of Research, Development, Test and Evaluation (RDT&E) funding in the federal budget. S&T is composed of three categories: basic research, applied research, and advanced technology development. It is the path by which new ideas are investigated (basic research-phenomenology), further research demonstrates military applicability (applied research-connectivity), and continues through technology demonstration (advanced technology development) to a level of maturity where the technology can be transferred to a program office for the final stages of the Research and Development (R&D) process. Close coordination with the S&T community as well as other services, academia, and industry leaders assist Marine Corps efforts to gain consensus and fund relevant S&T efforts. The ultimate goal is to investigate, develop, demonstrate, and deliver affordable state-of-the-art technologies to the Warfighter.

Collaboration

Each circle within the 3 Circle S&T community has a unique and pivotal role in the S&T process. Although they have overlapping interests and influences regarding the likelihood of the transition, the collaboration and engagement of these communities are critical for successful transitions (see fig. 2-2).

S&T developers transition their technology to the materiel developers, but the materiel developers must first have a requirement from the combat developer. Therefore, stakeholder involvement is critical to ensure Warfighter priorities are adequately addressed (requirements) and that the technologies being developed are aligned with the POR's resources and schedule.

The S&T Community Stakeholders

The Marine Corps S&T enterprise, which is an integral part of the larger Naval Research Enterprise (NRE), is a collaborative effort led by the Deputy Commandant (DC), Combat Development & Integration (CD&I). However, the USMC S&T enterprise also involves the Futures Directorate, MCWL, ONR, MCSC, PEO LS, and the EA (CG MCWL) for S&T. This 3 Circle relationship is depicted in figure 2-3.

DC, CD&I

The DC, CD&I is the principal agent in the combat developer circle. The combat developer represents the Warfighters who will deploy, operate, and maintain the systems needed for military operations. Combat developers write the requirements that the materiel developers must have to develop and procure materiel. Combat developers also generate new operational concepts, define future capability needs, identify new capability gaps/shortfalls, and state capability requirements. CD&I receives the Commandant's guidance, develops Marine Corps warfighting concepts, and determines required capabilities to enable

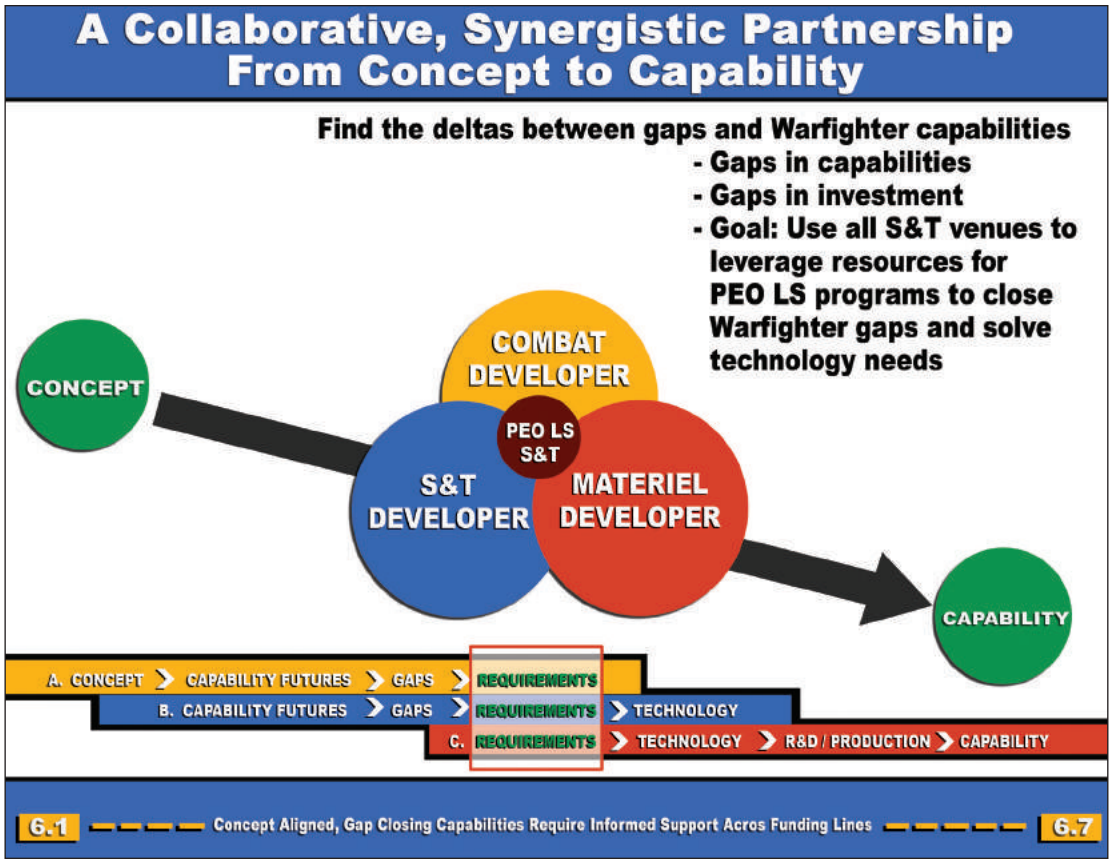

Figure 2-2. A Collaborative, Synergetic Partnership from Concept to Capability

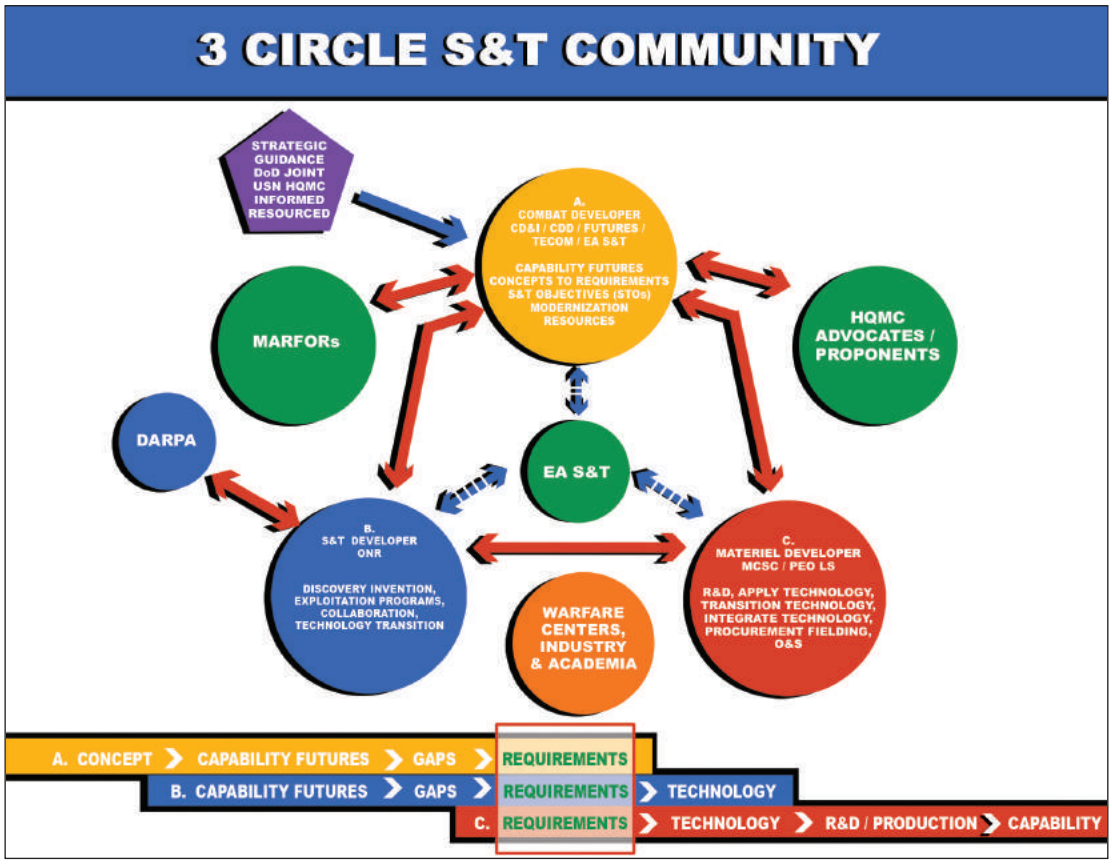

Figure 2-3. The 3 Circle S&T Community

the Marine Corps to field combat-ready and relevant forces.

- The **Director, Capabilities Development Directorate** develops warfighting capabilities and requirements. The Director, Capabilities Development Directorate accomplishes this through the Marine Corps Capability Based Assessment (CBA) resulting in the Marine Corps Enterprise Integration Plan (MCEIP). The MCEIP is produced annually, approved by the Marine Requirements Oversight Council (MROC), and signed by the Assistant Commandant of the Marine Corps. This critical document translates strategic guidance into capability development activities, and provides investment recommendations to achieve required capabilities within a fiscally constrained environment. This is done by refining and validating the MCCL, which are prioritized and measured against MROC approved scenarios, guidance, event task, condition, and standards. The gaps in the MCCL are identified and further prioritized to create the MCGL, which feeds into the Marine Corps Solutions Development Directive (MC SDD). MC SDD provides a solutions analysis, which in turn, yields solutions that span the Doctrine, Organization, Training, Material, Leadership and Education, Personnel, Facilities – Policy pillars with identified actions, to include initiatives that implement the solutions. Formulation of the Enterprise Capabilities Management Plan, consolidates CBA analytical results and provides a capability investment strategy to the enterprise to guide future Marine Corps capabilities development.
- The **Director, Futures Directorate/CG, MCWL** determines the future Marine Corps strategic landscape by assessing emerging security environments and by developing and evaluating Marine Corps operating concepts by integrating these concepts into Naval and Joint concepts. The Futures Directorate helps to identify potential gaps and opportunities, which inform the force development process.
- The **Office of S&T Integration** is tasked with implementing the Director, Futures Directorate/CG, MCWL S&T responsibility as the Marine Corps Commandant's EA for S&T. OSTI coordinates S&T within the combat development life cycle from 'requirement to transition.' Through coordination with the 3 Circle S&T community, OSTI develops the vision, policies, and strategies needed to exploit scientific research and technical development. OSTI provides technical oversight of proposals submitted to Office of Secretary of Defense (OSD) and DoD, while managing/monitoring the daily operations of the S&T programs under the OSTI portfolio. Additionally, OSTI develops and coordinates the prioritization of S&T requirements for OSD and the Department of the Navy. OSTI is also tasked with the development of the United States (US) Marine Corps S&T Strategic Plan. Within the US Marine Corps S&T Strategic Plan are STOs, which are products of the Marine Corps CBA process and are developed in coordination with the Marine Corps S&T enterprise.

MCSC and PEO LS

MCSC and PEO LS are principal agents in the materiel developer circle. The materiel developer administers and manages the activities of the workforce to meet the modernization requirements and to incorporate enhanced capabilities into PORs efficiently and effectively. The materiel developer community includes the acquisition executives, program executive officers, program managers, project officers, and support staffs. In response to a validated operational requirement from the combat developer, the materiel developer is responsible for assessing alternatives, conducting cost/benefit analysis, establishing R&D requirements, and procuring and fielding the required operational capability.

ONR

The Office of Naval Research is the principal agent in the S&T developer circle. The S&T developer delivers technologies that enable future Warfighters to gain and maintain their technical edge over our adversaries. The community consists of scientists, engineers, and academics who understand the technological frontier and what developments are possible for future systems. This group examines technical possibilities, identifies scientific gaps, develops S&T requirements, and executes scientific efforts. The S&T developer is also responsible for exploring the phenomenology, feasibility, and utility of S&T as it pertains to the improvement of legacy systems, the realization of future capabilities under development, and the advancement of discovery in areas yet to be exploited.

ONR identifies S&T solutions to address Navy and Marine Corps plans and scientific research as it relates to the maintenance of future naval power. ONR also manages the Navy's S&T funds to foster transition from S&T to higher levels of RDT&E. The Director, Futures Directorate/ CG, MCWL also serves as the Vice Chief Naval Research. The below advisors play an integral role in the ONR effort:

- **ONR Global Science Advisors** are civilian scientists, engineers, and technologists selected to participate in a one- to three-year career development tour. Science advisors serve as a Command's senior liaison with S&T organizations in government, academia, and industry. They communicate needs and requirements to the ONR and NRE to help shape S&T investments. They are worldwide in Joint, Navy, and Marine Corps Commands. Specifically, each Marine Expeditionary Force (MEF) has a Science advisor on staff to assist in providing operational ground truth for the S&T community.

Other S&T Stakeholders

- DARPA's singular and enduring mission is to make pivotal investments in breakthrough technologies for national security. The genesis of that mission and of DARPA itself dates to the launch of Sputnik in 1957, and a commitment by the United States that, from that time forward, it would be the initiator and not the victim of strategic technological surprises. Working with innovators inside and outside of government, DARPA has repeatedly delivered on that mission, transforming revolutionary concepts and even seeming impossibilities into practical capabilities. The ultimate results have included not only game-changing military capabilities such as precision weapons and stealth technology, but also such icons of modern civilian society such as the Internet, automated voice recognition and language translation, and Global Positioning System receivers small enough to embed in myriad consumer devices.

  DARPA explicitly reaches for transformational change instead of incremental advances. But it does not perform its engineering alchemy in isolation. It works within an innovation ecosystem that includes academic, corporate and governmental partners, with a constant focus on the nation's military services, which work with DARPA to create new strategic opportunities and novel tactical options. For decades, this vibrant, interlocking ecosystem of diverse collaborators has proven to be a nurturing environment for the intense creativity that DARPA is designed to cultivate.

- **TARDEC** develops, integrates, and sustains the technology solutions for all manned and unmanned DoD ground systems and combat support systems to improve current force effectiveness and provide superior capabilities for the future force. TARDEC leads research in ground systems

survivability, power and mobility, intelligent ground systems, force protection, and vehicle electronics architecture. TARDEC is a partner with industry, academia, and other government agencies to harness new technologies for emerging systems, integrate new energy and propulsion alternatives, reduce operating and maintenance costs of fielded systems and ensure that Soldiers have the best performing, most reliable, and easiest to maintain ground vehicles in the world.

➤ **Communities of Interest (COI)** cover 17 technical areas that span the cross-cutting science and technology in the DoD. The scope of each of these COIs and their associated technical sub-groups is available in Reliance 21. The collection of COIs, depicted in figure 2-4, serves as an enduring structure to integrate technology efforts throughout the DoD S&T enterprise. While they cover most of the DoD's S&T investment, some service-specific investments are not included in these groups. COIs were established in 2009 to encourage multi-agency coordination and collaboration in cross-cutting technology focus areas with broad multiple-component investment. COIs provide a forum for coordinating S&T strategies across the DoD, sharing new ideas, technical directions, technology opportunities, jointly planning programs, measuring technical progress, and reporting on the general state of health of specific technology areas. The COI that PEO LS is most interested in is the Ground & Sea Platforms (G&SP). The G&SP COI provides a forum for discussion of topics associated with a broad range of platform technologies for both ground and sea systems. The portfolio examines concepts in modularity, survivability and mobility as the primary emphasis areas. In addition, examination of required S&T for cost-effective maintenance and sustainment efforts for platforms is pursued in the portfolio. These efforts include:

- **Maintainability/Sustainability:** S&T that reduces life-cycle cost, reduces logistics burden, increases reliability, and provides timely support of ground and sea platforms. Areas of research include structural health monitoring, sustainment analysis tools, networked

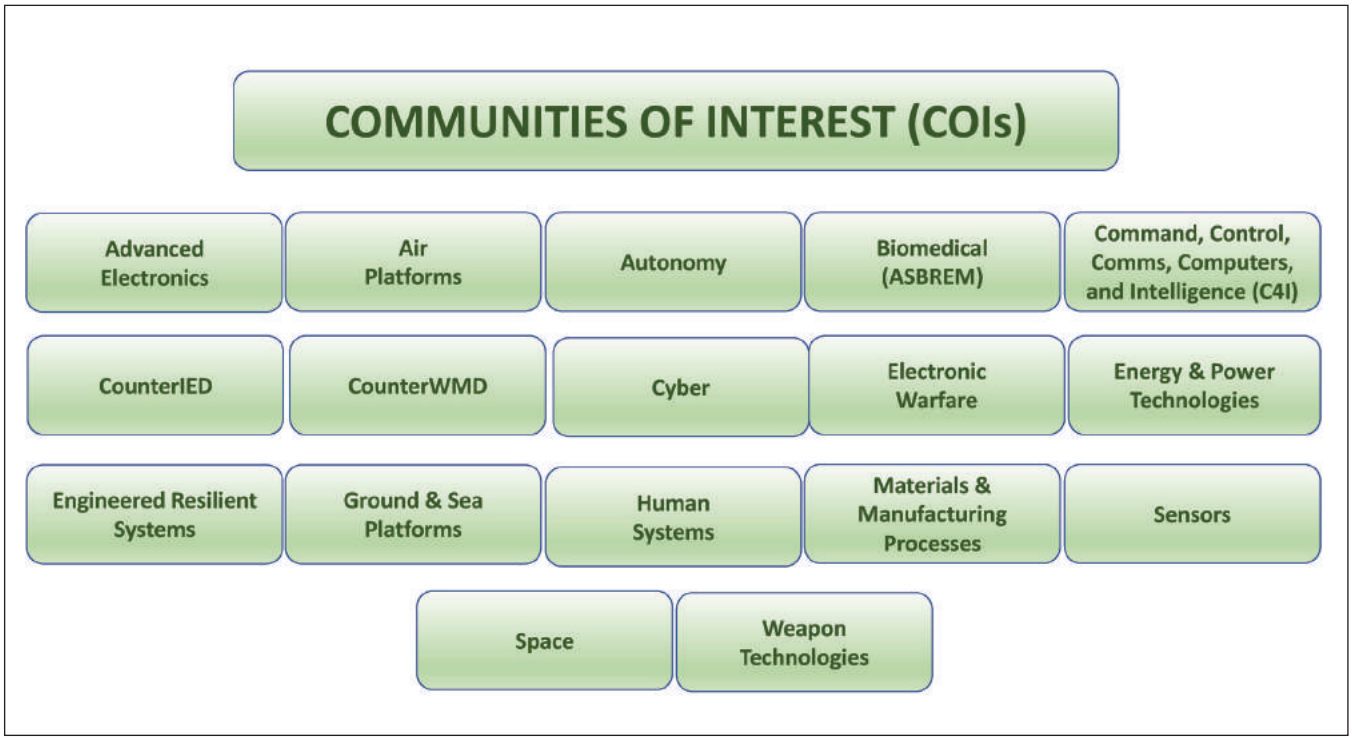

Figure 2-4. Communities of Interest

sustainment command and control, and high-reliability structures and components.

- **Modularity:** S&T that standardizes and designs interfaces, subsystems, and components that allow functional elements to be used across or within platforms. Areas of research include flexible designs for multi-mission adaptability, interoperable components and payloads, and platform infrastructure.
- **Mobility:** S&T focused on improving the mobility/maneuverability of ground and sea platform systems across all operational environments. Areas of research include sea stability during intense maneuvering, land stability in aggressive terrain, high-efficiency powertrain components, fuel economy, technologies enabling increased power generation, and amphibious maneuvering.
- **Survivability:** S&T that provides protection to ground and sea platforms and their occupants, while maintaining and enhancing the ability to accomplish the mission through development, evaluation, integration, maturation, and testing of technologies integrated into the platforms. Areas of research focus on platform-centric approaches to threat defeat, such as active protection (hard and soft kill), ballistic protection, and hazard protection including blast, shock, and fragmentation hazards and directed energy weapons.
- **Autonomy:** S&T that enables autonomous systems to include the strategic assessment of the challenges, gaps, and opportunities to the development and advancement of autonomous system, and identification of potential investments to advance or initiate critical enabling technology development. The Autonomy COI areas of research include Machine Perception, Reasoning and Intelligence; Human/Autonomous Systems Interaction and Collaboration; Scalable Teaming of Autonomous Systems; and Test, Evaluation, Validation, and Verification.
- **Unmanned Ground and Sea Vehicles:** S&T for maturation and integration of optionally manned competencies into ground and sea platforms to enhance force structure operational capabilities. Areas of research include conversion technologies for manned/unmanned operation and advanced unmanned vehicle development and integration concepts.

➤ **Industry:** Independent Research and Development (IR&D) is a program designed to allow firms to recover some of their independently funded R&D costs as part of the general and administrative expenses charged to existing contracts. These firms are given the independence to decide which technologies to pursue with these funds, as long as these efforts are of potential interest to DoD. The primary objectives of the DoD IR&D Program are to ensure that: (1) industry is aware of DoD's R&D activities and technological needs; (2) industry provides information to DoD about their IR&D activities; and (3) DoD makes effective use of IR&D accomplishments in defense applications. DoD plays an important role in facilitating the transition of IR&D accomplishments into applications that support the Warfighter. Further, it is DoD's responsibility to review all IR&D projects to identify which new products and services show promise, needing further development, and which technologies, if acquired, can provide immediate impact.

➤ **Academia:** Educational partnerships between academia and the S&T community provide a means for organizations to assist universities in extending their research capabilities in areas relevant to the needs of the Navy/Marine Corps, and they also

provide an opportunity for students to work on degrees in programs of interest to these organizations. The benefits are two-fold: First, the university develops scientific and engineering expertise applicable to future needs. Second, students working on Navy/ Marine Corps sponsored research receive an early exposure to those organizations, which expands the possible talent pool for future recruitment.

➤ **Naval Service Warfare Centers, Naval Undersea Warfare Centers, and Naval Information Warfare Centers** are part of the Naval Sea Systems Command (NAVSEA) and Naval Information Warfare Systems Command (NAVWAR) operated by the United States Navy. The mission of the NSWCs is to cohesively and seamlessly operate the Navy's full-spectrum research, development, test and evaluation, engineering, and fleet support centers for offensive and defensive systems, which are associated with surface warfare and related areas of joint, homeland and national defense systems from the sea. The Warfare Centers are the Navy's principal RDT&E assessment activity and supply the technical operations, people, technology, engineering services and products needed to equip and support the Fleet and meet the Warfighter's needs. They also provide engineering support to ensure that the systems fielded today perform consistently and reliably in the future.

There are a total of 10 NAVSEA Warfare Center Divisions and two NIWC NAVWAR Warefare Centers. Section 6 provides a detailed description regarding each of the following Warfare Center Divisions:

- Carderock Division of the Naval Surface Warfare Center, Maryland
- Corona Division of the Naval Surface Warfare Center, California
- Crane Division of the Naval Surface Warfare Center, Indiana
- Dahlgren Division of the Naval Surface Warfare Center, Virginia
- Indian Head Explosive Ordnance Disposal Technology Division of the Naval Surface Warfare Center, Maryland
- Panama City Division of the Naval Surface Warfare Center, Florida
- Port Hueneme Division of the Naval Surface Warfare Center, California
- Newport Division of the Naval Undersea Warfare Center, Rhode Island
- Naval Information Warfare Center Atlantic - Expeditionary Warfare Department

➤ **Defense Laboratory Enterprise (DLE)**, which includes the NSWC listed above, is composed of Army, Navy and Air Force laboratories that span 22 states, employing more than 38,000 scientists and engineers and participates in work exceeding $30B per year. The enterprise provides world leading competencies across a broad R&D portfolio, which includes the development of unique, often multidisciplinary, scientific capabilities beyond the scope of academic and industrial institutions to benefit the nation's researchers and national strategic priorities. The labs also sustain critical scientific/technical capabilities to which the government requires assured access. Additionally, the DLE executes long-term government scientific and technological missions, often with complex security, safety, project management, or other operational challenges.

➤ The **Joint Non-Lethal Weapons Directorate** was established in 1996 with the Commandant of the Marine Corps as the DoD Non-Lethal Weapon (NLW) Executive Agent. Non-lethal weapons provide Warfighters with additional escalation-of-force options while minimizing casualties and collateral damage. The DoD NLW Executive Agent has outlined the DoD NLW Program vision and charged the Joint

Figure 2-5. The Defense Innovation Marketplace Homepage

Non-Lethal Weapons Program (JNLWP) to lead the Joint Force in conducting R&D to enable "an integrated NLW competency." The JNLWP S&T Program contributes to the DoD NLW Program vision by investing in innovative technology and applied research to mitigate non-lethal effects capability gaps and to reduce developmental risk. The JNLWP S&T Program's intent is to "foster the ideation, maturation, and demonstration of innovative and compelling NLW technologies for the Joint Force through focused investment and collaboration internal and external to the DoD Research and Engineering (R&E) Enterprise."

Defense Innovation Marketplace

The Defense Innovation Marketplace (DIM), homepage depicted in figure 2-5, is a web-based forum, located at: www.defenseinnovativemarketplace.mil, and is designed as a communication resource and linkage between DoD S&T/R&D and Industry/ Academia. It provides a centralized resource for DoD's Acquisition/S&T professionals on information regarding industry's independent research and development activities. The DIM's goal is to be a communications resource that provides industry with improved insight into the R&E investment priorities of the DoD. The Marketplace contains DoD R&E strategic documents, solicitations, and news or events to better inform IR&D planning. The IR&D Secure Portal houses project summaries that provide DoD with visibility into the IR&D efforts submitted. As a hub of resources, the DIM enables interested organizations to become involved in the R&D enterprise.

How to Get Involved in the Process

The PEO LS S&T community fosters the cooperative development of requirements, informs and influences S&T budgeting resources, and advances the state of the art for the PEO LS portfolio.

The first step for a business, academic institution, or independent researcher to become involved is a period of investigation and preparation. Having a thorough understanding of the S&T challenges facing PEO LS programs and how your proposed solution can meet those challenges is vital to participating in S&T projects. The subsequent sections of the 2020 ATIP provide an outline of technical challenges facing the PEO LS portfolio. After you have reviewed the challenges and opportunities for the PEO LS S&T Portfolio, the S&T Venue List (Section 9) addresses the methods and venues for your involvement.

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Section 3.0

FUTURES

"Future force development must also contribute to an integrated operational architecture and enable information enviroment operations."

-General David H. Berger, Commandant of the Marine Corps

Introduction

In the 2019 Commandant's Planning Guidance, General David H. Berger stated, "The Marine Corps confronts an increasingly complex operational environment abroad and a challenging fiscal outlook. The Marine Corps can no longer accept the inefficiencies inherent in antiquated legacy systems that put an unnecessary burden on the warfighters....By exploiting the technical revolution in autonomy, advanced manufacturing, and artificial intelligence, the naval forces can create many new risk-worthy unmanned and minimally-manned platforms that can be employed in stand-in engagements to create tactical dilemmas that adversaries will confront when attacking our allies and forces forward."

These statements demonstrate the Marine Corps' commitment to innovation and determination to be technologically ahead of its adversaries and competitors. To do this, the Marine Corps must be capable of innovation across the range of military operations (ROMO) and the full spectrum of domain capabilities, to include maritime, land, air, space and cyber, as well as the human domain.

The PEO monitors Marine Corps, Navy, the other Services and Joint efforts that relate to futures assessment, concept development, and innovation that assist in articulating potential impacts and influences that span the PEO LS portfolio. This effort supports and enables the identification and prioritization of the PEO LS top program issues and associated technology needs that will in turn inform, influence, and align S&T investment.

Guiding Documents

Two guidance documents have proven to be especially impactful in this effort. The Secretary of Defense published the Defense Innovation Initiative which included guidance "to pursue innovative ways to sustain and advance our military superiority for the 21st century and improve business operations throughout the Department." Referencing advancements in stealth, networked precision strike, and surveillance in the 1970s and 1980s, the Secretary directed the identification of a "third offset strategy that puts the competitive advantage firmly in the hands of American power projection over the coming decades." The Third Offset Strategy describes the broad nature of capabilities that the DoD expects to realize over the coming years by pursuing developments in advanced technologies, conducting experimentation with prototype systems, and increasing emphasis on war gaming. This strategy will help the DoD better understand new concepts and the need to innovate across the entire DoD enterprise.

Wargaming

The Deputy Secretary of Defense addressed concerns with the DoD's decreased ability to test concepts, capabilities, and plans using simulation and other techniques, such as – Wargaming – in his memorandum "Wargaming and Innovation." The Deputy directed that, "To most effectively pursue an innovative third offset strategy, avoid operational and technological surprise, and make the best use of our limited resources, we need to reinvigorate, institutionalize, and systematize wargaming across the Department." He further explained that revitalizing wargaming across the DoD enterprise fits well with the DoD's Innovation Initiative and bolsters the Department's ability to field military relevant systems and technologies, adapting to dynamic tactical and operations challenges.

Concept-to-Capability Process

PEO LS continues to pursue the goals outlined in these two important directives as part of its Concept-to-Capability process. This process, depicted in Figure 2-1 in section 2 (S&T Collaboration and Engagement), provides a validated, repeatable process for addressing an uncertain future within the context of the Service's current force development system. This process is also executed in conjunction with the Deputy Commandant for Combat Development and Integration, Marine Corps Warfighting Laboratory/Futures Directorate (MCWL/FD) and the Capabilities Development Directorate (CDD). Ultimately this collaboration is conducted within the overarching Planning Programming, Budget and Execution (PPBE) and Service force development processes. The PEO LS approach further gains valuable insight from a series of conducted wargames designed to examine aspects of the Marine Corps' new Expeditionary Force 21 (EF 21) capstone concept, which included: Ground Warrior 2019, Expeditionary Advanced Base Operations 2019, and MAGTF Warrior 2019 wargames. These efforts also assist in mitigating future risks by providing well-researched areas for focused investment based on technical issues that share common warfighting connections to multiple programs within the PEO. Focusing S&T funding on these key areas enables the Marine Corps to maximize its Return on Investment (ROI) and to better prepare for the future.

The Combat Developer (represented by DC CD&I's MCWL/FD) depicted in Figure 3-1 initiates Concept to Capability process outlined in this plan. PEO LS engages with the MCWL/FD to understand and contribute to futures assessments, concept development, and other force development actions to include experimentation and wargaming. This engagement and communication helps inform future required capabilities. Those concepts, and the process that follows to produce the capabilities needed, are driven by wide-ranging assessments of the future that include everything from adversary capabilities to fiscal constraints.

Assessment of Plausible Future Security Environments

PEO LS S&T must access a wide variety of sources and perspectives to develop and validate future threats and opportunities as they apply to the PEO LS portfolio. To obtain a tailored perspective of the future, the S&T Director uses the Assessment of Plausible Future Security Environments (Figure 3-2), which examines the wide range of potential futures: preferable, probable, and alternative. The assessment of plausible futures helps to augment existing concepts as part of the initial steps of the Concept-to-Capability process.

This methodology examines current and future capability gaps to inform the ATIP, providing relevant context by identifying the most likely future security environment as well as the capabilities required to address the challenges the future force will likely face. The process references and responds to Department of Defense, Joint, and Service assessments and guidance relative to what the future is expected to hold. It also considers other likely

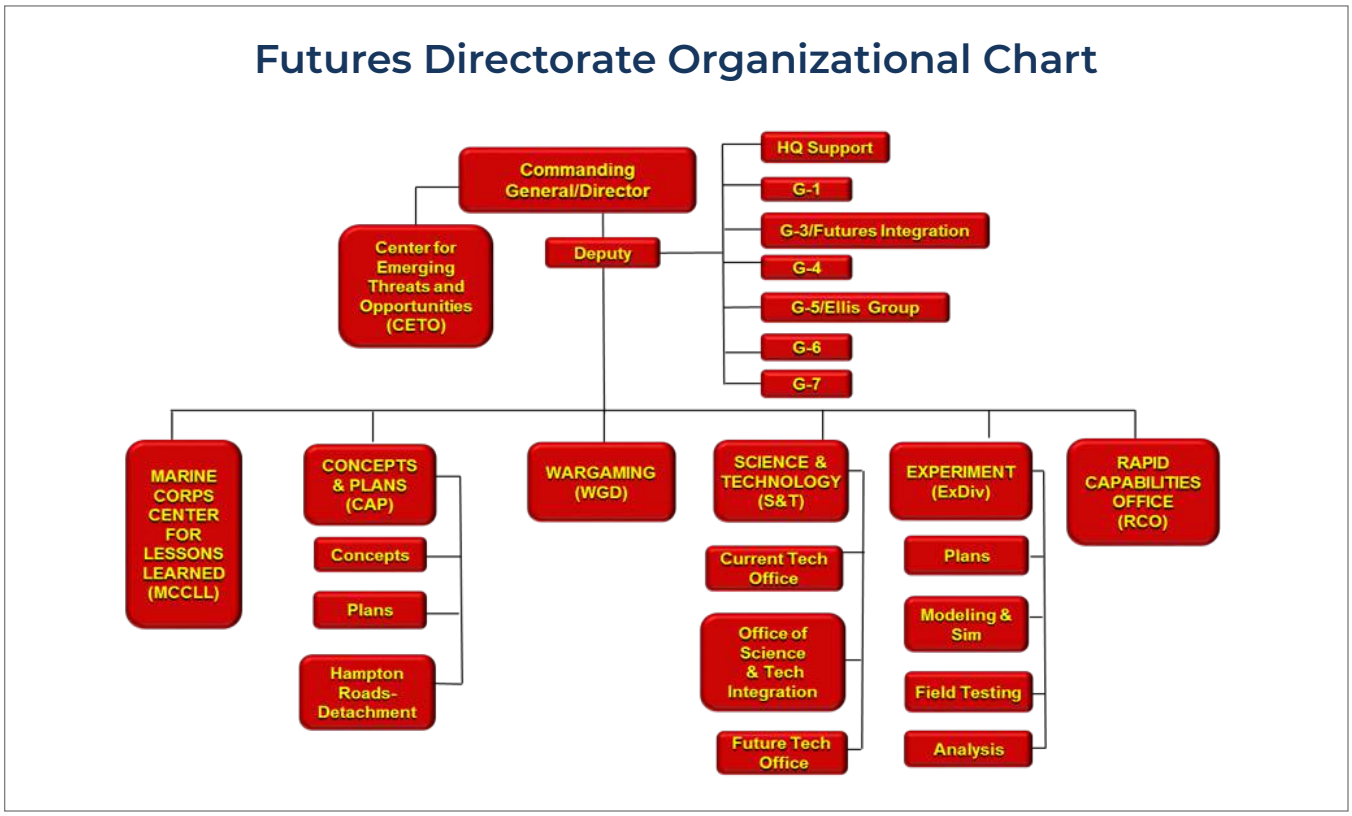

Figure 3-1. Futures Directorate Organizational Chart

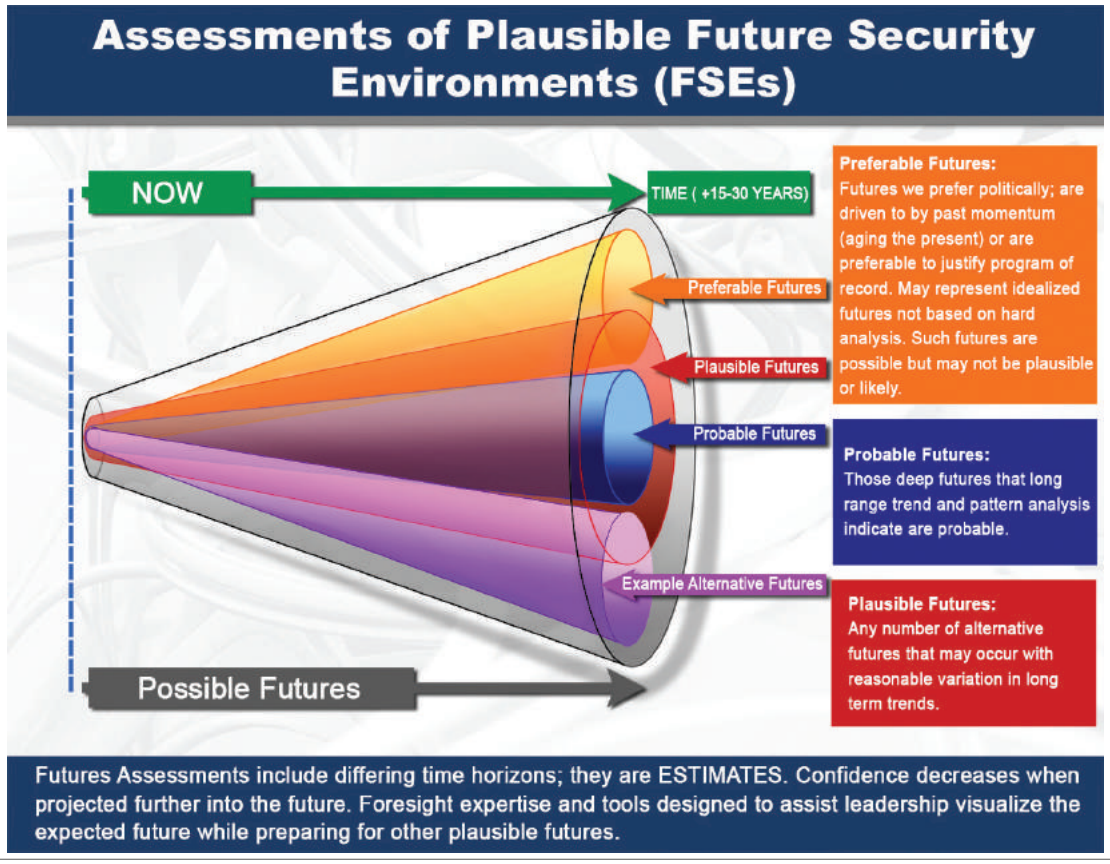

Figure 3-2. Assessments of Plausible Future Security Environments (FSEs)

and plausible futures (as well as less probable scenarios) from industry, academia, and international community experts.

These probable futures are derived from baseline forecasts that project existing trends into the out years. Trends and forecasts used to support PEO LS' examination of the most likely future security environments are outlined in the following key U.S. defense-related publications:

- *Sustaining U.S. Global Leadership: Priorities for 21st Century Defense* (DoD 2012).
- *Capstone Concept for Joint Operations: Joint Force 2020* (CCJO 2012).
- *Joint Operational Access Concept* (JOAC2012).
- *Mission Command White Paper* (CJCS 2012).
- 2012 U.S. *Marine Corps S&T Strategic Plan.*
- *Gaining and Maintaining Access: An Army-Marine Corps Concept* (ARCIC/MCCDC 2012).
- *The Marine Corps Service Campaign Plan 2014-2022* (2014).
- *Quadrennial Defense Review* 2014 (QDR).
- *Expeditionary Force 21* (HQMC 2018).
- *The Defense Innovation Initiative* (Secretary of Defense memo, 2014).
- *38th Commandant's Planning Guidance* 2019.
- *Wargaming and Innovation* (Deputy Secretary of Defense memo, 2015).
- *The National Military Strategy of the United States of America* 2018 (NMS).
- *Naval S&T Strategy: Innovations for the Future Force* (ONR 2018).
- A *Cooperative Strategy for 21st Century Seapower* (SecNav 2015).
- *National Security Strategy* (NSS 2015).
- 2015 *Marine Corps Security Environment Forecast* (MCSEF).
- *Joint Concept for Rapid Aggregation* (CJCS 2015).
- *Force Development Strategic Plan* (CG MCCDC, DC CD&I 2015).
- *Marine Corps Operating Concept*, "*How an Expeditionary Force Operates in the 21st Century*" (HQMC 2016)

Relevant trends and forecasts outlined in these documents include:

- An era of fiscal austerity and national debt.
- Cyber threats from governments and non-government actors.
- Technological diffusion/weapons of mass destruction proliferation.
- Increased urbanization, particularly in the littorals.
- The traditional view of the three primary domains (air, land and sea) within the "global commons," with the increasingly important addition of the space, cyberspace, and human domains.
- The demand for critical resources is likely to continue to exceed supply, even with advanced conservation and efficiency measures coupled with alternative sources.
- Transnational crime, regional instability, and violent extremism.
- An increased emphasis on a forward-postured crisis response force in readiness to address an unstable and uncertain operating environment, with an emphasis on Phases 0 through 2 (Shape, Deter, Seize Initiative).
- Influences within the Marine Corps on Future Development

"By automating the tasks that are repetitive, time-consuming, and routine, we will create the space in the schedule to train, educate, and develop our Marines to the level required by the operational environment."

-General David H. Berger, Commandant of the Marine Corps

The Commandant of the Marine Corps has said the Marine Corps must be able to innovate, adapt and win with the equipment that we currently have in our inventory. The ATIP is designed to leverage efforts throughout the S&T enterprise, to find solutions to the current technology needs of the PEO LS PORs, and to look into the future to see what is in the "Realm of the Possible." This Futures Section is intended to inform where the Marine Corps could go with its investment funding if the technology proves to be worth the needed investment and suggest technology trends that may influence the way the Marine Corps will fight in the future.

3.1 Artificial Intelligence

As you may have noticed in recent years, Artificial Intelligence (AI) has become quit popular. Many have become enamored with AI's ability to perform tasks more efficiently than humans, while others have become fearful of the potential technical singularity (when machines rule the world). No matter what side of the fence you fall on one thing is for certain, AI is here and will likely become a more integral part of our daily lives, if it isn't that way already. And like any technological advancement there is a lot of technical jargon that goes along with it: narrow AI, general AI, super AI, machine learning, deep learning, reinforced learning supervised and unsupervised learning, recurrent and convolutional neural networks, Bayesian networks and a plethora of additionally confusing terms. What this section will attempt to do is bring forward the most important aspects of AI to the Marine Corps and provide a brief description of those important pieces.

What Is Artificial Intelligence?

John McCarthy, known by many as the father of Artificial Intelligence, believed that *"every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."*

AI is not easily defined, and if you search you will find a broad range and likely some conflicting results. Wikipedia provides a generic, and slightly vague description of AI as "apparent intelligence exhibited by machines, rather than the natural intelligence displayed in humans or other animals." More specifically it is act of machines mimicking natural intelligence cognitive functions such as problem solving or learning (Dickerson, 2017). It is man-made; it can reason, make decisions, account for multiple and various factors, and in many ways, simulate human brain functions in general. To provide a deeper understanding a discussion of a common misconception is necessary; the term "robot" is not a synonym for AI, even though it is used that way in many instances. Artificial Intelligence is a reference to the software that manifests intelligence, whereas robots infer a physical element, a shell which carries out the decisions made by the AI engine behind it. In addition, robots don't necessarily need AI to carry out useful functions nor does a true AI need a robot to be functional. Slightly murky, yes. The truth is that AI is hard to define, because intelligence itself is hard to define; however, what everyone can agree on is that AI is not natural.

Exacerbating the misunderstanding of artificial intelligence is a phenomenon called

the AI Effect which John McCarthy (who many consider the father of AI) quipped, “As soon as it works, no one calls it AI anymore.” Michael Kearns, a professor at the University of Pennsylvania, explained further that, “As soon as someone gets a computer to do it, people say: 'That's not what we meant by intelligence.' People subconsciously are trying to preserve for themselves some special role in the universe." The simple fact that automatic garbage collection was once considered advanced artificial intelligence; however, now it is merely an algorithm that helps us sort through recyclables in our trash is a testament to this problem. As a society, we have become accustomed to computers routinely beating chess champions and winning at Jeopardy, Google and Bing searches that remember our topics of interest and help us find the information we need, and smart cars that have automatic breaking and collision avoidance systems all using some level of AI to power their application. Today, many of the rules- and logic-based systems that were previously considered Artificial Intelligence are no longer classified as AI. In contrast, systems that analyze and find patterns in data (machine learning) are becoming the dominant form of AI. But regardless of the mechanisms and behind the scenes, the level of AI can be broken down into three main categories: Artificial General Intelligence, Artificial Super Intelligence, and Artificial Narrow Intelligence.

Artificial Narrow Intelligence

Narrow AI is the only form of Artificial Intelligence that humans have achieved so far. This type of AI is good at performing a single task, such as playing chess or Go, making purchase suggestions, sales predictions and weather forecasts. Narrow AI works within a very limited context and can’t take on tasks beyond its field. So, you can’t expect the same engine that transcripts audio and video files to, say, order pizza for you. That’s the task of another AI. However, that doesn’t mean that narrow AI is inefficient. On the contrary, it is very good at routine jobs, both physical and cognitive. And it’s narrow AI that can ferret out patterns and correlations from data that would take eons for humans to find. It is narrow AI that is threatening to replace (or rather displace) many human jobs.

Narrow AI examples:

- At their current state of development computer vision and natural language processing, even with all of their recent advances, are still considered narrow AI.
- Speech and image recognition are narrow AI, and even Google’s translation engine, while highly sophisticated, is also form of narrow Artificial Intelligence.
- Self-driving car technology is still considered a type of narrow AI; however, it is more advanced as it requires the coordination of several narrow AIs.

Artificial General Intelligence

General AI, also known as human-level AI or strong AI, is the type of Artificial Intelligence that can understand and reason its environment as a human would. General AI has always been elusive. We’ve been saying for decades that it’s just around the corner; however, the more we learn, the more we realize that it will be difficult to achieve. It’s really hard to define what human-level artificial intelligence would be. While humans might not be able to process data as fast as computers, they can think abstractly and plan, solve problems at a general level without going into the details. They can innovate, come up with thoughts and ideas that have no precedence. Consider the invention of the telephone, ships, telescopes, concepts such as mail, social media, gaming, virtual reality. It’s very hard to teach a computer to invent something that isn’t there. Additionally, humans’ ability to perceive things, juggle between multiple unrelated thoughts and memories when making a decision. That’s very hard for computers to achieve.

Artificial Super Intelligence

According to University of Oxford scholar and AI expert Nick Bostrom, when AI becomes much smarter than the best human brains in practically every field, including scientific creativity, general wisdom and social skills, we've achieved Artificial Super Intelligence. Some believe that the distance between AGI and ASI is very short, happening in a blink of an eye and will continue to evolve at an exponential rate. What happens at that point is pure speculation. Noted Scholar Stephen Hawking and noted Entrepreneur Elon Musk see the development of full artificial intelligence as the potential end of the world.

Military Interests

For the DoD, AI provides two sorts of opportunities.

1. AI technologies might make existing tasks simpler, more reliable, or more efficient. Or,
2. AI technologies might be used to introduce wholly new capabilities. Another dichotomy is substitutive, where AI replaces people, or complementary, where AI improves or helps.

But these points are true of all automation. AI techniques provide new tools capable of helping the Marine in the field help accomplish these goals (autonomous resupply convoys or MUM-T). Using them is engineering, albeit advanced engineering. That AI and—if it were to advance significantly—AGI are of importance to DoD is so self-evident that it needs little elucidation here. Weapons systems and platforms with varying degrees of autonomy exist today in all domains of modern warfare, including air, sea (surface and underwater), and ground. To cite a few out of many possible examples:

- Northrop Grumman's X-47B is a strike fighter-sized unmanned aircraft, part of the U.S. Navy's Unmanned Combat Air System (UCAS) Carrier Demonstration program. Currently undergoing flight testing, it is capable of aircraft carrier launch and recovery, as well as autonomous aerial refueling.
- Anti-Submarine Warfare Continuous Trail Unmanned Vessel (ACTUV) program recently commissioned the "Sea Hunter", a 130 ft unmanned trimaran optimized to robustly track quiet diesel electric submarines.
- The Samsung SGR-A1 is a South Korean military robot sentry designed to replace human counterparts in the Korean demilitarized zone. It is capable of challenging humans for a spoken password and, if it does not recognize the correct password in response, shooting them with either rubber bullets or lethal ammunition.

It is an important point that, while these systems have some degree of "autonomy" relying on the technologies of AI, they are in no sense a step—not even a small step—towards "autonomy" (which will be discussed in the next section) in the sense of AGI, that is, the ability to set independent goals or intent. Indeed, the word "autonomy" conflates two quite different meanings, one relating to "freedom of will or action" (like humans, or as in AGI), and the other the much more prosaic ability to act in accordance with a possibly complex rule set based on possibly complex sensor input, as in the word "automatic". In using a terminology like "autonomous weapons", the DoD

At a higher strategic level, AI is recognized by DoD as a key enabling technology in a possible Third Offset Strategy, key elements of a Third Offset Strategy include:

- autonomous learning systems, e.g., in applications that require faster-than-human reaction times;
- human-machine collaborative decision making;

- assisted human operations, especially in combat;
- advanced strategies for collaboration between manned and unmanned platforms; and
- network-enabled, autonomous weapons capable of operating in future cyber; and
- electronic warfare environments.

3.2 Autonomy

Why Is Autonomy Important?

Autonomous systems, unmanned systems and other associated technologies are beginning to have a significant impact on warfare as we know it today. Many feel that with proper level of Research and Development (R&D), the physical and cognitive burdens placed on today's warfighter can be considerably reduced through the development and application of appropriately focused autonomous technologies. These newly designed and appropriately focused autonomous systems will not replace the warfighter but complement these future warriors by extending their reach as well as providing potentially unlimited persistent capabilities without degradation due to warfighter fatigue or without loss of situational awareness. Additionally, these systems will help the warfighter perform certain functions with speed, reliability and precision beyond existing human capability. Dr. David and Nielsen concluded in the Defense Science Board 2016 Summer Study on Autonomy that,

> *"While difficult to quantify, the study concluded that autonomy—fueled by advances in artificial intelligence—has attained a 'tipping point' in value. Autonomous capabilities are increasingly ubiquitous and are readily available to allies and adversaries alike. The study therefore concluded that DoD must take immediate action to accelerate its exploitation of autonomy while also preparing to counter autonomy employed by adversaries."*

What Is Autonomy?

As we bring the topic of autonomy into focus it is useful to provide a few definitions to ensure there is a clear understanding of what we are discussing as well as the relationships between the topics. Below is a list of definitions delivered by Dr. Lawrence G. Shattuck, Director, Human Systems Integration Program, Naval Postgraduate School, Monterey, CA in his presentation at NASA's Human Systems Integration Division 2015 workshop on Transitioning to Autonomy: Changes in Role of Humans in Air Transportation.

Autonomy is the ability of an intelligent system to independently compose and select among different courses of action to accomplish goals based on its knowledge and understanding of the world, itself, and the situation.

Artificial Intelligence (AI) is the ability of a system to act appropriately in an uncertain environment, where an appropriate action is that which increases the probability of success, and success is the achievement of behavioral sub-goals that support the system's ultimate goal.

Intelligent System is an application of AI to a particular problem domain. Usually very specialized -- not "general intelligence".

State of the Art is not as broadly competent as people and lacks common sense.

- In some domains machine intelligence equals all but the most skilled humans; in a few areas they excel above all.
- Taking on tasks once thought only do-able by humans.
- Accomplishing tasks no human can perform without their help.
- Their complexity makes it nearly impossible for anyone but an expert to understand

them, and that is becoming increasingly difficult as intelligent systems gain the ability to learn.

Robotics focuses on systems incorporating sensors and actuators that operate autonomously or semi-autonomously in cooperation with humans. Robotics research emphasizes intelligence and adaptability to cope with unstructured environments.

Automation emphasizes efficiency, productivity, quality, and reliability, focusing on systems that operate without direct control, often in structured environments over extended periods, and on the explicit structuring of such environments.

Agent is a self-activating, self-sufficient and persistent computation:

- ➤ May be an intelligent system.
- ➤ May include significant automation.
- ➤ Is capable of modifying the manner in which it achieves objectives (fulfills purpose).
- ➤ May reside and act entirely in the cyber world, or be embodied in a device such as a robot.

History of Military Use

Since the inception of Nikola Tesla wireless-radio technology in the 1890s, autonomous and semi-autonomous systems have found their way into military application. During World War I, Germany utilized Tesla's wireless-radio technology to guide an explosive laden motor boat into a British vessel (Singer, 2009). During World War II, the Germans again used this wireless-radio technology to remotely pilot a drone; manually steering the explosive laden drone to its target. During the Vietnam War, the U.S. flew the Firefly drone on nearly 3,500 reconnaissance missions in support of operations in South East Asia. Laser-guided munitions were a staple for forces during the Persian Gulf War and soon after, Global Position System Satellite navigation data would be introduced into a new era of smart munitions. The aftermath of the attacks on the World Trade Center 2001, provided an additional catalyst, furthering the movement towards autonomy as the Military expanded its drone fleet from less than 100 to more than 7,000 Unmanned Air Systems (UAS).

Congress got involved in movement towards autonomy when then Senator John Warner, Chairman of the Senate Armed Services Committee added in the 2001 National Defense Authorization Act that one-third of all attack aircraft to be unmanned by 2010 and one-third of all ground combat vehicles driverless by 2015. While their motivation had more to do with the public's growing distaste for American war casualties and its potential impact on U.S. foreign policy; the insertion of this language demonstrated the growing acceptance and belief that robotics and autonomous systems would play a significant role on the future battlefield (Singer, 2009).

Where Are We Today?

Today few images highlight the increasingly automated nature of modern warfare better than a photograph of the eerily opaque, windowless nose of the MQ-1 Predator drone, a centerpiece of U.S. military and counterterrorism efforts in the Middle East and Africa having flown hundreds of precision drone strikes targeting our nations foes. However, drone warfare is merely the leading edge of a broader worldwide trend toward more autonomous methods of warfighting. South Korea's SGR-A1 armed sentry robots guarding the DMZ, Israel's 'Iron Dome' active protection system, miniaturized lethal drones such as the U.S. Army's Switchblade, long-range intercontinental drones like the U.K. Taranis and the U.S. X47-B are just a few examples of the versatility that these automated systems provide. It's no small wonder why militaries around the world are investing in an increasingly automated future, and these investments are not limited to weapons in the

conventional sense. Military and intelligence agencies worldwide are developing increasingly sophisticated and autonomous software algorithms for use in cyberwarfare – conflicts between electronic agents in electronic space that nevertheless have the potential to inflict considerable human losses. Incorporating the advances in algorithm development for analyzing massive datasets, systems are being developed that have the capability to outperform human calculations of threat potential, target value, operational risk, mission cost, casualty estimates and other key strategic variables. Taken together, these developments represent a profound shift in our traditional understanding of the role of human beings in the conduct of war.

Commercially, there has been a rapid expansion in the global market for robotics and other intelligent systems to address consumer and industrial applications. Autonomy is being embedded in a growing array of software systems to enhance speed and consistency of decision-making, among other benefits. Additionally, governmental entities, motivated by economic development opportunities as well as growing security issues, are investing basic and applied research dollars to address the projected future needs for these types of systems. Applications include commercial endeavors such as IBM's Watson, the use of robotics in ports and mines worldwide, autonomous vehicles (from autopilot drones to self-driving cars), automated logistics and supply chain management, and many more. Japanese and U.S. companies invested more than $2 billion in autonomous systems in 2014, led by Apple, Facebook, Google, Hitachi, IBM, Intel, LinkedIn, NEC, Yahoo, and Twitter.

Where Are We Going?

The DoD has strategically increased its adoption of robotics and unmanned vehicle systems in the last decade, but the vast majority of the systems are remotely operated rather than autonomous. Recent programs such as the Autonomous Aerial Cargo Utility System (AACUS), an Innovative Naval Prototype, have shown a progression from pre-programming and remote control to autonomous functionality, but progress has been slow. The Department is engaged in R&D across many aspects of autonomy, but has not yet addressed the R&D needed to overcome the systemic challenges to the widespread use of autonomy across the broader mission sets to which it could be applied. Initially, robotics and unmanned systems were largely driven by perceived improvements in performance and cost; however, actual advantages are proving to be more complex. Safety improves by reducing the lethality of warfare and the ability to adopt riskier tactics because a system is unmanned. Accuracy also improves, with more endurance, range, and speed in comparison to manned vehicles. Systems are also more flexible and more mobile. Autonomy also enables the execution of new missions– particularly in domains such as cyber and electronic warfare, in which decision speed is critical to success.

The following areas were highlighted in the Defense Science Board's 2016 Summer Study on Autonomy as opportunities for DoD to exploit ongoing advances in autonomy:

- ➤ Reduction of Manpower-realizing the promise of unmanned systems to reduce manpower and cost:
  - Mitigation of unmanned–reduce manpower, cost, logistics of existing platforms
  - Reduction of operators–further reduction of manning and specially qualified operators to control more than one platform or asset
  - Information filtering–reduction of sheer data volume collected by unmanned systems. Systems that make decisions on what not to show
- ➤ Tactical Advantage-added advantages on the battlefield:

- Faster reaction time–local decisions faster than human cycle
- Deeper penetration–operation in inaccessible or denied environments
- Extended operation–can operate longer than human cycles
- Agility and adaptation–ability to adjust to changing environments and mission goals, ability to use in secondary missions

➤ Trusted Companion-System capable of providing real-time, tactical and proximate support to warfighters:

- Faithful servant–utilization of competent mules, closer proximity to humans, operations not in contact with adversary
- Loyal wingman–high tempo coordination and interaction, operations in contact with adversary

3.2.1 Manned-Un-Manned Teaming (MUM-T)

MUM-T is a term used to describe the relationships established between manned and unmanned systems while carrying out a common mission as an integrated team. More specifically, MUM-T is the overarching term used to describe platform interoperability and shared asset control to achieve a common operational mission objective. This term also includes the concepts of "loyal wingman" for air combat missions and segments of missions such as MUM air refueling. This capability is especially vital for missions such as target cueing and handoff between manned and unmanned systems, where the operators not only require direct voice communications between the participants, but also a high degree of geospatial fidelity to accurately depict each team member's location with regard to the object being monitored.

MUM-T efforts have steadily increased as technology has improved, and users have found new and innovative methods to exploit this enhanced mission capability. Current missions include reconnaissance, surveillance, and target acquisition (RSTA); transport; countermining; explosive ordnance disposal; and the use of armed unmanned tactical wheeled vehicles for checkpoint security inspections. While much of this effort has been focused on exploiting the potential of unmanned air vehicles, the MUM-T concept associated with ground operations is becoming more pervasive. These developments have been the catalyst for creating a number of key MUM-T capabilities, which include:

➤ Defeating explosive ground surface, sub surface (tunnel), and sea hazards from greater standoff distances.

➤ Developing of a squad multi-purpose Unmanned Ground Vehicle (UGV) that incorporates a modular payload architecture to rapidly adapt payload to mission needs with minimum impact to the operator's cognitive workload.

➤ Providing an organic aerial resupply capability to assure resupply for steady state and emergency operations that unburdens dismounted units over extended distances and reduces risk to personnel conducting manned resupply operations in contested terrain.

➤ Developing the capability to conduct multi-unmanned systems missions with minimal operator input providing a single operator with the ability to control multiple unmanned systems without cognitive overload.

As a technology concept, MUM-T acknowledges the capabilities and limitations of current technologies (as well as those of today's warrior) and provides a vision for how we can optimize these technologies to best support the warfighter. Future investments in effective MUM-T would greatly complement warfighters and enhance their ability, making them more effective and more survivable in the future A2/AD environment. While the explosive ordnance disposal (EOD) community has extensive

experience with MUM-T, the military must shed its preconception that robotic followers can only operate within the confines of current man-machine interface. These preconceived notions can limit our ability to realize the potential for innovative applications with regard to MUM-T and stifle the growth of what could be a cornerstone of future Marine Corps operational concepts.

3.2.2 The Test and Evaluation Challenge for Future Autonomous Systems

Autonomous systems present significant, unique challenges to the DoD test and evaluation (T&E) community. As the level of autonomy increases, test and evaluation needs to transition away from the execution of specifically planned scenarios to a new test paradigm that understands and validates the decisions made in a dynamic environment. The challenges facing the T&E community include the ability to evaluate emerging autonomous systems' safety, suitability and performance, as well as human interaction with autonomous systems. The T&E community must be able to predict a system's behavior and decision processing. The community must also be able to characterize the environment in which the autonomous system will operate and evaluate the ability of those systems that are sensing the environment and formulating a world model based on this sensed environment. The test technology community must advance the technology readiness levels of key supporting technologies and processes needed to improve DoD's T&E capability.

The Defense Science Board Task Force on the Role of Autonomy in DoD Systems recommended that USD (AT&L) review the current test technology programs, including those of the Test Resource Management Center, to ensure that the unique test requirements of autonomous systems are addressed. Among the topics identified were:

- Creating techniques for coping with the difficulty of defining test cases and expected results for systems that operate in complex environments and do not generate deterministic responses.
- Measuring trust that an autonomous system will interact with its human supervisor as intended.
- Developing approaches that make the basis of autonomous system decisions more apparent to its users.
- Advancing technologies for creating and characterizing realistic operational test environments for autonomous systems.
- Leveraging the benefits of robust simulation to create meaningful test environments.

Based on the results of their research, it is likely that the DoD will need to improve its operational test ranges so that they can better support the evaluation of autonomous systems.

3.3 PEO LS Future Focus

Exponential Technologies

Exponential technologies are those technologies that fundamentally disrupt the 'balance of power'. These technologies typically have the following characteristics:

- Decentralization: The work is performed by a diverse network of individuals using mass collaboration in a virtual environment.
- Transparency: The work is usually open-source.

The impact of 'transparency' is further amplified when technologies coalesce into open platforms, thus enabling insertion and upgrades by rapidly building on previous versions. Furthermore, the ability to combine and recombine technologies lends itself to exponential innovation – where the combined capability is greater than the sum of its parts.

PEO Land Systems' future investments will focus heavily on exponential technologies to include:

- ➤ Counter UAS Technologies
- ➤ Active Protection System (APS)
- ➤ Autonomy/Robotics
- ➤ Big Data Analytics
- ➤ Additive Manufacturing (3-D Printing)
- ➤ Artificial Intelligence/Deep Learning
- ➤ Condition Based Maintenance (CBM)
- ➤ MTVR Leader Follower
- ➤ Drone Elimination

Counter UAS Technologies

The list of countries that now possess and operate some type of UAS capability continues to grow with the proliferation of increasingly affordable and available technology. The widespread proliferation of Unmanned Aerial Systems (UAS) among both state and non-state actors is cause for concern to U.S. operational commanders. These unmanned aircraft are being developed with more technologically advanced systems and capabilities. Some have the ability to duplicate many of the capabilities of manned aircraft for both surveillance/ reconnaissance and attack missions. They also can be elusive, small enough and/or slow enough to elude detection by standard early warning sensor systems and in large numbers (Swarms) pose a formidable threat to friendly forces. To adequately address this growing threat the Marine Corps will have to develop an integrated, expeditionary suite of networked capabilities to detect, identify, cue, and kinetically or non-kinetically prosecute enemy unmanned air, ground, and surface / sub-surface systems.

Active Protection Systems (APS)

The rapid advancement of anti-armor systems is requiring the Marine Corps' as well as the other services to consider non-traditional protective measures as the cost and weight of traditional systems continue to rise. One of these non-traditional methods is the use of Active Protection Systems. A technology that safeguards vehicles and personnel from incoming fire by identifying warning cues, detecting threats, classifying threats and actively using countermeasures to defeat the threat.

APS technologies use sensors and/or radars, computer processing, fire control technology, interceptors and countermeasures to prevent line-of-sight guided anti-tank missiles/ projectiles from acquiring and/or destroying a target. There two categories of APS systems characterized by their defense mechanisms; "soft-kill" and "hard-kill." A Soft-kill system uses electronic countermeasures to confuse or jam the incoming missiles targeting mechanism by way of electro-optical signals, infrared, or laser jamming. While "hard-kill" countermeasures physically counteract incoming missiles and Rocket-Propelled Grenades by intercepting them at close range if needed.

The Department of the Army is looking at a range of domestically produced and allied international solutions for their Modular Active Protection Systems (MAPS) program. Rafael's Trophy system, Artis Corporation's Iron Curtain, Israeli Military Industry's Iron Fist, UBT/Rheinmetall's ADS system, and others are under consideration. The goal for the newest APS or MAPS will be to enhance the tracking sensor technology for identifying the origin and for detecting enemy optics prior to a hostile fire event. Ultimately, this will help create an autonomous or semi-autonomous shield to protect virtually any vehicle on which the system is installed.

Autonomy/Robotics

Autonomy and robotics provide capabilities that effect operational and tactical maneuver in the littorals through the use of unmanned autonomous systems with minimal human

interaction and control. These capabilities include unmanned ground vehicles, robots, air vehicles, sensors, UxS swarms, and connectors that work side by side with the Warfighter. Ideally, these systems will be able to collaborate and share information to reduce the operator workload, relieving him or her of physical and cognitive burdens. The goal is to reduce risk to human life by using unmanned systems to accomplish potentially dangerous tasks.

Big Data Analytics

Big Data Analytics describes the exponential growth and availability of data, both structured and unstructured, so large or complex that traditional data processes applications are inadequate. Big data analytics will help the user gain insights from a massive amount of data, enabling more accurate analysis, modeling and predictions. It will also transform the ability to draw actionable intelligence from a myriad of sensors and nodes at the tactical edge. It can provide commanders at all levels information ranging from mundane tasks, like a vehicle needs an oil change, to the immediate threat of a roadside Improvised Explosive Device. The near real-time transmitting, receiving, gathering and acting on this information can greatly benefit the Marine Corps.

Additive Manufacturing (3-D Printing)

Additive Manufacturing is the process of making a three-dimensional solid object of virtually any shape from a digital image. This is achieved by using an additive process, where successive layers of material are laid down in different shapes. 3-D printers could transform military logistics by allowing units to print equipment and spare parts in the field, greatly reducing response time. While there is a logistical burden associated with 3-D printing, it could be offset by its advantages. The Marine Corps wants to explore the potential for significantly increased efficiencies in logistics through reduction of inventories and determining other areas of military application.

Artificial Intelligence / Deep Learning

Earlier in this section we described Artificial Intelligence (AI) as the ability of a system to act appropriately in an uncertain environment, where an appropriate action is that which increases the probability of success, and success is the achievement of behavioral sub-goals that support the system's ultimate goal. One way to achieve AI is through use of Artificial Neural Networks (ANN), an advanced statistical technique that simulates learning and experience.

ANNs are statistical models directly inspired by and partially modeled on biological neural networks. They are capable of modeling and processing nonlinear relationships between inputs and outputs in parallel. The related algorithms are part of the broader field of machine learning and can be used in many applications. These artificial neural networks are characterized by containing adaptive weights along paths between neurons that can be tuned by a learning algorithm that learns from observed data in order to improve the model.

Deep learning is a process that applies ANN technologies to solve complex problems. This is done by weighting the neurons along a neural network path (a chain of neurons) to achieve the desired outcome or find the correct path. The neurons in this instance can be thought of as computational stages, where the path to the next stage is achieved through trial and error (either through supervised or unsupervised methods) until the correct outcome or path is achieved. The more complex the problem the longer the chain or computational stages and the deeper the learning.

A key area of interest for the Marine Corps lies in AI's ability to handle/analyze large volumes of decision support data, typically more than humans can handle. Much of this low level decisions support data can go unanalyzed or be overlooked, particularly during periods of high tempo contingency operations. Developing

a capability to deal with this "Big Data" issue will require the application of an AI capability that can concatenate hundreds of small rote operations/algorithms, quickly piecing together meaningful knowledge aiding decision makers at all levels make better informed decisions. The ability of a system to deal with large volumes of data and conduct rigorous repetitive, low-level tasks quickly and with minimal error has the potential of freeing the warfighter to conduct higher level tasks.

Condition Based Maintenance (CBM)

Condition Based Maintenance is a central component of Total Productive Maintenance (TPM). CBM is the application and integration of processes, technologies, and knowledge-based capabilities to achieve target availability, reliability, and operation. CBM also supports costs of Marine Corps systems and components across their life cycles. TPM is a comprehensive approach to maintenance intended not only to prevent and correct equipment failures, but also to optimize equipment performance and extend equipment life cycles. Another key component of TPM is Reliability Centered Maintenance (RCM), which is a method of analysis that captures and assesses operational and maintenance data to enable decisions that improve equipment design, operational capability, and readiness. RCM is a logical decision process that provides the "evidence of need" for both reactive and proactive maintenance tasks that support CBM processes. RCM involves performing only those maintenance tasks that will reduce the probability of a failure or mitigate the consequences of failure, based on analysis of each failure mode and the consequence of failure.

Summary

The Marine Corps' S&T investment today will enable the force to counter military threats as well as overcome any advantages that our future adversaries may seek. They can expand the options available to commanders, including options left of phase 0 that can potentially prevent conflict. The Marine Corps' ability to anticipate the mid to long term (3-5 years and 6-30 years) operating environment will be critical to finding the key technologies that will ensure the future force can adapt to win. Focusing S&T on these key technologies can provide the technological advantage the warfighter will need to succeed on the future battlefield and potentially provide a springboard to the next generation of unmatched military capabilities.

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Section 4.0

PEO LS TOP TECHNICAL ISSUES

The identification and prioritization of PEO LS programs' Top Technical Issues starts the process of determining which Top Technical Issues will result in the development of an associated capability. These issues are vetted through each program's S&T representative, lead engineer, deputy program manager, and program manager for concurrence and prioritization.

The Top Technical Issues across all PEO LS programs are then rolled up into similar categories that establish key focus areas and informs the prioritization of funding and research efforts. A top-down approach of aligning S&T investment areas with the bottom-up prioritized list of Top Technical Issues ensures a consolidated and focused effort to resolve each program's technical issue (see fig. 4-1).

This process allows S&T representatives from all PEO LS programs to work through the Top Technical Issues of their programs and identify capability gaps where S&T could potentially lead to requirement solutions. This collaborative approach has proven extremely valuable not only in identifying individual program technical cross-cutting issues, but also in identifying technology issues that are common among other PEO LS programs. By understanding these common technical challenges, PEO LS can better align and leverage resources across the S&T enterprise. Figure 4-2 identifies the Top Technical Issues of each PEO LS program.

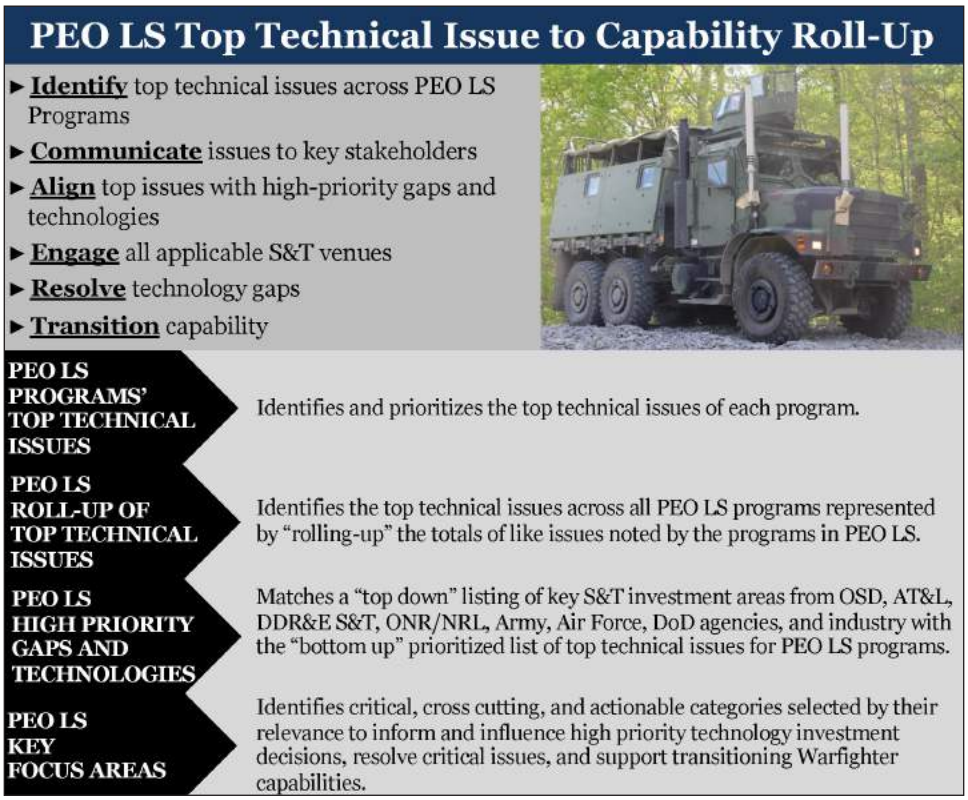


Figure 4-1. PEO LS Top Technical Issue to Capability Roll-Up

PEO LS Programs' Top Technical Issues Roll-Up

Program	Technical Issues
Assault Amphibious Vehicle (AAV)	• Reliability/Sustainment • Autonomous • Communications • Power and Energy
Amphibious Combat Vehicle (ACV)	• Survivability • Weight • Crew Visibility
Common Aviation Command & Control System (CAC2S)	• Bandwidth Efficient Radar Measurement Data Distribution • Bandwidth Efficient Networked Voice Communications Vehicles • Cross Domain Security Solutions • Small Form Factor CAC2S • Contextual Search Engines
Ground Based Air Defense (GBAD)	• Counter Unmanned Aircraft System (UAS) • Low-Altitude Air Defense (LAAD) C2 • Stinger Night Sight Replacement
Ground/Air Task Oriented Radar (G/ATOR)	• Lowering Manufacturing Costs • Increased Dynamic Range • Advanced Electronic Protection • Diminishing Manufacturing Sources and Material Shortages • Improvements in Detecting, Discriminating and Tracking Unmanned Arial Vehicles (UAVs)
Joint Light Tactical Vehicle (JLTV)	• Weight/Protection • Vehicle Network Architecture • Noise Mitigation • Situational Awareness • Tires
Logistics Vehicle Systems Replacement (LVSR)	• Fuel Consumption • Increased Survivability • Sustainability • Safety
Medium Tactical Vehicle Replacement (MTVR)	• Increased Survivability • Sustainability • Safety
Mine-Resistant Ambush Protected (MRAP) Family of Vehicles: Buffalo, Cougar, and M-ATV	• Transparent Armor • Sustainability • Stress Cracks in Welded Construction and Monolithic Hulls Both Using High Hard Steel
Lightweight 155mm Howitzer (LW 155)	• Navigation in a GPS Denied Environment • Safe and Transportable Battery High-Capacity Technology • On System Power Generation and Conservation • Secure Wireless: Ruggedized/Low Energy • Weight Management

Figure 4-2. PEO LS Programs' Top Technical Issues Roll-Up

Section 5.0

PEO LS S&T FOCUS AREAS

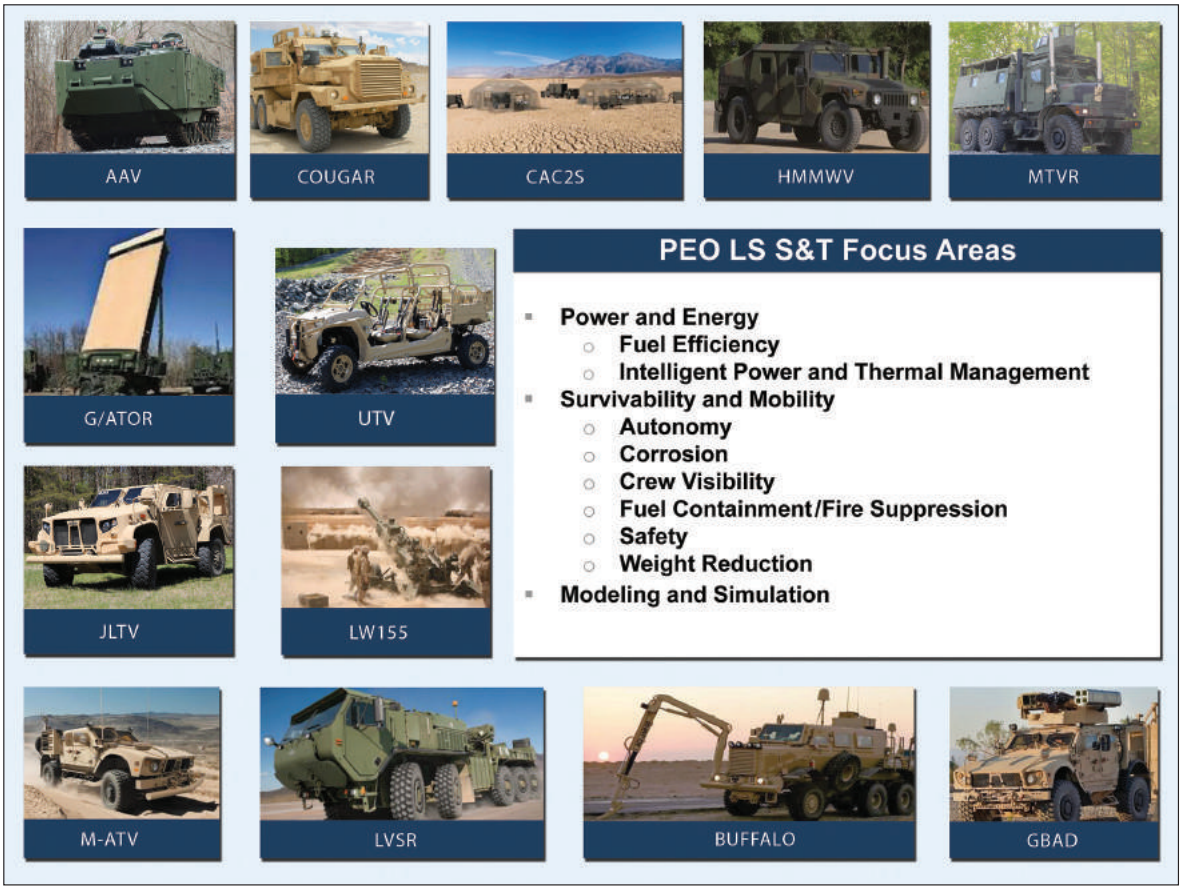


Figure 5-1. PEO LS S&T Focus Areas

PEO LS S&T focus areas originate from high-priority technology issues identified by each PEO LS program manager. They emphasize areas of focused S&T investment and engagement that are mission essential, cross-cutting, operationally relevant, and actionable. These focus areas serve to inform, influence, and align requirements and S&T technology investments while supporting the transition of critical capability to the Warfighter.

S&T Focus Areas

5.1 Power and Energy. This focus area encompasses technologies that expand the overall capability of the MAGTF by increasing the availability/capability of battlefield power, while decreasing the logistics footprint.

5.1.1 Fuel Efficiency. These technologies enhance vehicle performance, while reducing fuel consumption. Gains in this area also have a significant impact on the logistics footprint of the MAGTF.

5.1.2 Intelligent Power and Thermal Management. This element centers on the development of an integrated system that manages power utilization on vehicle platforms, heat properties in the cab, and other areas on the platform to maintain equipment and

crew comfort. Ideally, an effective power and thermal management system will improve electrical system efficiency and improve heat rejection by linking power and thermal management strategies into a single on-board architecture. Advanced power and thermal management tools are a critical step in the development of reliable and efficient vehicle platforms.

5.2 Survivability and Mobility.

5.2.1 Survivability consists of autonomy, fuel containment/fire suppression, and safety.

5.2.1.1 Autonomy. These technologies provide full autonomous capabilities and separate the Warfighter from potentially hazardous missions, while providing increased efficiency and economy of force.

5.2.1.2 Fuel Containment/Fire Suppression. This element includes technologies that safely extinguish internal and external vehicle fires without adversely affecting crews. Preferred solutions will implement a system-of-systems approach that provides fire suppression and/or containment for vehicle cabs, crews, tires, fuel tanks, and engine compartments.

5.2.1.3 Safety. Technologies are needed that increase vehicle stability and mitigate vehicle rollover, while maintaining the ability of vehicles to achieve their off-road and on-road mission profile.

5.2.2 Mobility consists of crew visibility, corrosion, and weight reduction. These technologies improve mobility and increase the survivability of both Marines and vehicles. They include advanced lightweight armor concepts, active protection systems, energy-absorbing structures, floating floors, shock-mitigating seats, and upgraded drive and suspension systems.

5.2.2.1 Crew Visibility. Clear and unobstructed crew visibility is essential for situational awareness. This area addresses technologies that can provide the ability to identify, process, and comprehend critical elements of information regarding the mission and the operational environment.

5.2.2.2 Corrosion. Damage from corrosion can cause significant maintenance requirements, decrease readiness, and potentially degrade operational capabilities. Marine Corps vehicles are stored and maintained for long durations in pre-positioned stock ashore, at sea, and in other areas that are exposed to salt air, rain, snow, heat, cold, and other corrosive elements. Corrosion resistance technologies will reduce total ownership costs and provide a significant increase in equipment readiness.

5.2.2.3 Weight Reduction. This area develops modular, scalable, lightweight, and affordable components or packages that are tailored to the mission to provide greater flexibility to the Warfighter.

5.3 Modeling and Simulation. This element uses tools that can facilitate a systems engineering approach to platform design by evaluating potential design and technology trade-offs for tactical wheeled vehicles. These trade-offs will address performance, payload, crew protection, life cycle costs, survivability, reliability, availability, and maintainability.

Section 5.1 Focus Area

POWER AND ENERGY

PEO LS continues to address the challenge of increasing energy and fuel efficiency of Marine Corps tactical vehicles. With the need of electronic devices in each of the vehicles increasing, there is also a significant increase in the demand for onboard power. Vehicle dependence on a common towable power generator only adds to the logistics burden and boosts fuel consumption. The benefits of optimizing energy and fuel efficiency are:

- Lightening the load of the Marine Air-Ground Task Force.
- Reducing the requirement for bulk fuel distribution and storage on the battlefield, thereby reducing the logistics footprint.
- Identifying methods to save fuel and to increase vehicle range.
- Reducing total ownership cost.

There is a two-pronged approach within PEO LS to address the needs and requirements of power and energy: **Fuel Efficiency** projects and **Intelligent Power and Thermal Management** projects.

Fuel Efficiency projects focus on increasing the efficiency of mechanical systems (e.g., engine, drive train, vehicle aerodynamics) to increase the amount of energy extracted from Marine Corps vehicles for every gallon of fuel used.

Intelligent Power and Thermal Management projects concentrate on solutions that increase the efficient use of electricity and power from other sources once these have been generated. Both focus areas are inherently aligned and these will continue to maximize the power and energy available for the Marine Corps vehicle fleet.

Marines on the move

PEO LS is actively engaged with other agencies and technology partners to address the Marine Corps' ongoing and future power and energy challenges. We continue to work alongside ONR, MCSC, US Army Research Development and Engineering Command, TARDEC, and various industry partners to seek improvements in the areas of fuel efficiency and alternative solutions for generating on-board (and exportable) vehicle power.

5.1.1 Fuel Efficiency

The Challenge

Marines can expect to fight in austere environments in the future and be more dispersed than in the past. Fighting with more fuel-efficient vehicles enables the MAGTF to travel lighter (and farther) while consuming less fuel. The existing tactical vehicle fleet, along with the fossil-fuel-consuming tactical supply items, will continue to be in the Marine Corps inventory for generations to come. Numerous avenues are being explored to maximize the energy extracted from each gallon of fuel and to minimize losses to heat, friction, and other inefficiencies. When implemented together,

these S&T investments, which are not limited to one vehicle or even one component, can minimize fuel use and maximize operational maneuver for each gallon of fuel used.

Potential Solutions

Small Business Innovation Research (SBIR) Efforts

Fuel Efficiency Improvements for Amphibious Vehicles

Composite materials offer weight reduction, corrosion resistance, torsional rigidity, and increased safety over conventional steel components. The primary goal of the project is to achieve TRL 6/7 on a composite suspension torsion bar for the AAV. Tasks include:

- completion of detail design/analysis of composite torsion bar,
- selection of materials and manufacturing processes that optimize performance and total ownership cost,
- verification of torsion bar design process and analysis modeling via specimen and/or sub-element testing, and
- validation of design via qualification testing.

A secondary effort of the program is to evaluate other potential components, such as the raised crew floor, that would benefit from the use of composite materials.

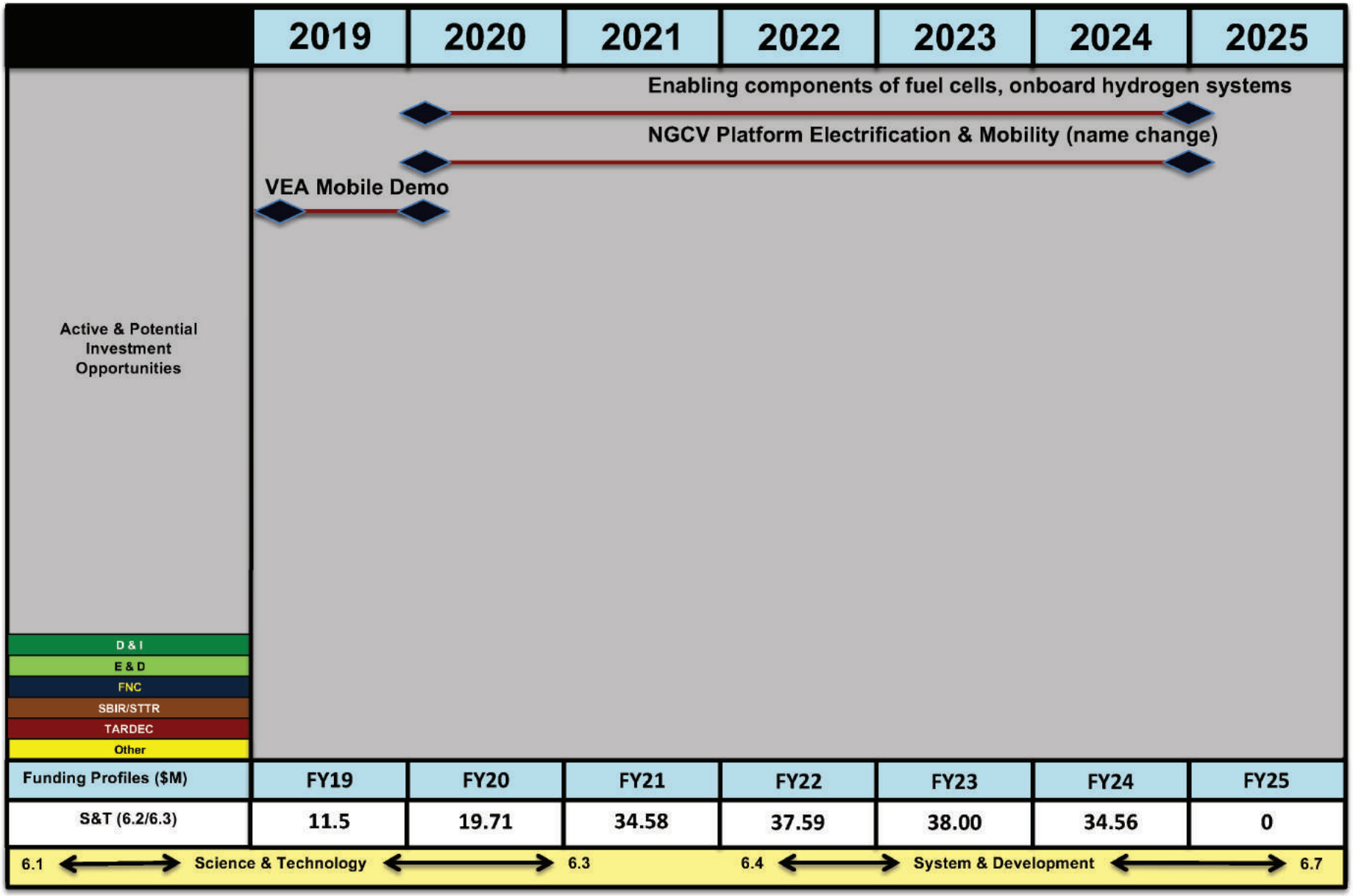
5.1.2 Intelligent Power and Thermal Management

The Challenge

The management, storage, and efficient use of vehicle power has led to the development of a suite of power control programs that can effectively prioritize and manage between command, control, communications, computers, intelligence, surveillance and reconnaissance, heating, ventilation, and air conditioning systems in an adaptive operational environment. Vehicle thermal management is critical as it can reduce thermal loads, efficiently eliminate heat, reuse waste heat, and integrate systems within the vehicle. This effort can boost operational effectiveness and have a reduced energy load. It can prolong vehicle operations and result in efficient electric generation and consumption. Managing the vehicle's various thermal loads and supplies can also assist with power consumption and resourcefully manage the vehicle's output.

The projects described below address many of the needs associated with this challenge through management of thermal loads and energy consumption on Marine Corps tactical vehicles.

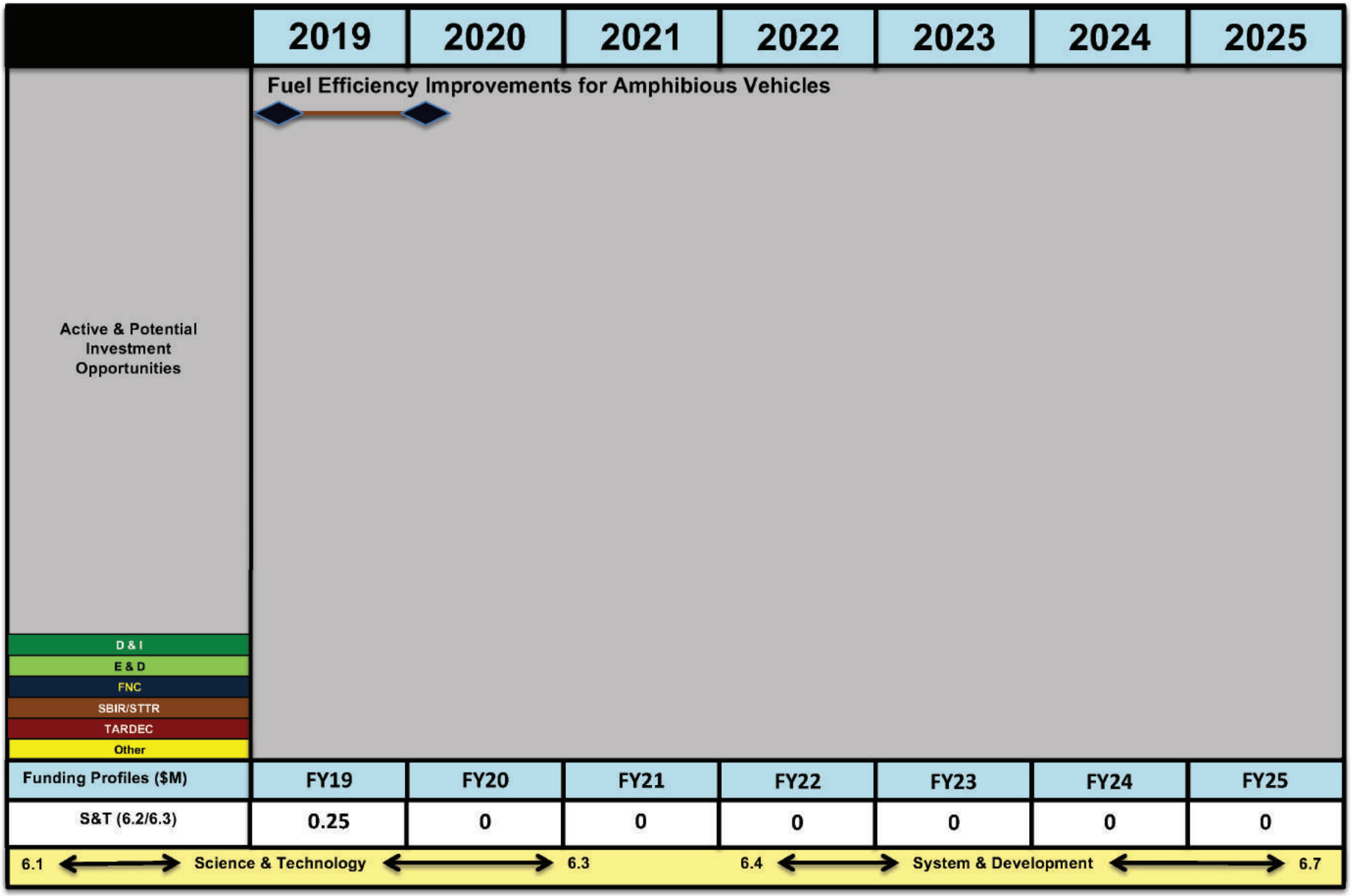
Power & Energy



Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	11.5	19.71	34.58	37.59	38.00	34.56	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

Fuel Efficiency



Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	0.25	0	0	0	0	0	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

Section 5.2 Focus Area

SURVIVABILITY AND MOBILITY

The Marine Corps' future operating environment will be increasingly complex and marked by the proliferation of conventional and unconventional threats. The solutions to these threats need to be affordable, scalable, and preferably take a system-of-systems approach. In addition to these novel solutions, maintaining and improving legacy vehicles' capabilities is critical to the Marine Corps' overall objectives. As an expeditionary force that is concentrating its efforts on re-honing its amphibious skills, the Marine Corps must ensure that its current and future tactical vehicle fleet is light, fast, easily transportable, and survivable.

The PEO LS continues to collaborate closely with the MCSC, MCCDC, ONR, and RDECOM, among other agencies in efforts to address the competing challenges of Survivability and Mobility.

The Survivability and Mobility Focus Areas introduce technologies that will enhance mobility and survivability for both the Marines and the vehicles. Survivability and Mobility are addressed together as a combined S&T Focus Area due to their symbiotic relationship.

5.2.1 Survivability consists of:

- 5.2.1.1 Autonomy
- 5.2.1.2 Fuel Containment/Fire Suppression
- 5.2.1.3 Safety

5.2.2 Mobility consists of:

- 5.2.2.1 Crew Visibility
- 5.2.2.2 Corrosion
- 5.2.2.3 Weight Reduction

5.2.1 Survivability

The Challenge

The design, development, production and maintenance of survivable PEO LS vehicles are complex engineering problems because the system-of-systems architecture of the vehicles themselves. Improving and maintaining legacy vehicles remains a substantial challenge within the PEO LS, especially in an environment where affordability is as important as capability. The solutions to these complex engineering problems not only must be cost effective, but it is required that the vehicle must provide the mobility for the Marines to successfully complete the mission.

Potential Solutions

DARPA Efforts

Soldier Protection Systems (SPS)

The DARPA SPS Program is developing and demonstrating lightweight armor material systems to defeat current and potential ballistic and blast threats with performance substantially better than today's protective armor systems. DARPA is focused on materials and material systems that can control the energy absorption and propagation of ballistics or blasts. Guided by mechanics-based modeling, new materials with superior mechanical properties are being developed and formulated into novel ballistic armor systems. In addition, hierarchical structures

that can achieve survivability against high-intensity underbody blasts are being developed to provide greatly enhanced protection to the occupants of both tactical and combat vehicles. These approaches aim to enable new lightweight armor that can defeat a broad spectrum of combined threats.

High-Assurance Cyber Military Systems (HACMS)

The goal of the DARPA HACMS program is to create technology for the construction of high-assurance cyber-physical systems, where high-assurance is defined to mean functionally correct and satisfying appropriate safety and security properties. Achieving this goal requires a fundamentally different approach from what the software community has taken to date. Consequently, HACMS will adopt a clean-slate, formal methods-based approach to enable semi-automated code synthesis from executable, formal specifications. In addition to generating code, HACMS seeks a synthesizer capable of producing a machine-checkable proof that the generated code satisfies functional specifications as well as security and safety policies. A key technical challenge is the development of techniques to ensure that such proofs are composable, allowing the construction of high-assurance systems out of high-assurance components.

Ground X-Vehicle Technologies (GXV-T)

The trend of increasingly heavy, less mobile and more expensive combat platforms has limited Soldiers' and Marines' ability to rapidly deploy and maneuver in theater and accomplish their missions in varied and evolving threat environments. Moreover, larger vehicles are limited to roads, require more logistical support and are more expensive to design, develop, field and replace. The US military is now at a point where—considering tactical mobility, strategic mobility, survivability, and cost—innovative and disruptive solutions are necessary to ensure the operational viability of the next generation of armored fighting vehicles.

DARPA's GXV-T program seeks to help overcome these challenges and disrupt the current trends in mechanized warfare. GXV-T seeks to investigate revolutionary ground-vehicle technologies that would simultaneously improve the mobility and survivability of vehicles through means other than adding more armor, including avoiding detection, engagement and hits by adversaries. This improved mobility and warfighting capability would enable future US ground forces to more efficiently and cost-effectively tackle varied and unpredictable combat situations.

Rapid Innovation Fund Efforts

Deployable Supplemental Buoyancy and Egress Device (DSBED)

This program will design and prototype a DSBED kit to facilitate/sustain personnel urgent egress from a broken/malfunctioning vehicle while in the water by adding buoyancy to prevent the vehicle from sinkage during urgent egress and recovery operation. The DSBED kit shall be installed and tested by Navatek, Ltd. on one selected AAV platform. With some modification, this new developing system/technology has the potential to be adopted to other amphibious platform as well.

Cracked Armor Laminated Patch Repair (CALPAR)

The purpose of this program is to perform design and analysis of patch to reduce load redistribution, repair-patch materials and repair process, coupon and structural part thermomechanical testing, ballistic V50 (cracks, patches) against AP and FSP threats,

field and depot level repair demonstration to USMC, and provide a final report and patch-repair procedures manual.

Small Business Innovation Research (SBIR) Efforts

Advanced Sealant for Next-Generation Transparent Armor Service Life (Phase 1)

The purpose of this program is to develop a new potting compound used in Transparent Armor (TA) to reduce the propensity of delamination resulting in longer life and better visibility to vehicle driver and occupants.

Extended Service Life of Transparent Armor (Phase 1)

The purpose of this program is to develop, advance, and demonstrate a transparent armor durability model that can be used by the Marine Corp and the TA industry base to provide confidence that a laminate design meets or exceeds the desired life. Further optimize Radio Frequency lamination to reduced residual stresses.

5.2.1.1 Autonomy

Autonomy is a combat multiplier that has the potential to save lives by reducing the Marine's exposure to high-risk tasks. Increasingly, unmanned ground vehicles (UGV) have been developed to work in concert with manned systems; the UGV augments the capability of the Marine and diverts manpower that would otherwise be required for logistics missions toward more tactical roles.

The preeminent value of the UGV is the standoff capability they afford to the Marine. For that reason, they have found their niche in route clearance and counter-improvised explosive device operations, dealing with such threats without putting anyone in the line of fire. In addition, autonomous vehicles can free up manpower from logistics missions, allowing human resources to be taken advantage of more efficiently.

The Challenge

The greatest struggle in the development of UGVs is balancing autonomy with vehicle performance. Current UGV's are not truly autonomous and need a remote human operator to maneuver quickly and navigate difficult terrain. Advancement in artificial intelligence, scene analysis, and similar developments will increasingly lighten the burden placed on the operator. The UGV of the future will be a 'man-in-the-loop' system where a human provides oversight to a vehicle that otherwise acts independently, or completely 'man-out-of-the-loop' system where the vehicle can act in complete absence of human input. This autonomous vehicle will need to capture many of the other S&T Focus areas, making this challenge even more complex.

Potential Solutions

ONR Efforts

Autonomous Amphibious Assault Vehicle (A-AAV)

The Autonomous - Assault Amphibious Vehicle (A-AAV) Project is aimed at developing and demonstrating Assisted Teleoperation and Autonomous transit capabilities and technology on United States Marine Corps (USMC) Assault Amphibious Vehicles (AAVs) in sea-to-shore amphibious operations for "means and methods" transition to a DoD POR.

Autonomous Logistics Operations Family of Tools (ALOFT)

Study "enterprise-level" impacts of unmanned/autonomous platforms to identify the most efficient platform mixes - (cost, performance, & risk) - across range of military operations (ROMO). DoD is investing heavily in unmanned and autonomous logistics systems in the expectation these will deliver the required capabilities. Most investment emphasize "system-level" performance. Few study how these systems will best work together. Future sea-based Marine operations require more

agility, precision and resilience to support distributed operations over a much larger battlefield.

Modular Autonomous Robotics System (MARS): Collaborative and Adversarial Behavior of Multiple Synthetic Agents

The purpose of this program is to provide systems architect support for the MARS program. Specifically, the contractor shall

- provide necessary program management to ensure successful cost, technical and schedule performance in accordance with the contractor's best practices,
- provide systems architecture support, and,
- investigate system architecture modeling approaches and associated tool sets and make a recommendation for adoption on MARS program.

MARS: Deliberative Planing, Reactive Control, Low-level Control

The Johns Hopkins University Applied Physics Laboratory (JHU/APL) shall provide engineering and testing in support of the "Maneuver/ Deliberative Planner," "Reactive Control," and "Low-Level Control" technologies areas for the Forlorn Hope program's Technology Area 1: Autonomy and Manned-Unmanned Teaming.

MARS: Systems Integration and Testing

SSC PAC is continuing development of the amphibious autonomy capability utilizing the Gibbs Quadski surrogate platforms.

SSC PAC has demonstrated the baseline ground autonomy functioning properly on the quadski and has demonstrated basic on-water vehicle maneuver capability with the same architecture.

A preliminary perception and inertial sensor data collection has been performed in the surfzone with 2-3' surf and that data is being analyzed.

SSC PAC has drafted an initial strawman autonomy architecture for the USAAC/ MARS program as a starting point when the contractors come on board.

MARS: Localization and Spatial Orientation Sub-System Development

The purpose of the program is to enable autonomous amphibious mission operations, Charles River Analytics proposes to integrate multiple localization, sensing, and processing capabilities into a Localization and Perception module to support Autonomous Amphibious Robot Optimized Navigation (AARON).

The AARON Localization and Perception module, which fits into the USAAC system architecture will provide state-of-the-art processing techniques to support effective localization in open water, through the sea-surf-shore interfaces, and inland in varied operating conditions, including day, night, fog, smoke, and precipitation. AARON will perform localization (both with and without GPS) onboard each vehicle using a variety of sensors fused within a Robot Operating System (ROS) framework.

MARS: Perception and World Model Sub-System Development

The objective of this project is to engineer a system that models the environment via sensory input and provides mapping information, which aids in the autonomy of an amphibious vehicle. The final deliverable for this project is the World Model software stack that can be distributed across multiple unmanned amphibious vehicle fleets.

MARS: Sensor and Perception sub-system development

Leveraging substantial prior and ongoing development in land and maritime autonomy, and advancement of open, modular, and extensible appliqué autonomy solutions, the Neya Systems led team proposes to develop and demonstrate Swarming Multi-Modal Amphibious Robotic System (SMARS).With partners drawn from industry this effort will develop and deliver Perception and Wave Modeling modules as part of the sensing and

computing hardware and autonomy software to transform an amphibious platform into an unmanned asset capable of performing diverse missions in concert with other manned and unmanned assets.

5.2.1.2 Fuel Containment/Fire Suppression

The Challenge

Fuel Containment and Fire Suppression technologies remain important to the PEO LS Science and Technology representatives. Addressing fires caused by accelerants and Improvised Explosive Device (IEDs), accidental fires caused by leaks or malfunctions, or battle damage fires all present the same core challenges: to increase the survivability of the vehicle and its occupants.

5.2.1.3 Safety

The Challenge

Safety preserves personnel and equipment, but safety considerations cannot contradict the mission of the Marine Corps' operational objectives. Safety considerations include vehicle stability, safety equipment that include restraint harnesses, fire suppression, clear fields of view, training, policy, procedures, and lines of communication with the Warfighters.

5.2.2 Mobility

The Challenge

The Marine Corps is organized on the concept of Expeditionary Maneuver Warfare and relies on tactical flexibility and agility to project strength against critical targets. The mobility of its fighting force is therefore of utmost importance. The challenge is to find an affordable balance of payload, protection, and performance that maximizes the effectiveness of USMC vehicles.

Potential Solutions

ONR Efforts

Adaptive Morphing Materials (ADM)

The purpose of this program is to perform applied research of polymeric materials and fabrication methods.

Armored Reconnaissance Vehicle (ARV)

The purpose of this program is to execute, and manage a robust S&T program to research revolutionary technologies and demonstrate the realm of the possible for the next generation Armored Reconnaissance Vehicle.

Electrohydraulic Exoskeletons with Haptic Sensation Powered/Cooled by "Robot Blood"

The purpose of this program is to research novel energy storage approach where the electrolyte is distributed throughout the exoskeleton components in a human-like circulatory fashion.

Extreme Power Internal Combustion Engine

The purpose of this program is to conduct feasibility studies, combustion M&S, and kinematic analyses of a Navy patented novel rotary internal combustion engine concept that affords high power and torque in a small, lightweight, and fuel efficient package.

Fundamentals of Radiative Transfer Modeling of Complex Sediments with Variable Saturation Levels

This program is physics-based approach to retrieving geotechnical parameters from spectra to reduce the amount of empiricism that currently exist in the derivation of surficial sediment strength from hyperspectral imagery.

Predictive/Adaptive Mobility (PAM)

The purpose of this program is to predict upcoming environment and terrain characteristics and intelligently adapt to optimize, mobility, agility, and safety.

Trafficability and Mobility Analysis from Remote Sensing

The purpose of this program is to use remote sensing focused on terrain and soil characteristics to generate the mobility corridors from the Modified Combined Obstacle Overlay to improve maneuver planning in the littorals.

Unmanned Swarming Amphibious Assault Craft (USAAC) Conceptual Design and Technology Research

The purpose of this program is to generate and test a prototype build.

SBIR Efforts

Lightweight Track Technology

The purpose of this program is Develop a lightweight track product for land and water mobility by using innovative materials, design, and manufacturing processes to reduce scheduling, manpower and time burden while achieving increased cost efficiencies to translate into lifecycle cost reductions. The Marine Corps seeks a lightweight track product design that provides enhanced water track and land mobility through reduced weight, less ground pressure, better traction and lateral stability; reduced platform vibration, noise, radar/acoustic signatures, weight, and rolling resistance; improved track life and energy efficiency; corrosion and maintenance-free operations; and lower life cycle costs.

Lightweight Roadwheel Technology

The purpose of this program is to develop aggressive lightweight road wheel technologies applied to marine and on/off road complex mission profiles for medium weight class tracked platform. The approach can be using innovative materials, design, and manufacturing processes; reduce scheduling, manpower, and time constraints; maximize roadwheel commonality between different tracked platforms; and achieve increased cost efficiencies to translate into lifecycle cost reductions.

FCT Efforts

Improved Amphibious Tracks (IAT)

The use of novel materials and designs for IAT are being tested with an objective to improve overall performance of the Assault Amphibious Vehicle Family of Vehicles (AAV-FoV). Advances in rubber and composites, including the addition of carbon nano-fiber materials, can allow the IAT to provide a 2,000 lb weight savings, while improving fuel economy (30%), reducing track noise (10 dB), and reducing maintenance (3,000 miles between maintenance actions).

5.2.2.1 Crew Visibility

On the battlefield, any number of factors, both natural and manmade, can obscure the crew's ability to see. Despite the obstruction of darkness, smoke, or weather, the crew must maintain the ability to navigate, identify vehicles, maneuver, and sustain situational awareness. On the future battlefield, the enemy will have increased access to night vision devices, infrared surveillance, and other tools to pierce the fog of war; it will be crucial to maximize crew visibility to combat most potential obstructions.

The Challenge

Paramount importance is given to crew survivability but the cost, weight, and optical limits of transparent armor can burden vehicles with hindered visibility. Optimizing visibility without sacrificing the safety of the crew or imposing a heavy penalty on size, weight, power, and cost presents a significant technological challenge.

Potential Solutions

DARPA Efforts

Squad X Core Technologies (SXCT)

DARPA's SXCT program aims to develop novel technologies that could be integrated into user-friendly systems that would extend squad awareness and engagement capabilities without

imposing physical and cognitive burdens. The goal is to speed the development of new, lightweight, integrated systems that provide infantry squads unprecedented awareness, adaptability and flexibility in complex environments, and enable dismounted Soldiers and Marines to more intuitively understand and control their complex mission environments. SXCT plans to explore four key technical areas:

- Precision Engagement: Precisely engage threats while maintaining compatibility with infantry weapon systems and without imposing weight or operational burdens that would negatively affect mission effectiveness. Capabilities of interest include distributed, non-line-of-sight targeting and guided munitions.
- Non-Kinetic Engagement: Disrupt enemy command and control, communications and use of unmanned assets at a squad-relevant operational pace (walking with occasional bursts of speed). Capabilities of interest include disaggregated electronic surveillance and coordinated effects from distributed platforms.
- Squad Sensing: Detect potential threats at a squad-relevant operational pace. Capabilities of interest include multi-source data fusion and autonomous threat detection.
- Squad Autonomy: Increase squad members' real-time knowledge of their own and teammates' locations in GPS-denied environments through collaboration with embedded unmanned air and ground systems. Capabilities of interest include robust collaboration between humans and unmanned systems.

5.2.2.2 Corrosion

For the Marines who preserve and maintain thousands of pieces of ground equipment in often harsh saltwater environments, fighting corrosion is uniquely challenging. To face it, the Marine Corps has established an extensive corrosion-prevention program for all tactical ground equipment. The intent is to reduce maintenance requirements and costs through developing corrosion prevention and control products, materials, technologies, and processes.

The Challenge

The Marine Corps will identify and implement anti-corrosion technologies to extend the service-life of its existing fleet as well as reduce required maintenance, and prolong the operational viability of legacy systems.

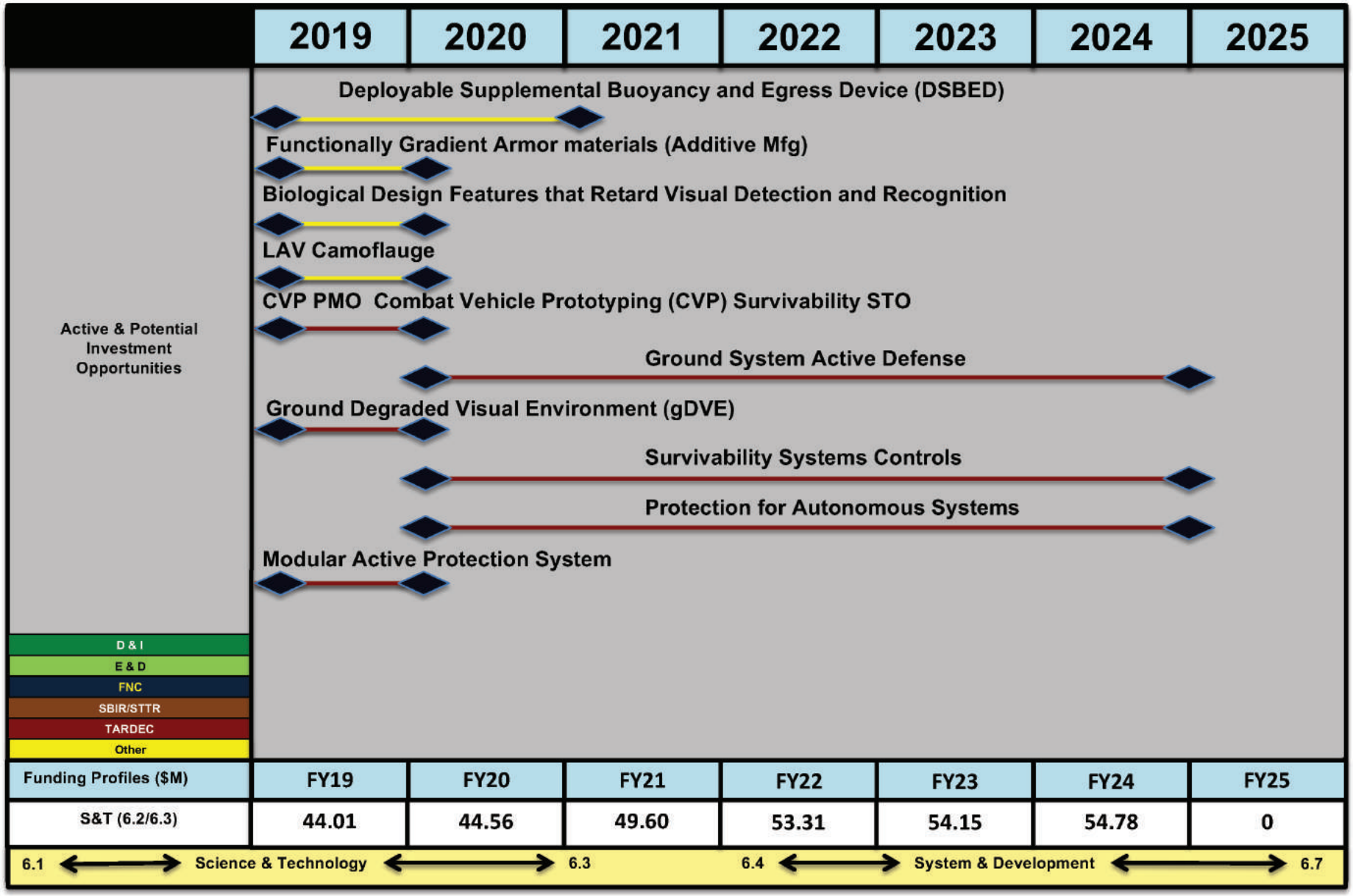
5.2.2.3 Weight Reduction

Weight reduction extends the reach of the Marine Corps vehicle fleet by improving fuel efficiency, increasing the ability to navigate harsh terrain, and enhancing maneuver from sea. Light-weighting results in a more agile and flexible fighting force.

The Challenge

Marine Corps vehicles are designed to optimize efficiency, therefore there are a limited number of areas where weight can be reduced without losing critical functionality. Weight reduction measures must be affordable and cannot compromise the reliability of the vehicle or the survivability of its crew.

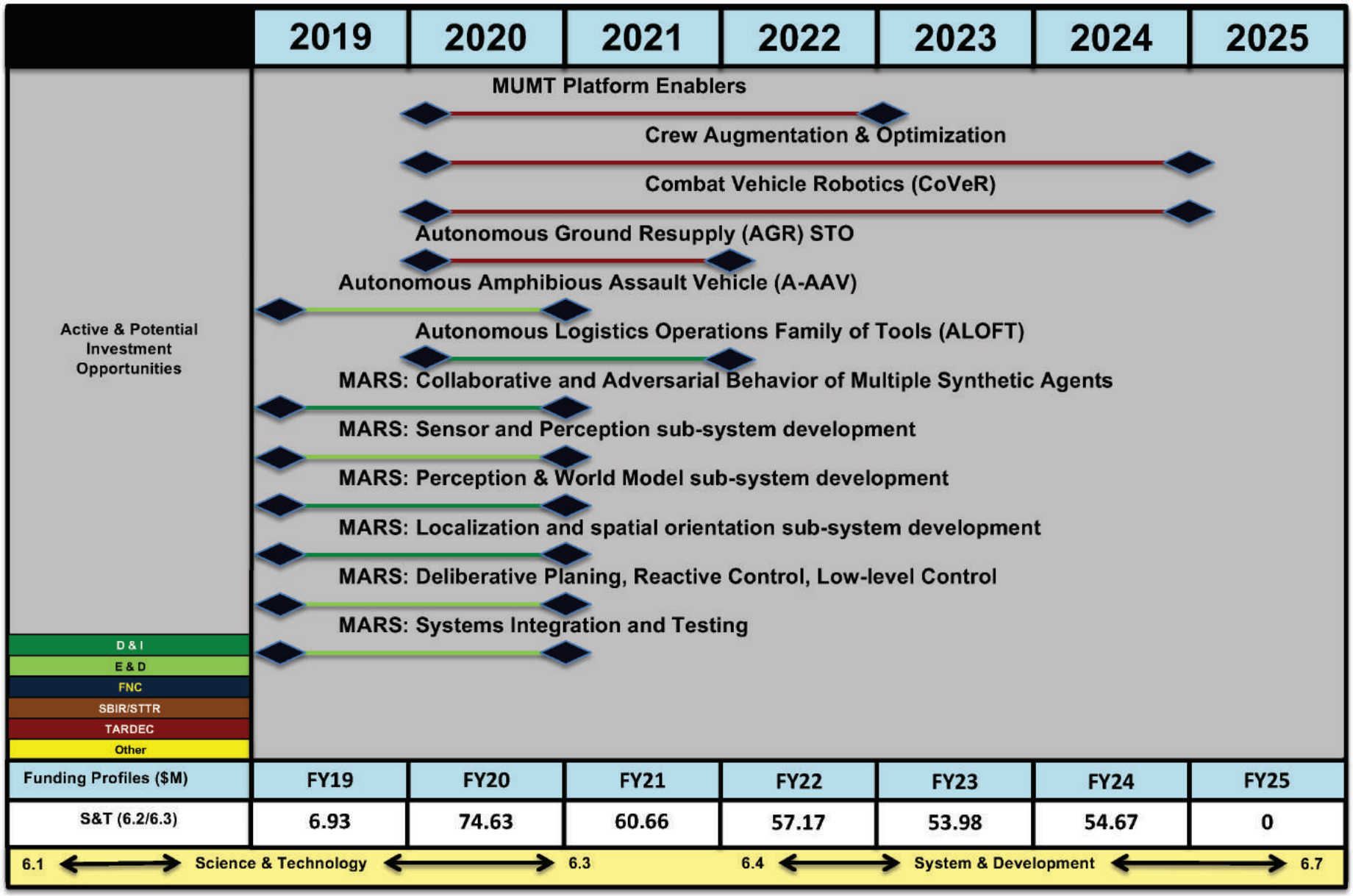
Survivability



Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	44.01	44.56	49.60	53.31	54.15	54.78	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

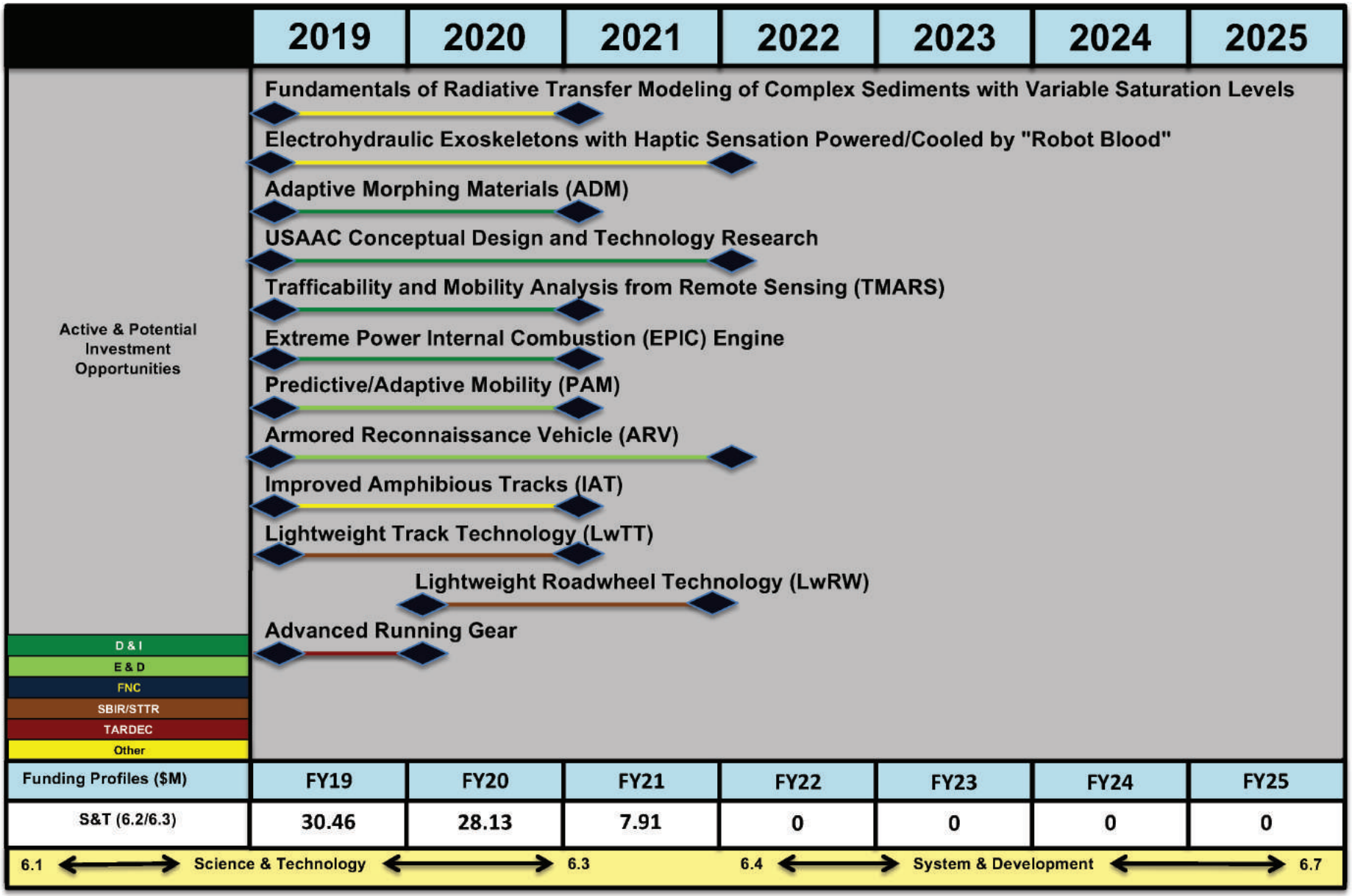
Autonomy



Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	6.93	74.63	60.66	57.17	53.98	54.67	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

Mobility



Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	30.46	28.13	7.91	0	0	0	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

Section 5.3 Focus Area

MODELING AND SIMULATION

As the pace at which technology refreshes continues accelerating, Modeling and Simulation (M&S) becomes increasingly important to industries wanting to gain a complete understanding of how cost, schedule, and performance (CSP) are impacted during a product's lifecycle. The ultimate value of a fully integrated M&S toolset will be the ability to maximize the effectiveness of limited resources through simulation-based acquisition, while bringing optimized, focused capabilities to the Warfighter.

PEO LS has a continuing requirement for the development of an integrated suite of non-proprietary multi-variable M&S aggregation tools that have been validated and have a high degree of fidelity. These tools must collect and aggregate industry component and platform data for various vehicle systems/platforms, analyze the aggregated data through scenario-based simulation, and provide normalized CSP output that will allow leadership to confidently assess the value of a proposed system or upgrade.

Computer-based simulation of the functions of tactical vehicle systems must be expanded to shorten development time and reduce program risk and cost. Currently, not enough components are accurately simulated and few are simulated together as a system. A fully integrated simulation-based acquisition approach incorporating co-simulation tools will:

- Enable comprehensive virtual vehicle designs to be functionally tested on computers.
- Optimize vehicle prognostics and performance tools.
- Assess candidate vehicles against critical performance parameters.
- Inform the requirements process by identifying system requirements that are realistic and achievable.
- Inform life-cycle cost (LCC) estimates and significantly reduce the total LCC of the system.
- Save money by reducing design, testing, and evaluation time.
- Allow high-fidelity requirements trade-offs with accurate predictions of CSP.
- Evaluate potential new technology insertions and their effects on CSP.

The Challenge

To achieve the PEO LS vision, solutions must be rendered to solve data centric challenges which allow for a more uniform decision-making process. The inherent complexities within M&S make it difficult to standardize the situational inputs into a concise and unifying conclusion that leadership could use to make mission-critical decisions. PEO LS M&S efforts have found that holistic modeling of systems on a component by component basis proves difficult due to the number interactions and the data needed to support an entire system. This challenge is compounded by efforts to understand the impact of alternate technology implementation to CSP and a system's lifecycle. To achieve a pragmatic solution, PEO LS requires a solution that can manage large amounts of data while simultaneously standardizing it for easy end-user analysis.

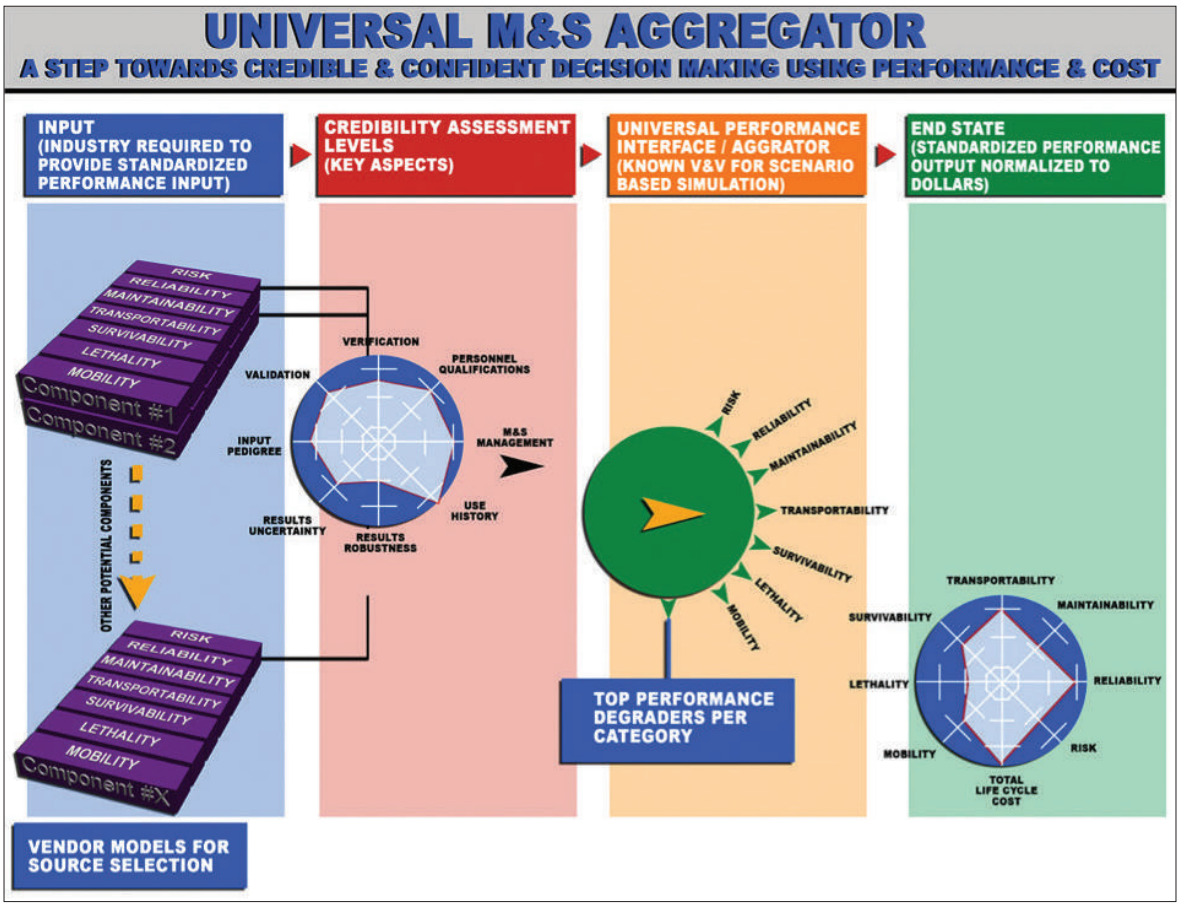


Figure 5.3-1. Universal M&S Aggregator

Potential Solutions

DARPA Efforts

Transformative Design (TRADES)

DARPA's TRADES program aims to advance the foundational mathematics and computational tools required to generate and better manage the enormous complexity of design. TRADES intends to develop engineering tools to address design representation, analysis, and synthesis. The final TRADES technologies should allow designers to more easily navigate the design space to discover non-intuitive yet realizable designs that fully leverage new materials and advanced manufacturing approaches, ultimately showing a way forward for future design systems and processes.

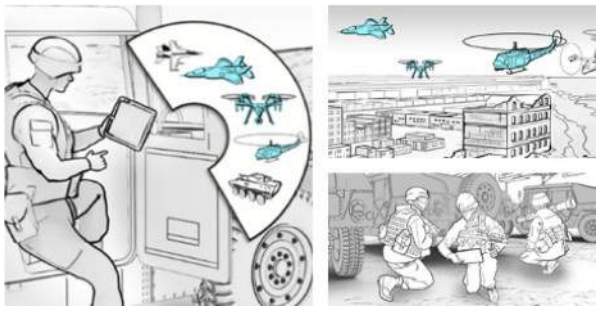
Prototype Resilient Operations Testbed for Expeditionary Urban Operations (PROTEUS)

The goal of the Prototype Resilient Operations Testbed for Expeditionary Urban Operations program is to create and demonstrate tools to develop and test agile expeditionary urban operations concepts based on dynamically composable force packages. The program seeks to:

- Develop software for simultaneous and dynamic real-time task organization, force package (i.e. platforms & weapons) combination and configuration, and tactics planning suitable for implementation in devices available to Marines in the 2030-2040 timeframe;
- Develop a purpose-built virtual test environment to exercise and demonstrate this capability with an appropriately detailed virtual representation of combined

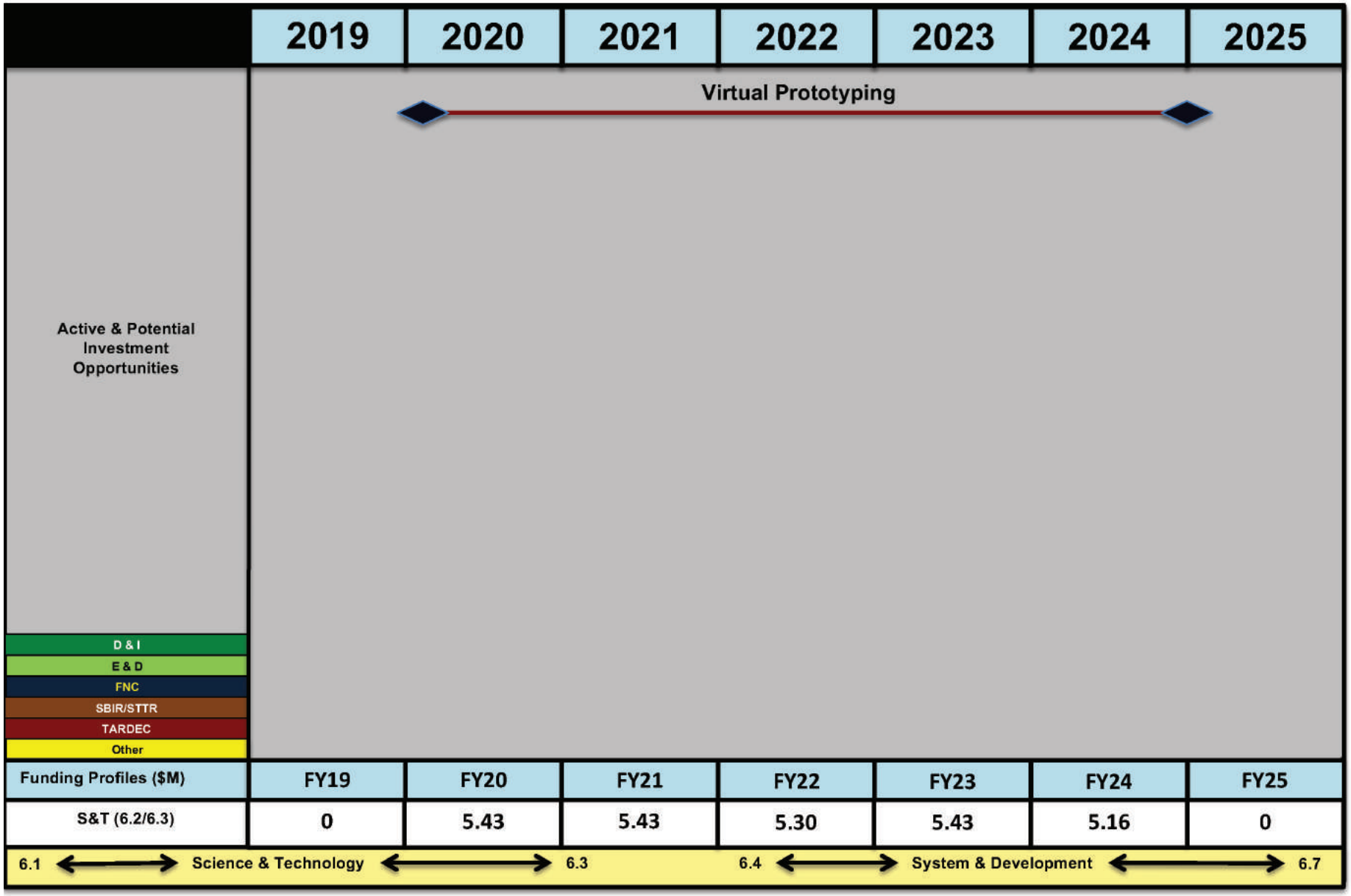
arms operations in a complex urban battlespace; and

- Exercise both capabilities in a series of benchmarking tests involving a participant cohort for both friendly and opposing forces drawn from active duty Marines. These tests will demonstrate that the ability to dynamically compose small unit organization, capabilities and tactics enables superior performance in the battlespace quantified using metrics such as lethality/(area-cost), resilience, and cost imposition.



If successful, the software tools and concepts developed in the PROTEUS program will enable assessment and exploration of new approaches to combined arms operations involving coordination of effects in multiple domains.

M&S

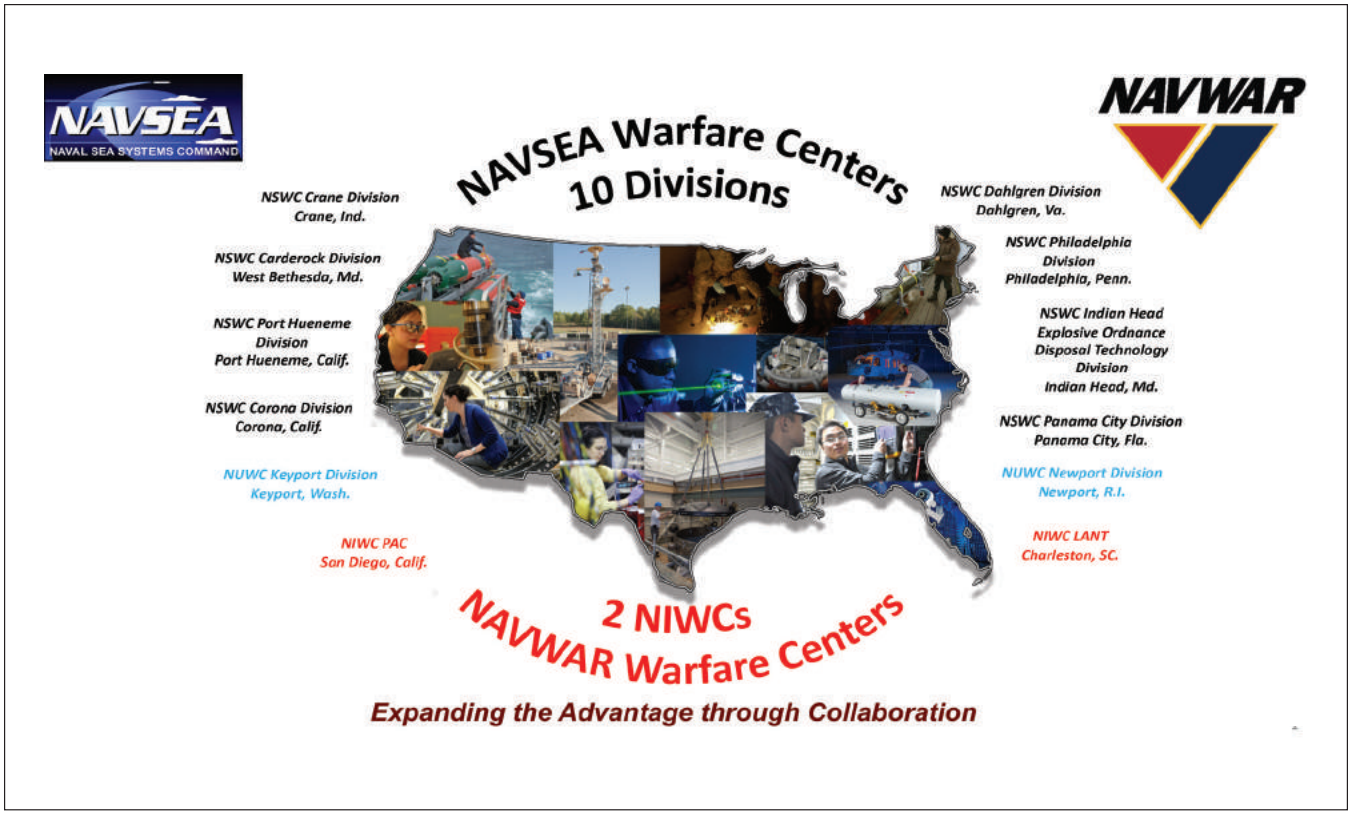


Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	0	5.43	5.43	5.30	5.43	5.16	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

Section 6.0

NAVAL WARFARE CENTERS



Naval Sea Systems Command (NAVSEA) exists to make Naval (Navy and Marine Corps) programs successful. The vision of NAVSEA is to be the Navy's trusted partner for identifying and providing innovative, cost-effective technical solutions to the warfighter. NAVSEA is responsive to the Naval enterprises, the Joint Force and national requirements, while partnering with industry, other DoD laboratories, and academia. Within NAVSEA, support for the warfighter is accomplished at both the Naval Surface Warfare Center (NSWC) and the Naval Undersea Warfare Center (NUWC).

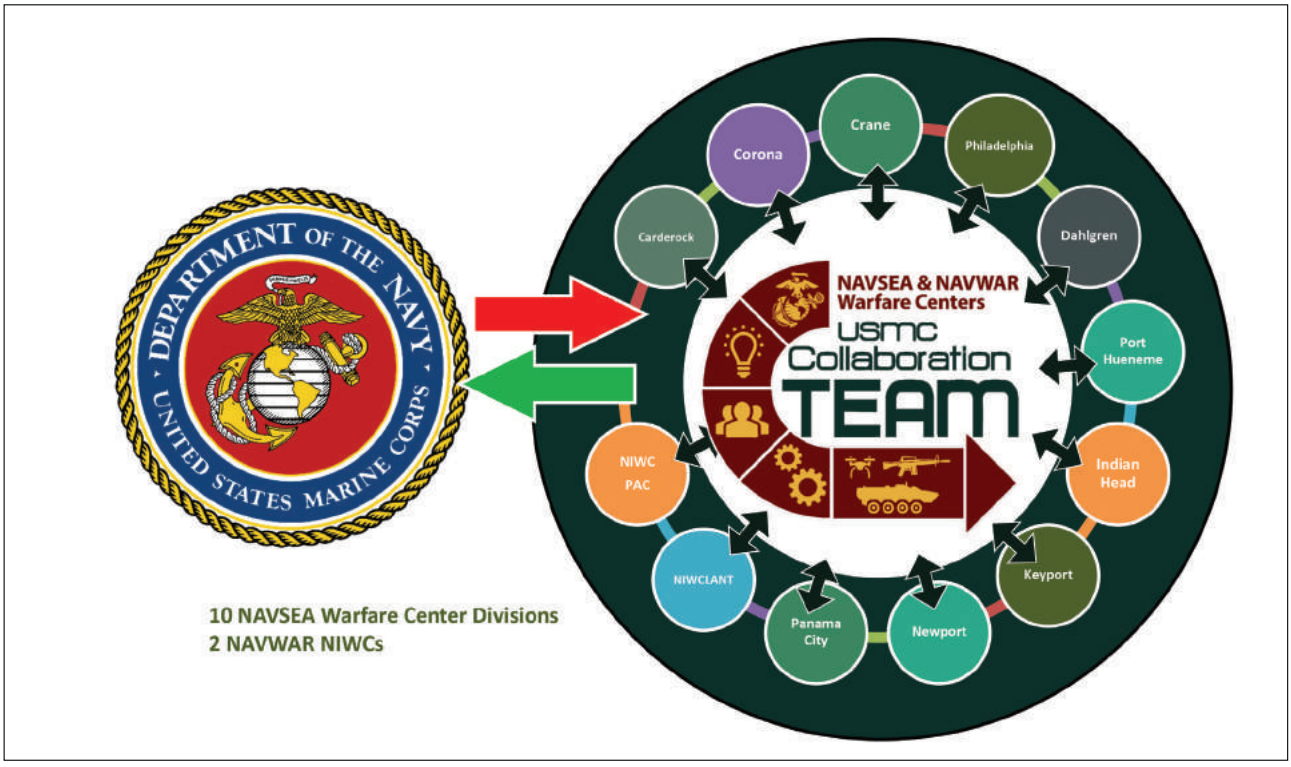
The mission of the NSWC is to operate the Navy's full-spectrum research, development, test and evaluation, engineering, and fleet support centers for ship systems, surface ship combat, and weapons systems, littoral warfare systems, force warfare systems, as well as other offensive and defensive systems associated with surface warfare and related areas of joint, homeland, and national defense systems from sea and ashore. NSWC also provides the Navy's core technical capability for the integration of weapons, combat, and ship systems into surface ships and vehicles, and for development and integration of energetic materials for joint applications.

The mission of NUWC is to operate the Navy's full-spectrum research, development, test and evaluation, engineering, and fleet support center for submarines, autonomous underwater systems, and offensive and defensive weapons systems associated with undersea warfare and related areas of homeland security and national

defense. NUWC also provides the Navy's core technical capability for the integration of weapons, combat, and ship systems into submarines and undersea vehicles.

The Warfare Centers view the Marine Corps as an important strategic partner. To facilitate a productive relationship with the Marine Corps, the Warfare Center Division Technical Directors chartered the NAVSEA Warfare Center USMC Collaboration Team (CT). The vision for the CT is to work seamlessly across the Warfare Centers Divisions to support and advocate for technically superior and cost-effective solutions for the Marine Corps. In 2018, the CT added the Naval Information Warfare Centers (NAVWAR) as partners to jointly support the Marine Corps. The two divisions under NAVWAR are NIWC Atlantic and NIWC Pacific. The result is a one-team solution for the Marine Corps to access the full technical depth of the NAVSEA and NAVWAR Warfare Centers. CT members are the readily available resource to facilitate Marine Corps stakeholder engagement with the Warfare and Systems Centers Divisions.

The following NSWC Division Fact Sheets highlight each warfare center's capabilities and focus on capabilities relevant to the Marine Corps.



NAVAL WARFARE CENTERS USMC Collaboration Team Stakeholder Engagement

NSWC Carderock Division

Mission

Provide research, development, test and evaluation, analysis, acquisition support, in-service engineering, logistics and integration of surface and undersea vehicles and associated systems. Develop and apply science and technology associated with naval architecture and marine engineering, and provide support to the maritime industry. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Description

The Carderock Division consists of approximately 2,000 scientists, engineers and support personnel working in more than 40 disciplines ranging from fundamental science to applied/in-service engineering. We are the Navy's experts for maritime technology. The Division houses world-class facilities and laboratories. Carderock's Headquarters is located in West Bethesda, Maryland. The Division also conducts research and development at several remote sites across the country.

Technical Capabilities leveraged by USMC:

- CD03 Advanced Naval Capability (Marine Corps Vehicles) Concepts and Technology
- CD05 Combatant Craft and Expeditionary Vehicles
- CD07 Hull Forms and Fluid Dynamics
- CD14 Surface, Undersea, and Weapon Vehicle Materials
- CD15 Surface and Undersea Vehicle Structures
- CD16 Alternative Energy and Power Sources R&D
- CD17 Liquid Waste Management, Science and Systems
- CD18 Solid Waste and Hazardous Material Management, Science and Systems, and Ships and Subs Systems Safety
- CD20 Surface, Undersea and Expeditionary Vehicle Vulnerability Reduction and Protection

Facilities

- Acoustic Research Detachment
- Advanced Ceramics Laboratory
- Biotechnology Laboratories
- Center for Innovation in Ship Development
- Circulating Water Channel
- Combatant Craft Department
- David Taylor Model Basin
- Deep Submergence Pressure Tank Facility
- Dosimetry Laboratories
- Electrochemical/Battery Laboratories
- Environmental Protection Laboratories
- Explosives Test Pond
- Fatigue and Fracture Laboratories
- Fire Tolerant Materials Laboratories
- IR Systems
- Large Cavitation Channel (LCC)
- Large Scale Grillage Test Facility
- Magnetic Fields Laboratory
- Magnetic Materials Laboratory
- Maneuvering and Seakeeping Basin (MASK)
- Manufacturing Technology Laboratory

- Marine Coatings Laboratories
- Marine Corrosion Control and Evaluation Laboratories
- Marine Organic Composites Laboratories
- Materials Characterization and Analysis Laboratory
- Metal Spray Forming Laboratory
- Nondestructive Evaluation (NDE) Laboratories
- Radar Imaging Modeling System (RIMS)
- Rotating Arm Facility
- Ship Materials Technology Center
- Shock Trials Instrumentation
- Signature Materials Laboratory
- Small Gas Turbine Test Facility
- South Florida Testing Facility
- Southeast Alaska Acoustic Measurement Facility (SEAFAC)
- Structural Dynamics Laboratory
- Structural Evaluation Laboratory
- Subsonic Wind Tunnel
- Survivability Engineering Facility
- Welding Process and Consumable Development Laboratories

Current Marine Corps Support Areas

- USMC Platform/Vehicle Hydrodynamics and Hydromechanics
- USMC Platform/Vehicle Integration and Design
- Survivability
- Structures
- Materials
- Power/Energy
- Environmental Quality and System Safety

Current Marine Corps Programs Supported

PEO Land Systems

AAV Hydrodynamics and Hydrostatic Efforts

- AAV Survivability Upgrade C Variant PDR and CDR
- Remote Weapon Station (RWS) project - current manned turret in the AAV SU P variant with an RWS
- Water production qualification testing of the LRIP vehicles
- Ship Launch and Hydrostatic Analysis (GHS) of the LRIP AAV SU P variant design and CDR AAV SU C variant design
- Conduct Time to Sink analysis using existing RAM/RS spreadsheet for the AAV SU P and C variants and provide an assessment of risk associated with reserve buoyancy

ACV

- LFT&E/Survivability

ACV 1.1

- ACV Interactive Electronic Technical Manual (IETM), using MIL-STD-40051-1C and the Interactive Authoring and Display System (IADS)
- ACV against a Surf Zone Mine at US Army ATC
- Hydrodynamic Support
  - Demonstrate the following characteristics for each ACV 1.1 candidate vehicle (2 vehicles) through testing and/or analysis

- Measure static pitch, roll and freeboard at crew-loaded weight (LC1) and Gross Vehicle Weight (LC3) and determine Reserve Buoyancy from provided CAD models. This task includes 2 ACV candidate vehicles.
- Calculate the Self-Righting characteristics of both vehicles at LC1 and LC3.
- Evaluate the vehicle's ability to survive in a 10-foot PM using a watertight vehicle.

JLTV

- LFT&E/Survivability

Marine Corps Systems Command

- Additive Manufacturing
  - Acquisition and Engineering Support to the MCSC Expeditionary Fabrication Program
  - Advanced Manufacturing Operations Cell
- Corrosion Prevention and Control and Materials Program
  - PM MHTV
- Expeditionary Power
  - PMM 140.2 OPTICS – Conduct alternative power source study and developmental effort at improved rechargeable battery solution to supplement the PM IW SBNVG
  - SEAL and the FCT Office support in the execution of a two-year comparative testing and analysis of both near-term battery systems (Lithium-ion 6T) and advanced cell chemistries
  - MEHPS user evaluation set to evaluate EMD hybrid power systems in an operational scenario with the intent of informing the Mobile Electric Hybrid Power Sources (MEHPS) Performance Spec and CPD
  - Dismounted Warfighter Operational Energy (DWOE) effort sponsored by OSD
  - Identify power and energy gaps and project power demand for the dismounted rifle squad
  - Improved Solar Battery System (IBS), Worldwide Ruggedized Power Supply (WRPS), Advanced Battery Charger (ABC), Medium Hybrid Expeditionary Energy System (MHEES), Improved Solar Panels (ISP), 600W Power Manager and Power Source Technical Working Group and Power Source Technical Working Group performance testing/technical support
  - Lithium battery test agent in support of characterizing the improved Bren-Tronics DPD Improved Battery System
  - Fabrication and delivery of USMC Generator Mounting Rail Kits and provide accompanying hardware installation kits

Marine Corps Expeditionary Energy Office

- Power/Energy
- Additive Manufacturing Initiatives

Marine Corps Operational Test and Evaluation Activity

- Integrated JLTV Live Fire Test & Evaluation Activities

Joint Program Executive Office Chemical and Biological Defense - Joint Project Manager Protection

- Joint Service Aircrew Mask Strategic Aircraft Wind Tunnel testing for the XM69 respirator

Marine Corps, Installation and Logistics

- Additive Manufacturing Demonstrations

MCWL

- Long Range Unmanned Surface Vehicle

Marine Corps S&T Efforts

Signature Management:

- Workforce Electromagnetic Capability Development
- Acoustic Data Notebook
- Virtual Prototyping
- Machine Learning for Fleet Signatures
- Development of Advanced Signatures Characterization

Recapitalization and Revitalization:

- Live Range Integration for LVC M&S
- Establishment of RDTE Network
- Corrosion and Coatings SFOMF
- MAKE/IDEA Lab
- Unmanned System Autonomy and Tracking in a Controlled Maritime Environment
- SFOMF

Unmanned:

- USV Lab Afloat
- USV Lab Ashore
- LDUUV Shore Side Lab
- UAS Lab Aloft and Lab Hangar
- Autonomous USV Navigation & Control
- Combatant Craft Division Capability Enhancements
- UsV CSHLRT for Navy Ships
- Magnetic Anomaly Detection (MAD) UAV
- UUV Maneuvering and Control
- Assured Navigation in GPS-Denied Environments
- Rocket Propelled Grenade (RPG) of the Sea Vehicle with Modular Payloads
- Super Swarm MVP

Fleet Support:

- Rearming at Sea
- Cycle of Assessment (formerly SWAT) - Fleet Exercises, Surface Warfare Analysis Team (SWAT), War Gaming
- USWRE Security and Surveillance Security Table Tap and Hackathon

Platform Integrity:

- Advanced Materials for Hypersonic Applications
- Large Scale Additive Manufacturing in a Testing Environment
- Modeling of Lithium-ion Battery Performance and Safety (Lithium Battery Modeling for Shipboard Applications??)
- Hypersonic & Supersonic Penetration M&S
- Repeatability Study on AM Systems
- Advanced Power Generation and Load Support
- Measuring Wave Height and Directional Spectra from a Moving Submarine or UUV

Ship Design:

- ISDE
- Submarine Design Space Exploration within RSDE
- Multi-Fidelity Modeling Framework
- Digital Engineering Methods for Platform Integration of Power and Energy Systems

- Submarine Concept Design Training
- High-Fidelity Investigation of Extreme Ship Responses
- Naval Architecture Workforce Development

Digital Strategy:

- Data Analytics and Visualization for Design Space Exploration
- Digital Twin on Virtualization Pilot Ship
- Cross NRDE Digital Twin Collaboratory
- Navy Hydrodynamic Digital Twin for Operator Guidance and Optimized Control
- Data Science & Analytics CoP
- Universal Hub: Enterprise Data Catalog
- Digital Twin LSV/SeaJet CBM DEMO
- Digital Twin Sub HM&E CBM
- Submarine Multi-Mission Distributed Simulation (SMMDS) Design and Development for LVC M&S
- Undersea Acoustic Simulation Solutions for LVC M&S
- Machine Learning Tools for Corrosion

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NSWC Corona Division

Mission

NSWC Corona is the Navy's only independent analysis and assessment center, with more than 3,200 Sailors, civilian scientists, engineers, support staff, and contractors.

The mission of NSWC Corona is to “Serve warfighters and program managers as the Navy's independent assessment agent throughout systems’ lifecycles by gauging the Navy’s and Marine Corps’ warfighting capability of weapons and integrated combat systems, from unit to force level, through assessment of those systems' performance, readiness, quality, supportability, and the adequacy of training.”

Technical Capabilities

- AC01 Warfare Systems Performance Assessment
- AC02 Quality and Mission Assurance Assessment
- AC03 Metrology, Test, and Monitoring Systems Assessment
- AC04 Naval Surface & Air Range Systems Engineering
- AC05 Weapons Systems Interface Assessment
- AC06 Naval Systems Material Readiness Assessment
- AC07 Strategic Systems Testing and Analysis, and Surveillance Assessment
- AC08 Ground Combat Weapons and Ammunition Test, Evaluation, and Assessment

Facilities

NSWC Corona is home to three premier national laboratory and assessment centers: Joint Warfare Assessment Lab (JWAL); Measurement Science and Technology Lab (MSTL); and Daugherty Memorial Assessment Center (DMAC). Along with the "Corona Engineers," these state-of-the-art facilities enable Corona to fulfill its unique mission for the Navy. The JWAL and DMAC are at the core of Corona's integrated approach to warfare assessment, and the MSTL is where Corona researches and establishes the metrology and calibration standards for the procedures for the Navy and Marine Corps. NSWC Corona’s Fallbrook Detachment is strategically positioned next to Marine Corps Base Camp Pendleton, providing integrated Test and Evaluation (T&E) support to the fleet.

Using a rigorous, disciplined independent assessment process, Corona provides the fleet, program managers, and acquisition community with the objective assessment needed for the Navy and Marine Corps to gauge warfighting capability of ships, aircraft, and ground systems; assess warfare training; and analyze new defense systems - even those systems in the concept phase.

Current Marine Corps Programs Supported

PEO Land Systems

PM Air Command Control and Sensor Netting (AC2SN)

- Marine Air-Ground Task Force (MAGTF) Common Aviation Command and Control Systems (CAC2S) Analysis and Assessment
- Composite Tracking Network (CTN) Analysis and Assessment

PM Ground/Air Task Oriented Radar (G/ATOR)

- G/ATOR Block 1 AD/SR Test, Analysis, and Assessment Support
- G/ATOR Block 2 GWLR Test, Analysis, and Assessment Support

PM Ground Based Air Defense (GBAD)

- Counter-Unmanned Aerial Systems Test, Analysis, and Assessment Support

Program Executive Office for Enterprise Information Systems

PM Global Combat Support System-Marine Corps

- Business Intelligence Information Technology support
- Data Analytics and Readiness Assessment
- Information Assurance
- Configuration Management

Marine Corps Systems Command

PfM Logistics Combat Element Systems (LCES), PM Ammunition

- Total Life-Cycle Engineering for Class V(W) Ground Ammunition
- In-Service Engineering Agent
- T&E for Operational Reliability, Service Life, and Surveillance
- Technical Agent for Fleet Malfunction Investigations and Mishaps
- Global Inventory Supply Chain Management and Pre-Positioning
- Knowledge and Information Management
- Joint Services Production Engineering Assessments
- T&E for Javelin and Tube-launched Optically-tracked Wire-guided (TOW) Missiles

PfM LCES, PM Supply/Maintenance Systems

- Test Measurement and Diagnostic Equipment (TMDE) Maintenance
- Automated Test and Equipment Program (ATEP) Calibration
- Metrology and Calibration (METCAL) Engineering
- Infantry Weapons Gage Calibration Program (IWGCP) Maintenance

PfM Supporting Establishment Systems

- Emergency Response System Development and Maintenance
- Public Safety Network Engineering
- Secure Operational Network Infrastructure and Communications Analysis

PfM Ground Combat Element Systems (GCES), PM Infantry Weapons

- Test and Evaluation Support

PfM Command Element Systems (CES), PM C2 Systems

- Joint Battle Command Platform T&E
- MAGTF Common Handheld T&E

PM Training Systems (TRASYS)

- Training Assessment Program Development
- Tactical Warfare Simulation Certification and Accreditation
- Tactical Training Ranges/Development and Maintenance
- Virtual Battlespace Two Certification & Accreditation

Amphibious Vehicle Test Branch

- Test Instrumentation and Data Collection

SEAL

- GPS Liaison
- ALPS
- Item Unique Identification Engineering

Marine Corps Installations Command

- Logistical Utilities Management and Energy Systems Development
- Advanced Metering Infrastructure C&A
- Industrial Control Systems Assessment

Marine Corp Base, Camp Pendleton Environmental Security Division

- Geographic Information Systems
- Knowledge and Information Management and Accreditation
- SharePoint Support

Marine Corps Operational Test and Evaluation Activity

- ACV 1.1
- JLTV
- Operational Test and Analysis Division

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NSWC Crane Division

Mission

Provide acquisition engineering, in-service engineering and technical support for sensors, electronics, electronic warfare and special warfare weapons. Apply component and system- level product and industrial engineering to surface sensors, strategic systems, special warfare devices and electronic warfare/information operations systems. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Description

Naval Surface Warfare Center, Crane Division, (NSWC Crane) is a shore command of the U.S. Navy, under the Naval Sea Systems Command headquartered in Washington, DC. It is a business-based enterprise operating under the Navy Working Capital Fund. Sixty-Seven percent of the workforce is made up of scientists, engineers, and technicians.

NSWC Crane Headquarters is located in southwestern Indiana and is a tenant on the third largest Navy installation in the world. With nearly 100 square miles of land, no encroachment, strong state and local support, and a cost of living index 22.7 percent below the U.S. national average, Crane is indispensable to the nation as a high-value provider of innovative solutions and services.

Multi-service partnerships with Crane Army Ammunition Activity and Army/Indiana National Guard's Camp Atterbury Joint Maneuver Training Center, Muscatatuck Urban Training Center (MUTC), and Hawthorne Army Depot in Nevada strengthen Crane's ability to rapidly assess new technologies immersed in an operational-type environment with electronic attack clearance and restricted air space.

In 2013, NSWC Crane realigned our technical capabilities, thus increasing our military value assessment while integrating our adjacent technology products and narratives. NSWC Crane specializes in sensors, electronics, electronic warfare, and special warfare weapons. Our primary mission focus areas are Special Missions, Strategic Missions, and Electronic Warfare/Information Operations. In support of these Mission Focus Areas, Crane's scientists, engineers, and professional workforce provide stewardship and high-military value knowledge, contracts, hardware, and software across the following Technical Capabilities with support from the Business Capabilities.

Technical Capabilities

- CR04 Electronic Warfare Systems RDT&E/ Acquisition/Life Cycle Support
- CR10 Infrared Countermeasures and Pyrotechnic RDT&E and Life Cycle Support
- CR15 Strategic Systems Hardware
- CR16 Special Warfare and Expeditionary Systems Hardware
- CR18 Advanced Electronics & Energy Systems
- CR19 Sensors and Surveillance Systems

Current Marine Corps Programs Supported

PEO Land Systems

PM AC2SN

- CAC2S
- Marine Air Command and Control System (MACCS)
- Composite Tracking Network

PM G/ATOR

- Radar Equipment Group
- Parts Task Trainer

PM-Light Tactical Vehicles (LTV)

- Joint Light Tactical Vehicle (JLTV)
- Utility Tasked Vehicle (UTV)
- High Mobility Multi-Wheeled Vehicle (HMMWV)

PM Medium & Heavy Tactical Vehicles (M&HTV)

- Medium Tactical Vehicle Replacement (MTVR)
- Mine-Resistant Ambush Protected (MRAP) All-Terrain Vehicle (MATV)
- COUGAR Egress

PM GBAD

- Advanced Man-Portable Air Defense System
- Counter-Unmanned Aerial Systems

Marine Corps Systems Command

PfM CES, PM-Intelligence Systems (IS)

- Ground Based Operational Surveillance System
- USMC Counter Radio-Controlled Improvised Explosive Device Electronic Warfare
- Topographic Production Capabilities
- Tactical Cyber Innovation Toolkit

PfM CES, PM-Command and Control Systems (C2)

- MAGTF Common Hand Held

PfM CES, PM-Communication Systems (Comm)

- Systems Planning Engineering and Evaluation Device
- Global Broadcast System
- Remote Video Viewing Terminal
- AN/TPS-59 Radar

PfM GCES, PM-Fires (IW)

- Anti-Armor Systems (TOW, Javelin, SMAW, SABER)

PfM GCES, PM-Infantry Weapons

- PM-IWS Procurements, Engineering and Testing (M13 Mod7 Sniper Rifle, MK 125 Tripod, .50 Cal Poly Case Ammo, etc.)
- Optics and Non-Lethal Systems (AN/PVS-15, AN-PAS13G, INOD3)

PfM LCES, PM-Engineering Systems

- Automated Test Systems (EMSS, VADS)
- General Purpose Tools and Test Systems
- Combat Support Systems (SSK, ABV, FFME, NBOE)

PfM LCES, PM-Ammunition

- Ammunition (MK323, .50 Cal Poly Case, SOST MK318, M72 LAW FTE, etc)

S&T Working Groups

- Functions are aligned along technical capabilities (TCs) that support the division's strategic S&T goals. Each technical discipline of interest is linked to a S&T WG that provides cross-cutting coordination of their respective elements of investment within their area of responsibility.
- This cross cutting coordination fosters unity of efforts and begins to morph an S&T culture that encourages collaboration.

This type of infrastructure allows the S&T Division to provide a more comprehensive and integrated technology solution.
Advanced Electronics and Energy Systems

- Advanced Electronics and Energy Systems
- Electronic Warfare Systems
- Infrared Countermeasures and Pyrotechnics
- Sensors and Surveillance Systems
- Special Warfare and Expeditionary Systems Hardware
- Strategic Systems hardware
- Disruptive / Transformative Innovation
- Enabling Technologies

FY20 Naval Innovative Science & Engineering (NISE) Projects

- Electrified Battlefield & Wireless Power Reception Technology Maturation
- Mission Model Validation
- Deinterleaver Testbed
- Directional Modulation for Low SNR Direct Signal
- NIFC-EW
- PASSIVE DEFENSE (PD)
- Model Based Product Support for Enterprise ISEA of the Future
- Thing 1: Stellar Scalpel
- LVC in the NILE
- Hypersonics LVC Application for HWIL/ SWIL Connectivity
- Refinement and Demonstration of a Small Form-Factor (SFF) Common Aviation Command and Control System (CAC2S) Prototype
- Automated Mission Engineering using MBSE and Set Based Design Methods
- Joint AI Distribution Experiment - NSWC Crane (JADE-C)
- Expeditionary ANTX Support
- Expeditionary FLEX/Wargame
- High Assurance Interface Protocols (HAIP)
- Advanced Power Generation and Power Distribution
- Distributed Fusion Architecture for C-UxS
- Fleet Innovation Challenge (FIC) EO Capability Operations and Maintenance.
- Real-time EMS Visualization and ALT-PNT Man-portable System (REVAMPS)
- MBSE Tool Integration
- Universal Hub Enterprise Data Catalog
- Model Data Management and CM
- Lightweight Individual Artifice Radio (LIAR)
- Thing 2
- Naval Additive Manufacturing Part Identification Exercise (NAMPIE) #3 Participation
- ML for Radar Emitter ID
- Lithium Battery Modeling for Shipboard Applications
- Natural Language Processing for Data Pre-Processing
- Quantum Modeling Capability: 0D/2D Interfaces for Room Temperature IR Photodetection
- Project Spectre (BSCI)
- Ge on Al anodes for Li-ion batteries

- Gray Scale Analysis and Obsolescence Support Utilizing Computed Tomography
- Quantum Light Detection and Ranging (Quantum-LIDAR)
- BIG DATA PLATFORM
- Engineering M&S Integration into Mission Architectures for EW and ExW
- Optical Closed Loop Projectile Tracking
- LMBA MMIC Design
- Implement BEAST (Bit Efficient Algorithm Software Techniques) to FPGAs
- Reactive Material Synthesis (RMS) of Gun Barrel & Other Applications
- Validating Composite Design of Structural Components
- Controlled Radiation Affects Novel Epitaxy-In Unknown Manners (CRANE-IUM)
- Ageing Assessment and Lifetime Prediction of Traditional Stochastic and AuxeticFoams for Defense Applications
- Modular Area Detection and Optical Warfare Laser (MAD OWL) Multi-Line Laser (MLL)
- Special Warfare & Expeditionary Systems LVC Expansion
- Long range stand-off gas plume detection
- Ultra-Deployable Multi-Channel, Digital Beamformer

NSWC Dahlgren Division

Mission

Provide research, development, test and evaluation, analysis, systems engineering, integration and certification of complex naval warfare systems related to surface warfare, strategic systems, combat and weapons systems associated with surface warfare. Provide system integration and certification for weapons, combat systems and warfare systems. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Description

Through the years, Dahlgren has established itself as the major testing area for naval guns and ammunition. Today, it continues to provide the military with testing and certification using the Potomac River Test Range in Dahlgren, Virginia, and provides Fleet support at the Dam Neck Activity, overlooking the Virginia Capes Fleet Operations Area, Virginia Beach, Virginia.

NSWCDD conducts basic research in all systems-related areas and pursues scientific disciplines including physics, mathematics, laser and computer technology, software, mechanical, electrical and systems engineering, and biotechnology and chemistry.

Technical Departments

- Strategic and Computing Systems (A)
- Electromagnetic & Sensor Systems (B)
- Gun & Electric Weapon Systems (E)
- Weapons Control & Integration (H)
- Warfare Analysis & Digital Modeling (M)
- Readiness & Training Systems (R)
- Integrated Combat Systems (V)

Facilities

NSWCDD occupies four geographic locations, the Naval Observatory in DC and Dahlgren, Wallops Island, and Dam Neck in Virginia. The NSWCDD Headquarters at Dahlgren is near Quantico and the Pentagon while the Dam Neck Activity is near Marine Corps Forces Command in Norfolk. NSWCDD includes several unique national facilities including the Littoral Operational Area Range and the Potomac River Test Range. NSWCDD operates state-of-the-art facilities supporting all assigned technical areas including: sensors, hardware-in-the-loop (HWIL), terminal seekers, unmanned systems, fire control systems, integrated warfare systems, directed energy, railgun, chemical-biological defense, and electromagnetic environmental effects.

Current Marine Corps Support Areas

- Vehicle Capability Insertions design, integration, fielding and sustainment
- Expeditionary Command and Control design, integration, and testing
- Expeditionary Analysis, Modeling and Simulation
- Human Systems Integration (HSI)
- Electromagnetic Environment Effects (E3)
- Directed Energy Weapons
- Advanced Sensor Development
- Autonomous and Unmanned System Development
- Chemical & Biological Sensors and Defense Development
- Guns and Ammunition T&E
- Life Cycle Cost Estimates
- Guided Projectile Design

Current Marine Corps Programs Supported

PEO Land Systems

PM AAA

- AAV Remote Weapon Station
- ACV Gun Weapon Station Analysis
- AAV & ACV HSI
- AAV E3 Engineering
- ACV E3 Engineering

PM AC2SN

- CAC2S Test & Evaluation
- CAC2S Systems Integration Lab
- CAC2S Voice Communication System Software (VCSS) Development
- Composite Tracking Network (CTN)

PM G/ATOR

- G/ATOR Software Support Activity
- G/ATOR Engineering and Acquisition
- E3 Engineering
- G/ATOR Special Training System

PM GBAD

- Compact Laser Weapon System (CLaWS)
- Directed Energy Engineering and Directed Energy Weapon Review and Approval Process (DEW RAP)
- E3 Engineering
- HSI
- Marine Air Defense Integrated System (MADIS) Trainer
- JLTV Software Integration
- Cybersecurity Engineering

PM Motor Transport

- Joint Light Tactical Vehicle (JLTV) E3 Engineering
- JLTV HSI

Marine Corps Warfighting Lab

- Engineering Support

Marine Corps Systems Command

PfM CES – PM C2S

- Combat Operations Center (COC) Engineering
- Joint Battlespace Viewer sustainment
- E3 Engineering
- PfM CES – PM Intelligence Systems
- Communication Technology Engineering
- Ground Based Operational Surveillance System (G-BOSS) T&E support
- Electronic Warfare System (EWS)
- CREW E3 Engineering

PfM LCES, PM-Ammo

- 9mm Blank Cartridge
- 5.56mm Marking Cartridge
- 5.56mm Frangible Cartridge
- .50 Caliber Polymer Case Ammunition
- 40mm Training Ammunition
- Anti-Personnel Obstacle Breaching System (APOBS)
- Shoulder-Launched Multipurpose Assault Weapon (SMAW)
- Light Anti-Tank Weapon (LAW)
- Battlefield Effects Simulators (BES)
- Missiles & Rockets

- Miniature Mission Setter (MMS)
- Tube-launched, Optically-tracked, Wireless-guided (TOW) and TOW Obsolescence and Safety (TOS) Missiles E3 Engineering

PfM GCES, PM-Infantry Weapons (IW)

- Raids and Recon Depot Support
- Anti-Armor
- M40A5 Rifle Improvement Project

PfM GCES, PM-Fires

- Target Handoff System
- Ground Counter Fire Sensor
- Lightweight Counter Mortar Radar (LCMR)
- Next Generation Targeting System
- Survey/Meteorological
- Remotely Operated Ground Unit for Expeditionary Fires (ROGUE-Fires)
- Navy/Marine Expeditionary Ship Interdiction System (NMESIS)
- Common Laser Range Finder –Integrated Capability
- Ground Weapon Radar Support
- High-Mobility Artillery Rocket System (HIMARS)
- Sea-Launched Army Tactical Missile System (ATACMS) from Shipboard HIMARS E3 Engineering
- Guided Multiple Launch Rocket System (GMLRS)
- Family of Artillery Munitions (FAM)
- Ship Interdiction and Neutralization Capability (SINC)
- E3 Engineering

PM-Light Armored Vehicle (LAV)

- Family of Artillery Munitions (FAM)
- Mobility Counter Mobility Team
- E3 Engineering

PM Tanks

- Active Protection System E3 Engineering

PM TRASYS

- E3 Engineering

SEAL

- Systems Engineering
- CIED Modernization Master Plan (MMP)
- System Security Engineering and Anti-Tamper Support

Office of Naval Research

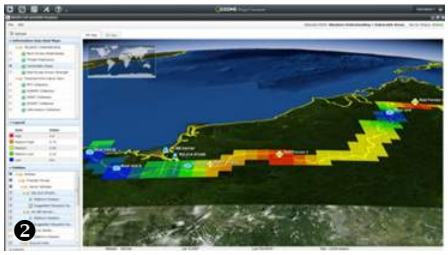
- GBAD Directed Energy on the Move Vehicle Integration
- 81mm Advanced Capability Extended Range Mortar (ACERM)
- 155mm Moving Target Artillery Round (MTAR)
- Autonomous Remote Engagement System (ARES)

FY20 NISE Projects

- 30mm Airburst Munition
- Artificial Intelligence for Guidance Navigation & Control
- SkyView GPS Absent Navigation
- Unit-Level Mission Autonomy Software

NSWC Dahlgren Division

NSWCDD Capabilities and Programs Supporting the USMC



1. Standard and Custom Environmental Testing 2. Software Development 3. Concept Prototyping
4. JLTV ROGUE Fires 5. HSI 6. Platform Integration 7. GBAD Lasers 8. Mortars and Ammo

NSWC Indian Head Explosive Ordnance Disposal Technology Division

Mission

Research, develop, test, evaluate (RDT&E), manufacture and provide in-service support of energetics and energetic systems. Provide Soldiers, Marines, Sailors and Airmen with information and technology to detect, locate, access, identify, render safe, recover, exploit and dispose of explosive threats.

Description

The NSWC Indian Head Explosive Ordnance Disposal Technology Division (NSWC IHEODTD) located in Indian Head, MD brings together the largest full-spectrum energetics facility in the DoD with the largest concentration of explosive ordnance disposal technology resources and information in the world. The Division's unique synergy and balanced capabilities address all aspects of the energetics technical discipline, including basic research, applied technology, technology demonstration, prototyping, engineering development, acquisition, low-rate production, in-service engineering, weapons system integration, system safety, mishap & failure investigations, surveillance, EOD technology & information, and demilitarization.

Technical Capabilities

- Threat and Countermeasure Information Development and Dissemination for EOD, IED, and CREW
- Technology Development and Integration for EOD, IED, and CREW
- EOD unmanned systems
- Energetic and Ordnance Component and Ordnance Systems for:
  - S&T
  - Air Warfare
  - Surface Warfare
  - Undersea Warfare
  - Expeditionary and Ground Warfare
  - Emergent & National Requirements.

Major Facilities

- Aircrew Escape Ordnance Devices Development & Prototyping Complex
- Detonation Physics RDT&E and Acquisition
- Bombproofs, blast chambers, self-contained gun ranges
- Continuous Twin-Screw Processing R&D and Scale-up
- 20-mm, 37-mm, 40-mm and 88-mm extruders
- Novel Materials R&D
- Nano-energetic materials characterization
- Complete suite of analytical capabilities
- Cast Composite Rocket Motor and PBX R&D & Scale-Up Complex
- Ordnance Test Facilities
- Chemical, Physical Property and Metallurgy Labs
- Quality Evaluation (QE)/ Surveillance Facility
- Specialty Energetic Chemical Scale-up Facility
- High Pressure Explosives, Physics & Combustion Lab

- Bomb testing; Strand burning; Combustion instability testing
- MEMS Clean Room, Underwater Warheads RDT&E and Modeling & Simulation
- Foreign Ordnance Electronics Exploitation Laboratory
- Magnetic Signature Test Facility
- Ordnance Disassembly Complex
- Hypervelocity Test Facility
- Oxygen Cleaning Laboratory
- EOD Diver Complex

Current Marine Corps Programs Supported

PEO Land Systems

PM AAA

- PdM Amphibious Assault Vehicle (AAV) - Engineering and Sustainment, CROWS Integration

PM Motor Transport

- PM Motor Transport - System Safety Support
- PdM JLTV - Logistics Support

PM M&HTV

- PM MTVR - System Safety Support
- PM LVSR - Logistics Support

PM GBAD

- System Safety Support

PM G/ATOR

- System Safety Support

PM AC2SN

- System Safety and Cyber Security Support

Marine Corps Systems Command

PM Light Armored Vehicle

- System Safety Support

PfM LCES, PM Ammo

- PM AMMO System Safety Support
- Multi Point Initiator (MPI)
- MK22 Mod 4 Rocket Motor Insensitive Munitions (IM)
  - Insensitive Munitions (IM)
  - MIL-STD 1901 Compliance Redesign
  - Service Life Extension Testing
- MICLIC Arresting Cable Release Mechanism (ACRM)
- ACRM- System Safety Support
- TOW and Javelin - Engineering Services
- APOBS IPT Support
- LAW Warhead Production

PfM LCES, PM Engineer Systems

- Explosive Ordnance Disposal (EOD)
- MK154 Electrical Systems:
  - Design Review and Production

PfM GCES, PM Fires

- Cyber Security Support
- Team Tanks - Systems Safety Support
- Team Anti-Armor Systems - Engineering Services
- Team FSCT – Systems Engineering, Technical Support and System Safety Support
- Team FDST – System Safety Support

- Team Artillery – System Safety Support

PfM-CES, PM C2 Systems

- Cyber Security Support
- COC - Test and Evaluation/Software Support
- TSOA - S&T Project Management/ Software Engineering

PfM-CES, PM Intelligence

- Electronic Warfare Systems – System Safety Support

SEAL

- Experimentation and Demonstration Support
- Command Safety – Safety Support
- Automotive Research Team (ART) – Engineering Services
- Triton Hearing Protection Program

Joint Non-Lethal Weapons Program Office

- Indirect Fire Munition Engineering/ Technical Support
- BAA & Contract Support
- USAF Pre-Emplaced Vehicle Stopper (PEVS) Pilot Program
- NATO Maritime Interdiction Operations Training Center (NMIOTC) Non-Lethal Weapons Curriculum Integration
- Army Solid State-Active Denial Technology (SS-ADT) Focused Assessment
- NORTHCOM CDO Warfighter Workshop/ Table-Top Exercise
- Viper Radio Frequency Vessel Stopping Warfighter Workshop

Marine Corps Operational Test and Evaluation Activity

- Operational Test & Analysis Division (OTAD) – Math Statistician

Marine Corps Warfighting Lab

- Advanced Naval Technology Exercises

Office of Naval Research

- High Reliability DPICM Replacement (HRDR)
- Densified Propellant (DP) SMAW
- MTAR
- TechSolutions 60mm Mortar Improvements
- Mine Counter Measures (MCM) Program
- Autonomous Assault Amphibious Vehicle (A-AAV) Program

Marine Corps Combat Development and Integration Fires and Maneuver Integration Division

- Battalion Organic Fires Valuation Workshops

Marine Corps Installations and Logistics

- Next Generation Logistics

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NSWC Panama City Division

Mission

Conduct research, development, test, evaluation, and in-service support of mine warfare systems, mines, naval special warfare systems, diving and life-support systems, amphibious/ expeditionary maneuver warfare systems, and other missions that occur primarily in coastal (littoral) regions. Execute other responsibilities as assigned by Commander, Naval Surface Warfare Center.

Description

NSWC PCD performs Research, Development, Test, and Evaluation to include Science and Technology development across the full spectrum of Littoral warfare systems and operations. The warfare center technical expertise in expeditionary warfare encompasses afloat and shore based C4; expeditionary systems to ship interfaces; assault breaching systems; land mine and obstacle countermeasures to include technologies to detect and neutralize a broad spectrum of explosive hazards in environments extending from the surf zone to the objective; targeting sensors; seabasing systems; and Ship-to-objective maneuver systems.

Technical Capabilities

- PC20 Chemical and Biological Warfare Individual Protection Systems
- PC21 Expeditionary Coastal and Maritime Security System Engineering and Integration
- PC25 Air Cushion Vehicle Systems
- PC26 Expeditionary Maneuver Warfare Systems Engineering and Integration
- PC27 Special Warfare Maritime Mobility Mission Systems and Mission Support Equipment
- PC28 MCM Detect and Engage Systems, Modular Mission Packaging, and Platform Integration and Handling
- PC29 Littoral Mission Systems Integration and Modular Mission Packages Certification
- PC30 Unmanned Systems Engineering and Integration, Autonomous Operations, Joint Interoperability and Common Control
- PC31 Mine Sensor and Target Detection Technology, Mine Delivery Platform Integration, and Minefield Architecture
- PC33 Diving and Life Support Systems
- PC34 Surface Life Support Systems for Extreme Environments

Facilities

Located on 650 acres, NSWC PCD operates state-of-the-art facilities supporting all assigned mission areas such as: LCAC Repair and Maintenance Facility, Air Operations, Sea Fighter (FSF-1), and the Littoral Warfare Systems Facility. The Gulf Coast is an ideal location for Expeditionary Operations and Testing; NSWC PCD manages the water space for the Joint Gulf Test Range (JGTR), which includes Eglin ranges and spans the Gulf of Mexico, bays, estuaries, rivers and harbors. As part of the JGTR, NSWC PCD performs amphibious operations and have developed an Expeditionary Maneuver Test Range for vehicle testing. NSWC PCD also has state of the art acoustic and magnetic test facilities, including a non-magnetic test area to support sensor development efforts that doubles as a laser test range.

Technical Departments

- Littoral & Mine Warfare Systems (A)
- Expeditionary & Maritime Systems (E)
- Science and Technology (X)

Current Marine Corps Support Areas

- Combat Engineer Route Reconnaissance and Clearance (R2C) and Mobility/ Counter-Mobility design, integration, testing, fielding, and sustainment
- Expeditionary Command and Control design, integration, testing, fielding, and sustainment
- Expeditionary Analysis, Modeling, and Simulation
- S&T development of advanced technologies for explosive hazard detection and defeat, counter tactical surveillance and targeting, and swarming to support operations across the spectrum of combat environments.

Current Marine Corps Programs Supported

PEO-Land Systems

PM AAA

- AAV Emergency Egress Lighting

PM M&HTV

- MRAP Cougar Model Based Enterprise (MBE) Configuration Management

Marine Corps Systems Command

PM-Command and Control Systems

- Lead Systems Integrator, Design Agent, In-Service Engineering Agent for Expeditionary Command and Control System
- Joint Battlespace Viewer sustainment

PM-Engineer Systems

- NSWC PCD is the Technical Agent (TDA, ISEA, and AEA) for systems of the USMC Engineering Systems Route Reconnaissance and Clearance and Mobility/ Counter-Mobility missions.
- Unmanned Breacher Vehicle Research and Development

PM-FIRES

- Organic Precision Fires-Mounted Integration with Light Armored Vehicle

SEAL

- Expeditionary M&S and FACT Support

CD&I

- FMID - JLTV Transportability Analysis

Office of Naval Research

- Ground Penetrating Synthetic Aperture Radar (GP SAR)
- Standoff Interferometric Target Detection Experiment/ATR (SITD)
- LOCUST Integration with Expeditionary Systems
- LOCUST Expeditionary Launch Module
- Sandfly Magnetic Expeditionary Threat Localization (METL)
- ASV/AUV Imaging System (ALIS)
- VSW-SZ Littoral Acoustic Detection (VLAD)

- UUV/UAV Surface Combatant Strike (Super Swarm)
- Super Swarm INP Integration & Experimentation Lead
- High Volume Long Range Precision Strike Rapid Prototyping Program

The Joint Improvised-Threat Defeat Organization

- Counter Threat Object Recognition

Marine Corps Warfighting Lab

- Fight the Naval Forces Forward ANTX
  - Set-based Design Evaluation Tool (SET)

Rapid Capabilities Office

- Organic Precision Fires

FY20 NISE Projects

- Mission-ready Unmanned AAV
- Swarm MVP (Minimum Viable Product)
- Afloat UAS Detection System
- Multi-Warfare Simulation Environment (MWSE)

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NSWC Port Hueneme Division

Mission

Provide test and evaluation, systems engineering, integrated logistics support, in-service engineering and integration of surface ship weapons, combat systems and warfare systems. Provide the leading interface to the surface force for in-service maintenance and engineering support provided by the Warfare Centers. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

Description

Naval Surface Warfare Center, Port Hueneme Division (NSWC PHD) maintains technical expertise at locations across the United States: Engineering and Logistics at Port Hueneme, California; Search Radar Engineering at Virginia Beach, Virginia; and Live Fire Testing at White Sands, New Mexico.

Port Hueneme Division is recognized as the Navy's Center of Excellence for In- Service Engineering, Test and Evaluation, and Integrated Logistics Support for surface warfare combat and weapon systems. Since its inception in 1963, Port Hueneme Division has been supporting the combat and weapon systems of the Fleet by providing highly skilled personnel and state-of-the-art facilities to lead the development and support of Navy surface ship warfare systems throughout their life cycles.

Port Hueneme Division focuses its technical capabilities on direct connectivity to the Fleet on a global basis and the immediate availability of around-the-clock access to products, services, and Fleet support capabilities. Capabilities will support predictive system failure, remote diagnostics, and corrective action via real-time, networked communications.

Port Hueneme Division capabilities include "Cradle to Grave" lifecycle engineering and sustainment planning to ensure that combat, weapon, radars, air and surface surveillance systems work effectively together to accomplish ship, Strike Group, and Theater Warfare assigned missions throughout their life. Naval Enterprise area assignments include: Surface, Aviation, Expeditionary Combat, NETWAR/ FORCEnet, and Undersea for over 50 major acquisition programs. In addition, NSWC PHD provides overland live fire testing of Naval weapons in support of weapons systems acquisition (missiles and laser systems), assembly of weapons for overland and at sea live-fire testing, launch of research rockets, and assembly/launch of low- and medium-fidelity theater ballistic targets.

Technical Capabilities

Provide In-Service Engineering (ISE), Test &Evaluation (T&E), and Integrated Logistics Support (ILS).

- PH01 Strike Force Interoperability and Theater Warfare Systems
- PH02 Surface and Expeditionary Combat Systems
- PH03 Surface and Expeditionary Weapon Systems
- PH04 Underway Replenishment Systems
- PH07 Surface and Expeditionary Missile Launcher Systems
- PH08 Radar Systems
- PH09 Directed Energy Systems
- PH10 Littoral Mission Module
- PH11 Ballistic Missile Defense T&E Specialized Target Vehicle Development, Integration and Deployment

Marine Corps Support Areas

- Test & Evaluation (T&E), Integrated Logistic Support (ILS), and In-Service Engineering (ISE)
- Enterprise Product Life Cycle Management Integrated Decision Environment (ePLM IDE), Sustainment and Product Support modeling and analytics/end-to-end product data management

Current Marine Corps Programs Supported

PEO-Land Systems

PM AAA

- AAV Family of Systems (FoS) ePLM IDE product data configuration management implementation

PM AC2SN

- Composite Tracking Network T&E, M&S, ILS & ISE support

PM G/ATOR

- G/ATOR In-Service Engineering Agent (ISEA) assisting in T&E, Production Monitoring, Spares Management, Interactive Electronic Technical Manual (IETM) Maintenance and Update, Engineering Change Proposal Development, Review and Execution, Reliability Maintainability and Availability (RM&A) Engineering, Help Desk Tracking and Subject Matter Expert, (SME) Support, Integrated Logistics Support, (ILS) , Configuration Management (CM), and Product Support Management (PSM) through the lifecycle.

PM GBAD

- GBAD Acquisition Integrated Logistics Support (ILS) focused on Product Support Modeling and Analytics to improve Product Data Management.

Marine Corps Systems Command

PM Communications MAGTF Command, Control, Communications (PfM CES)

- AN/TPS-59(V)3 Long Range Radars (LRR) assisting in T&E and Systems Engineering to include Identification Friend or Foe (IFF) Mode 5 Development and Certification.

NUWC Newport Division

Mission

The Naval Undersea Warfare Center Division Newport provides research, development, test and evaluation, engineering, analysis and assessment, as well as Fleet support capabilities for submarines, autonomous underwater systems, and offensive and defensive undersea weapon systems, and stewards existing and emerging technologies in support of undersea warfare.

Description

The Newport Division consists of approximately 3,200 scientists, engineers and support personnel working in more than 40 disciplines ranging from fundamental science to applied/ in-service engineering. NUWC Division Newport provides the technical foundation that enables the conceptualization, research, development, fielding, modernization, and maintenance of systems that ensure our Navy's undersea superiority. NUWC Division Newport is responsible, cradle to grave, for all aspects of systems under its charter, and is engaged in efforts ranging from participation in fundamental research to the support of evolving operational capabilities in the U.S. Navy fleet. The major thrust of NUWC Division Newport's activities is in applied research and system development.

With headquarters in Rhode Island, NUWC Division Newport operates detachments at West Palm Beach, Florida, and Andros Island in the Bahamas. Remote test facilities are located at Seneca Lake and Fisher's Island in New York, and Dodge Pond, Connecticut.

Facilities

- Acoustic Wind Tunnel
- Anechoic Chamber
- Combat Systems Evaluation & Analysis Laboratory
- Launcher Laboratory
- Narragansett Bay Test Facility (NTBF)
- Over-water Arch Facility
- Propulsion Test Facility
- Quiet Water Tunnel
- Submarine Towed and Deployed Systems Research, Development, Test and Evaluation Complex
- Survivability Test Facility
- Undersea Warfare Analysis
- Virginia Payload Tube Facility

Technical Capabilities Leveraged by Marine Corps

- Undersea technologies and SMEs in Underwater Unmanned Vehicles (UUVs)
- Underwater capabilities that support the USMC Reconnaissance – specifically shallow water

Current Marine Corps Support Areas

- ANTX – Technical Points of Contact (TPOC) for Mission Areas and Data Processing
  - 2017: S2ME2 – Ship to Shore Maneuver Exploration and Experimentation
  - 2018: U5G - Urban 5th Generation Marine Exploration and Experimentation Exercise
  - 2019: FNFF – Fight the Naval Force Forward

Current Marine Corps Programs Supported

- CY 2017: Autonomous Hydrographic Coastal Survey (AHCS) with the Rapid Capabilities Office

- Rapid Capabilities Office was identifying and assessing technologies that could provide higher fidelity of coastal hydrography while decreasing risk to the warfighter in order to enhance the ability to conduct amphibious operations and inform future investments.
- Assessment areas:
  - Technical: Platform, Sensor, Data Transmission, Planning/Analysis
  - Operational: Size/Weight, Ease of Use, DOTMLPF Impacts

NIWC Atlantic - Expeditionary Warfare Department

Mission

Rapidly delivering C4ISR, Cyber and IT systems and engineering services to meet the Information Warfare needs of the Marine Corps and Special Operations Command.

Description

Naval Information Warfare Center (NIWC) Atlantic, Expeditionary Warfare Department (ExW) delivers Information Warfare capabilities to the Marine Corps. We provide full spectrum C4ISR systems and services to Marines and Special Forces. We engineer end-to-end C4ISR systems in the family of ground tactical vehicles. We develop and sustain Enterprise IT system capabilities and solutions.

Technical Focus Areas

NIWC Atlantic, Expeditionary Warfare Department (ExW) is developing the knowledge, skills, abilities, and resources in the following Technical Focus Areas (TFA) through execution and training:

- Assured Communications
- Autonomy
- Cloud Computing
- Cyber Warfare
- Data Science/Analytics
- DevOps
- Internet of Things (IoT) and Embedded Systems
- Mobility
- Model-Based Systems Engineering
- On-Demand Manufacturing

Facilities

A 30,000 square foot Expeditionary Integration Facility is reconfigurable to support multiple concurrent platform systems design and testing. This facility hosts a network of enabling software that enables USMC teams to execute MBSE across all team functions, from mission thread to risk analysis or program management.

A 100,000 square foot Vehicle Integration Facility provides the capability for production scale C4ISR integration. Configured to rapidly customize vehicular platforms with mission equipment.

NIWC Atlantic are partnering with other Warfare centers to develop a one stop shop capability in Charleston, SC for automotive maintenance and improvement in conjunction with world class C4ISR integration capabilities.

A 40,000 square foot Swing Space Facility is a secure government Test & Evaluation (T&E) laboratory. This space offers the capability to connect to various secure Government networks in coordination with other DoD C4ISR projects.

An outdoor Radio Frequency (RF) test and analysis facility with the equipment, personnel, and expertise to ensure RF capable systems are compatible with other subsystems and its host platform.

A Positioning, Navigation, and Timing Lab provides systems development and integration, Navigation Suite Certification, Navigation Suite Modeling and Simulation, and Technology Assessment and Forecasting. This PNT lab provides motion simulation for Sea, Land and Air Applications.

A Mixed Reality lab, bringing new Virtual Reality (VR) and Augmented Reality (AR) systems integration and production capabilities through the development of AR/VR guides, visual engineering design overlays, quality assurance and install validation and reporting tools, and training simulators that will greatly improve efficiency and human performance.

NIWC Atlantic will host a National Cyber Range node in Charleston, South Carolina.

Current Marine Corps Programs Supported

PEO-Land Systems

PM Motor Transport

- JLTV

PM AAA

- AAV
- ACV

PM M&HTV

- MTVR
- MATV
- COUGAR Egress

PM GBAD

- Marine Air Defense Integrated System (MADIS)

Marine Corps Systems Command

PfM CES, PM-IS

- DCGS-MC (All-Source, GEOINT, SIGINT)
- Communications Emitter Sensing Attacking System (CESAS)
- Technical Control Analysis Center (TCAC)
- Terrestrial Collections
- Tactical SIGINT Collection System (TSCS)
- Identity Operations
- USMC Counter Radio-Controlled Improvised Explosive Device Electronic Warfare (CREW)

PfM CES, PM-C2

- Combat Operations Centers
- Joint Battle Command Platform
- Combat Data Network (CDN)
- Tactical Service Oriented Architecture (TSOA)
- Global Command Control System (GCCS)
- Joint Tactical COP Workstation
- MAGTF Common Hand Held (MCH)

PfM CES, PM-Comm

- Tactical Communications Systems

PfM GCES, PM-Fires

- Mobile Transport System-Enhanced
- HIMARS Support Kit
- Resupply Vehicle (RSV)

PfM LCES, PM-Engineering Systems

- Route Reconnaissance & Clearance

PM Light Armored Vehicle

- LAV C2 upgrade

PfM SES, PM-N&I

- Enterprise Systems, Networks & Infrastructure
- Network Communications Infrastructure
- Enterprise Wireless Systems
- Enterprise Mobility
- Software Defined Networking

- Emergency Response Systems
- Data Center Consolidation
- Data Analytics & Artificial Intelligence
- Marine Corps Enterprise IT Services
- Machine Learning & Automation
- Cyber Security & Information Assurance
- Application Development, Testing and Evaluation (SECDEVOPS)
- Enterprise IT Staging & Delivery
- Science & Technology Rapid Assessment, Prototyping, Integration and Delivery
- Continuous Integration

PfM SES, PM-Applications

- Enterprise Process & Initiatives
- Managed Services Organization (MSO)

Marine Corps Tactical Systems Support Activity

- MCEN PY
- Enterprise Testing & Evaluation
- Enterprise CYBER DT

Marine Corps Warfighting Laboratory Home

Rapid Capabilities Office

- Principal Technology Investigator

DC-I War Room

- Deputy PMs

Marine Corps Command, Control, Communications and Computers

- Data Center and Cloud Service Strategy

Marine Corps Programs and Resources Department, Installations and Logistics, Manpower and Reserve Affairs

- Business Mission Area (BMA) SECDEVOPS
- Cloud Application Migration
- Cloud Engineering Services Development

MCIOC (SOCOM)

- Information Operations (IO)
- Military Information Support Operations (MISO)

FY20 NISE Projects

PEO LS, MCSC, USMC highlights include:

- 2 Factor Biometrics and Pin Pad Authentication (BPPA)
- Alfred – prototype voice assistant capable of performing search and answering technical questions
- Augmented Reality for LAV Operations
- Automatic Image Inspector
- D3: Disparate Data Distillation- Natural Language Processing Topic Modeling applied to Capture Enemy Material
- Free Space Optics (FSO)
- High Frequency Assured Network – HF Ground Mesh Networking Waveform Development
- LiFi for the USMC Command Post
- Programmable Power Management System for Command and Control Mobile Platforms
- Naval Enterprise Universal Repository for Analytical Learning (NEURAL)
- SPIDER SENSE: Sensor Platform to Identify Expeditionary Cyber Signals for Exploration

- Tactical Cloud for USMC Command Post
- Tactical Deployable MUOS
- TSOA connector for Sitaware
- Cursory – Auto-summarization Natural Language Processing Techniques applied to intel reports / Chat

Section 7.0

DARPA WATCHLIST EFFORTS

The dynamic nature and trajectory of new technologies have the potential to provide dramatic improvements to the systems within the PEO LS portfolio, as well as providing increased capability to the Warfighter. Therefore, PEO LS strives to enhance its body of technical knowledge by monitoring relevant efforts of cutting edge organizations such as Defense Advanced Research Projects Agency. Because these efforts do not specifically apply to a PEO LS Focus Area, they are captured within this section for consideration.

For sixty years, DARPA has held to a singular and enduring mission: to make pivotal investments in breakthrough technologies for national security.

The genesis of that mission and of DARPA itself dates to the launch of Sputnik in 1957, and a commitment by the United States that, from that time forward, it would be the initiator and not the victim of strategic technological surprises. Working with innovators inside and outside of government, DARPA has repeatedly delivered on that mission, transforming revolutionary concepts and even seeming impossibilities into practical capabilities. The ultimate results have included not only game-changing military capabilities such as precision weapons and stealth technology, but also such icons of modern civilian society such as the Internet, automated voice recognition and language translation, and Global Positioning System receivers small enough to embed in myriad consumer devices.

DARPA explicitly reaches for transformational change instead of incremental advances. But it does not perform its engineering alchemy in isolation. It works within an innovation ecosystem that includes academic, corporate and governmental partners, with a constant focus on the nation's military services, which work with DARPA to create new strategic opportunities and novel tactical options. For decades, this vibrant, interlocking ecosystem of diverse collaborators has proven to be a nurturing environment for the intense creativity that DARPA is designed to cultivate.

These efforts expose the S&T director to advanced concepts and emerging technologies with the potential to address current and/or possible future capability gaps.

This section presents many of the technologies that the PEO LS S&T exploration process has identified as possessing potential to address current/future capability gaps. While these programs represent only a fraction of DARPA's overall portfolios, which encompasses a much broader spectrum of military technology development, the identified programs appear to have the greatest applicability to the PEO LS effort.

Communications in Contested Environments (C2E)

The Communications in Contested Environments program seeks to enable the development and deployment of adaptive communication systems through a three-part approach that is motivated by processes in the commercial world, which allow incorporation of third-party technologies that are from neither the hardware developer nor the core software provider. At the base of the C2E approach, a modular hardware architecture provides the flexibility to refresh capabilities and outpace application demands and adversary threats without requiring wholesale system overhauls. In addition, a new waveform-development

model leverages re-usable waveform processing elements and formal methods to enable faster development across multiple hardware platforms. Thirdly, the C2E network vision fully embraces the diversity and multiplicity of radio types across platforms in the airborne battle space, to provide highly reliable, networked and scalable information distribution to every element of the fighting force.

Secure Handhelds on Assured Resilient networks at the tactical Edge (SHARE)

The SHARE program aims to enable the exchange of information at multiple levels of security classification on a single handheld device. SHARE would use a resilient secure network that links handheld devices without needing to route traffic through secure data centers. This capability would operate over existing commercial and military networks while maintaining the security of sensitive information and safety of operations.

Open Manufacturing

The goal of the DARPA Open Manufacturing program is to lower the cost and speed the delivery of high-quality manufactured goods with predictable performance. It aims to do so by creating a manufacturing framework that captures factory-floor and materials processing variability and integrates probabilistic computational tools, informatics systems and rapid qualification approaches. These newly developed concepts and approaches will be used to characterize and reduce the risk of new manufacturing technologies.

XDATA

The goal of the DARPA XDATA program is the development of computational techniques and software tools for processing and analyzing large, imperfect and incomplete data. For scalable analytics, this approach includes researching distributed databases, statistical sampling methods and new algorithmic advances to lower the computational complexity of pattern matching. For information visualization, the approach includes developing human-computer interaction tools that are web-based, factor computation between client and server, and build from an open code base to enable rapid customization to different missions. Warfighters' missions now rely on a virtual net of sensors and communications systems for battlefield awareness more than at any time in history. At the same time, demands for timely and actionable information have spiked as Warfighters at every level—whether at the planning table or on patrol—are called upon to make well-informed decisions. XDATA seeks to develop software to efficiently fuse, analyze and disseminate the massive volumes of data this network produces.

MEMEX

Memex seeks to develop software that advances online search capabilities far beyond the current state of the art. The goal is to invent better methods for interacting with and sharing information, so users can quickly and thoroughly organize and search subsets of information relevant to their individual interests. The technologies developed in the program would provide the mechanisms for improved content discovery, information extraction, information retrieval, user collaboration and other key search functions.

Aerial Dragnet

DARPA's Aerial Dragnet program aims to achieve the technically difficult goal of detecting and tracking small UAS in urban terrain. The program seeks innovative technologies to provide persistent, wide-area

surveillance of all UAS operating below 1,000 feet in a large city. While Aerial Dragnet's focus is on protecting military troops operating in urban settings overseas, the system could ultimately find civilian application to help protect US metropolitan areas from UAS-enabled terrorist threats.

OFFensive Swarm-Enabled Tactics (OFFSET)

DARPA's OFFSET program envisions future small-unit infantry forces using swarms comprising upwards of 250 small UASs and/or small unmanned ground systems to accomplish diverse missions in complex urban environments. By leveraging and combining emerging technologies in swarm autonomy and human-swarm teaming, the program seeks to enable rapid development and deployment of breakthrough capabilities. OFFSET aims to provide the tools to quickly generate swarm tactics, evaluate those swarm tactics for effectiveness, and integrate the best swarm tactics into field operations. To accomplish these goals, OFFSET will develop an active swarm tactics development ecosystem and supporting open systems architecture.

Mobile Force Protection (MFP)

DARPA's Mobile Force Protection (MFP) program focuses on a challenge of increasing concern to the US military: countering the proliferation of small, unmanned aircraft systems (sUASs). These systems—which include fixed- or rotary-wing aircraft and have numerous advantages such as portability, low cost, commercial availability, and easy upgradeability—pose a fast-evolving array of dangers for US ground and maritime convoys. Countering these threats in real time requires a range of technology advances to enable rapid detection, identification, tracking, and neutralization of adversary sUASs—all while mitigating collateral damage.

Improv 2

The proliferation of low cost, highly sophisticated commercial technology and the global access to knowledge about how to construct and apply these systems has narrowed the divide and placed sophisticated systems and capabilities in the hands of hobbyists across the world. The DARPA Improv program investigated the threat posed by commercial-off-the-shelf (COTS) devices. The Improv 2 program will examine the potential to create small systems comprising COTS components, open source software, and easily fabricated components and examine their current and future potential to provide useful military capability.

Military Imaging and Surveillance Technology (MIST)

The MIST program seeks to develop a fundamentally new optical Intelligence, Surveillance, and Reconnaissance capability able to provide high-resolution 3-D images to locate and identify a target at much longer ranges than is possible with existing optical systems. Several prototype optical surveillance and observation systems are planned for development, which aim to: (1) demonstrate probabilities of recognition and identification at distances sufficient to allow stand-off engagement; (2) overcome atmospheric turbulence, which now limits the ability of high-resolution optics; and (3) increase target

identification confidence to reduce fratricide and/or collateral damage. The program aims to develop and integrate the necessary component technologies including high-energy pulsed lasers, receiver telescopes that have a field of view and depth of field that obviates the need for steering or focusing the optical system, computational imaging algorithms to improve system resolution, and data exploitation and analysis tools.

Advanced Wide FOV Architectures for Image Reconstruction and Exploitation (AWARE)

The DARPA Advanced Wide FOV AWARE program seeks to realize wide FOV, higher resolution, and multi-band imaging capability for increased target discrimination and search in daytime and nighttime conditions. The envisioned imaging systems would be sufficiently lightweight and compact to be fielded on a variety of ground and airborne platforms. The first AWARE systems are expected to be deployed on multiple platforms, providing superior resolution (for better target identification at greater distances), increased operational capability (for the ability to see panoramic scenes with multiple-target tracking), and better day/night visibility (to mitigate brownout conditions for helicopter landings). In addition, AWARE's modular component technologies could have a broad impact on DoD imaging applications, including targeting, persistent surveillance, sensing, and imaging with color fusion. The AWARE program aims to solve the current fundamental scaling limitations in imaging systems and demonstrate a design methodology for building compact systems capable of forming images with an unprecedented combination of high resolution and wide FOV.

Shared Spectrum Access for Radar and Communications (SSPARC)

The SSPARC program seeks to improve radar and communications capabilities through spectrum sharing. Spectrum congestion is a growing problem. It increasingly limits operational capabilities due to the increasing deployment and bandwidth of wireless communications, the use of net-centric and unmanned systems, and the need for increased flexibility in radar and communications spectrum to improve performance and to overcome sophisticated countermeasures. Radar and communications jointly consume most of the highly desirable spectrum below 6 GHz. SSPARC seeks to develop sharing technology that enables sufficient spectrum access within this desirable range for radar and communications systems to accomplish their evolving missions.

Adaptable Navigation System (ANS)

The DARPA ANS program addresses three basic challenges through its Precision Inertial Navigation Systems and All Source Positioning and Navigation efforts:

- Better inertial measurement units that require fewer external position fixes;
- Alternate sources to GPS for those external position fixes; and
- New algorithms and architectures for rapidly reconfiguring a navigation system with new and non-traditional sensors for a particular mission.

Spatial, Temporal, and Orientation Information in Contested Environments (STOIC)

The DARPA STOIC program seeks to develop a backup PNT system that provides GPS-level and better performance without relying on GPS. STOIC comprises three technical areas that when integrated would have the potential to provide global PNT independent of GPS:

- Earth-fixed navigation using very low frequency (VLF) signals;
- Deployable optical clocks based on technology developed under the DARPA QuASAR program; and
- Precision time transfer and ranging over data links.

Dynamic Network Adaptation for Mission Optimization (DyNAMO)

The Dynamic Network Adaptation for Mission Optimization (DyNAMO) program is developing and testing technologies that enable adaptive, mission-responsive networking among diverse airborne platforms in contested environments. Wireless networks have evolved into complex systems having many configurable parameters/features, including link data rates, power settings, inter-network gateways, and security associations. The optimal settings for these features vary greatly depending on the mission for which the network is deployed and the environment in which it is operating. Currently, the majority of these features are optimized off-line for specific scenarios and assumptions and are preset before use in a mission. There is no capability for the settings to adapt if the actual mission or environment differs from the original assumptions used to configure the network.

The DARPA DyNAMO program is developing information-centric approaches to bridge disparate networks and to adaptively configure and control networks and networks of networks for operation in dynamic and contested environments. The program is addressing optimization within legacy and future military networks, interactions between networks, and availability of necessary network services to support mission success.

Network Universal Persistence (Network UP)

The Network Universal Persistence (Network UP) program seeks to develop and demonstrate radio technology that maintains network reliability through periods of frequent signal degradation that may occur during operations in multiple environments. From time to time, network outages may occur and data transmission may be challenged. Networks in dynamic wireless environments can end up mostly attempting to establish the network rather than sending data. The Network UP program is addressing this issue by employing a new approach and novel architecture to improve performance.

ReSource

The primary objective of ReSource is to provide the military with the ability to rapidly and efficiently upconvert military waste into valuable resources onsite and on demand. By the end of the program, developed platforms should be capable of resourcing on-demand products that could include the following: edible macronutrients; traditionally petroleum-derived products such as lubricants, adhesives, and tactical fibers; potable water; and other value-added molecules for an emergency ration (e.g., caffeine).

Living Foundries

Current and emerging Department of Defense (DoD) capabilities rely upon access to a number of critical, high-value molecules that are often prohibitively expensive, unable to be domestically sourced, and/or impossible to manufacture using traditional synthetic approaches. DARPA's Living Foundries program aims to enable adaptable, scalable, and on-demand production of such molecules by programming the fundamental metabolic processes of biological systems to generate a vast number of complex molecules that are not otherwise accessible. Through Living Foundries, DARPA is transforming synthetic biomanufacturing into a predictable engineering practice supportive of a broad range of national security objectives.

For additional information concerning any of the DARPA programs highlighted in this document, please contact:

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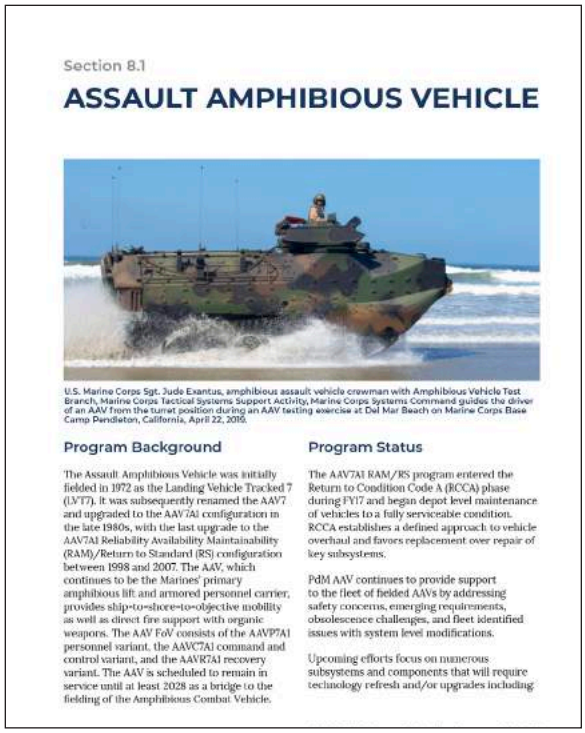
Section 8.0

PEO LS PROGRAMS

Program Executive Officer Land Systems consists of seven program offices overseeing nineteen programs. The following sections discuss each of the pertinent PEO LS programs. Each program has a dedicated section that is described in the three parts listed below. The goal is to use all available S&T venues to leverage resources for PEO LS programs to close Warfighter gaps and solve program technology requirements.

Part One describes the program's background, status, and Top Technical Issues.



Section 8.1

ASSAULT AMPHIBIOUS VEHICLE

U.S. Marine Corps Sgt. Jude Exantus, amphibious assault vehicle crewman with Amphibious Vehicle Test Branch, Marine Corps Tactical Systems Support Activity, Marine Corps Systems Command guides the driver of an AAV from the turret position during an AAV testing exercise at Del Mar Beach on Marine Corps Base Camp Pendleton, California, April 22, 2015.

Program Background

The Assault Amphibious Vehicle was initially fielded in 1972 as the Landing Vehicle Tracked 7 (LVT7). It was subsequently renamed the AAV7 and upgraded to the AAV7A1 configuration in the late 1980s, with the last upgrade to the AAV7A1 Reliability Availability Maintainability (RAM)/Return to Standard (RS) configuration between 1998 and 2007. The AAV, which continues to be the Marines' primary amphibious lift and armored personnel carrier, provides ship-to-shore-to-objective mobility as well as direct fire support with organic weapons. The AAV FoV consists of the AAVP7A1 personnel variant, the AAVC7A1 command and control variant, and the AAVR7A1 recovery variant. The AAV is scheduled to remain in service until at least 2028 as a bridge to the fielding of the Amphibious Combat Vehicle.

Program Status

The AAV7A1 RAM/RS program entered the Return to Condition Code A (RCCA) phase during FY17 and began depot level maintenance of vehicles to a fully serviceable condition. RCCA establishes a defined approach to vehicle overhaul and favors replacement over repair of key subsystems.

PdM AAV continues to provide support to the fleet of fielded AAVs by addressing safety concerns, emerging requirements, obsolescence challenges, and fleet identified issues with system level modifications.

Upcoming efforts focus on numerous subsystems and components that will require technology refresh and/or upgrades including

Figure 8-1. Part One

Part Two is the program's quad chart, which addresses the program's fundamental information and characteristics, i.e., specific information, including a detailed program description, status, and schedule.

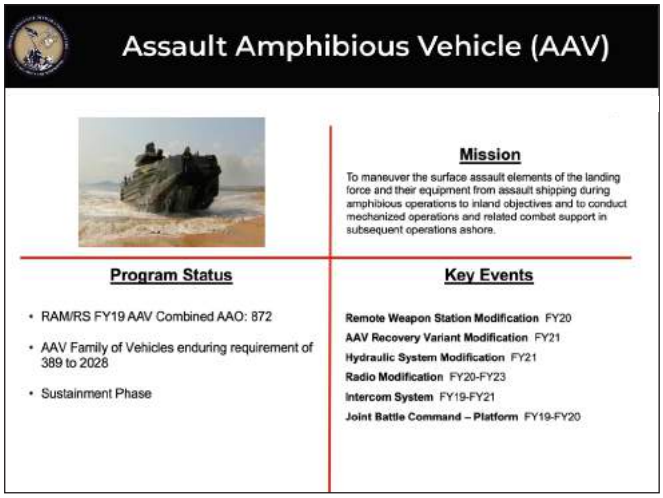


Figure 8-2. Part Two

Part Three graphically addresses the Top Technical Issues for each program. Each technical issue and related S&T projects are aligned to the current program schedule. The graphic is divided into the following four sections:

Row one identifies the program's major milestones.

Row two display's S&T initiatives that are targeted to solve the technology issue.

The dark blue diamond with a yellow number in the center depicts the expected Technology Readiness Levels (TRL) at the beginning and end of projects.

TRLs are used to measure the maturity level of the S&T activities and initiatives.

- **TRL 1** - Basic principles observed and reported.
- **TRL 2** - Technology concepts or applications (or both) formulated.

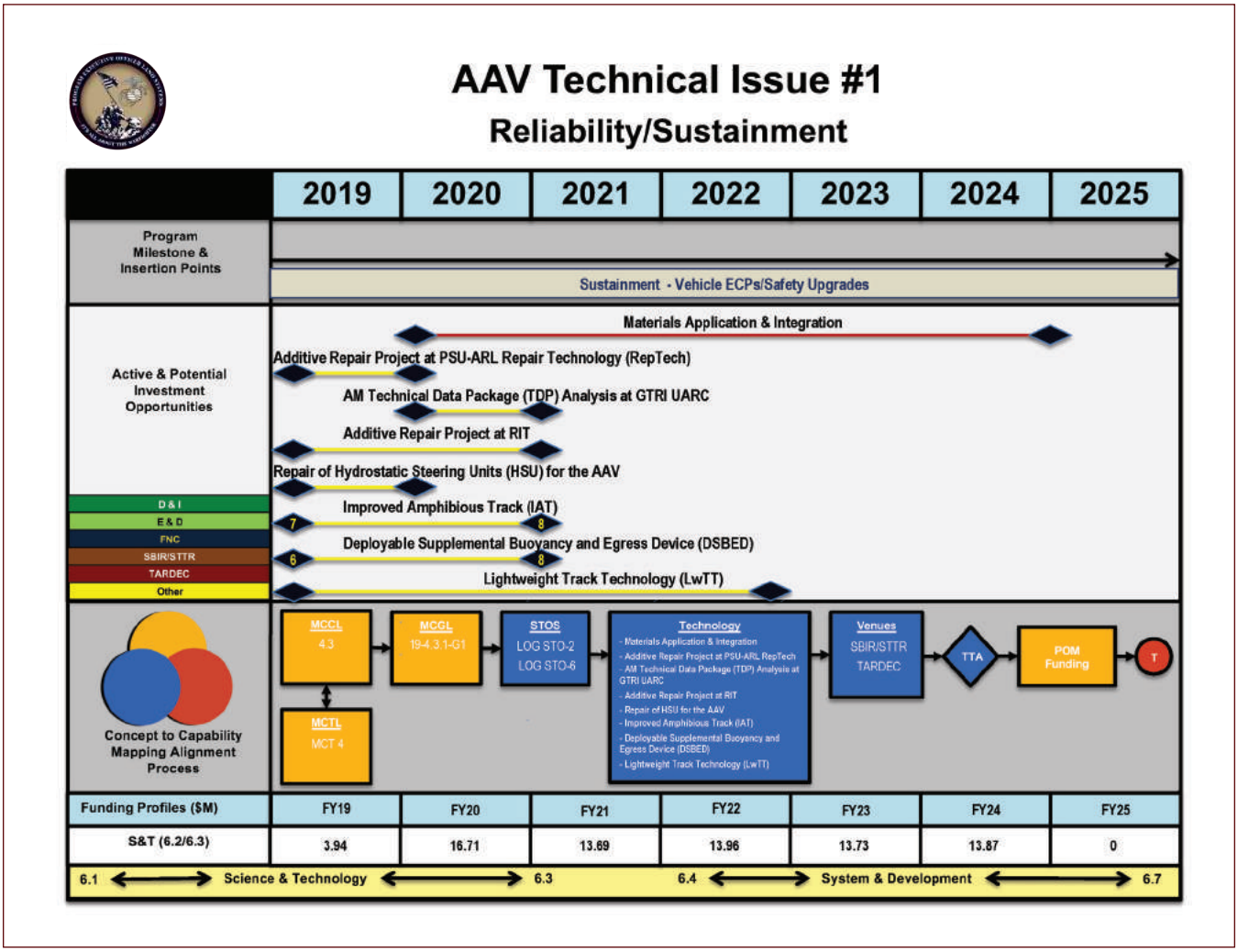


Figure 8-3. Part Three

- **TRL 3** - Analytical and experimental critical function or characteristic proof-of-concept.
- **TRL 4** - Component or breadboard validation in a laboratory environment.
- **TRL 5** - Component or breadboard validation in a relevant environment.
- **TRL 6** - System/subsystem model or prototype demonstration in a relevant environment.
- **TRL 7** - System prototype demonstration in an operational environment.

The color key on the far left side of the chart identifies the seven different types of S&T venues.

Discovery and Invention (D&I) programs consist of basic and early applied research.

Exploitation and Development (E&D) focuses on incorporating research into systems in preparation for inclusion into acquisition programs.

Future Naval Capabilities (FNC) provides the best technology solutions to formally defined capability gaps and usually leverages past D&I and E&D successes.

Small Business Innovation/Small Business Technology Transfer (SBIR/STTR) are composed of programs that are focused on small business innovation.

Tank Automotive Research, Development and Engineering Center (TARDEC), located in Warren, Michigan, is the US Armed Forces' research and development facility for advanced technology in ground systems. It is part of the RDECOM, a major subordinate command of the United States Army Materiel Command. Current technology focus areas include Ground Vehicle Power and Mobility (GVPM), Ground System Survivability, and Force Protection Technology, among others.

Other is a variety of other investment types, including projects involving the Office of the Secretary of Defense; initiatives that are sponsored by the program office, such as Phase "A" studies and congressional "plus ups"; and all those not otherwise covered. See Section 9 for a detailed list of applicable S&T venues.

Row three traces the issue from the originating Marine Corps Capabilities List, through the identified gap via the Marine Corps Gap List, to the Science and Technology Objectives that are identified in the Marine Corps S&T Strategic Plan, and other S&T venues that address the technical issue to illustrate the transition of technology to the Program of Record.

The mapping alignment process traces the technology issue/S&T initiative from the required capability to the transitioned technology. Using AAV Technical Issue #1, Reliablity/Sustainment as an example, MCCL 4.3 identifies the capability that is associated with the technical issue. Applicable tasks identified from the Marine Corps Task List (MCTL), 19-4.3.1-G1 identifies the gap, and LOG STO-2 and LOG STO-6 addresses the Logistic (LOG) STO addressing reliability/sustainment. The issues are then traced through potential technologies and venues to the funded transition of that advanced technology capability. This is done for each program's top technical issue to map from the concept to the capability, identifying how to solve this technical problem, and how it can transition into a program of record.

The bottom three rows describe the funding profile associated with the S&T initiatives for each listed year.

In summary, the Advanced Technology Investment Plan captures the active S&T initiatives that are currently being pursued by PEO LS and are aligned to high-priority technical issues and capability gaps in order to "Focus the Future Faster" by delivering gap-closing capabilities to the Warfighter.

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Section 8.1

ASSAULT AMPHIBIOUS VEHICLE

U.S. Marine Corps Sgt. Jude Exantus, amphibious assault vehicle crewman with Amphibious Vehicle Test Branch, Marine Corps Tactical Systems Support Activity, Marine Corps Systems Command guides the driver of an AAV from the turret position during an AAV testing exercise at Del Mar Beach on Marine Corps Base Camp Pendleton, California, April 22, 2019.

Program Background

The Assault Amphibious Vehicle was initially fielded in 1972 as the Landing Vehicle Tracked 7 (LVT7). It was subsequently renamed the AAV7 and upgraded to the AAV7A1 configuration in the late 1980s, with the last upgrade to the AAV7A1 Reliability Availability Maintainability (RAM)/Return to Standard (RS) configuration between 1998 and 2007. The AAV, which continues to be the Marines' primary amphibious lift and armored personnel carrier, provides ship-to-shore-to-objective mobility as well as direct fire support with organic weapons. The AAV FoV consists of the AAVP7A1 personnel variant, the AAVC7A1 command and control variant, and the AAVR7A1 recovery variant. The AAV is scheduled to remain in service until at least 2028 as a bridge to the fielding of the Amphibious Combat Vehicle.

Program Status

The AAV7A1 RAM/RS program entered the Return to Condition Code A (RCCA) phase during FY17 and began depot level maintenance of vehicles to a fully serviceable condition. RCCA establishes a defined approach to vehicle overhaul and favors replacement over repair of key subsystems.

PdM AAV continues to provide support to the fleet of fielded AAVs by addressing safety concerns, emerging requirements, obsolescence challenges, and fleet identified issues with system level modifications.

Upcoming efforts focus on numerous subsystems and components that will require technology refresh and/or upgrades including:

- Tactical communications modernization with radios,
- Intercoms and antennas;
- Remote weapon station;
- Hydraulics modernization;
- Recovery variant modernization;
- Suspension efficiencies;
- Power and energy management;
- Autonomy; and
- Lightweight tracks.

The AAV Program requirements of the RCCA (modernization, modification, and sustainment) may be met with non-developmental items and mature technology. The following areas, however, offer opportunities where advanced technology could benefit the AAV.

Due to the phase the AAVs are now entering, there are less opportunities for new engineering, design, and complete testing of potential modern technology solutions. PdM AAV relies more on available non-developmental items, commercial off-the-shelf, and/or proven systems already fielded to other sources that can be quickly adapted to the current vehicles to address needed capabilities. Testing of these capabilities is focused on system integration and assessment of potential impacts to the platform.

AAV's Top Technical Issues

1. Reliability/Sustainment

The AAV is a 47-year-old platform that will remain in service until at least 2035. The day-to-day logistics, maintenance, and technical challenges of managing such a dated platform would be mitigated by advanced technology that increases reliability, and reduce operations and maintenance support costs. Advances in additive manufacturing and cold spray technologies could assist with corrosion, wear prevention, parts obsolescence, diminishing manufacturing sources, and material shortages to enhance maintenance efficiency and effectiveness throughout equipment life cycle. Alternative lightweight, economical materials that enhance safety, protect buoyancy, improve track and other running gear life and fuel consumption/energy efficiency, reduce vibration/noise, provide corrosion and maintenance-free operations could also assist with life cycle costs.

2. Autonomous

Perception sensors, remote and artificial intelligent vehicle control with near-instantaneous decision making and advanced mobility features, including obstacle avoidance, path planning, and negotiation capabilities that enable surface maneuver from ship through the surf zone, emerge and navigate ashore, and to include the support of other mission sets, package development and integration with autonomous FoV efforts.

3. Communications

Small, lightweight, and versatile antennas for both line of sight and near vertical incidence sky-wave modes non-concurrently, while on-the-move supporting tactical beyond line-of-sight voice and data.

4. Power and Energy

Intelligent power management systems, marinised power inverters, and lightweight efficient high energy storage embarkable onboard naval ships.

Assault Amphibious Vehicle (AAV)

August 2019

Mission

To maneuver the surface assault elements of the landing force and their equipment from assault shipping during amphibious operations to inland objectives and to conduct mechanized operations and related combat support in subsequent operations ashore.

Program Status

- RAM/RS FY19 AAV Combined AAO: 872
- AAV Family of Vehicles enduring requirement of 389 to 2028
- Sustainment Phase

Key Events

Remote Weapon Station Modification FY20

AAV Recovery Variant Modification FY21

Hydraulic System Modification FY21

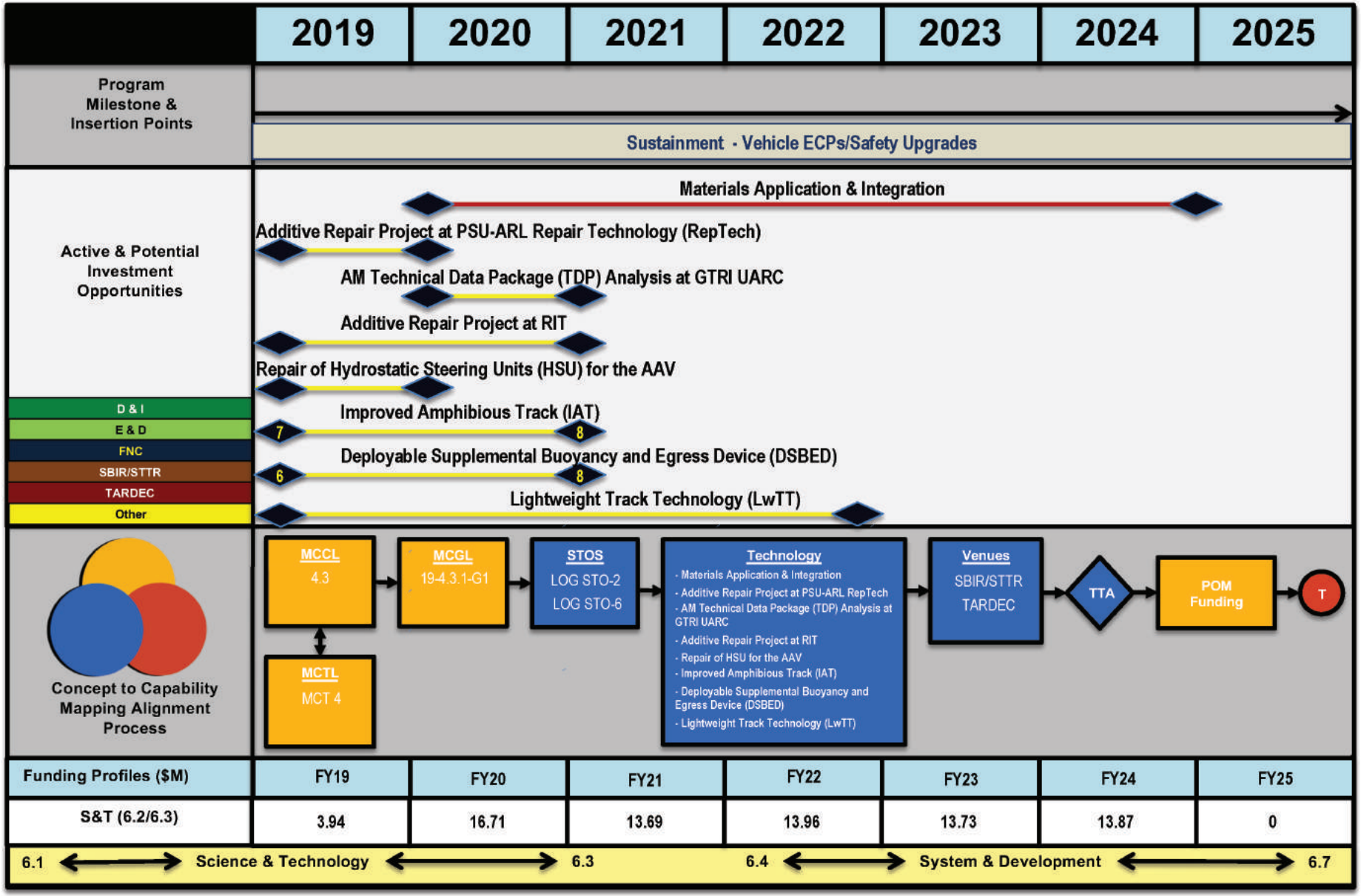
Radio Modification FY20-FY23

Intercom System FY19-FY21

Joint Battle Command – Platform FY19-FY20

AAV Technical Issue #1

Reliability/Sustainment

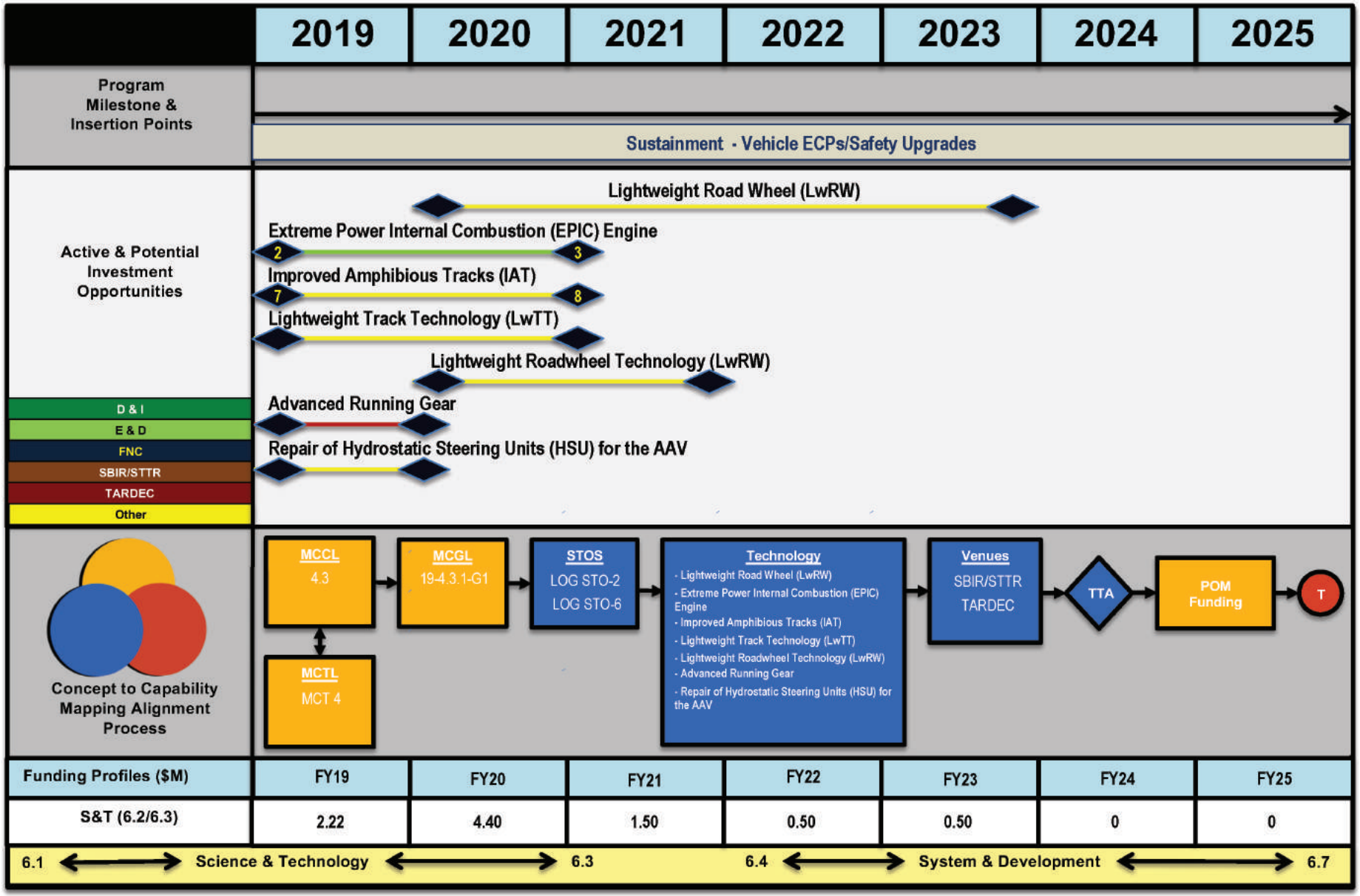


Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	3.94	16.71	13.69	13.96	13.73	13.87	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

AAV Technical Issue #1

Reliability/Sustainment

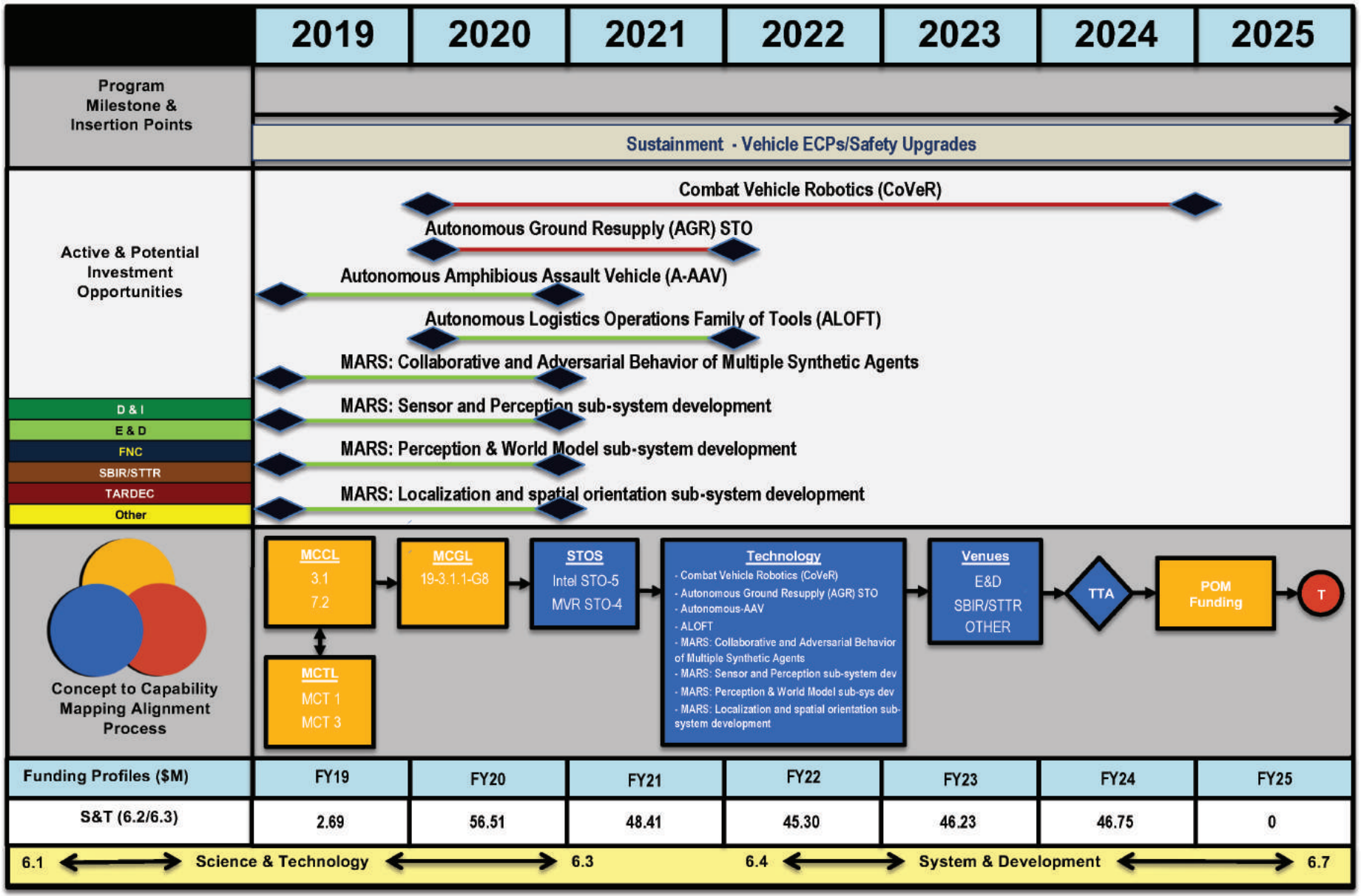


Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	2.22	4.40	1.50	0.50	0.50	0	0

6.1 Science & Technology 6.3 6.4 System & Development 6.7

AAV Technical Issue #2

Autonomy



AAV Technical Issue #2

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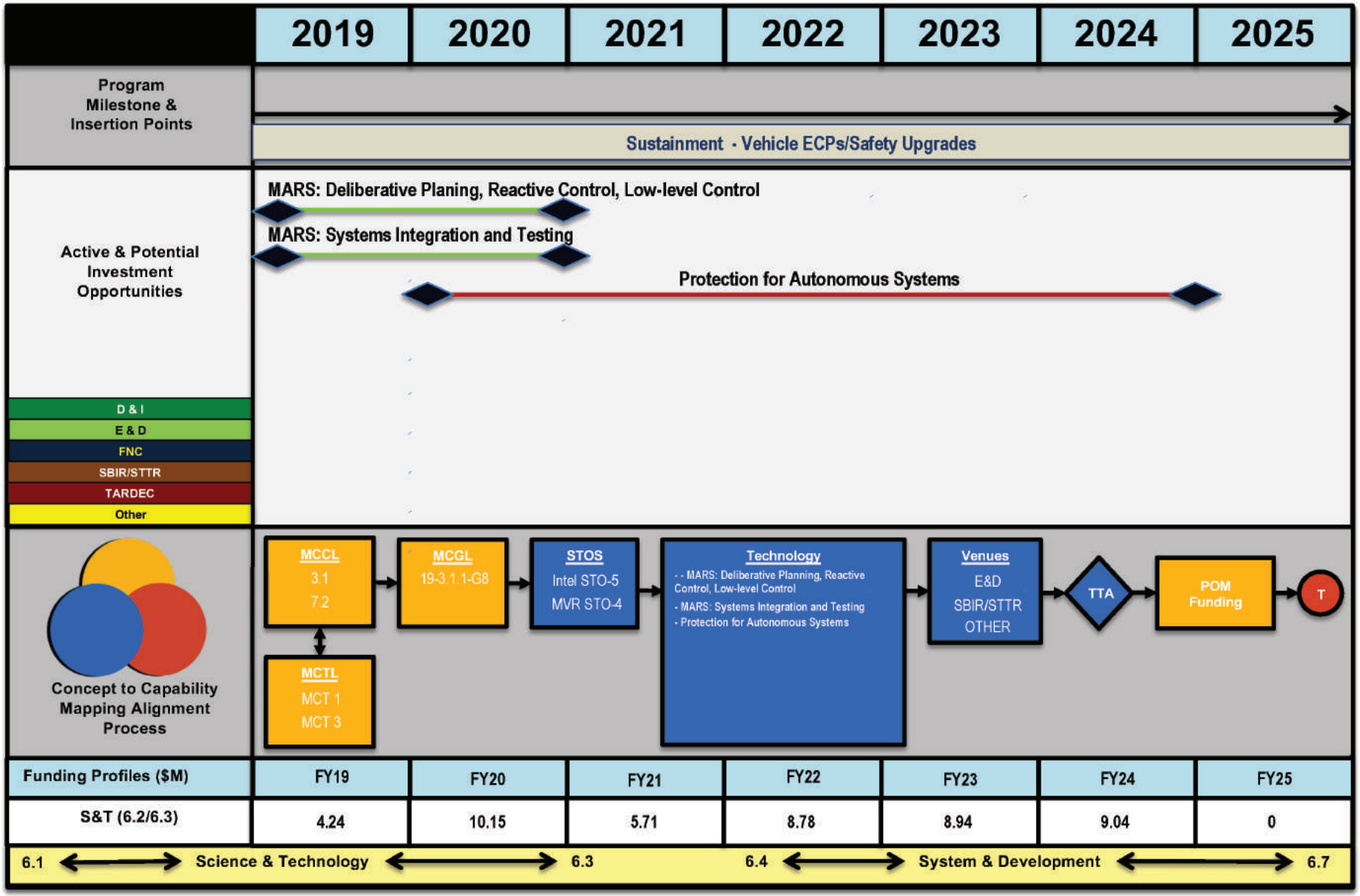
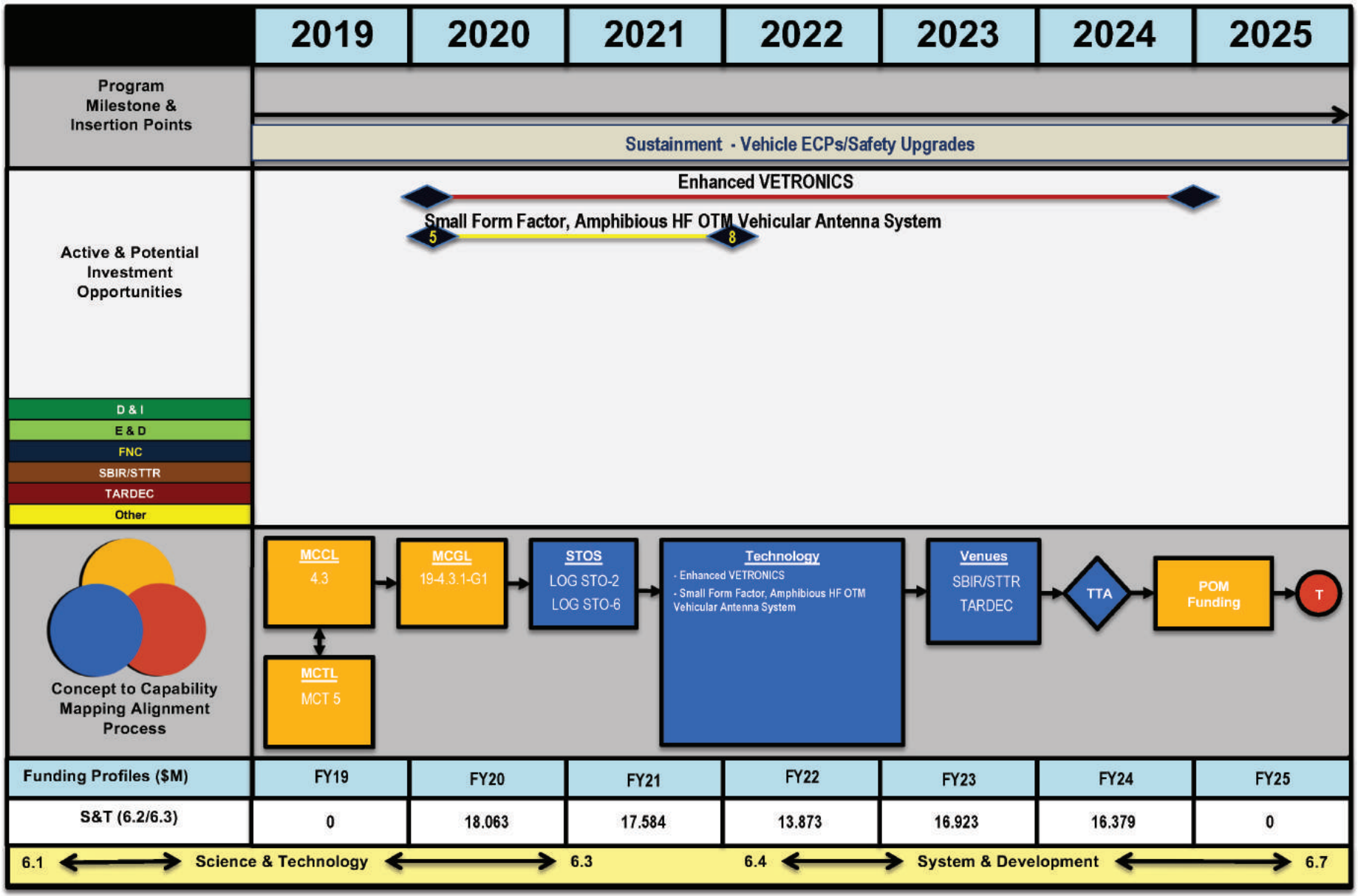


AAV Technical Issue #3

Communication



Section 8.2

AMPHIBIOUS COMBAT VEHICLE

ACV Photo by Ashley Calingo

Program Background

The Amphibious Combat Vehicle is an armored personnel carrier that is balanced between performance, protection, and payload for employment within the Ground Combat Element and throughout the range of military operations, to include a swim capability.

Operationally, the ACV will be employed in such a manner that allows combat units to launch from amphibious ships, operate through the surf zone onto a beachhead, and continue the inland fight toward the objective. ACVs will provide a very robust combat capability, with features including MRAP-level survivability, and amphibious ability to negotiate three-foot significant wave height and six-foot plunging surf.

Program Status

The option was exercised on BAE's Engineering, Manufacturing, and Development (EMD) contract to build low rate initial production (LRIP) vehicles after a successful Milestone C in June FY18. The Marine Corps conducted additional developmental testing in FY18-19 on the EMD vehicles while manufacturing LRIP vehicles. Production qualification and reliability qualification testing on the LRIP vehicles is planned in FY19-20, and an initial operational test and evaluation is also planned for FY20. The ACV is expected to achieve Initial Operational Capability in FY20, and Full Operational Capability in FY22.

ACV's Top Technical Issues

1. Survivability

Technologies that provide lightweight survivability solutions with specific focus on

blast protection, direct fire protection, and active protection systems are needed for the ACV.

2. Weight

Technologies that provide lightweight solutions for vehicle materials and components are needed for the ACV to achieve future survivability, lethality, and mobility upgrades.

3. Crew Visibility

The ACV crew must maintain direct sensory knowledge of their surroundings to safely and effectively employ the system. This requirement includes, but is not limited to, fully blacked out land/water operations, station keeping, obstacle detection (including near-surface obstacles), and operation in urban environments. Technologies that provide the necessary situational awareness for the crew - including position, navigation, and timing in GPS-denied environments - are critical to the execution of the ACV mission.

Amphibious Combat Vehicle (ACV)

August 2019

Program Description

The ACV 1.1 requirement defines expeditionary protected mobility and general support lift for Marine infantry. The ACV is a full replacement for the legacy AAV in the Marine Division's Assault Amphibian Battalions.

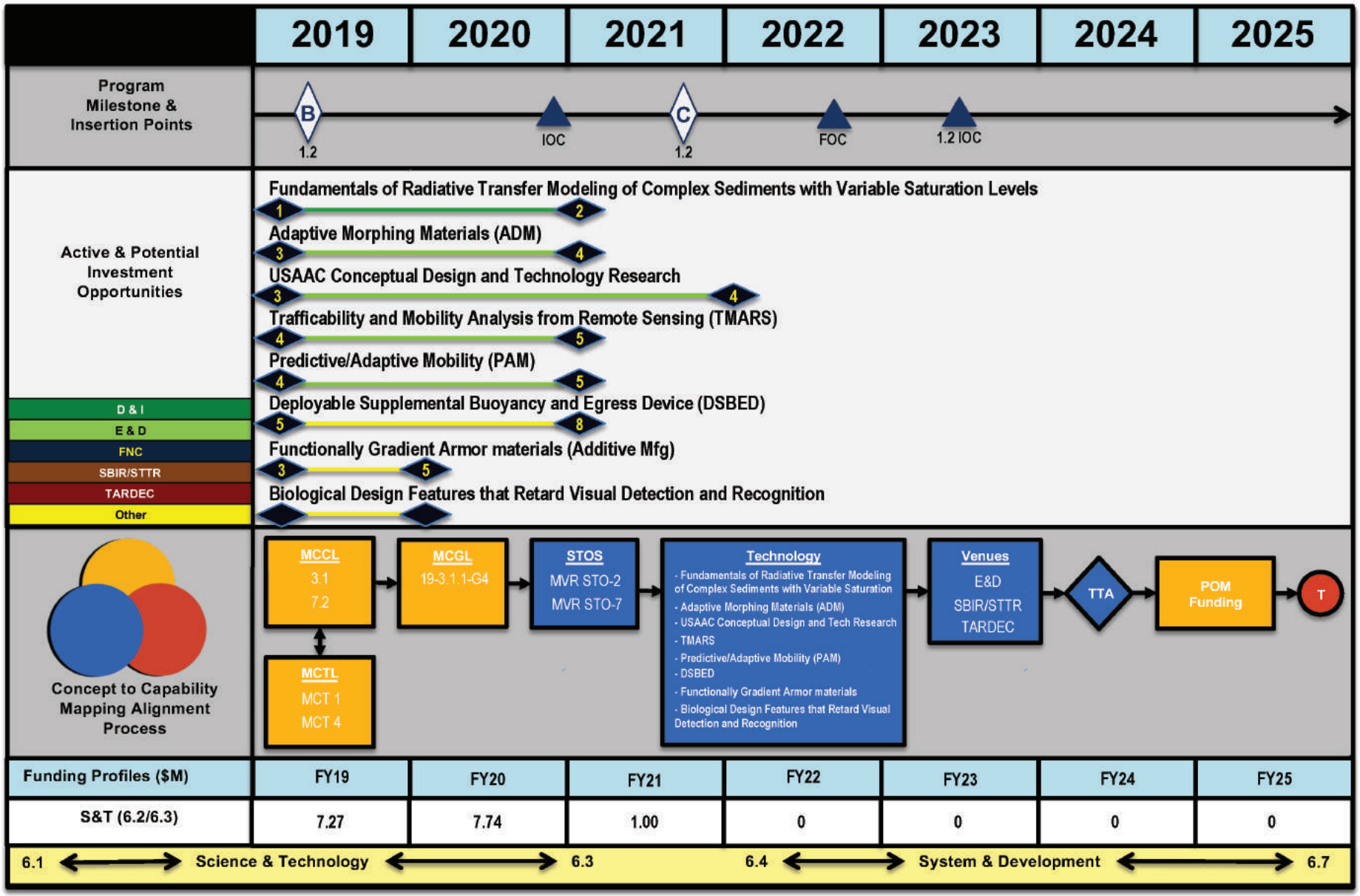
Program Status/Issues/Concerns

- AAO is 204
- Program on schedule
- BAE Systems awarded LRIP Lot 1 Contract Jun 18 and LRIP Lot 2 awarded Dec 18
- LRIP Lots 1 & 2 will produce 30 vehicles each
- LRIP Lot 3 ADM Jul 19
- LRIP Lot 3 to be awarded 2QFY20
- LRIP Lot 3 will produce 56 vehicles

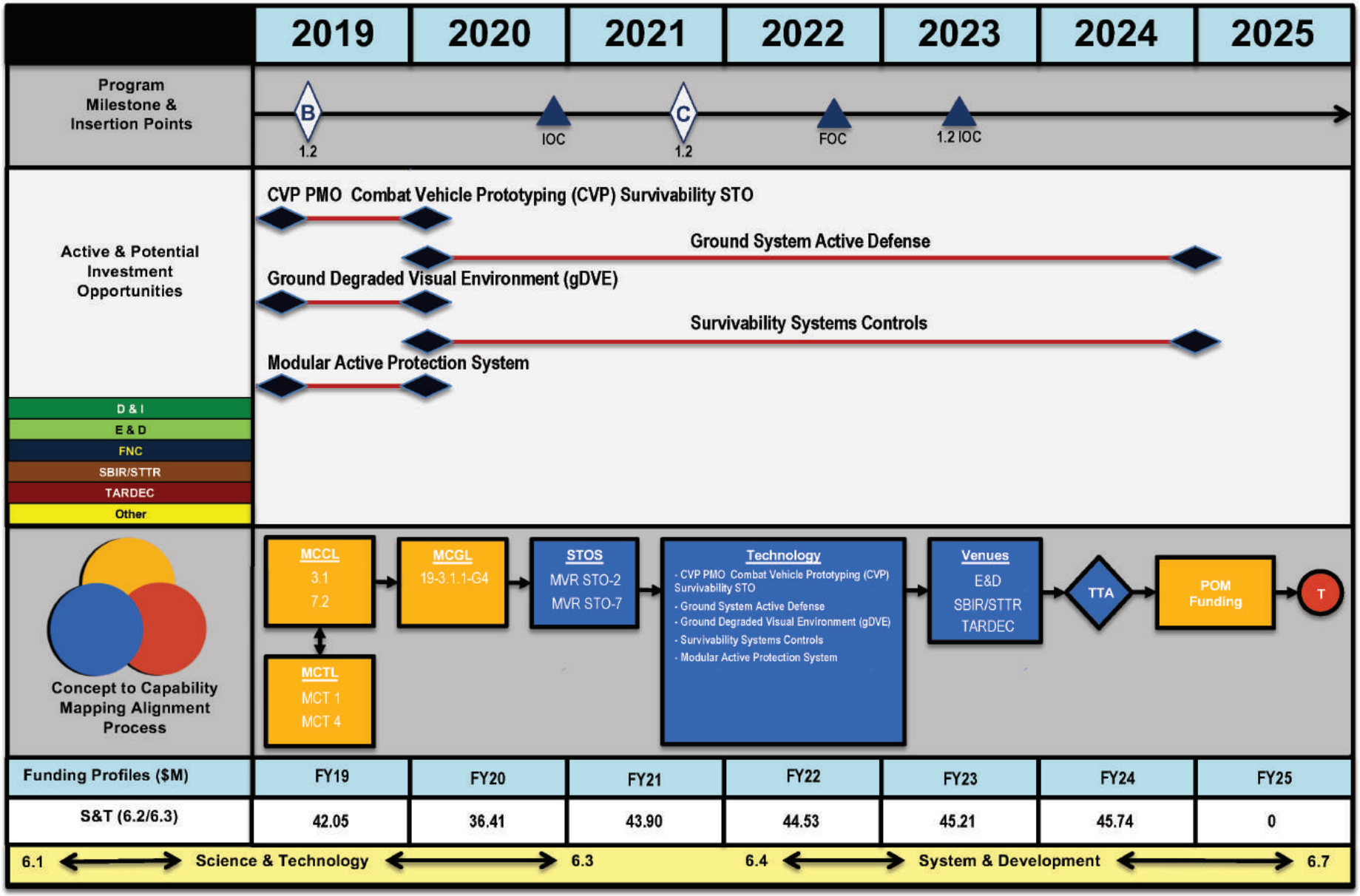
Key Events

- Milestone C: 19 Jun 18
- FRP Decision: 4QFY20
- IOC: 4QFY20
- FOC: 4QFY22

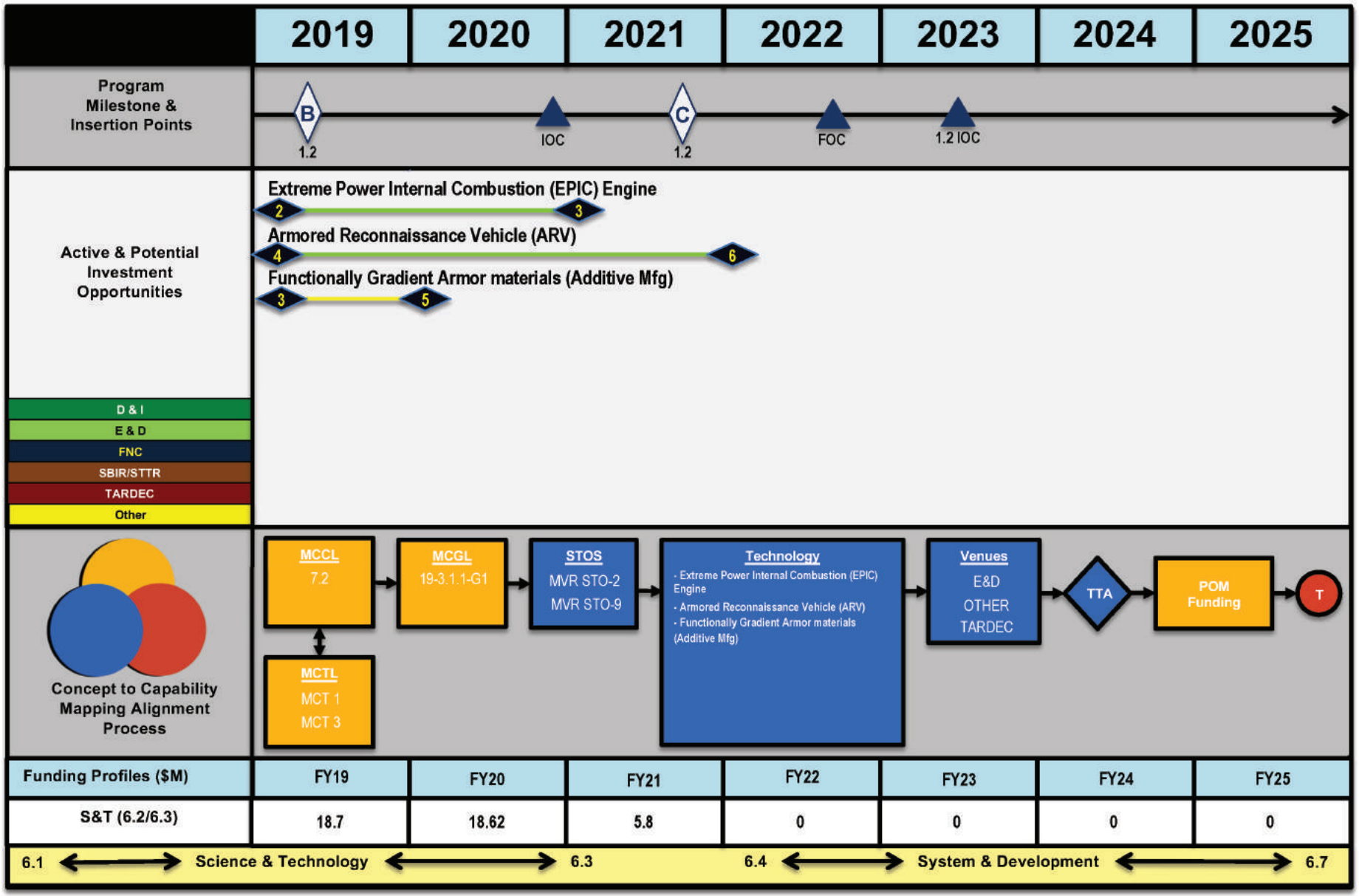
ACV Technical Issue #1
Survivability



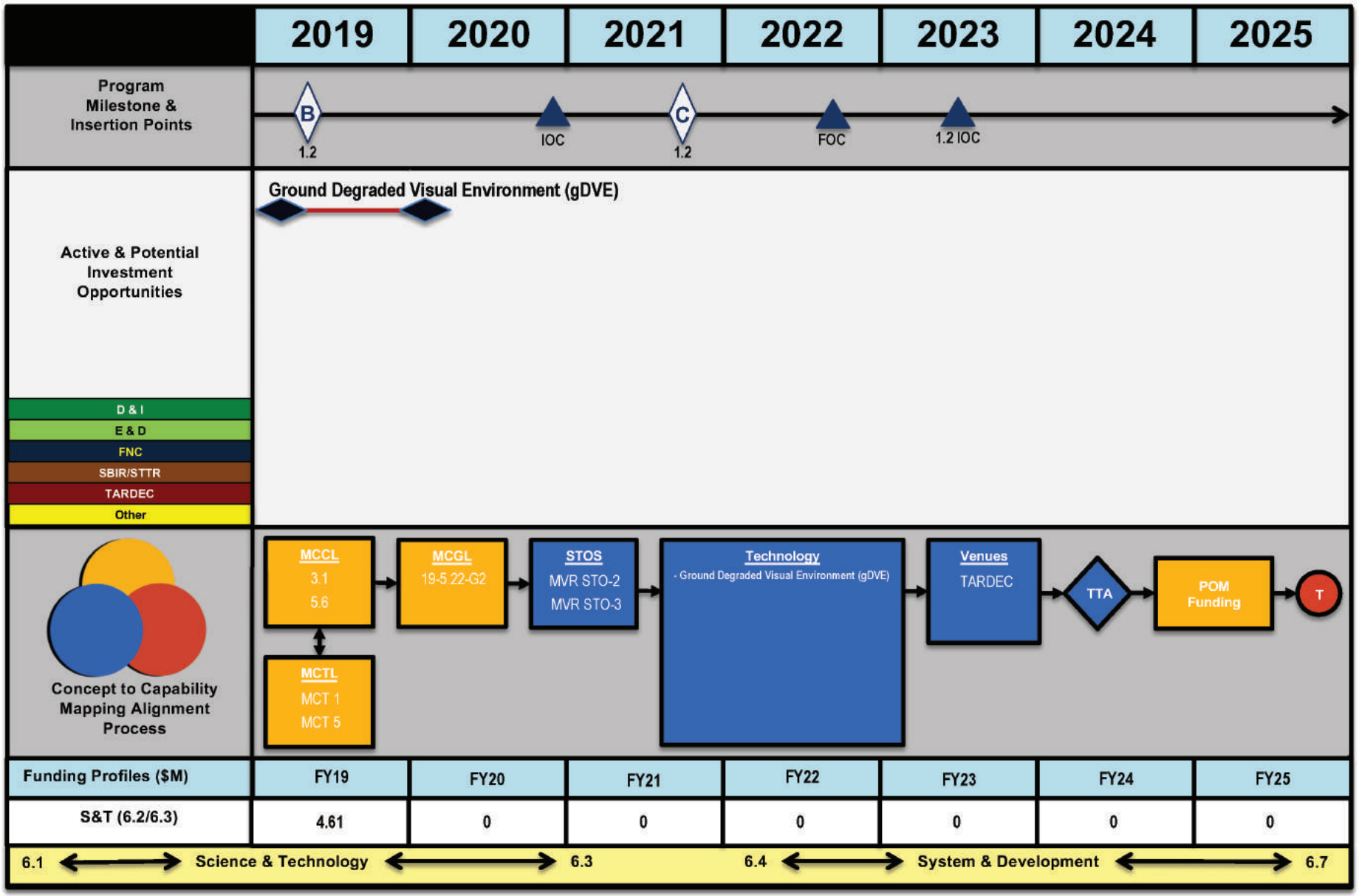
ACV Technical Issue #1
Survivability



ACV Technical Issue #2
Weight



ACV Technical Issue #3
Crew Visibility



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Section 8.3

COMMON AVIATION COMMAND AND CONTROL SYSTEM

Common Aviation Command and Control System

Program Background

The CAC2S is a modernization effort to replace the existing aviation command and control equipment of the Marine Air Command and Control System (MACCS). It also provides the Aviation Combat Element (ACE) with the necessary hardware, software, equipment, and facilities to effectively command, control, and coordinate aviation operations. CAC2S accomplishes the MACCS missions using a suite of operationally scalable modules to support the MAGTF, joint, and coalition forces. CAC2S integrates the functions of aviation command and control into an interoperable system that supports the core competencies of all Marine Corps warfighting concepts. CAC2S, in conjunction with the MACCS's organic sensors and weapon systems, supports the tenets of Expeditionary Maneuver Warfare and fosters Joint interoperability.

The CAC2S program employs an evolutionary acquisition strategy using an incremental and phased approach for development and fielding of the CAC2S. The Capabilities Production Document identifies two increments needed to meet and achieve the full requirements set forth for CAC2S. Increment I of the CAC2S modernizes the assault support, air support, air defense, and ACE battle management capabilities of the MACCS.

Increment I of the CAC2S is accomplished through a two-phased approach. Phase 1 accommodates the rapid fielding of operationally relevant capabilities that include: mobility, situational awareness, tactical communications, information dissemination, and operational flexibility. Phase 1 established the baseline CAC2S capabilities for the MACCS and improved overall Aviation Command and Control performance and effectiveness. Phase 1 was accomplished by upgrading fielded MACCS equipment with mature, ready technologies; it also established an initial product baseline for a Processing and Display Subsystem (PDS) as well as a Communications Subsystems.

Phase 2 addresses the requirements for remaining ACE Battle Management and Command and Control requirements.

Additionally, it implements the Sensor Data Subsystem that fuses input from expeditionary sensors, real-time and near real-time data from ground force C2 centers, weapon systems, and Joint Strike Fighter sensors into a common operational picture of the battlespace. Phase 1 Limited Deployment Capability was achieved in 4QFY11. Phase 2 will accommodate the integration of technologies necessary, allowing CAC2S to meet remaining ACE Battle Management and Command and Control requirements. Phase 2 completion will result in delivery of the full CAC2S Increment I capabilities; full deployment fielding began in FY17.

Although requirements beyond Increment I are not yet defined, it is envisioned that CAC2S will continue to be developed in an evolutionary acquisition approach with follow-on increments being defined and captured in subsequent Joint Capabilities Integration and Development System documents. Those increments will potentially focus on capabilities for an airborne node, integration of air traffic control functionality, ground based air defense node, advanced decision support tools, unmanned aerial systems ground station interoperability, integrated fire control, single integrated air picture, integrated architecture behavior model, integration with fifth generation aircraft, and full network enabled command and control.

Program Status

Phase 1 achieved Full Operational Capability in September 2013. Currently, 20 Phase 1 systems are deployed in units comprising the Marine Air Control Group of the Marine Aircraft Wing and the Marine Corps Communications and Electronics School in Twentynine Palms, California.

The government successfully completed Initial Operational Test and Evaluation of the Phase 2 systems in 2QFY16. The government released a Request for Proposal on 7 October 2016 and awarded a contract in FY17. The production contract will enable the program to field systems to attain the program's acquisition objective and provide software sustainment services to produce software builds that maintain the system's cybersecurity posture and address software corrections and capability improvements.

CAC2S' Top Technical Issues

1. Bandwidth Efficient Radar Measurement Data Distribution

CAC2S currently interfaces with United States Marine Corps (USMC) air surveillance radars using high bandwidth, Local Area Networks (LANs) that are connected by tactical fiber optic cables. The Project Management Office (PMO) seeks solutions that enables radar measurement data to be extracted from existing radar outputs/interfaces and compresses this data to enable it to be sent to CAC2S in a bandwidth efficient manner.

2. Bandwidth Efficient Networked Voice Communications Vehicles

The CAC2S AN/MRQ-13 Communications Subsystems (CS) currently interfaces with the CAC2S operations facility using high bandwidth, LANs that are connected by tactical fiber optic cables. As such each CS currently functions as a dedicated communications platform for the agency with which it is deployed. The PMO seeks bandwidth efficient solutions that enables the tactical voice radios contained within the CS to be connected to the CAC2S operations facility using fielded data radios/ wireless communications systems. Additionally, the preferred solution will allow bandwidth efficient networking of CS's across a WAN enabling users to remotely employ tactical voice radios contained within a CS.

3. Cross Domain Security Solutions

MACCS units are increasingly tasked to support exercises and operations that involve coalition forces. The PMO seeks NSA-approved, Marine

Corps Enterprise Network (MCEN) authorized, small form factor solutions that enables CAC2S to operate in cross domain environments, allowing exchange of select information with coalition partners through automated processes, while maintaining security requirements of the discrete network domains.

4. Small Form Factor CAC2S

CAC2S is designed to operate as main unit MACCS agencies (DASC, TACC, TAOC). These agencies often deploy smaller, mobile, forward echelon detachments that require similar information and capabilities (or a subset) that are available with a main unit. Meanwhile, transport and employment considerations for forward echelon forces severely limits the SWaP/footprint of the equipment that these detachments can deploy. The PMO seeks solutions that minimize the footprint of equipment required to employ CAC2S capabilities with forward echelon detachments. The preferred solution will consider environmental conditioning and power consumption/generation factors that tend to increase a system's footprint due to the required addition of ancillary equipment.

5. Contextual Search Engines

CAC2S processes inputs from aircraft, sensors, data links, and other C2 systems. The data is stored and fused in a global track file and displayed to the operator for situational awareness and decision making. Typically, operators in C2 systems get overwhelmed by "too much information" and suffer from the "glare" of information. Data typically flows through the system, but the operator cannot locate or access the data when it is needed. The PMO seeks technologies that can discern the themes and relationships among data in unstructured content. Search results can identify relevant results based on context, not just keyword matches, by examining contents of a document as well as the files by which it is surrounded.

Common Aviation Command and Control System (CAC2S)

August 2019

AN/MRQ-13

OPFAC

AC2S

Program Description

Common Aviation Command and Control System (CAC2S) modernization efforts replaces existing Marine Air Command and Control System (MACCS) equipment. Phase 1 fielded a product baseline Processing and Display System (PDS) and Communications System (CS). Phase 2 provides the integration of sensor capabilities and provides an Air Command and Control Subsystem (AC2S). Fielding of Phase 2 completes CAC2S Increment 1.

Program Status

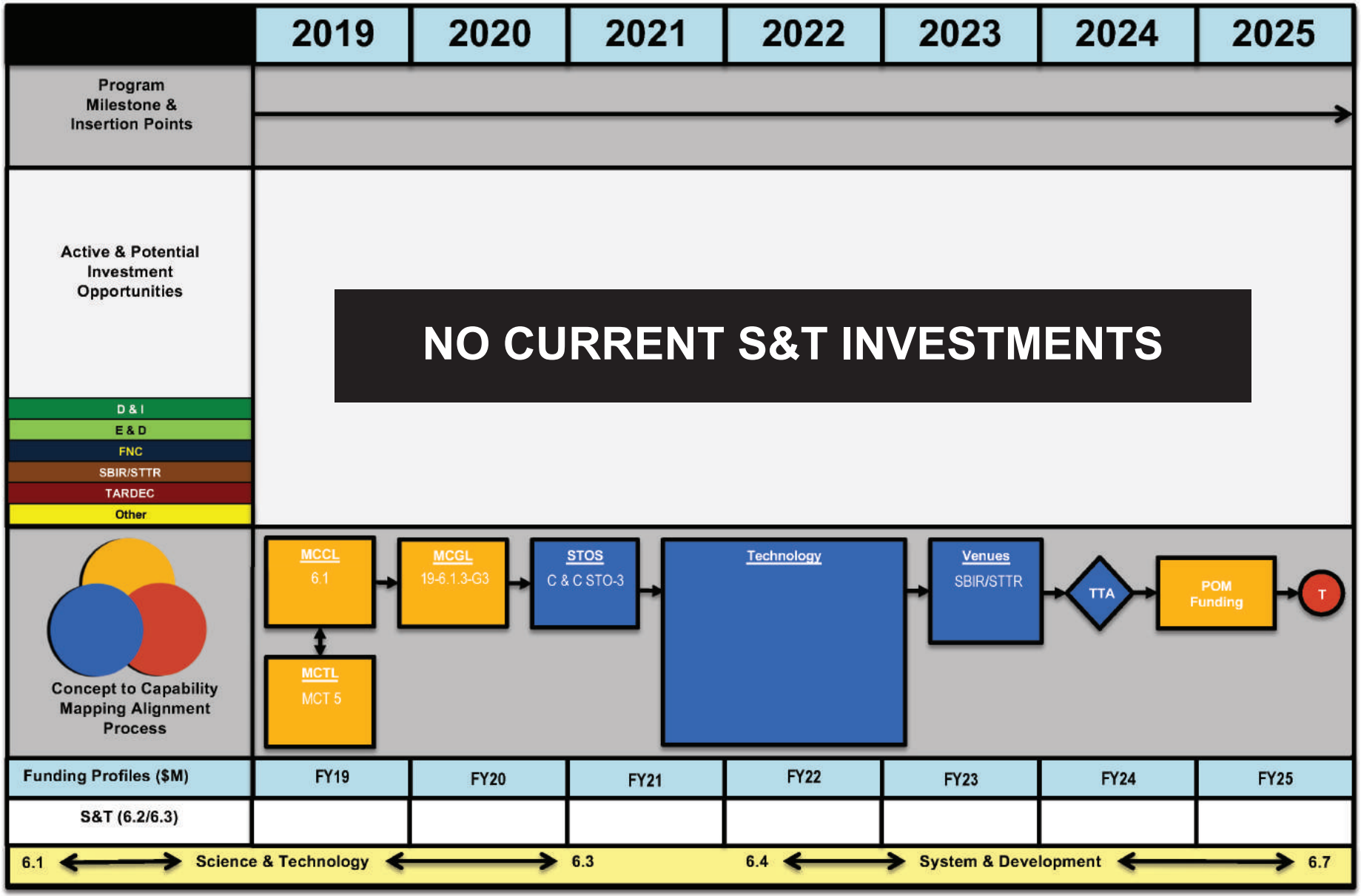
- AAO 50 systems
- Authority to Operate (ATO) valid through 31 Jan 21
- Updating MRQ13 suite for radios and communications infrastructure planned

Key Events

- Full Deployment (FD) event planned for 1QFY21
- Full Rate Production completes May 2020
- ECP 20-01 HF Radio (PRC 160) planned implementation and fielding 3QFY20

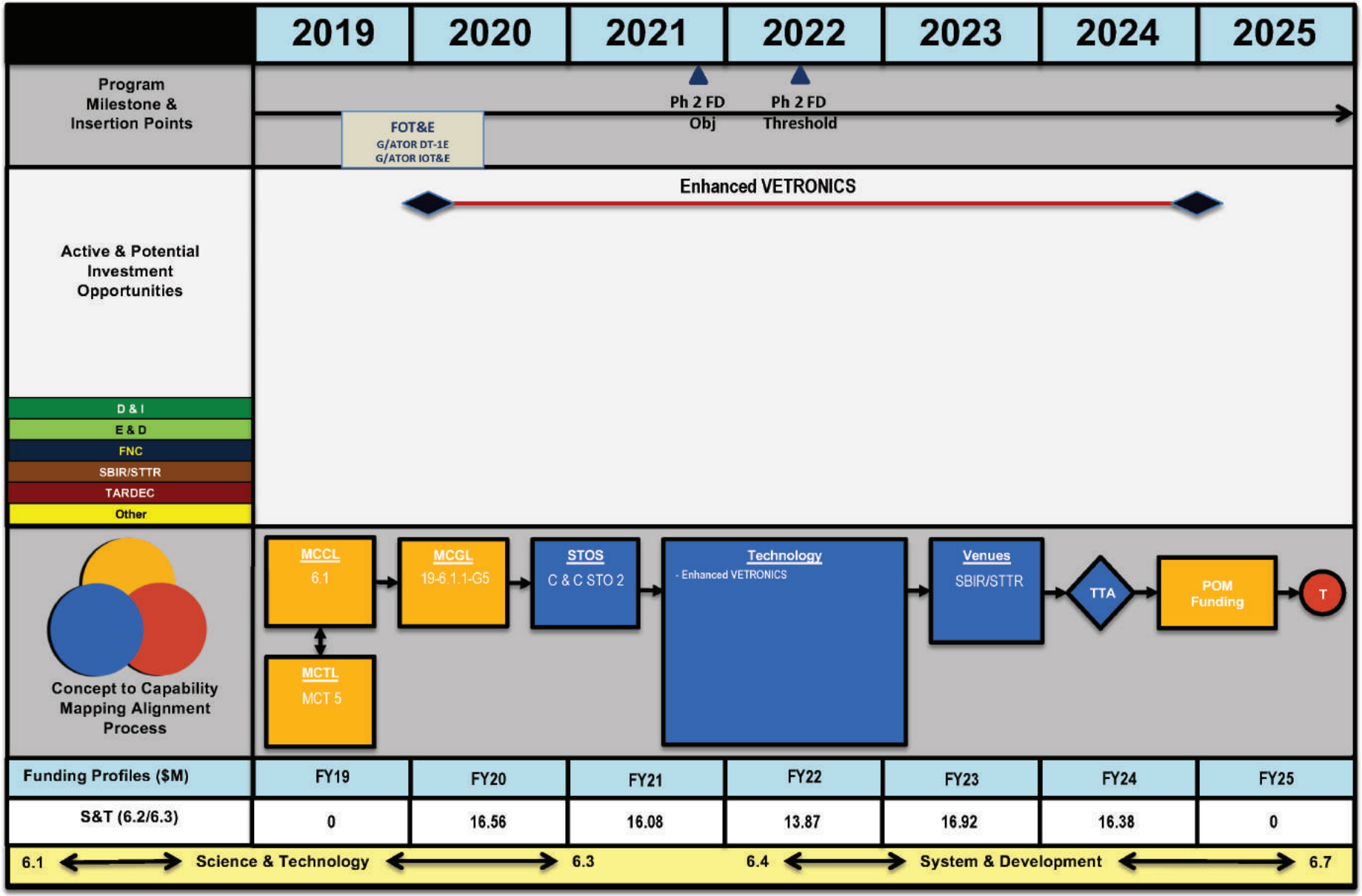
CAC2S Technical Issue #1

Bandwidth Efficient Radar Measurement Data Distribution



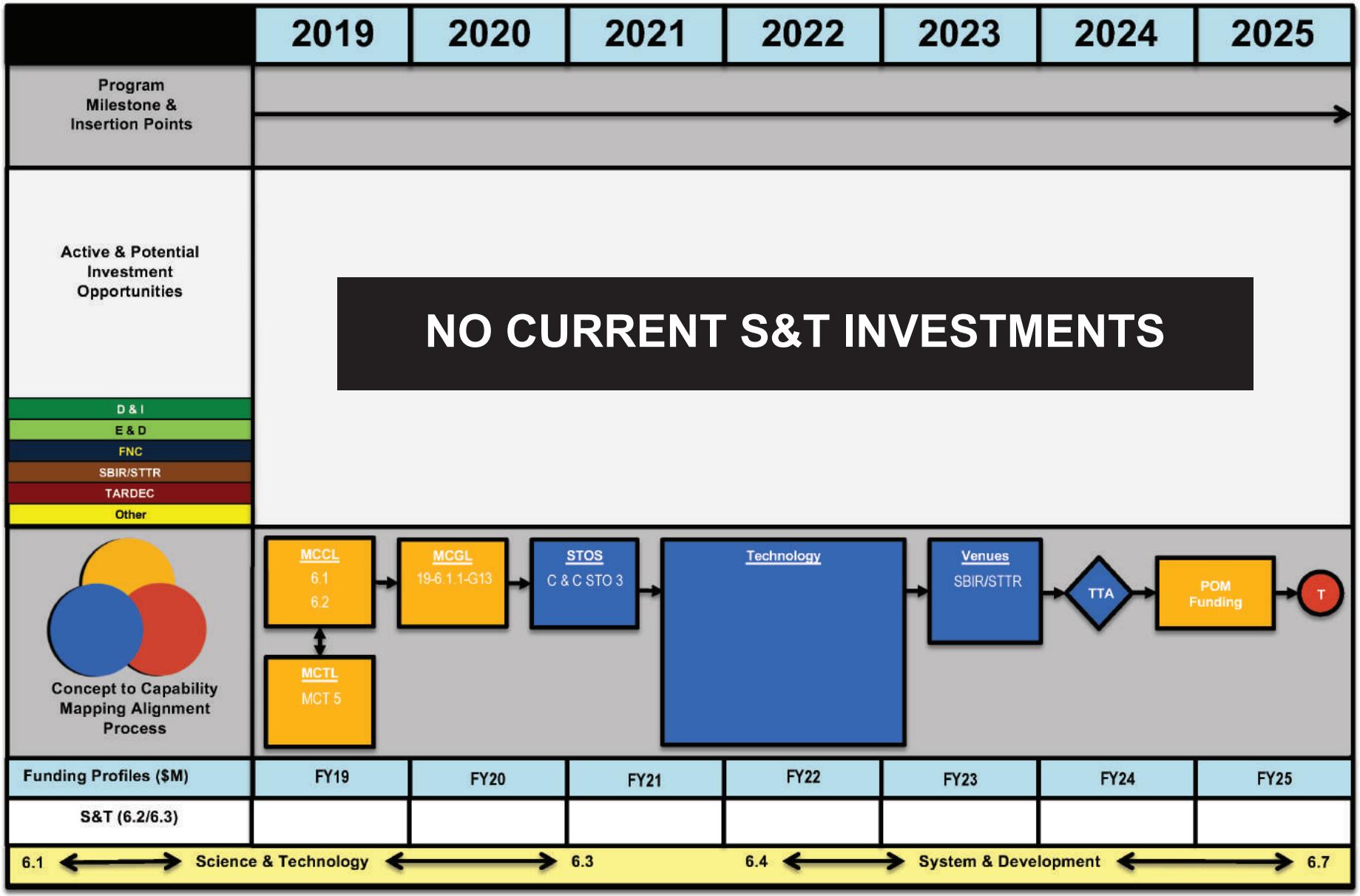
CAC2S Technical Issue #2

Bandwidth Efficient Networked Voice Communications Vehicles



CAC2S Technical Issue #3

Cross Domain Security Solutions



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Section 8.4

GROUND BASED AIR DEFENSE

Ground Based Air Defense

Program Background

The Marine Corps' organic GBAD capabilities are centered on the Low-Altitude Air Defense (LAAD) Battalions of Marine Air Wings (MAW). LAAD battalions currently use the FIM-92 Stinger missile, originally fielded in 1981 and upgraded since to Block I configuration, as its primary weapon system for air defense. It is expected that the Stinger missile will be the primary GBAD asset for the near future, and the missile is currently undergoing a Service Life Extension Program (SLEP) to maintain its operational effectiveness and longevity. An Analysis of Alternatives (AoA) for the GBAD Future Weapon System (FWS) has been completed and resulted in a Capability Development Document (CDD) in FY18. The CDD outlines an agile and cost-effective, detect, track, identify, and defeat capability against low-altitude, observable, and low-radar cross-section air threats.

Programs and projects included in the GBAD portfolio are:

- Stinger Missile SLEP
- Advanced Man-Portable Air Defense (A-MANPADS) System Fire Unit Vehicles (FUV)/Section Leader Vehicles (SLV)
- LAAD C2
- Stinger Night Sight Replacement
- Identification Friend or Foe Mode IV Replacement
- GBAD FWS

Program Status

Stinger Missile SLEP

A Stinger Missile SLEP began in FY14 and is scheduled to complete delivery in 4th Qtr FY-20. The SLEP is essential and required to meet the War Reserve Munitions Requirement and to provide sufficient training rounds after 2019. The SLEP is a joint effort with the Army's Program Executive Officer – Cruise Missile Defense System to prolong the life of the Stinger Missile by replacing aging components such as the flight motors and missile energetics.

A-MANPADS Increments 0 & I

A-MANPADS was designated an Abbreviated Acquisition Program (AAP) in 2005 and is executing a single-step to full capability acquisition strategy by integrating commercial off-the-shelf and NDI subsystems. The concurrence to pursue the full Approved Acquisition Objective for 38 SLV and 143 FUV was received in 2015. An Engineering Change Proposal (ECP) approving the transition to the HMMWV M1114 for all A-MANPADS FUVs, to

rectify obsolescence and operational deploy ability of the previous chassis. Included the ECP was the replacement solution for the Harris Communication secure tactical wireless capability, SECNET-11, which reached obsolescence and is being replaced with the AN/PRC-152A radio.

LAAD C2

A-MANPADS vehicles contain hardware and software for a tactical data link capability, which allows the LAAD BN to connect to various C2 agencies to receive an air picture down to the LAAD Fire Teams. The fielded datalink capability is currently supported by a Joint Range Extension (JRE) Sustainment contract, however; PM GBAD is exploring the Army's Forward Area Air Defense (FAAD) C2 as a replacement for the current JRE system. FAAD C2 will allow PM GBAD to field government owned software and buy down risk for C2 in the MADIS family of systems. Validation testing of FAAD C2 took place September to October 2018 and will inform the Program Office's decision to continue down that procurement path.

Stinger Night Sight Replacement

The AN/PAS-18 Stinger Night Sight is being replaced by the AN/PAS -13V(2) updating the software to contain the stinger reticle. The AN/PAS -13V(2) will be replaced with a system yet to be identified by the US Army and USMC Program Office Optics, that will provide greater target resolution and detection capability against the full spectrum of threats to include UASs.

GBAD FWS

The GBAD Program Office is currently investigating potential kinetic and non-kinetic capability to counter the full spectrum of threats to include UASs. Efforts include the GBAD On-the-Move (OTM) Future Naval Capability program, funded by the Office of Naval Research and developed by Naval Surface Warfare Center, Dahlgren, Virginia. This effort is investigating the feasibility of hosting a directed energy solution on tactically relevant vehicles such as the JLTV or HMMWV.

GBAD's Top Technical Issues

1. Counter Unmanned Aircraft System

Based on the proliferation of inexpensive low, slow, and small UAS; a cost effective kinetic and/or non-kinetic counter UAS capability is required to negate the threat at the system's weapon keep out or sensor ranges. The counter UAS system should provide a low cost per shot system with a high probability of kill against a group 1 UAS.

2. LAAD C2

The capability to disseminate an air picture down the LAAD fire team for early warning and cueing purposes is an enduring requirement. PM GBAD has a requirement to field a C2 capability to the LAAD community to support the evolution of current GBAD capability to what the MADIS family of systems will provide.

3. Stinger Night Sight Replacement

Enabling technologies are needed to produce a lightweight, compact night sight, compatible with the stinger missile and suitable to achieve detection and identification of thermal targets (i.e. Type 1-3 UAS and rotary/fixed-wing aircraft) at ranges suitable for man-portable air defense operation. Technologies currently identified as being required are 1) lightweight, quiet, and efficient micro chiller that can be incorporated into a hand held Mid Wave IR thermal sight; 2) High Density Focal Plane Array (16:9 ratio of 1280 or 1920 horizontal pixels) with small 12 micron or smaller pixel pitch; and 3) lightweight compact optical zoom that provides a 20-degree Field of View for missile engagement and narrow FOV for target identification.

GBAD Advanced-Man Portable Air Defense System (A-MANPADS)

August 2019

Program Description

GBAD A-MANPADS provides close-in, low altitude, surface-to-air fires, and command and control in defense of the MAGTF Commander's designated vital areas

- FUV: The primary mobile platform for A-MANPADS; it is the mobile firing component of the GBAD system integrated on an up-armored M1114 capable of transporting four Stinger missiles and a turret mounted M-240B or M2 machine-gun. The FUV receives queuing from SLV via tactical data link (TDL). The AAO is 143 FUVs.
- Section Leader Vehicle (SLV): The C2 component of the ground based air defense system and employs a Section Leader Gateway for communicating with higher HQs, distributing the air picture and providing targeting data to the FUV via TDL. The AAO is 13 SLVs.
- Stinger Missile: The primary weapon system for executing close in low altitude surface-to-air fires.

Program Status/Issues/Concerns

- **Fire Unit Vehicle (FUV):** Completed fielding and training Operating Forces and the Air Defense School House.
- **SLV:** Continuing sustainment and engineering efforts to maintain C2 capability for the LAAD community.
- **Stinger Missile:** Stinger Missile Service Life Extension Program (SLEP): Stinger Blk I missiles undergoing Army sourced SLEP. **Identification Friend or Foe (IFF):** Undergoing upgrade to Mode 5 encryption via Army production contract
- **Ground Support Equipment (GSE):** Maintain GSE serviceability

Key Events

• Battalions and Air Defense School House Stinger FIREXs	FY19
• Stinger Blk I SLEP missile delivery	FY19
– Commenced FY17; concludes	4QFY20
• JRE Support Contract	4QFY19
• GSE Health Assessment	1QFY20
• IFF Belt Pack Mode 5 IOC	2QFY20

GBAD Counter-Unmanned Aerial System(C-UAS) Fixed Site

August 2019

Program Description

- GBAD C-UAS Fixed Site will deliver kinetic and non-kinetic C-UAS capabilities to defeat the full spectrum of Low-Altitude Low Observable/Low Radar Cross Section threats to MAGTF commander's vital areas and USMC CONUS & OCONUS Critical Infrastructure.
- The program consists of modular and scalable components designed to detect, track, ID and defeat UAS.
  - Expeditionary Marine Air Defense Integrated System (E-MADIS) for dismounted and fixed site operations in Theater
  - Installation Marine Air Defense Integrated System (I-MADIS) for permanent operation aboard USMC Installations
  - Compact Laser Weapon System (CLaWS) provides Hard Kill C-UAS capability in defense of forward deployed fixed site operations
  - Man-packable C-UAS capability (Modi and Skyview Man Portable)

Program Status

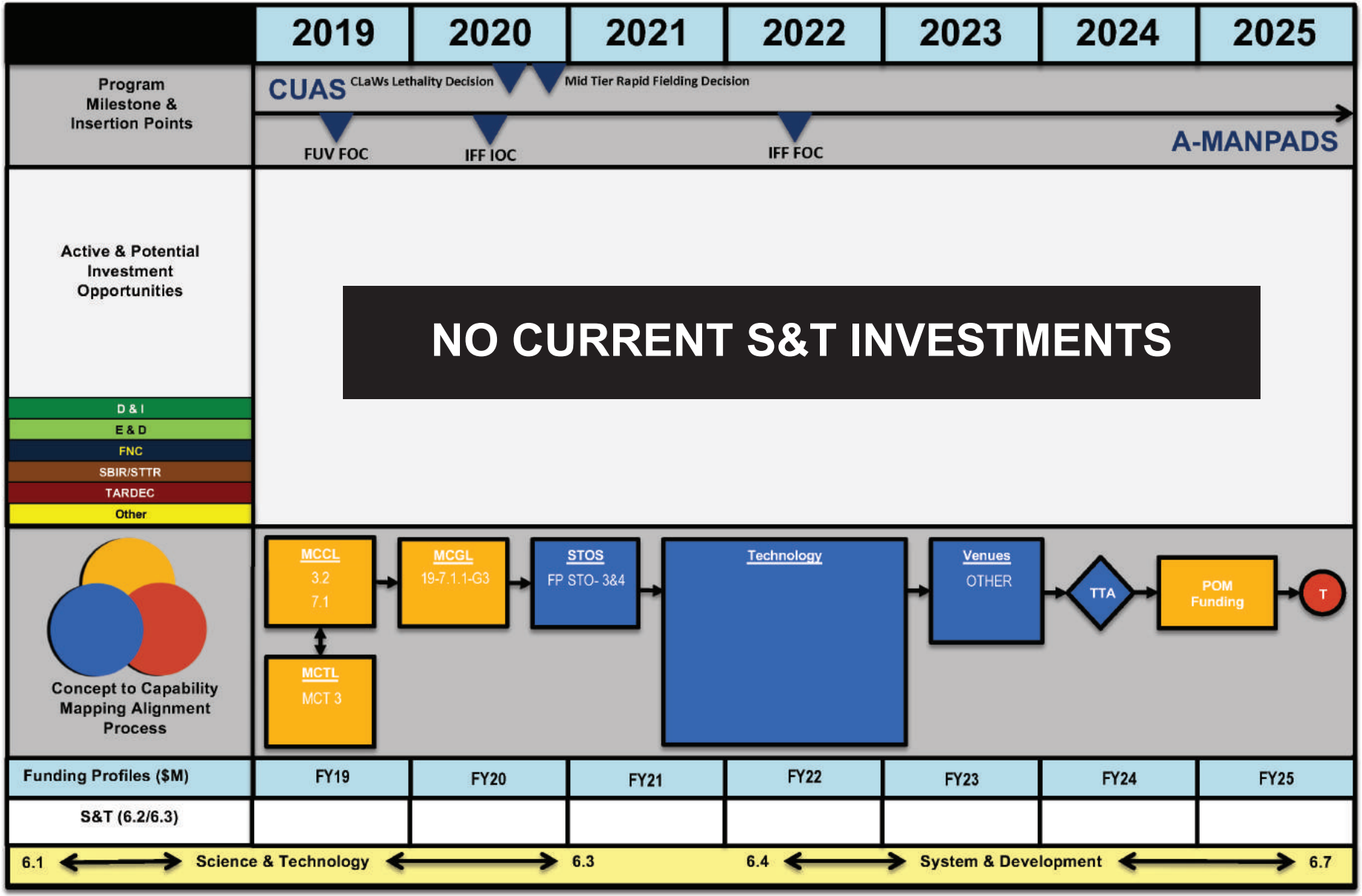
- Delivered capability:
  - 6 E-MADIS (Fixed site C-UAS kit)
  - CLaWS
    - (4) MARCENT FY19
    - Achieved operational status 3QFY19
  - (16) MODi (man-wearable RF defeat) to MARSOC and MARCENT
- I-MADIS requirements in development
  - Anticipate Capabilities Document approval 4QFY19
- Funding
  - Currently funded for (1) system in FY20
  - FY20 UPL submitted for (4) E-MADIS
    - Supports payback for North and South sites and PACOM systems

Key Events

- Rapidly spiraling additional capabilities through 4QFY19
  - Hard-kill solution with 1v1 UAS interceptor (Coyote) and Smart Shooter procurement
  - Operational status achieved with 2kW CLaWS integrated with Army FAAD/C-RAM C2
  - 5kw laser upgrade for fixed site
  - High Powered Microwave UAS interceptor for 1v1/SWARMS
- Continued training for fielded systems
  - North and South Site
    - Monthly classroom training
    - Quarterly practical application
  - PACOM
    - Semi-annual training
- I-MADIS fielding starting in FY21

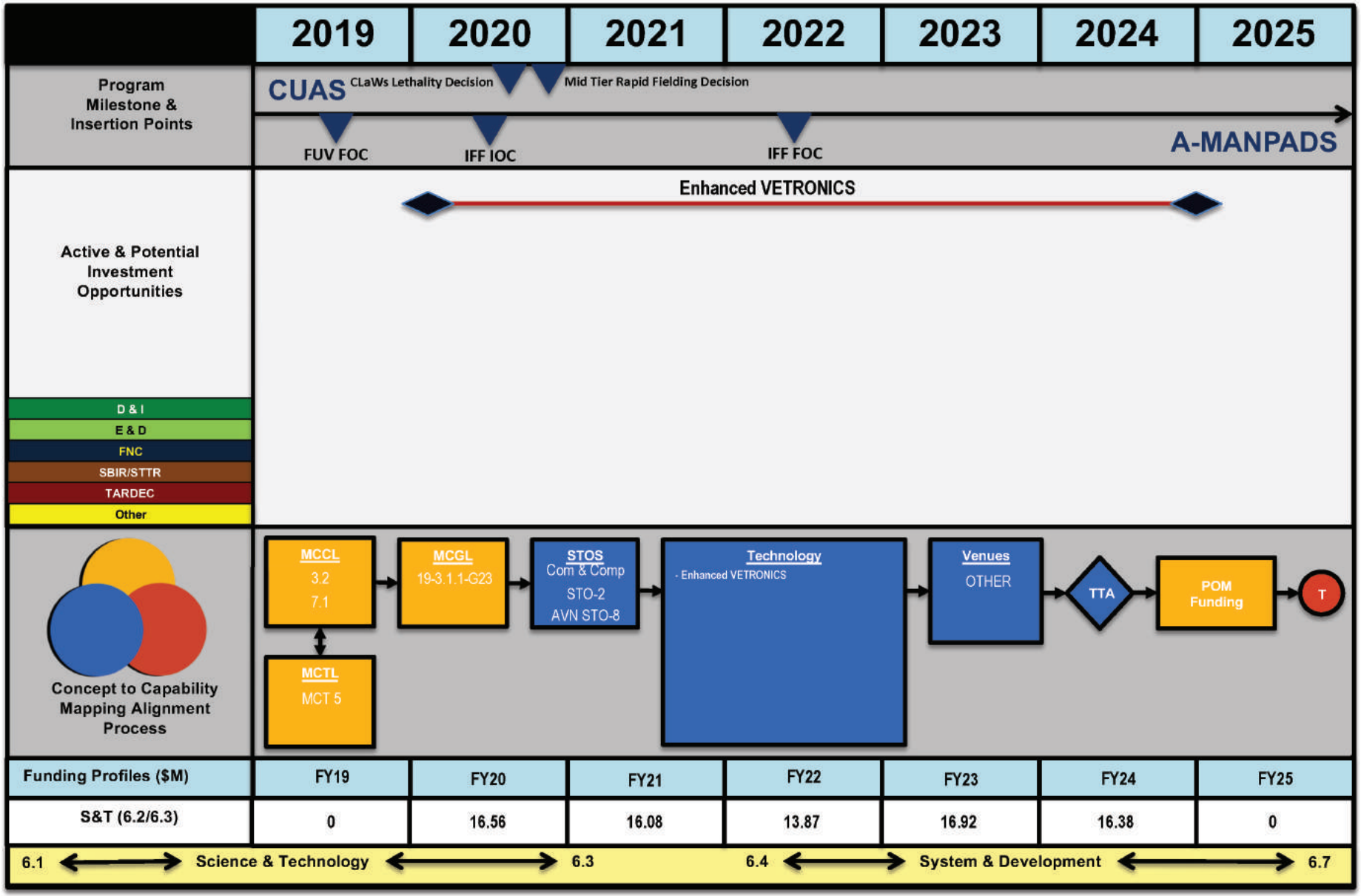
GBAD Technical Issue #1

Counter Unmanned Aircraft System (UAS)



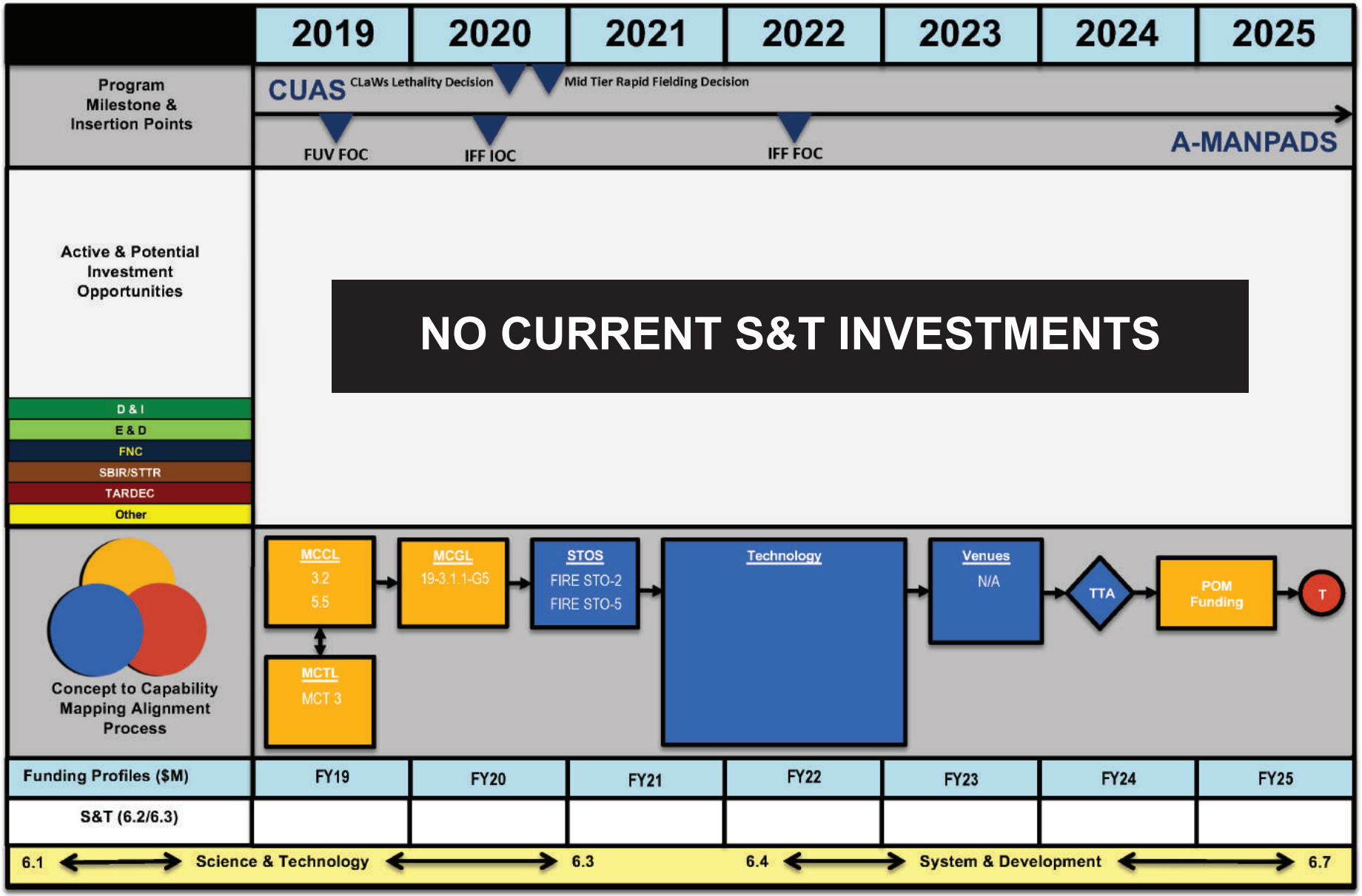
GBAD Technical Issue #2

Low-Altitude Air Defense (LAAD) C2



GBAD Technical Issue

#3 Stinger Night Sight Replacement



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Section 8.5

GROUND/AIR TASK ORIENTED RADAR

G/ATOR

Program Background

G/ATOR is an expeditionary, lightweight radar employed by units within the Air Combat Element (ACE) and Ground Combat Element (GCE) of the MAGTF. Within the ACE, G/ATOR will provide enhanced situational awareness and additional capabilities to conduct short-medium range radar surveillance and air defense. Within the GCE G/ATOR will provide ground weapons locating capability for counterbattery and counter-fire missions. G/ATOR provides real-time radar measurement data to the CAC2S, Composite Tracking Network, and Advanced Field Artillery Tactical Data System. This system contributes to sea-based air defense sensors and Command and Control capabilities to provide Naval and Joint forces with an expeditionary radar that extends landward battle space coverage.

G/ATOR is a single materiel solution for the mobile Multi-Role Radar System and Ground Weapons Locating Radar (GWLR) requirements and replaces five legacy radar systems. G/ATOR is a three dimensional, short/medium range multi-role radar designed to detect unmanned aerial systems, cruise missiles, air breathing targets, rockets, artillery, and mortars.

G/ATOR is comprised of three major subsystems: the Radar Equipment Group (REG), Communications Equipment Group (CEG) and Power Equipment Group (PEG). The REG is an integrated radar and trailer towed behind a MTVR. The CEG is a communications and radar control system transported on the armored M1152A1 High Mobility Multipurpose Wheeled Vehicle. The PEG is a pallet assembly containing a tactical generator, cables and ancillary equipment transported on the bed of the MTVR.

G/ATOR is being developed and fielded in three blocks and will be employed by the MAGTF across the range of its capabilities. Air Defense/Surveillance Radar G/ATOR Block 1 (GB1) provides capabilities in the short range air defense and air surveillance mission areas; Ground Weapons Locating Radar G/ATOR Block 2 provides the ground weapons locating capability for counterbattery and counter-fire missions and Expeditionary Airport Surveillance Radar G/ATOR Block 4 (GB4) will address Air Traffic Control missions. GB 4 is not included in the Acquisition Program Baseline. Resourcing is planned for future budget builds. G/ATOR Block 3 was a series of enhancements that are now incorporated into other blocks. The term Block 3 is no longer used.

Program Status

The AN/TPS-80 G/ATOR system received a successful Milestone C in March 2014 from the Assistant Secretary of the Navy (Research, Development and Acquisition). Northrop Grumman Mission Systems has delivered six Gallium Arsenide (GaAs) technology LRIP Systems and is under contract to deliver nine G/ATOR LRIP systems with Gallium Nitride (GaN) technology. The total Approved Acquisition Objective is 45 systems. The delivery of six GaAs LRIP systems was completed in January 2018. The delivery of GaN LRIP systems began in July 2018. The Initial Operational Capability (IOC) for GB1 and GB2 were achieved in FY19.

G/ATOR's Top Technical Issues

1. Lowering Manufacturing Costs

Technologies are needed that reduce manufacturing cost across multiple areas of production, including: 1) Air ducts that provide precise mounting and cooling of the Transmit/Receive (T/R) modules and array elements (the air duct is very time consuming to produce and assemble, and thus is very expensive); 2) T/R module packaging, which requires expensive materials and hermetic sealing that reduces yield; and 3) an active rectifier, which is required for clean power input to the system and which requires a multi-step, medium yield manufacturing process.

2. Increased Dynamic Range

Under certain adverse conditions, G/ATOR requires additional dynamic range. Dynamic range is limited by the third-order intercept point of the receive chain and the number of effective bits in its analog to digital converters. Increasing the dynamic range of these components would improve the G/ATOR performance in certain adverse (other than nominal) environments. Avenues of improvement include improvements in T/R module design, as well as receiver design.

3. Advanced Electronic Protection

The G/ATOR PMO is seeking advanced electronic protection technologies and techniques that will diminish G/ATOR susceptibility to electronic attack measures. This is an area for research into not merely what is available today to defeat the current electronic attack capabilities but also to look to the future, to predict the next generation of electronic attack means/methods and to develop techniques/technologies to negate or defeat them.

4. Diminishing Manufacturing Sources and Material Shortages (DMSMS)

With the advancement of electronics technology, the G/ATOR system has several components that require upgrading within LRIP and early Full Rate Production. Each of the processors will need to be refreshed to include the Pallet Support Electronics, Communications Control Processing Unit, Radar Signal Processor, Receiver Exciter Control Module , and Antenna Control Module. Changing processors will likely require a change to the Operating Systems (OS) so techniques and tools to transfer software between OS is needed. Additionally, some of the semiconductor components utilized in

the Waveform Generators and T/R modules are no longer produced in the same manner, design, or wafer size. These DMS items require redesigned LRUs that must be tested at the component, LRU, and system levels to ensure proper form, fit, and function within G/ATOR. Northrop Grumman is currently undertaking these tasks to ensure that G/ATOR remains operating at optimal performance.

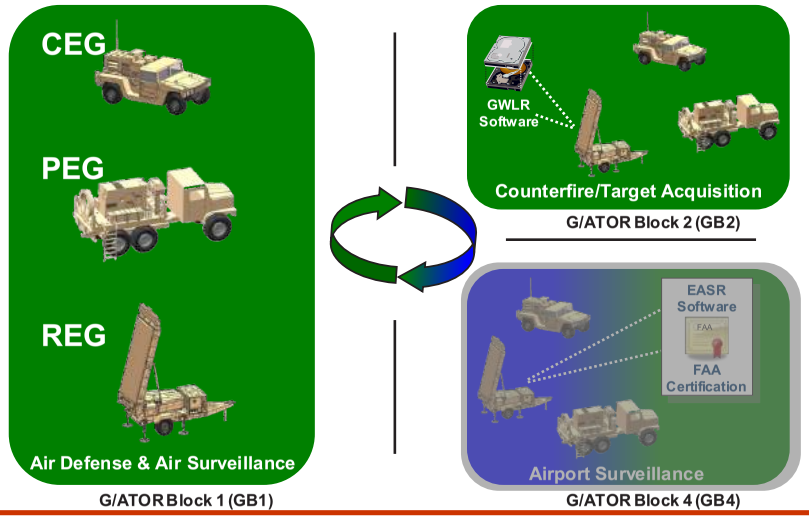
5. Improvements in Detecting, Discriminating and Tracking UAVs

The threat from UAVs has increased and technology enabling their detection and tracking is increasingly important. The G/ATOR system would benefit from advanced technologies and techniques that will increase G/ATOR's ability to both detect and identify UAVs. This would include improvements in detecting slow moving objects in the presence of clutter and the ability to discriminate UAVs as targets of interest from other slow moving objects such as birds, cars, and atmospheric phenomena.

Ground/Air Task Oriented Radar

August 2019

Acquisition Strategy



G/ATOR Description

- 3D, short/medium range multi-role radar designed to detect unmanned aerial systems, cruise missiles, air breathing targets, rockets, artillery and mortars
- Replaces five legacy radar systems with a single MAGTF solution
- Provides increased range, accuracy, tactical mobility and reliability

Program Status

Status

- 15 LRIP systems
- GB1 fielded 2 systems
- GB1 LRIP 7 temp-loan 4 Feb 19—4QFY19
- GB2 fielded 4 systems
- FRP Contract awarded 7 Jun 19—6 systems placed on order
- G/ATOR Block 4 (Expeditionary Airport Surveillance Radar (EASR)

Key Events

Recent History

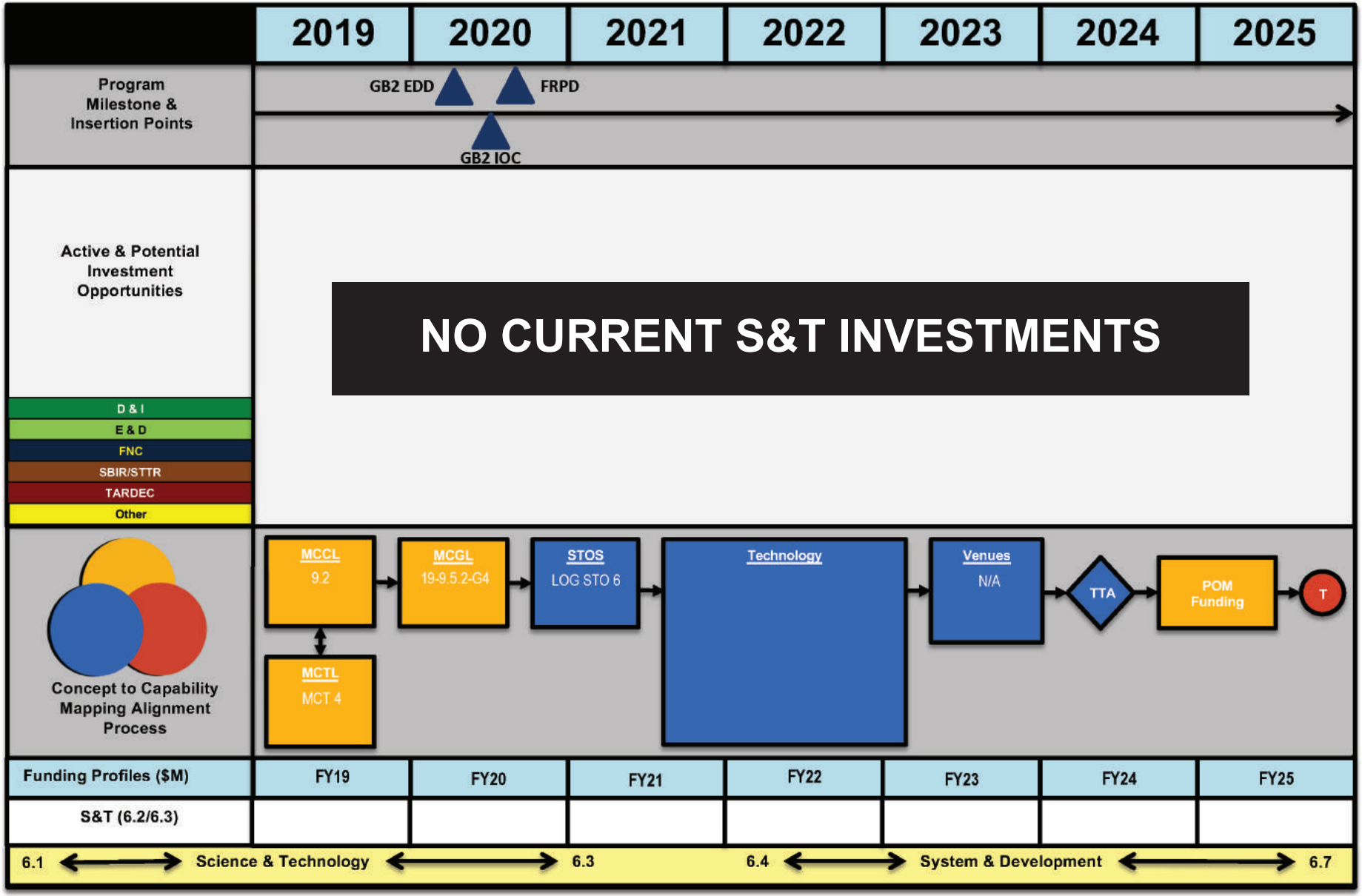
- G/ATOR Milestone C for GB1 and GB2 Mar 14
- GB1 IOC Feb 18
- GB1 integrated DT/IOT&E completed Oct 18
- GB2 integrated DT/IOT&E completed Dec 18
- GB2 IOC Mar 19
- Engineering Tests Apr/May 19 (~2 wks)
- FRP Decision May 19
- Spares Contract Award Jun 19
- FRP Contract Award Jun 19

Current/Upcoming Events

- Fielding 2 systems Aug 19
- Fielding 1 system Aug/Sep 19
- Receiving 4 systems in FY20

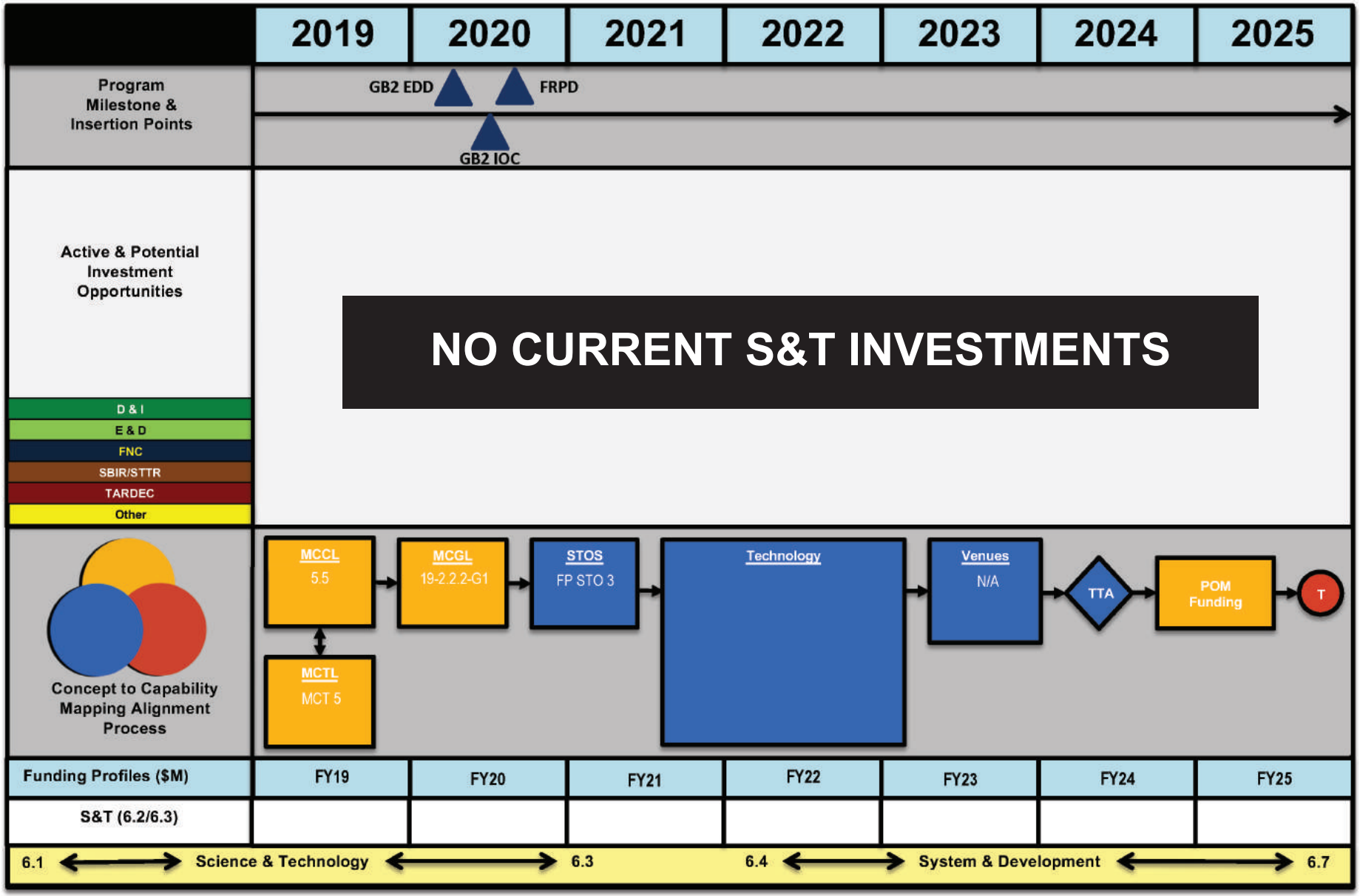
G/ATOR Technical Issue #1

Lowering Manufacturing Costs



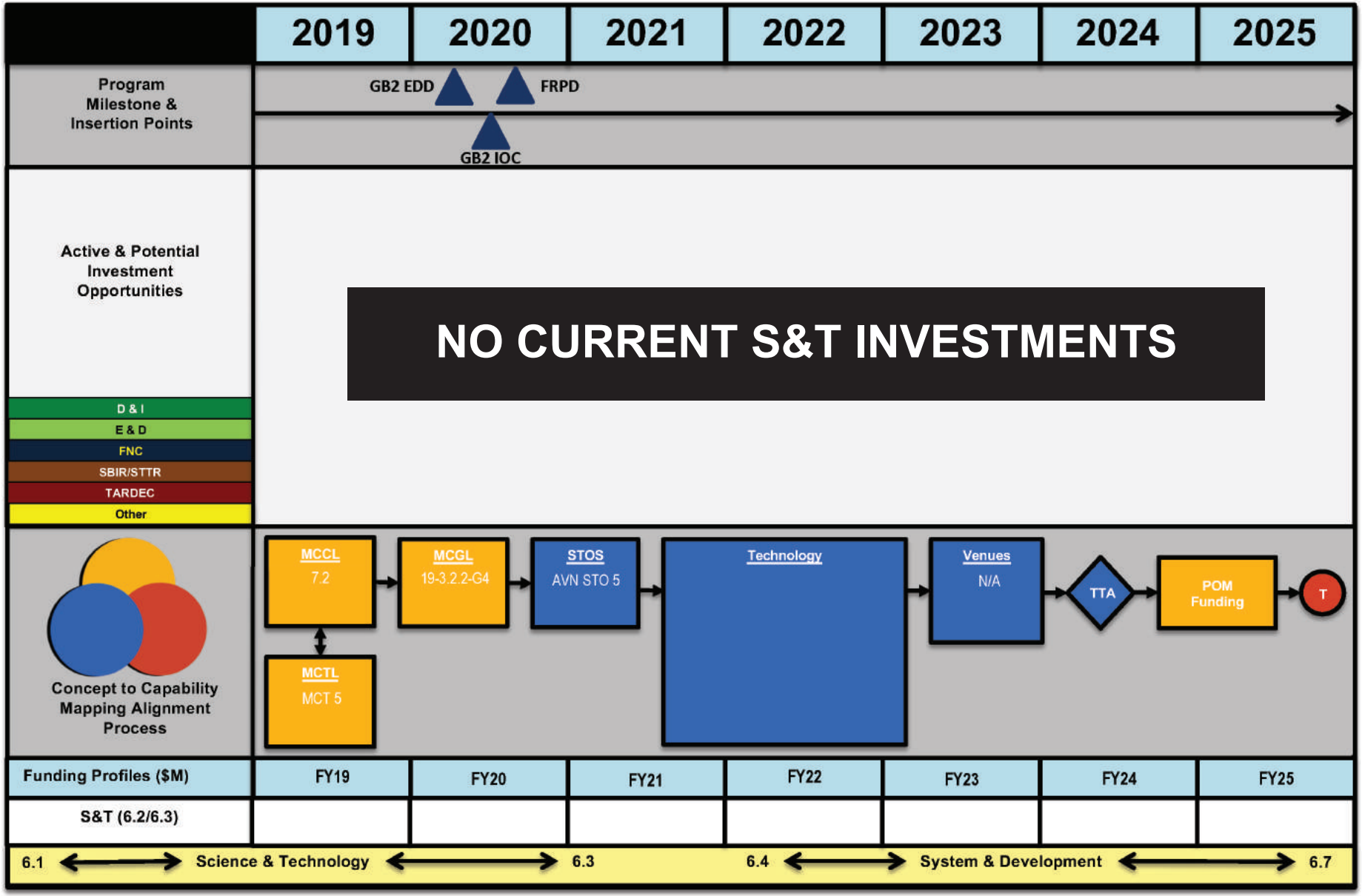
G/ATOR Technical Issue #2

Increased Dynamic Range



G/ATOR Technical Issue #3

Advanced Electronic Protection



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Section 8.6

JOINT LIGHT TACTICAL VEHICLE

A Joint Light Tactical Vehicle displays its ability to handle multiple terrain types by physically adjusting its suspension during a demonstration at the School of Infantry West, Marine Corps Base Camp Pendleton, California, Feb. 27, 2019.

Program Background

The JLTV is an ACAT IC Army-Marine Corps defense acquisition program that introduces a new generation tactical wheeled vehicle to replace a portion of the services' HMMWV fleet. The program's goal is to develop a new family of multi-mission light tactical vehicles with superior crew protection and performance compared to the current HMMWV fleet. The JLTV family of vehicles will balance critical weight and transportability constraints against performance, protection, and payload requirements, while ensuring an affordable solution for the Army and Marine Corps.

The development of the JLTV reinforces the services' approach to interoperable platforms that provide expeditionary and protected maneuver capabilities to forces that the HMMWV fleet of vehicles currently support. The JLTV will improve payload efficiency through state-of-the-art chassis engineering, enabling the vehicles to be deployed with the appropriate level of force protection through the use of scalable armor solutions. The JLTV program will minimize maintenance costs through increased reliability, and better fuel efficiency. JLTVs can be configured to support multiple mission packages derived from two base vehicle configurations: the four-door Combat Tactical Vehicle and two-door Combat

Support Vehicle. Commonality of components, maintenance procedures, and training among all vehicle configurations will also minimize total ownership costs.

Program Status

The JLTV program is currently in the Production and Deployment Phase. On 25 August 2015, Mr. Frank Kendall, former Under Secretary of Defense for Acquisition Technology and Logistics (USD AT&L) approved the Milestone C decision authorizing the program to enter into the Production and Deployment Phase and to proceed into LRIP. A production contract that included LRIP quantities was awarded to Oshkosh Defense that same day. The first LRIP test vehicle was delivered in September 2016. Production qualification and reliability qualification testing began during the 1QFY17, live fire test events began during the 2QFY17 and the Multi-service Operational Test and Evaluation (MOT&E) concluded in April, 2018. The Marine Corps is scheduled to achieve its IOC during the 1QFY20. Full Operational Capability (FOC) is scheduled for the 4QFY22.

JLTV's Top Technical Issues

1. Weight/Protection

The JLTV design meets competing requirements for a balanced solution of protection, payload, and performance. Although the JLTV armor system meets the functional requirements, reductions in weight and improvements in vehicle protection are desired. The program office is seeking lower weight and affordable survivability solutions for both the transparent and opaque armor systems, and is interested in evaluating active protection solutions.

2. Vehicle Network Architecture

The JLTV design was configured to support modularity and interoperability with existing and future combat enablers provided by other program managers throughout the DoD. Essential to this modularity and interoperability is the ability to provide an affordable vehicle network architecture that supports sharing of data resources for on-board systems. The vehicle network architecture delivers shared processing, common user interface screens, GPS data, remote radio control, electronic warfare system control, and weapon systems employment. The JLTVs design currently provides a network switch that can support multiple vehicle configurations, minimizes additional and/or re-wiring to support the new system's interfaces, and leverages shared processing (hosting virtualized software) to reduce additional hardware needs. The improved vehicle network solution must be scalable, interoperable, and forward-leaning in order to meet affordability constraints and the need for ever-increasing processing power. Therefore, the Marine Corps is seeking a low cost/affordable network switch which will provide a technically viable solution to provide for "plug-n-play" of additional C4 hosted solutions. Furthermore, solutions to remote radio control and growth in computer processing power in conjunction with expanded software (USMC-specific applications) capabilities are desired.

3. Noise Mitigation

The interior noise within the JLTV cabin can result in increased difficulty to communicate between personnel when an intercom system is not in use. The program office is seeking an affordable method to reduce internal noise. Primary noise sources include the engine alternator, vehicle exhaust, and drivetrain gearboxes.

4. Situational Awareness

The JLTV provides the required situational awareness (SA) outlined in performance documentation but the weight impact of additional transparent armor has limited the overall SA that is provided to the crew. To address this concern, the program office is seeking an affordable camera system to provide

360 degree SA for the crew. Desired capabilities include selectable and stitched video selection and non-thermal low light cameras. The desire is to use 3 or less cameras.

5. Tires

The expeditionary nature of the Marine Corps and JLTV leads to traversing challenging and unprepared terrain. Testing across varied terrain has resulted in damage to JLTV tires, primarily punctures in the tire sidewall. The program office is seeking a design that will reduce sidewall punctures from natural terrain features.

Joint Light Tactical Vehicle (JLTV)

August 2019

Program Description

JLTV provides a family of light tactical vehicles for combat mission roles, providing increased survivability, mobility, payload and reliability over the current family of HMMWVs. JLTVs provide a high level of scalable protection, improved sustainment and net-ready maneuver platforms which are tactically mobile across all terrain.

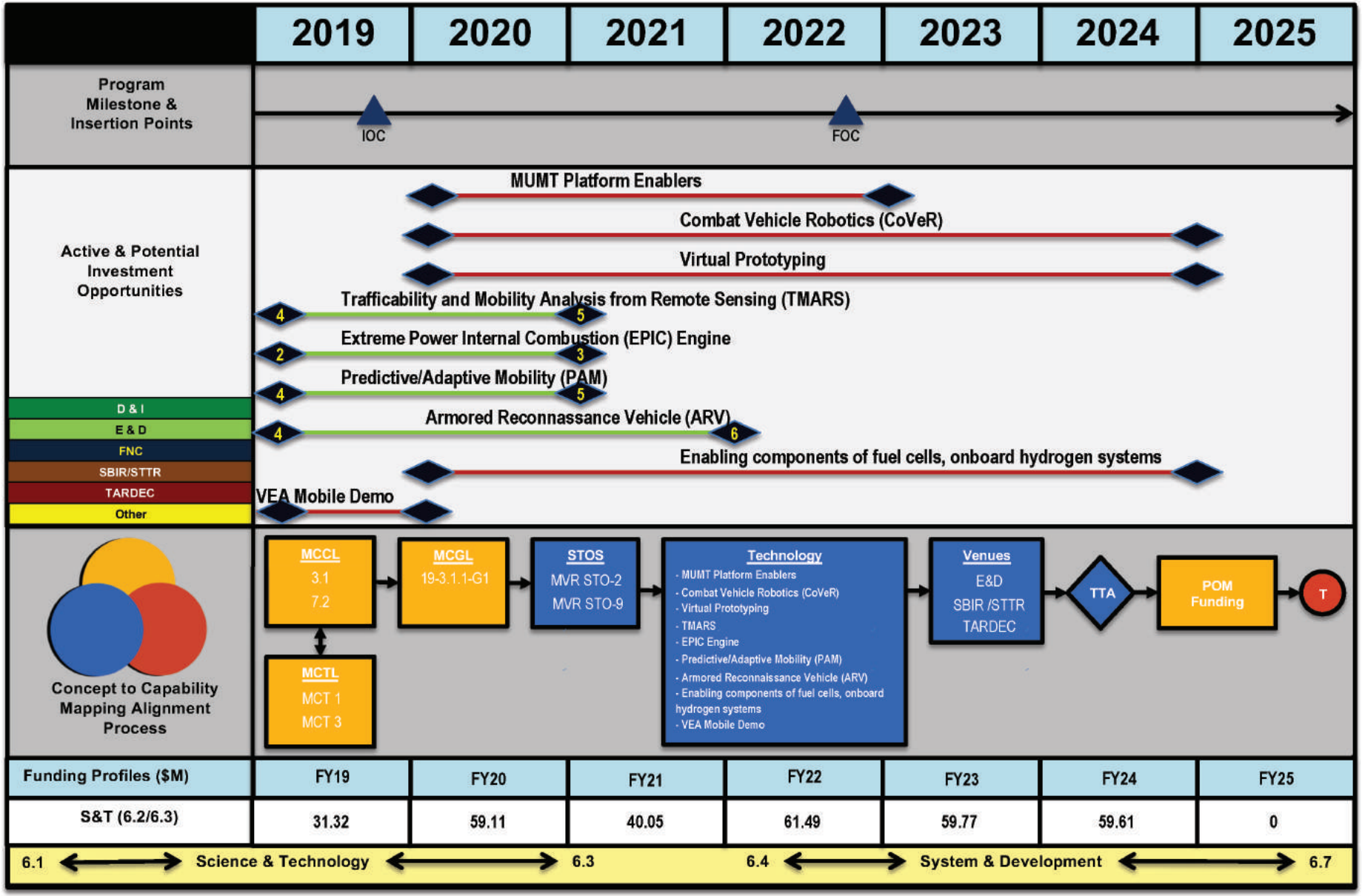
Program Status

- Status:
  - JLTV approved for fielding 12 Dec 18
  - 29 Mar 19 CMC endorsed establishing a unitary JLTV fleet by 2030
    - USMC Approved Acquisition Objective increased from 9,091 to 15,390 vehicles
    - Accepted risk in HMMWV program until replaced by JLTV
  - JLTV met requirements for Full Rate Production on 20 Jun 19
  - USMC has met requirements for IOC; awaiting CD&I declaration

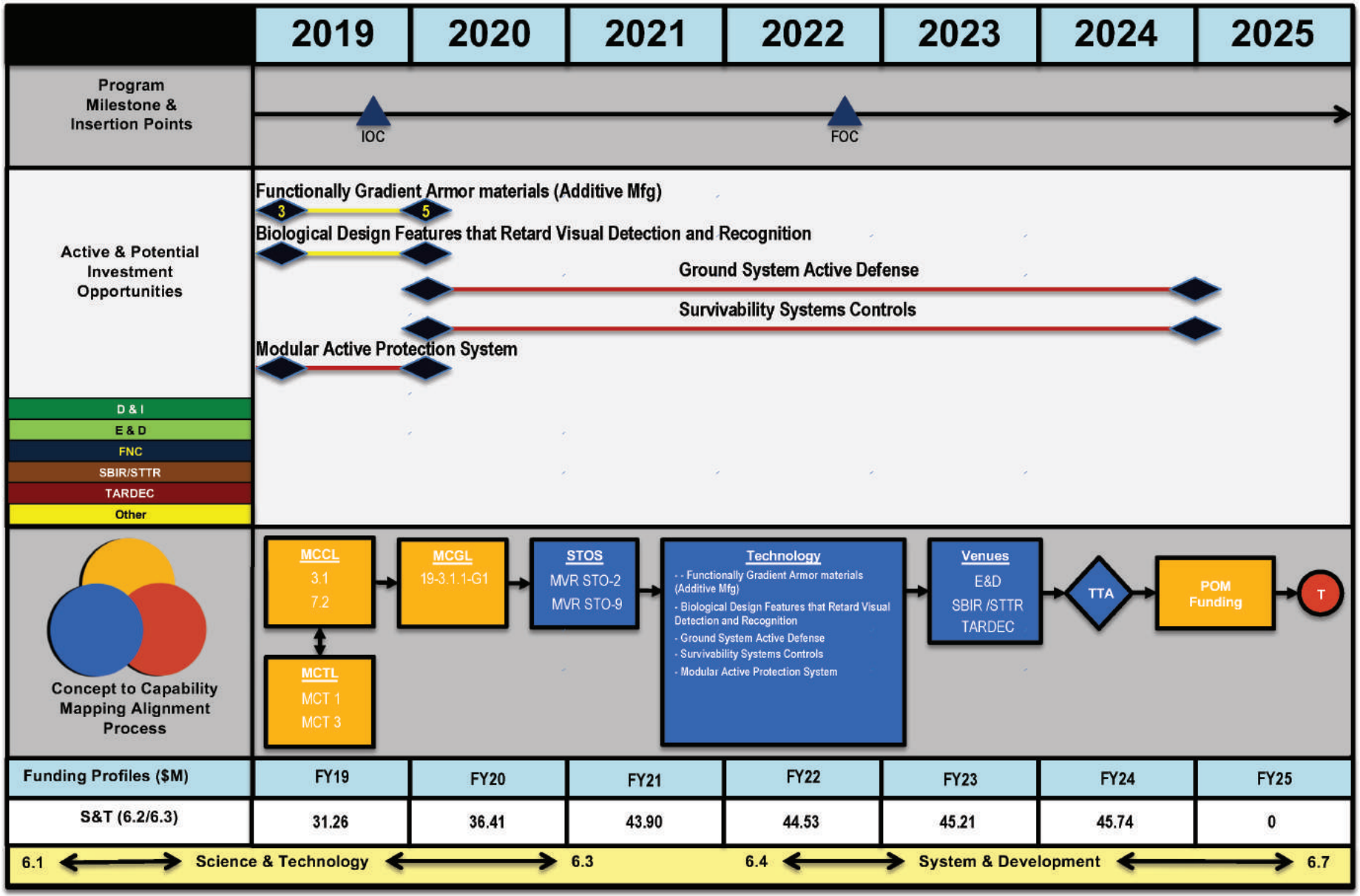
Key Events

• JLTV fielding to 3rd Battalion, 8th Marines	Jul 19
• USMC Initial Operational Capability	Jul 19
• FOT&E with 3rd Bn, 8th Marines	Aug 19
• MTMIC JLTV Training Package, ready to train	Oct 19
• I & III MEF initial fielding	Sep 19
• USMC Full Operational Capability	Sep 22

JLTV Technical Issue #1
Weight/Protection



JLTV Technical Issue #1
Weight/Protection

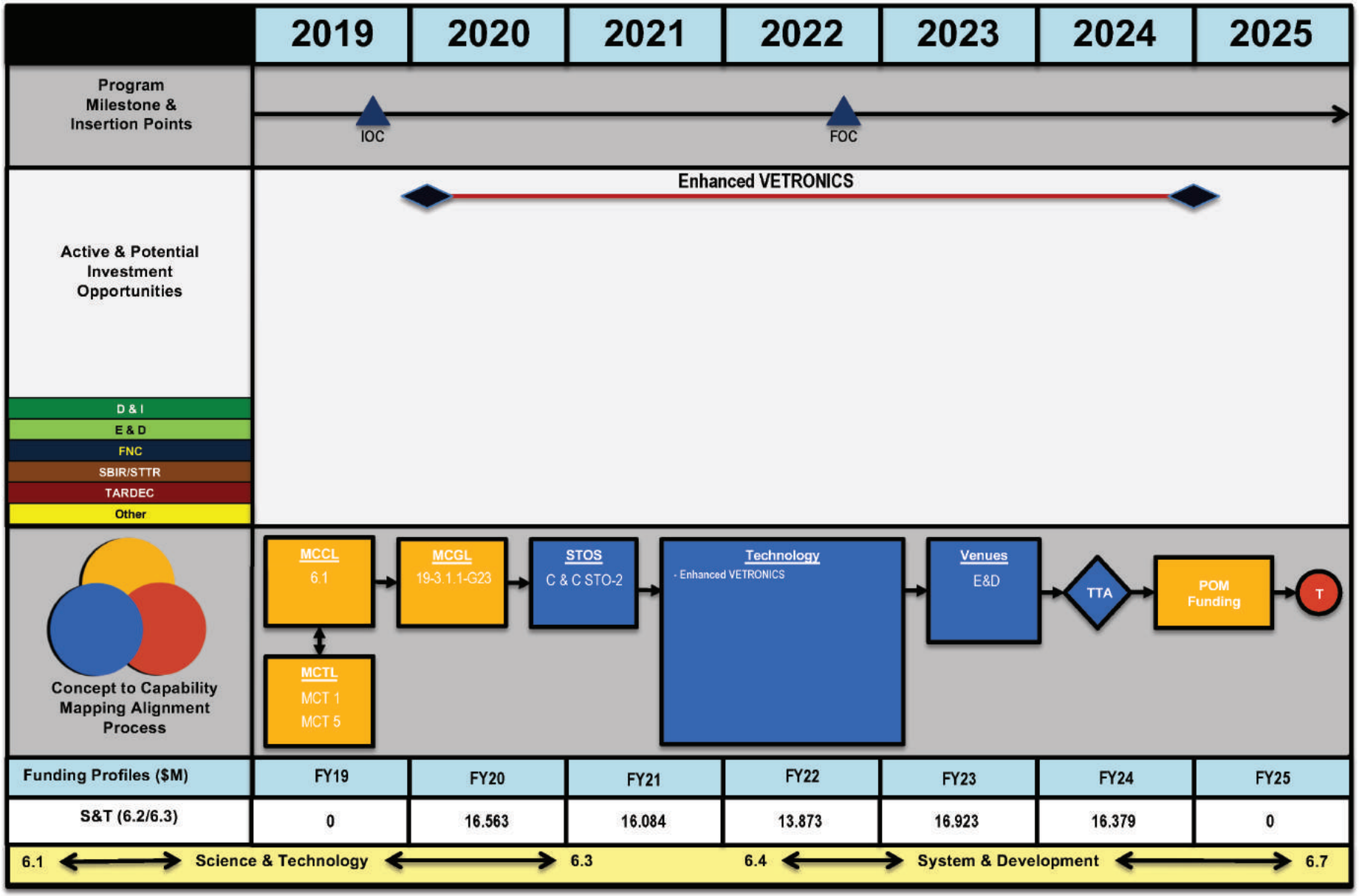


Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	31.26	36.41	43.90	44.53	45.21	45.74	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

JLTV Technical Issue #2

Vehicle Network Architecture

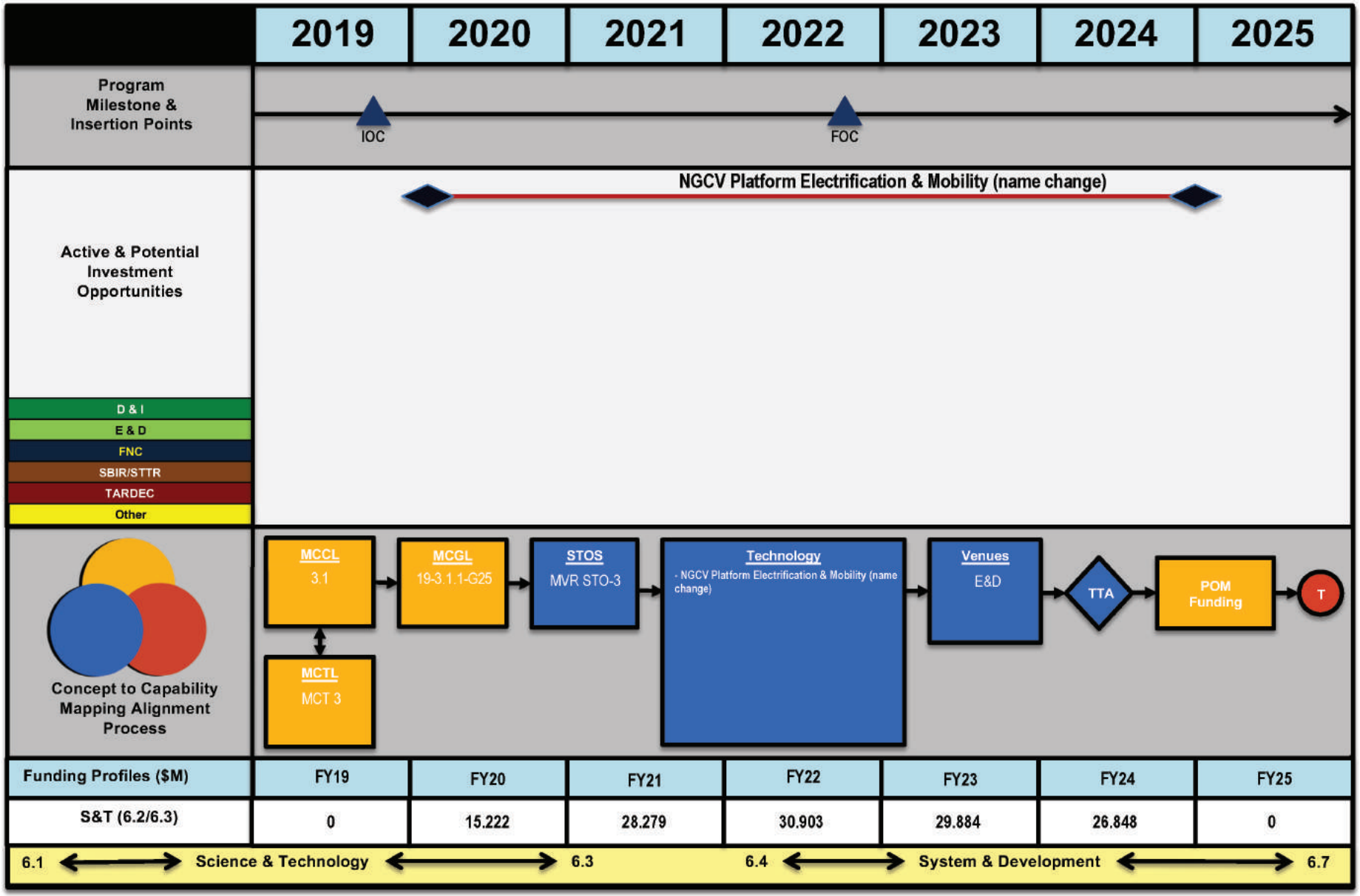


Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	0	16.563	16.084	13.873	16.923	16.379	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

JLTV Technical Issue #3

Noise Mitigation



Section 8.7

LOGISTICS VEHICLE SYSTEMS REPLACEMENT

Logistics Vehicle Systems Replacement

Program Background

The LVSR serves as the Marine Corps' heavy logistics vehicle and transports large quantities of supplies across the battlefield. The LVSR is deployed in the Marine Logistics Group, Marine Divisions, and Marine Aircraft Wings.

The LVSR includes three variants: MKR 18 Cargo, MKR 16 Tractor, and MKR 15 Wrecker. The MKR1 18 Cargo has a 22.5-ton (20,412 kilograms) on-road/16.5-ton (14,969 kilograms) off-road payload, a 600-horsepower diesel engine, integrated control and diagnostic electronics, and factory-installed armor integrated into the vehicle design. Other LVSR variants differ.

The LVSR can travel up to 65 miles per hour on paved surfaces and ford five feet of water. It has a cruising range of 300 miles. The tactical-distribution heavy hauler is capable of carrying fuel, water, ammunition, standardized containers, palletized cargo, and heavy equipment.

The all-wheel drive LVSR has a straight body design supporting its three distinct variants. The LVSR, with a standard two-person cab (and a third position for an optional machine gunner position), uses the TAK-4™ independent suspension system for improved mobility and off-road maneuverability. The acquisition objective of 2,000 vehicles has been fielded.

Program Status

The LVSR MKR 18 Cargo variant achieved Initial Operating Capability in September 2009, and the first LVSRs were deployed to Operation Enduring Freedom in support of the Mobile Trauma Bay in that same month. The LVSR is currently in sustainment.

LVSR's Top Technical Issues

1. Fuel Consumption

Given the LVSR's 2.0 miles per gallon fuel consumption rate and the fully burdened cost of fuel, even a moderate increase in fuel efficiency can potentially save lives and millions of dollars. Practical, cost-effective technologies are required to increase the fuel efficiency of the LVSR while maintaining payload capacity and mobility.

2. Increased Survivability

Technologies are required that maintain or increase survivability of the vehicle and occupants from emerging threats, including technologies that can increase armor protection while maintaining or reducing current weight; improvements in blast resistant seats; crew egress systems; and advanced fire-suppression systems. New methods to mitigate or repair current protection systems issues, such as transparent armor delamination, are critical to the ongoing sustainment of the Armored LVSR fleet.

3. Sustainability

Availability and cost of maintenance parts along with the absence of a verified Technical Data Package increase the challenges associated with sustaining the LVSR platform. Innovative solutions to procure replacement parts and systems that have become obsolete in the commercial market resulting in decreased maintenance time are beneficial.

4. Safety

Safety technologies are required to increase vehicle-to-driver feedback, vehicle control, and vehicle stability. They are also needed to mitigate the effects of vehicle rollovers while maintaining the ability of the LVSR to achieve its 30% on-road/70% off-road mission profile.

Logistics Vehicle Systems Replacement (LVSR)

August 2019

Program Description

The LVSR is the Marine Corps heavy-tactical distribution system. LVSR Cargo variant transports bulk liquids (fuel and water); ammunition; standardized containers; bulk, break-bulk, palletized cargo and bridging equipment. LVSR Wrecker variant performs heavy wrecker/recovery missions, while the LVSR Tractor variant tows heavy engineer equipment and combat vehicles.

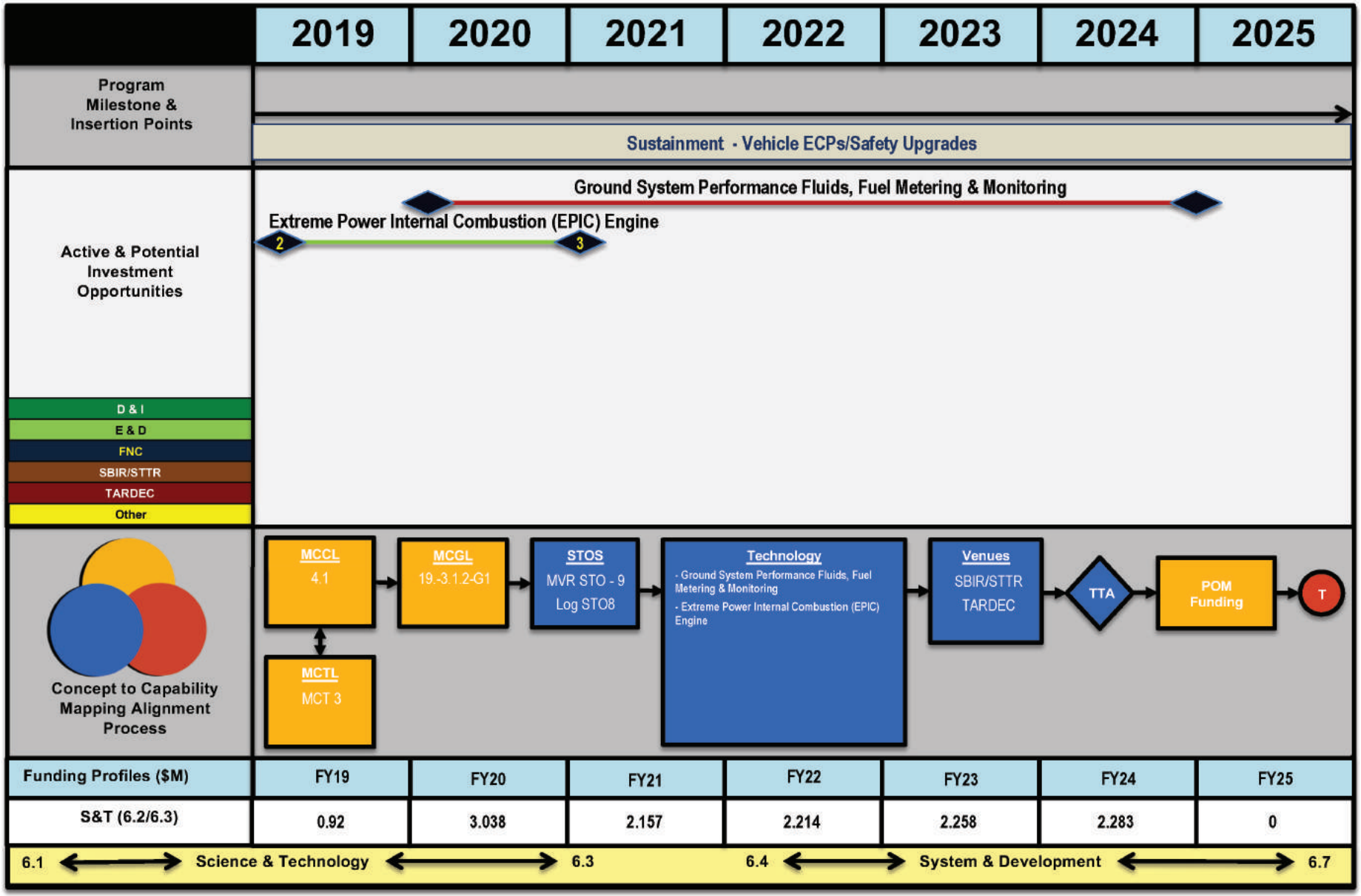
Program Status/Issues/Concerns

- AAO: 1,996
- PICA: USMC
- Program is in sustainment
- Additional PMCS and material coatings to existing brake components under development to mitigate brake water and corrosion issue
- Cab corrosion has been identified and is being worked with the OEM. Aug 19 contract award for OEM to mitigate.

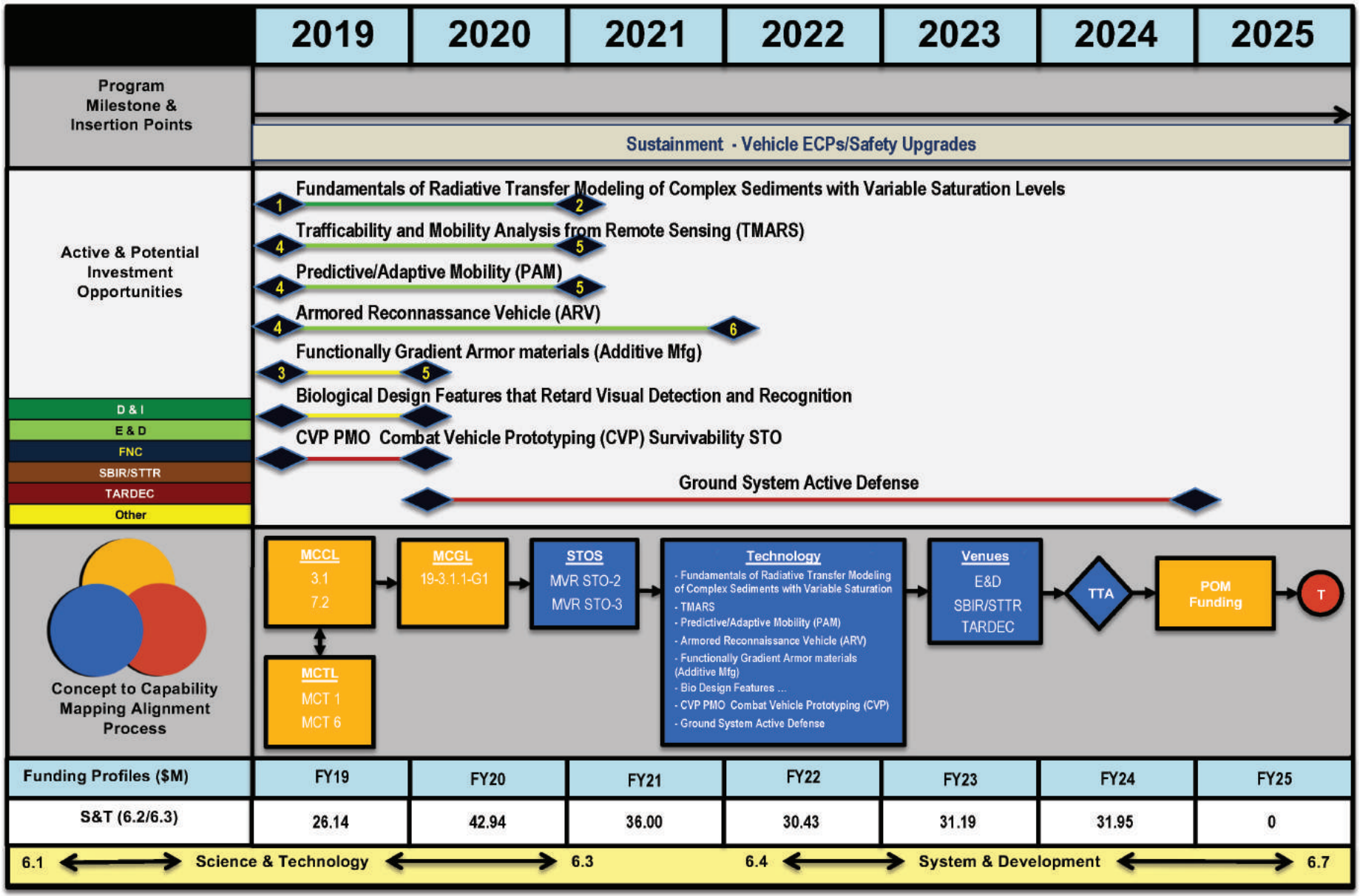
Key Events

• RIA armor prototype production completion:	4QFY19
• 349 JBC-P systems fielding:	2QFY20
• II MEF vehicle armor installations:	2QFY20
• Autonomous Driver Leader/Follower completion:	4QFY22

LVSR Technical Issue #1 Fuel Consumption



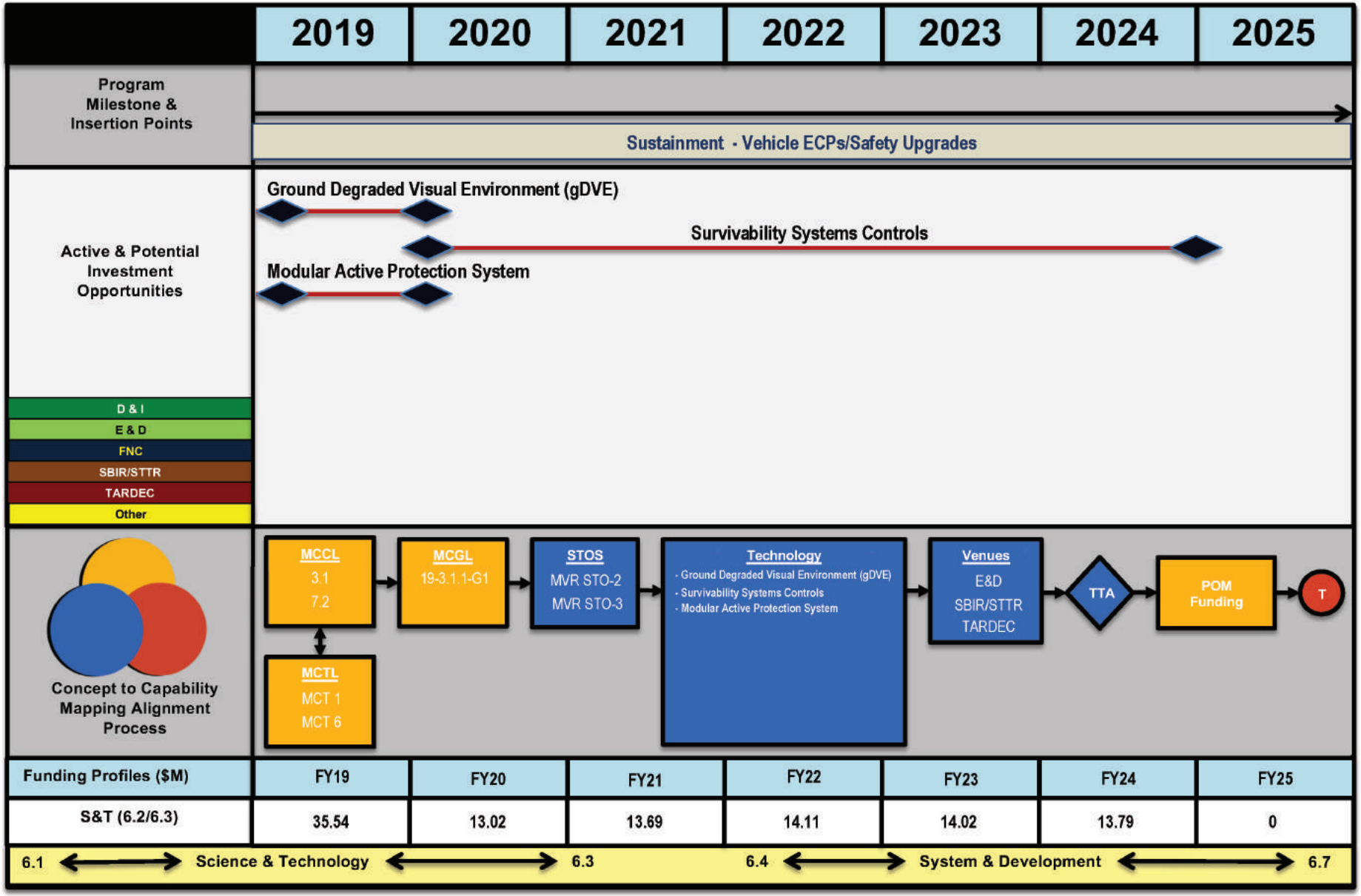
LVSR Technical Issue #2
Increased Survivability



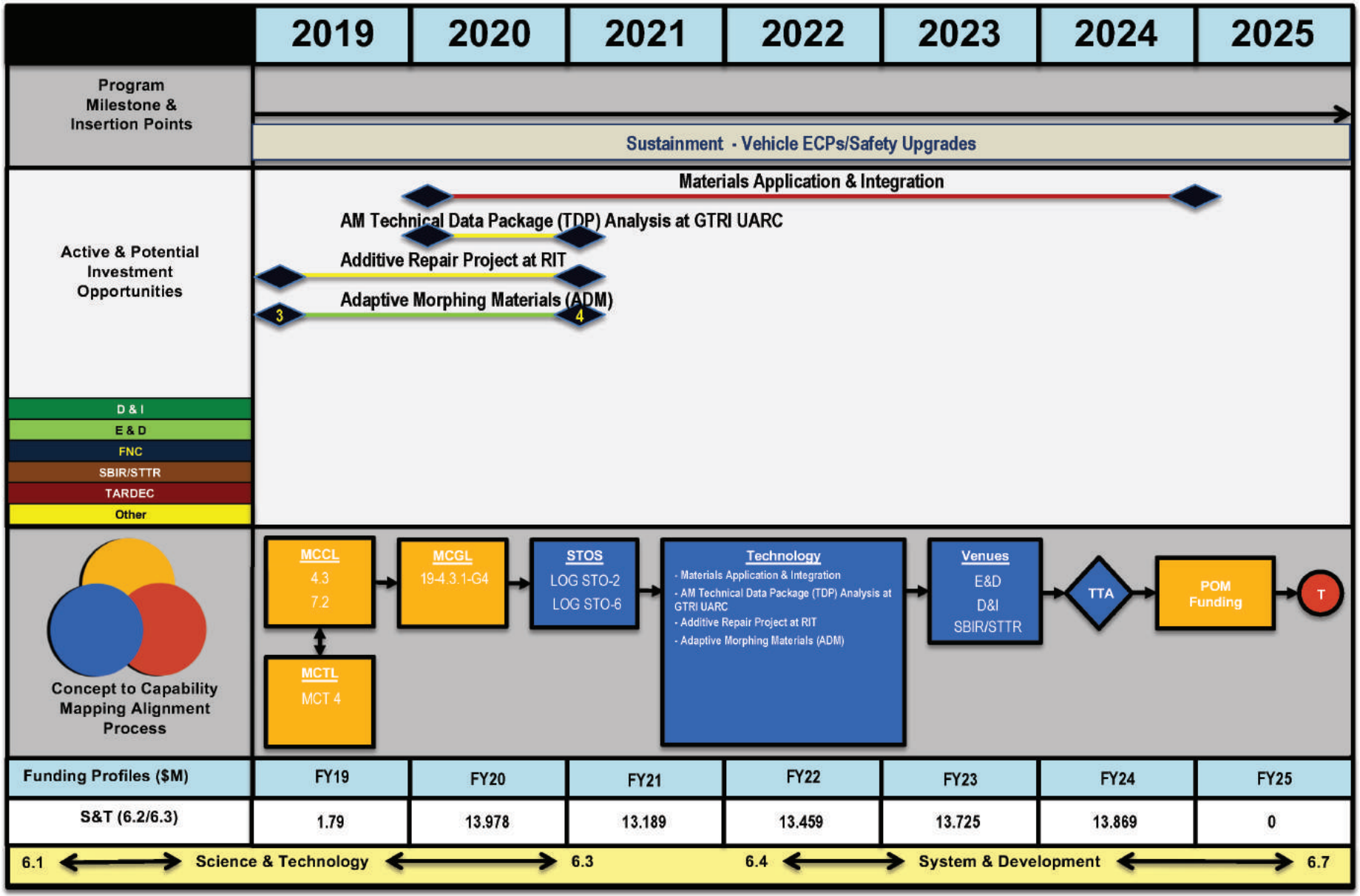
Funding Profiles ($M)	FY19	FY20	FY21	FY22	FY23	FY24	FY25
S&T (6.2/6.3)	26.14	42.94	36.00	30.43	31.19	31.95	0

6.1 ⟷ Science & Technology ⟷ 6.3 6.4 ⟷ System & Development ⟷ 6.7

LVSR Technical Issue #2
Increased Survivability



LVSR Technical Issue #3 Sustainability



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Section 8.8

MEDIUM TACTICAL VEHICLE REPLACEMENT

Medium Tactical Vehicle Replacement (MTVR)

Program Background

The MTVR family of 6-wheel, 7-ton, all-terrain multi-purpose vehicles serves as the Marine Corps' primary means of moving supplies and equipment across severe environments. The vehicles were first fielded in 2001. The platforms have an on-road cruising range of 300 miles (483 kilometers), the ability to ford five feet (1.5 meters) of water and traverse 60% gradients and 30% side slopes with the maximum cross-country load. Operational performance is further enhanced by advanced technologies such as the TAK-4® independent suspension system and integrated control and diagnostics system. MTVR variants include: Standard Cargo and Extended Wheel Base Cargo Trucks, dump trucks, tractors, wreckers and High Mobility Artillery Rocket System Resupply Trucks. Approximately half of the vehicles are armored and some possess a reducible height capability.

More than 8,000 MTVRs are in service with the Marine Corps. The Navy Expeditionary Combat Command also possesses more than 1,800 MTVRs that are used in riverine and combat engineering missions.

To improve the vehicle's level of protection against mines and improvised explosive devices, the MTVR Armor System was designed as a permanent modification to the vehicle. It provides complete 360-degree protection as well as overhead and underbody protection for the cab occupants.

The MTVR was designed with a 22-year service life. Recently, the USMC extended the life of the vehicles to 2042.

Program Status

The MTVR began service in 2001. More than 2,000 MTVRs have seen service in Iraq and Afghanistan. With its 70% off-road mission profile and highly survivable armor package, the MTVR has been used heavily in theater for logistics missions as well as for other missions as assigned. The MTVR is currently in sustainment.

MTVR's Top Technical Issues

1. Increased Survivability

Technologies are required that maintain or increase survivability of the vehicle and occupants from emerging threats, including technologies that can increase armor protection while maintaining or reducing current weight, improvements in blast resistant seats, crew egress systems, and advanced fire-suppression systems. New methods to mitigate or repair current protection systems issues such as transparent armor delamination are critical to the ongoing sustainment of the Armored MTVR fleet.

2. Sustainability

Availability and cost of maintenance parts along with the absence of a verified Technical Data Package increase the challenges associated with sustaining the MTVR platform. Innovative solutions to procure replacement parts and systems that have become obsolete in the commercial market resulting in decreased maintenance time are beneficial.

3. Safety

Safety technologies are required to increase vehicle-to-driver feedback, vehicle control, and vehicle stability. They are also needed to mitigate the effects of vehicle rollovers while maintaining the ability of the MTVR to achieve its 30% on-road/70% off-road mission profile.

Medium Tactical Vehicle Replacement (MTVR)

August 2019

Program Description

The Medium Tactical Vehicle Replacement (MTVR) is a medium lift tactical vehicle capable of transporting 7.1-ton off-road payload, 15-ton on-road and is available in six variants: cargo, extended wheelbase cargo, dump, tractor, wrecker and HIMARS Resupply Vehicle. Variants come both armored and unarmored. Some armored variants have reducible height armor for greater shipboard transport flexibility. Produced from 2000-2015. Item exit date of 2042.

Program Status

- AAO: 7,952 USMC / 1,530 USN
- PICA: USMC
- Currently in sustainment
- Current Initiatives
  - MTVR Fuel Efficient (FE) modification
  - HIMARS Conversion Acquisition (New Battalion FY21)
  - HIMARS Resupply Trailer replacement (M1095)

Key Milestones / Events

3QFY19

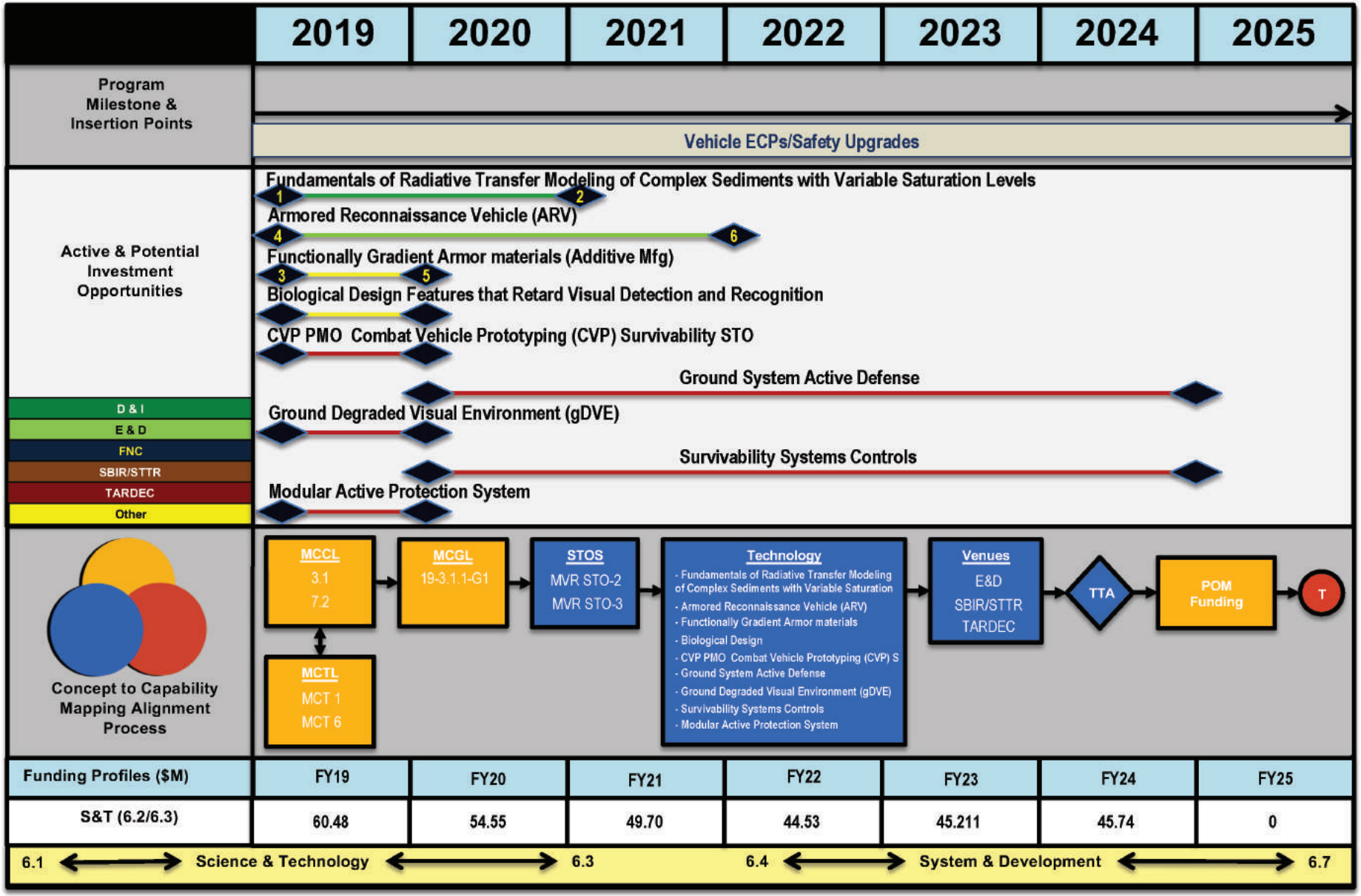
- HIMARS RSV Conversion Contract Award
- HIMARS SOW
- FE Installations MEFs, MARFORRES
- 60% IETM Verification

4QFY19

- MROC AAO reduction
- HIMARS PDR
- Wrecker testing completes
- FE Installation MEFs, BIC

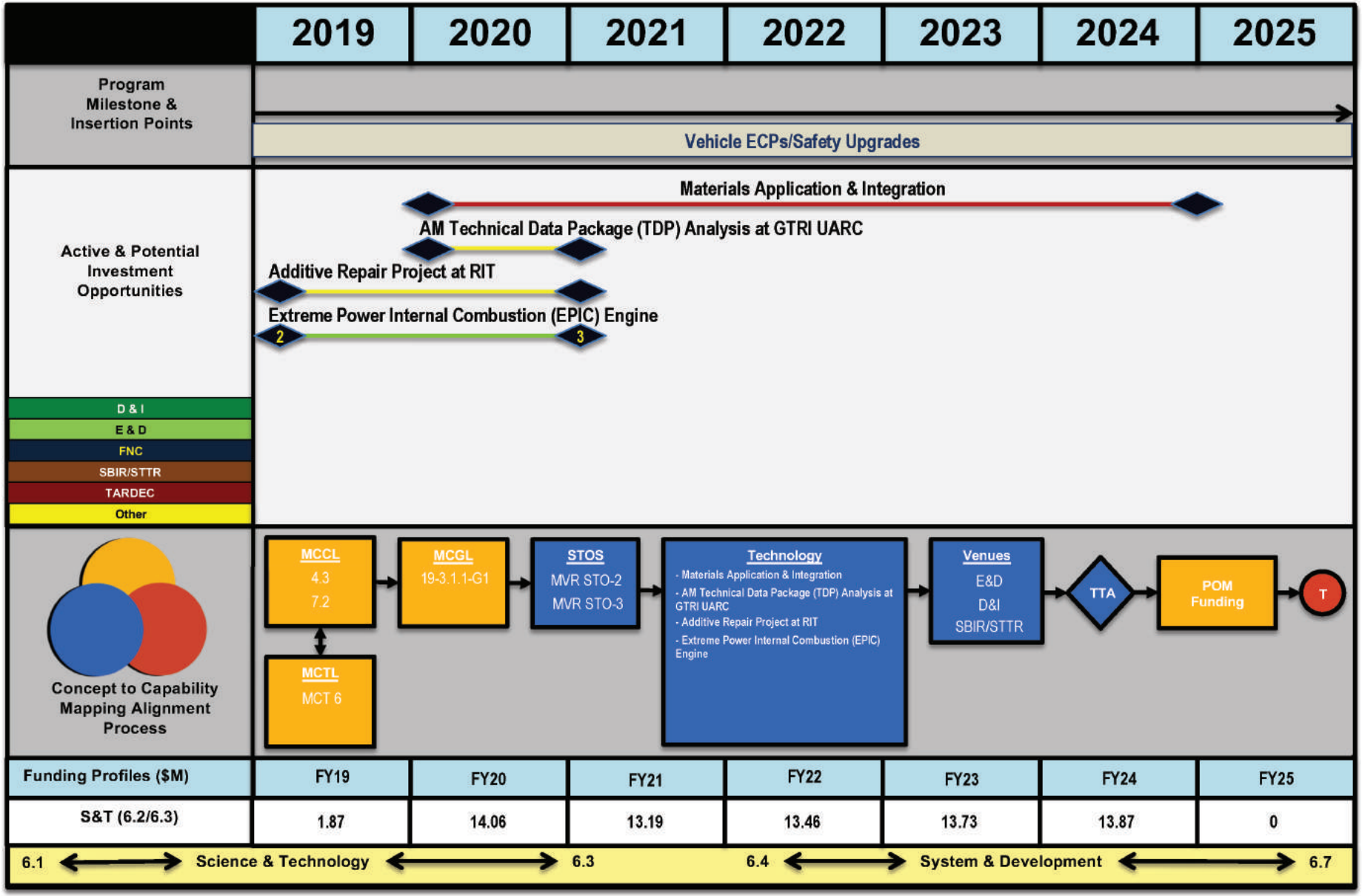
MTVR Technical Issue #1

Increased Survivability



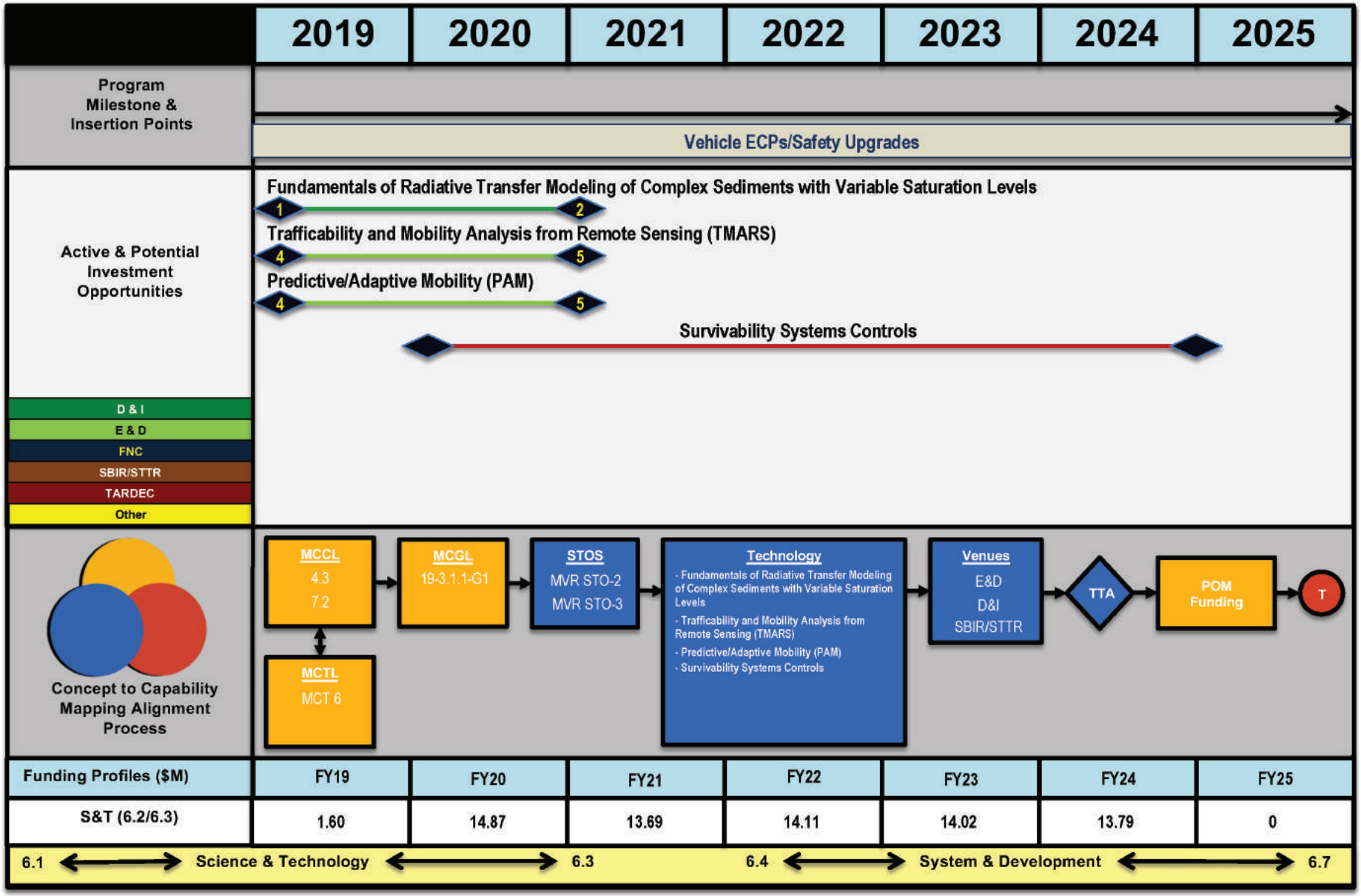
MTVR Technical Issue #2

Sustainability



MTVR Technical Issue #3

Safety



Section 8.9

BUFFALO/COUGAR/M-ATV

From left to right: Buffalo, Cougar 6x6, M-ATV

Program Background

The Marine Corps' Category (CAT) III Buffalo, CAT I and CAT II Cougar variants, and M-ATV are designed to reduce casualties and increase the survivability of personnel subjected to mine explosions, IED detonations and Small Arms Fire. These vehicles were designed under the MRAP umbrella to meet requirements identified during Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), with a focus on continual improvements in force protection and vehicle survivability through technology insertion. Now incorporated into the Medium and Heavy Tactical Vehicles fleet, the USMC will retain M-ATVs, Cougars, and Buffalos to satisfy the enduring requirement established by the Marine Corps Requirements Oversight Council.

The M-ATV, designed to operate in rugged terrain and on the primitive road network in OEF, provides better overall mobility characteristics than Cougar and Buffalo variants. It supports mounted patrols, reconnaissance, security, convoy protection, data interchange and command and control functions. The addition of the Underbody Improvement Kit further enhances the platform's protection against underbody threats. This kit combines armor and interior occupant upgrades, as well as automotive enhancements to increase survivability while maintaining platform safety and off-road capability.

The Cougar platform includes two primary vehicle variants, the CAT I and CAT II, all fielded with the upgraded independent suspension system. The CAT I (4X4) variant is capable of transporting five crew members and one gunner and supports small unit combat operations in urban and confined areas such as mounted patrols, reconnaissance, communications, and command and control. The CAT II (6X6) variant is capable of transporting nine crew members and one gunner and supports multi-mission combat operations in urban or confined areas such as convoy security, troop, and cargo transportation. In addition to these two primary variants, a select number of Cougar CAT I vehicles have been fitted with the Saber TOW system, which is an anti-heavy armor missile system. The TOW-integrated Cougars provide a survivable platform from which armored and urban enclosed threats can be defeated. Similarly, a select number of the Cougar CAT II vehicles have been modified into ambulance variants providing the ability

to transport and conduct emergency care on multiple critical battlefield casualties while in close proximity to enemy troops. The Cougar ambulance can transport up to four wounded patients or two patients carried on litters plus three crew members.

The USMC CAT III MK2A2 Buffalo is a six-wheel, six-passenger, all-wheel drive vehicle that was developed to conduct route clearance operations. The Buffalo is a blast-protected vehicle that operates in explosive hazardous environments and provides route clearance capability and personnel protection against IEDs, anti-personnel, and anti-tank mines. The Buffalo has a 30-foot articulating arm used to investigate suspected buried IEDs and enable the crew to classify the explosive hazard with precision while protecting the operator.

Program Status

M-ATVs, Cougars, and Buffalos are currently fielded to all three Marine Expeditionary Forces.

MRAP's Top Technical Issues

1. Transparent Armor

Advancements are needed in the area of transparent armor. The current transparent armor meets the requirements for ballistic performance; however, significant logistics and financial burdens are realized as a result of delamination. Delamination reduces visibility and makes it more difficult for the crew members to operate safely and view the surroundings effectively. Finding a solution that retains the armor's ballistic performance and maintains visibility would provide the USMC significant cost savings due to replacement and reduce the logistics burden.

2. Sustainability

Availability and cost of maintenance parts along with the absence of a verified Technical Data Package increase the challenges associated with sustaining the MRAP platforms. Innovative solutions to procure replacement parts and systems that have become obsolete in the commercial market resulting in decreased maintenance time are beneficial.

3. Stress Cracks in Welded Construction and Monolithic Hulls Both Using High-hard Steel

The fleet has undergone a reset at various depots and commercial locations in the continental Unites States. When hulls were stripped and inspected, stress cracks were discovered throughout the welded high-hard construction of Cougars and in high hard panels of M-ATVs. Significant cost was added to the process due to the extensive repair of cracks and replacement of high hard panels. Cracking continues to be discovered in previously reset assets. It is critical that the types of cracks be characterized, the root causes discovered, and repair procedures established that will maintain structural integrity, reduce future cracking, and provide required ballistic protection.

Buffalo

August 2019

Program Description

The Buffalo is a heavy-category CAT III vehicle which provides a route clearance capability and personnel protection against anti-personnel (AP) and anti-tank (AT) mines. The Buffalo has an extendable boom with an attached claw and air digger. Because its primary mission is route clearance it was designated as a B00357K and assigned to Combat Engineer units. Since the vehicle has no weapon systems, it cannot operate in a combat environment alone.

Program Status/Issues/Concerns

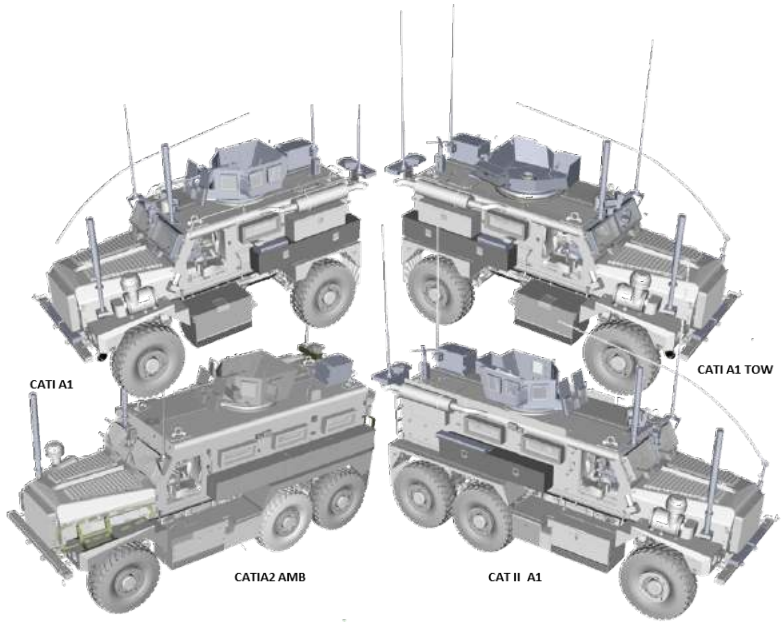
- AAO: 30
- PICA: US Army
- Program is in sustainment
- Block III Upgrade ongoing at MDMC Albany
  - Transparent Armor Upgrade (TAU) and TAU Weather Covers
  - Windshield Frame Upgrade
  - Third Plane of Egress (3POE) Window
  - Floor Blast Mitigation Matting
- MARCENT C4ISR ECP requirements unfunded

Key Events

- Complete Block III Upgrade: 4QFY19

Cougar

August 2019



Program Description

The Cougar Family of Vehicles (FoV) is an infantry mobility vehicle designed to resist Anti-Vehicle mines, IED detonations and small arms fire. The Cougar FoV is comprised of a four-wheel (4x4 CAT I) version and a six-wheel (6x6 CAT II) version. The Cougar FoV is used for small unit combat operations in urban or confined areas. The Cougar FoV mission includes mounted patrols, reconnaissance, communications, command and control.

Program Status

- AAO: 670
- PICA: USMC
- Program is in sustainment
- Egress Kit Upgrade Installation for 179 USMC assets, 200 USN, and 215 USAF

Key Events

- Egress Installation at Naval Information Warfare Center NIWC Atlantic: 2QFY19 – Until Complete

MRAP All Terrain Vehicle (M-ATV)

August 2019

Program Description

The M-ATV provides protected ground mobility capable of operating in a threat environment involving ambushes employing the use of mines, Improvised Explosive Devices (IEDs), Rocket Propelled Grenades (RPGs), Explosively Formed Penetrator (EFPs), and small arms fire.

Program Status/Issues/Concerns

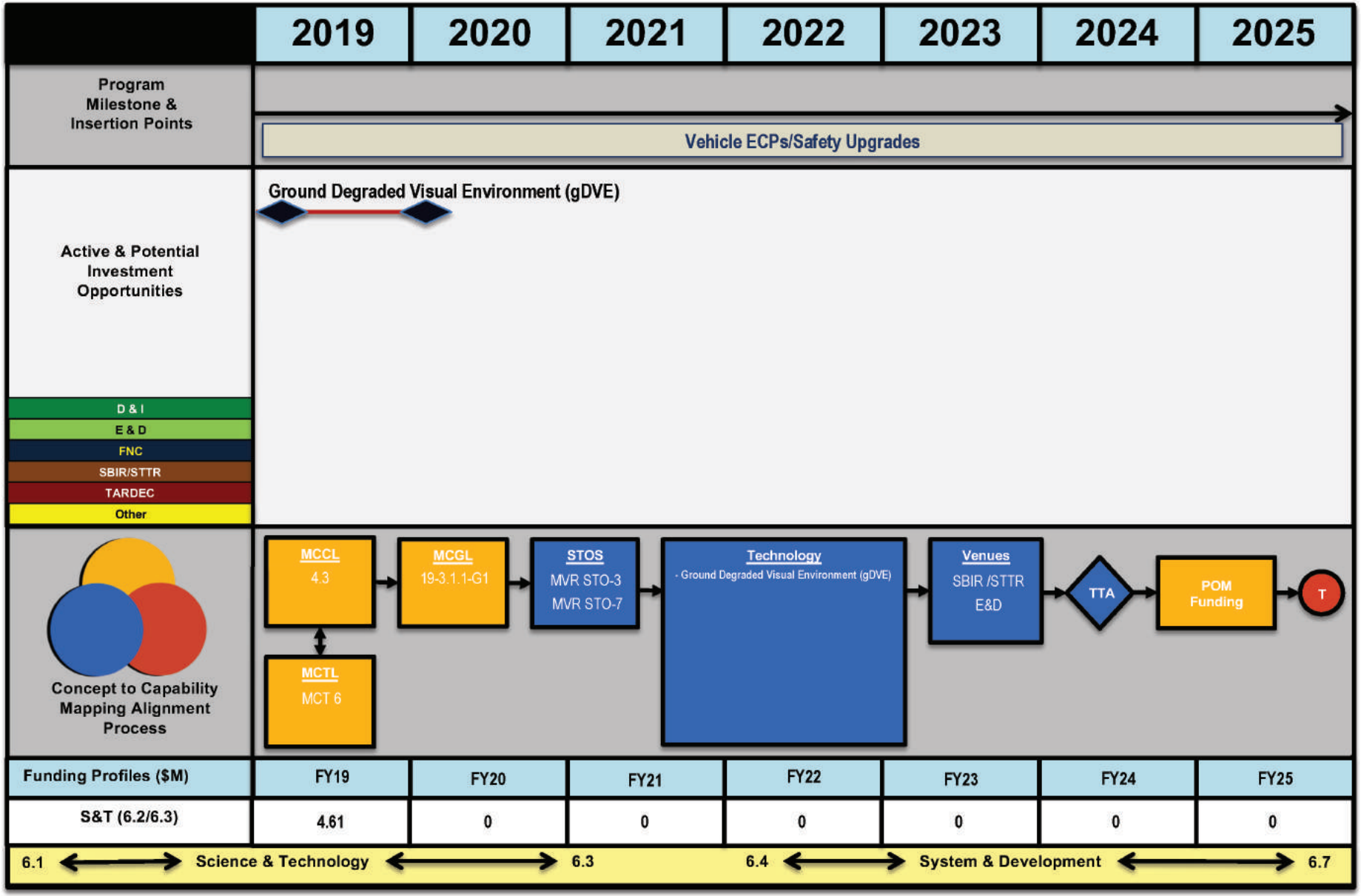
- PICA: US Army
- Program is in sustainment
- AAO: Reduced to 464 from 705 per TOECR change 309938 signed 11 Feb 19
- Divestment strategy will be to transfer to other Services
- Redistribution of RESET vehicles to the MEFs complete
- 377 of 389 vehicles are in place at MAP-K

Key Events

- IROAN/RESET of remaining 239 M-ATVs canceled. Additional vehicles above the current AAO will be divested.
- Redistribution of RESET vehicles to prepositioned locations will continue through FY19
- RESET line at Red River Army Depot and Maintenance Center Barstow complete

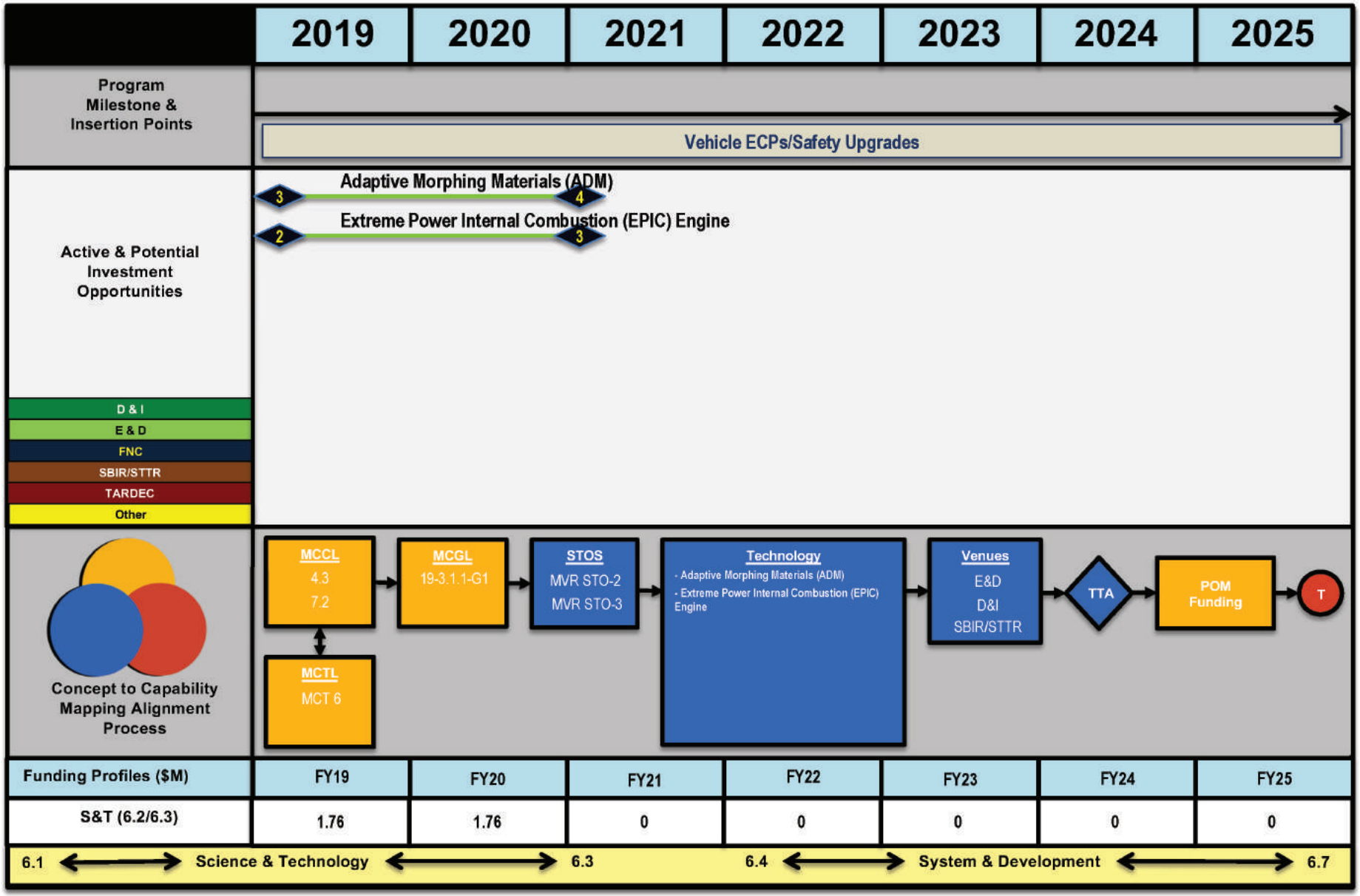
MRAP Technical Issue #1

Transparent Armor



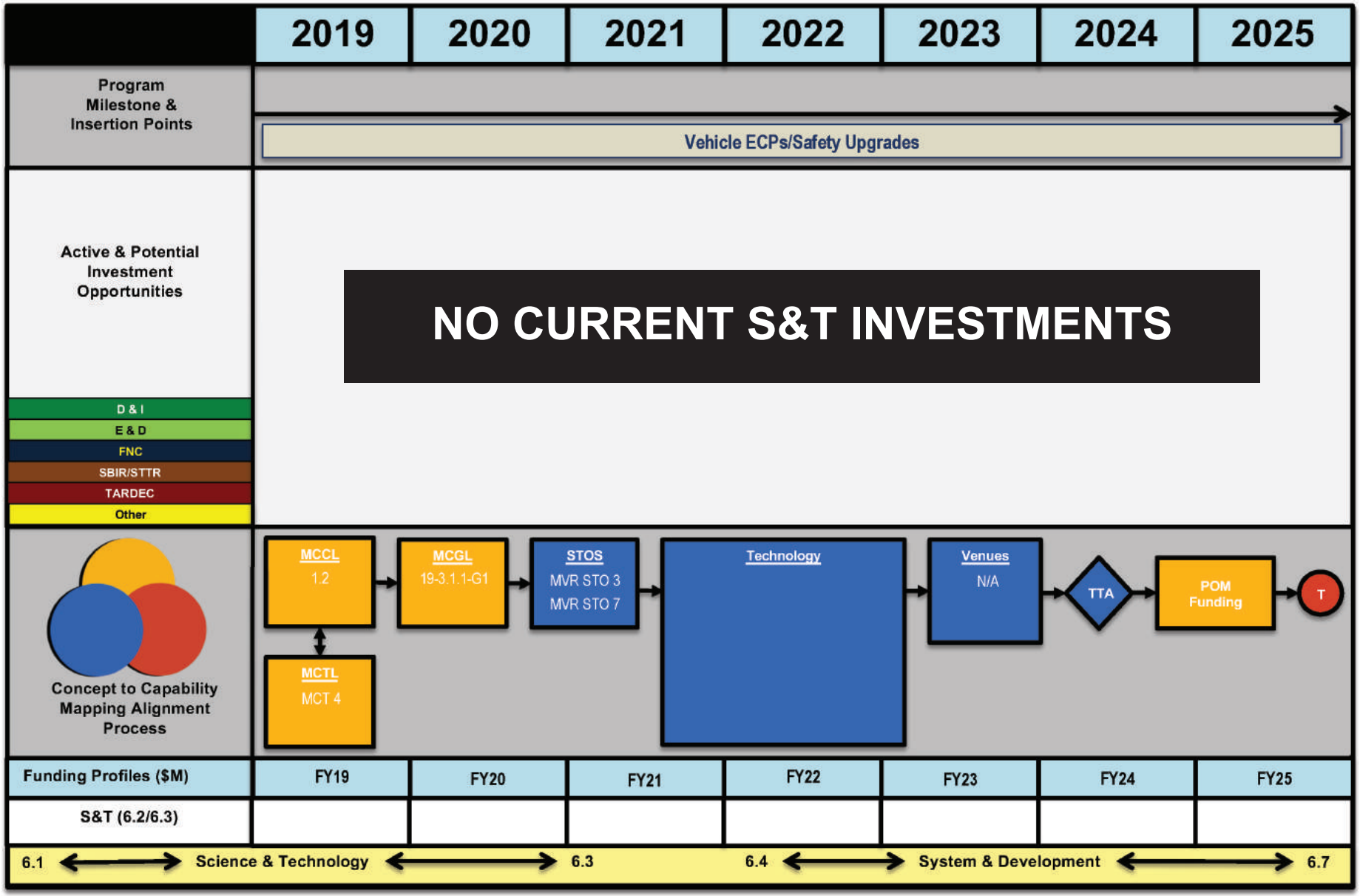
MRAP Technical Issue #2

Sustainability



MRAP Technical Issue #3

Stress Cracks in Welded Construction and Monolithic Hulls Both Using High-Hard Steel



Section 8.10

LIGHTWEIGHT 155MM HOWITZER

Lightweight 155mm Howitzer (LW155)

Program Background

Assembled by BAE Systems in Hattiesburg, Mississippi, the Lightweight 155 is a Marine Corps led joint program with the Army. The M777A2 replaced the Marine Corps' outdated M198 155mm weapon. The cornerstone of the Program Manager, Towed Artillery System (PM TAS) portfolio is the M777A2 Lightweight 155, the "Triple Seven," Howitzer.

The M777A2 is capable of firing standard unassisted projectiles to a range of 15 miles (24 kilometers), assisted projectiles to 19 miles (30.5 kilometers), and the Excalibur munitions to ranges in excess of 25 miles (40 kilometers).

The Triple Seven is the world's first artillery weapon to make widespread use of titanium and aluminum alloys. The the lightweight M777A2 can be air-lifted into remote high-altitude locations inaccessible by ground transportation and is capable of being transported by the Marine Corps' V-22 Osprey, as well as medium and heavy-lift helicopters.

Program Status

The M777 Program is currently conducting activities to "refresh" the system's digitized fire control system. A leap-ahead, towed artillery technology, the digital fire control has transformed how Marines employ artillery As part of the refresh effort, a new Gunners Display and Assistant Gunners Display has been fielded. Using recent advances in display technology, the display has greater reliability along with greatly improved sunlight readability at a lower overall cost. Other ongoing refresh initiatives include a new Mission System Computer, Chief of Section Display, Power Supply, and upgraded system software.

LW 155's Top Technical Issues

1. Navigation in a GPS Denied Environment

The navigation systems for the digitized Howitzers are dependent on GPS assistance to maintain full operational capability. GPS denial would degrade Howitzer operational tempo and adversely impact delivery of timely fire in support of maneuver. Innovative approaches to counter or mitigate GPS denial at minimum size, weight, and power are required. The technologies could be items such as anti-jam antennas, sensor fusion schemes to leverage other available sensors, or other technologies to establish Howitzer location to better than 4m accuracy in a GPS-denied environment.

2. Safe and Transportable Battery High Capacity Technology

The M777A2 Howitzer powers its electronics with onboard (rechargeable) batteries. The current platforms have power requirements in excess of 2 KWH. Current High Capacity Battery technologies are mainly Lithium Ion based, that requires extensive regulatory qualification testing when the power pack exceeds 1 KWH. As a result, towed artillery program managers seeking improved battery performance are required to execute major development efforts-at significant expense-to design and qualify "system specific" power packs. To mitigate this, the PM requests that industry invest in safe and transportable battery technology that could be implemented into weapons systems in a modular fashion, without the need for "system specific" power packs and the extensive regulatory qualification requirements that come with them.

3. On System Power Generation and Conservation

The M777A2 Howitzer powers its electronics with onboard rechargeable batteries. The current platforms have power requirements in excess of 2 KWH. Due to the current limitations of high capacity batteries, the PM requests alternative innovative technologies that would provide power to the electronics on the Howitzer and extend runtime over the existing configuration. Alternatively, the PM requests investment by industry in displays, computers, and other electronic components with a decreased power consumption. Either solution, or a combination of both, would be used to increase operational capability.

4. Secure Wireless: Ruggedized/Low Energy

Communications between interfacing components of the M777A2 digital fire-control systems is accomplished over physical wires. The required cabling constrains the solution space and introduces points of failure, particularly for cables that need to flex or be moved as part of normal operations. A short-haul, low-energy wireless data transmission can eliminate use of physical wires. Although commercial standards exist, a ruggedized solution using a dongle-like device is required. The solution should be adaptable to enable either serial or Ethernet wireless communications between components. This technology may be incorporated into future devices such as wearable devices and onboard sensors.

5. Weight Management

As a result of various product improvements and corrections to field issues, the M777A2 weight has increased closer to the Joint Operational Requirements Document (JORD) threshold weight of 10,000 lbs. In addition, a developmental M777 Extended Range (M777ER) project may add an additional 800 lbs. to the Howitzer. PM TAS has begun to investigate alternative weight reduction measures and feels there is potential for insertion of lightweight materials into the M777ER adapter kit, which could also be applied to the baseline M777A2 Howitzer.

Lightweight 155mm Howitzer

August 2019

Program Description

- M777A2 (LW155) provides direct, reinforcing, and general support fires to maneuver forces. Replaces all howitzers in all missions in the USMC.
- Prime Contractor: BAE Systems (UK)
- Production completed Jan 14
- Average Cost Per Unit: $2.076M
- MDA: ASN (RDA), Joint US Army/USMC Program
- Weight: 10,000 lbs. or less
- Range: 30 km (assisted)
- Fires PGK and Excalibur

MS C = Nov 02 **AAO =** 389 **IOC =** Dec 05 **FOC =** Jun 11

Program Status

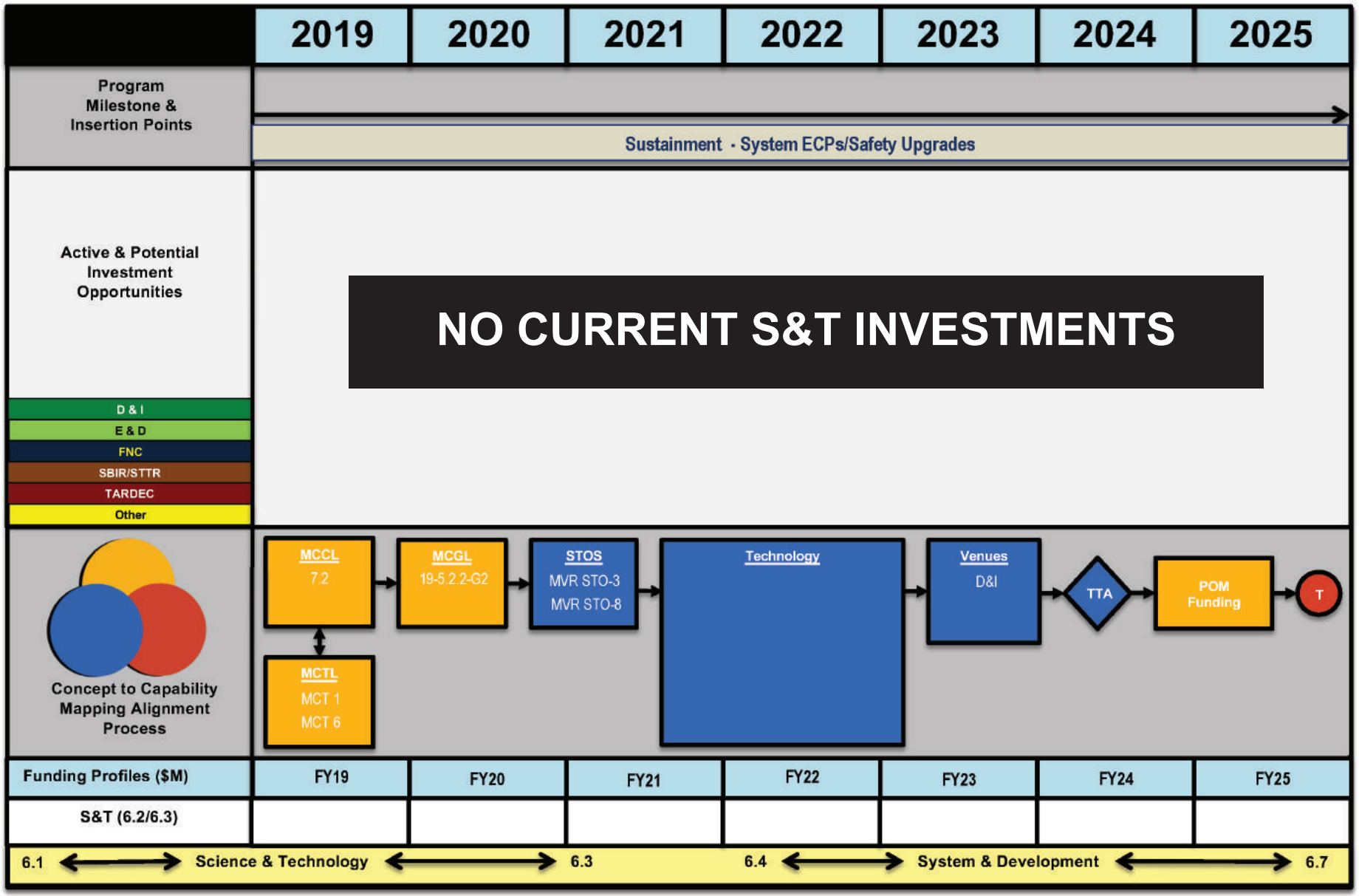
- AAO: 389
- PICA: US Army
- Program is in sustainment
- Program supported by Performance Based Lifecycle Support (PBLCS) – FFP Contract with BAE Systems until May 2023 (based on meeting on time delivery metrics)
- FMS to Canada (37), Australia (54), India (145 in production)
- Contract awarded for 18 additional howitzers for US Army
- Repair procedure validated for cracks found in cradle structure. All cradles in fielded howitzers have been repaired.

Key Events

• Awarded year 7 of PBLCS contract	May 19
• Final retrofit of new Digital Fire Control System – Refresh (DFCS-R) components at Marine Corps Prepositioning Program - Norway (MCPP-N).	Sep 19
• Release of software version 5.0.0 to stay compatible with latest version of Advanced Field Artillery Tactical Data System (AFATDS) version	Sep 19
• First retrofit of new DFCS-R to US Army	Sep 19
• Award contract for Software Defined Radio Hardware Integration Kit contract	Nov 19

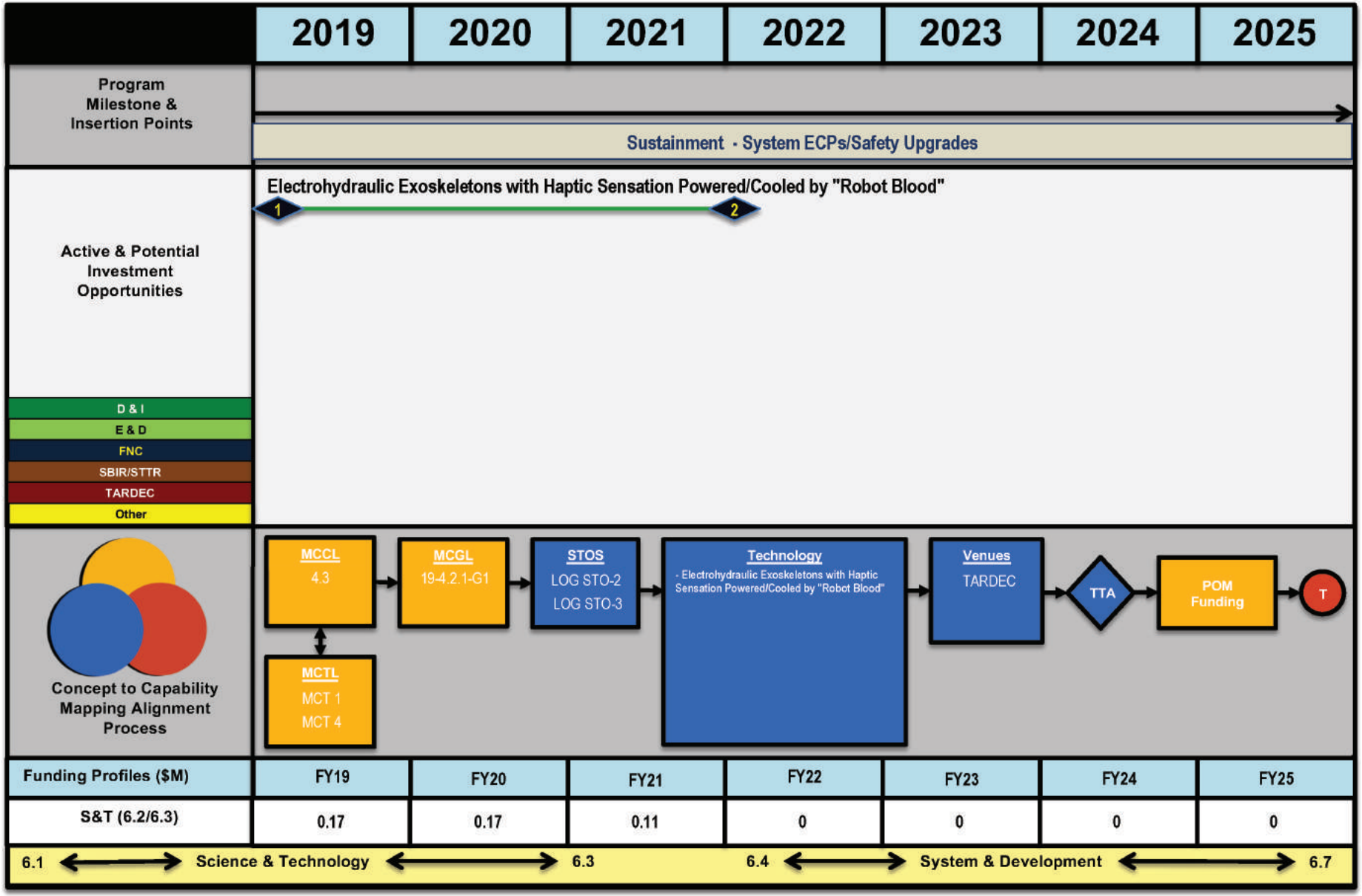
LW155 Technical Issue #1

Navigation in a GPS Denied Environment



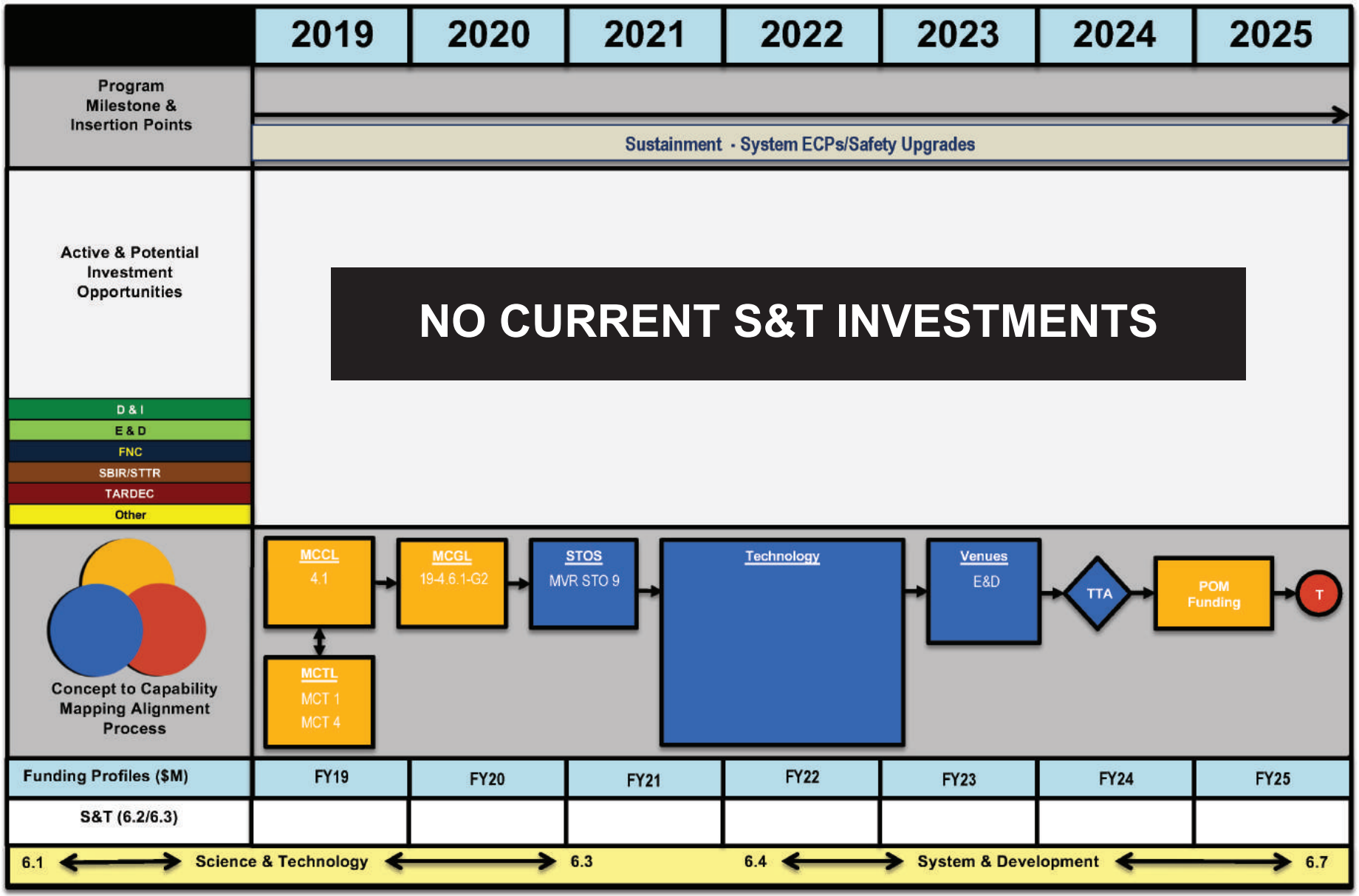
LW155 Technical Issue #2

Safe and Transportable Battery High Capacity Technology



LW155 Technical Issue #3

On System Power Generation and Conservation



Section 9.0

S&T VENUE LIST

The S&T Venue List was developed as a quick reference to identify opportunities within the S&T Enterprise.

This list is not a complete representation of venues that the government uses, but is a list of venues that PEO LS and the Marine Corps use to address specific technology needs and is provided so that PEO LS program offices and industry partners have a better understanding of the opportunities that these venues can provide.

Many venues identified on this list are very specific in nature and may provide funding from outside sources in order to address the needs of the individual program offices.

The included website addresses, email addresses, and phone numbers are verified annually. It is possible that some of these addresses and phone numbers have changed since this publication.

The columns headers describe who is eligible and how funding is secured along with eligibility of the project and the methodology used. Each venue has a different timeline for submission and duration.

Please see the next page for the PEO LS S&T Venue List.

VENUE	PURPOSE	WHO	WHEN	DURATION	FUNDING	ELIGIBILITY	TRL	CONTACT INFORMATION	WEBSITE
Cooperative Research and Development Agreements (CRADA)	Allows collaboration R&D between the Federal government and non-Federal partners to speed the commercialization of federally developed technology.	Varies Agencies DoD DoI	Each Service	0-5yrs	A formal written agreement (not a procurement contract or grant) between one or more federal laboratories and one or more nonfederal parties. The Federal laboratory provides personnel, facilities, equipment, or other resources without reimbursement (no funds) to the nonfederal party. The nonfederal party may supply the same resources, as well as funds, to Federal Labotory under the agreement. This Agreement provides the means to offer intellectual property rights and other fedral resources that would otherwise not be available to a non-federal partner in a manner consistent with the laboratory's mission.	Private Corp (U.S. or Foreign) Non-Profit and Not For Profit (U.S. or Foreign) State and Local Governments (U.S.) Other Federal Agencies	1 to 10	–	http://www.onr.navy.mil/Science-Technology/Directorates/Transition/Technology-Transfer-T2/Partnership-Options.aspx https://www.onr.navy.mil/en/work-with-us/technology-transfer-t2/Partnership-Options/DON-T2-handbook
Data Exchange Agreement (DEA)	Government-to-government subordinate agreement that provides a mechanism for the exchange of Research and Development information to: • create closer alliances • marshall U.S. and friendly foreign nations' technological capabilities • enhance the security of the free world • improve interoperability and standardization and identify cooperative opportunities	Navy International Program Office (NIPO)	Anytime, it usually takes about 12 months to establish a DEA	–	Any amount provided during any fiscal year in relationship to other funding Agreements. Valid for a period of five years Eligible to Renew Data exchange is: • "generic", not platform specific • subject to disclosure guidelines (case-by-case) basis	Navy, US Government Agencies and Foreign Governments	2 to 4	**Jay Wilkins** jacob.wilkinsl@navy.mil (202) 433-5004	–
Discovery & Invention (D&I)	Fund Research to: • Develop Naval-relevant fundamental Knowledge • Provide the basis for future Navy and Marine Corps systems and • Maintain the health of the Defense Scientist and Engineer workforce	ONR	Yearly	0-2yrs	Estimated $200K Estimated 2 years BA1 or 2 Amount and period of performance of each selected proposal may vary depending on research area and the technical approach	Varies Depending on Source	1 to 4	–	http://www.onr.navy.mil/Science-Technology/Directorates/office-research-discovery-invention.aspx
Federally Funded R&D Centers (FFRDC)	Studies/Trade-offs of broad Naval operation and composition	CAN, APL, etc.	On-going	–	–	–	Varies	–	http://www.nsf.gov/statistics/ffrdclist/
Foreign Comparative Test (FCT)	Supports the warfighter by leveraging mature equipment and technologies from allied and coalition partner nations to satisfy U.S. defense requirements by: • Rapidly fielding quality military equipment • Eliminating unnecessary duplication of research, development, test, and evaluation • Reducing life cycle or procurement costs • Enhancing standardization and interoperability • Promoting competition by qualifying alternative sources • Improving the U.S. military industrial base	OSD/AT&L	OSD yearly call November	1-2yrs	$200K-2M Varies; total program is ~$32.8M 12 to 18 months	Government-to-Foreign Industry	7 to 9	**ONR FCT Program Manager** DoN_FCT_Contact@onr.navy.mil **OSD FCT Program** FCT@osd.mil **USMC FCT Program** Jacqueline Brent jacqueline.brent@usmc.mil (703) 432-8961	http://www.onr.navy.mil/en/Science-Technology/Directorates/Transition/Foreign-Comparative-Testing-FCT.aspx

VENUE	PURPOSE	WHO	WHEN	DURATION	FUNDING	ELIGIBILITY	TRL	CONTACT INFORMATION	WEBSITE
Future Naval Capabilities (FNC)	Provides the best technology solutions to stated OPNAV requirements by bundling discrete but interrelated S & T products that deliver a distinctly measurable improvement to align with the pillars of the Chief of Naval Operation's and the Commandant of the Marine Corps' vision for the future-Naval Power 21-and to focus on providing Enabling Capabilities (ECs) to close warfighting gaps.	ONR	ONR yearly call April/May	3-5yrs	0-$30M Each product ~$4.25M Each program ~$20-$30M	Each major Navy/Marine Corps Systems Command	3 to 6	**Sam Kirby** samuel.kirby@navy.mil	http://www.onr.navy.mil/en/Science-Technology/Directorates/Transition/Future-Naval-Capabilities-FNC.aspx
Innovative Naval Prototype (INP)	To design, build, and demonstrate prototypes of innovative (high BA 2 or BA 3) technology. Focus on high-risk/high-payoff opportunities emerging from the D&I portfolio that can significantly impact Naval capabilities if technology can mature.	ONR	Yearly Call October	4-8yrs	$150-$200M 4-8 years	Anyone can propose an INP.	5 to 7	**Ken Heeke** kenneth.heeke@navy.mil	–
Joint Capability Technology Demo (JCTD)	The JCTD Program executes operational prototypes to address the most pressing technology gaps facing the Department of Defense. Starting in FY15 JCTD, projects primarily be initiated to develop technology solutions in the four EC&P focus areas	OSD / EC&P	Throughout FY15 and FY16	2yrs	0-$10M ~$10M of S&T funding plus in-kind funding from sponsors	Federal Service programs. Proposals must have a COCOM as the primary sponor and suport joint, coalition, or inter-agency capabilities.	6 to 9	jctdhelpdesk@osd.mil	http://www.acq.osd.mil/ecp/PROGRAMS/JCTD.html
Marine Corps Futures Directorate	To identify future challenges and opportunities, develop warfighting concepts, and comprehensively explore options in order to inform force development.	MCCDC Marine Corps Warfighting Lab	On-Going	–	–	–	–	MCWL_PAO2@usmc.mil	https://www.marinecorps.mil
Navy Manufacturing Technologies (ManTech) Centers of excellence	The Navy ManTech Program executes its projects primarily through its Centers of Excellence. The Centers of Excellence were established as focal points for the development and transition of new manufacturing processes and equipment in a cooperative environment with industry, academia and the Naval Research Enterprise	ONR	Annually	1-3yrs	$500K-$3M The Centers of Excellence: • Execute projects; manage project teams • Serve as corporate expertise in technological areas • Collaborate with acquisition program offices / industry to identify and resolve manufacturing issues • Develop and demonstrate manufacturing technology solutions for identified Navy requirements • Provide consulting services to Naval industrial activities and industry • Facilitate transfer of developed technologies The Navy Program currently has nine centers of excellence.	• defense contractors • the Naval Research Enterprise • Navy acquisition Program Offices • academia	5 to 7	–	https://www.dodmantech.com/mantechprograms/CentersOfExcellence

VENUE	PURPOSE	WHO	WHEN	DURATION	FUNDING	ELIGIBILITY	TRL	CONTACT INFORMATION	WEBSITE
Quick Reaction Fund (QRF)	Focus is on shorter cycle time Conventional Forces and responding to emergent needs during the execution years that take advantage of breakthroughs in rapidly evolving technologies	OSD	Proposals may be submitted any time during the year as opportunities and need arise	0-1yr	$100K- $1M Max	–	7 to 9	–	https://www.acq.osd.mil/ecp/DOCS/NDIA_ST_Conference_2018_MAR.pdf https://www.acq.osd.mil/ecp/DOCS/ECP_Mission_Overview_May2015.pdf
Rapid Innovation Fund (RIF)	The Rapid Innovation Fund (RIF) is designed to transition innovative technologies, primarily from small businesses, that resolve Department of Defense operational challenges.	OSD / ONR(BAA)	Annual BAA Issued early September	24 months Max	$3M Max	Industry and Academia Navy laboratories may team with other responsible sources from academia and industry but are not eligible to receive awards.	5 to 7	**Jeff Kent** jeffrey.a.kent@usmc.mil	https://defenseinnovationmarketplace.dtic.mil/business-opportunities/rapid-innovation-fund/
Rapid Reaction Fund (RRF)	Focus is on emerging technologies addressing irregular warfare capabilities with the goal of leveraging the DoD science and technology base, other federal departments, academia and industry to accelerate fielding of affordable, sustainable capabilities and concepts to counter emerging threats	OSD	Proposals may be submitted any time during the year as opportunities and need arise	6-8 months	Varies	Varies	7 to 9	**Jon Lazar** jon.e.lazar.civ@mail.mil	http://www.acq.osd.mil/rd/organization/
SBIR Phase I Start up	Feasibility study to evaluate the scientific and technical merit of an idea	ONR	Tri Annual Solicitation November April July	0-.5yr	$150K Max $80K with $70K option 6 months Competitive Solicitation	Small Businesses	0 to 3	**Robert Smith** Robert.L.Smith6@navy.mil (703) 696-7954	http://www.navysbir.com/
SBIR Phase II	Expand on the results of and further pursue the development of Phase I.	ONR	At completion of Phase I	0-2yrs	Based on the results achieved in Phase I, usually does not exceed $1,000,000 total costs for 2 years	Small business that has successfully completed Phase I	2 to 7	**Robert Smith** Robert.L.Smith6@navy.mil (703) 696-7954	http://www.navysbir.com/
SBIR Phase III	Commercialization of the results of Phase II	ONR	As Phase III funds are identified	1-3yrs	$1.5M Max $Unlimited Unlimited time Funding can come from the Government or Private Sector	Any SBIR company that has identified non-SBIR source of funds	6 to 9	**Robert Smith** Robert.L.Smith6@navy.mil (703) 696-7954	http://www.navysbir.com/
Small Business Innovation Research (SBIR)	Funds the critical startup and development stages and encourages the commercialization of technology, product or service from a Small Business (NTE 500 employees)	–	Tri Annual Call March July October	–	Determine topic feasibility and scientific or technical merit in 3 phases.	Determine topic feasibility and scientific or technical merit in 3 phases.	0 to 9 over the 3 phases	**Robert Smith** Robert.L.Smith6@navy.mil (703) 696-7954	http://www.navysbir.com/index.html https://www.sbir.gov/about/about-sttr

VENUE	PURPOSE	WHO	WHEN	DURATION	FUNDING	ELIGIBILITY	TRL	CONTACT INFORMATION	WEBSITE
Small Business Technology Transfer (STTR)	Foster the innovation necessary to meet the nation's scientific and technological challenges. Provides: • Funding opportunities in the federal innovation research and development arena • Expansion of public/private sector partnership to include the joint venture opportunities for small business and the nation's premier nonprofit research institutions	OSD/ONR/NAVAIR	Annual Call June	–	Determine topic feasibility and scientific or technical merit in 3 phases.	Small Businesses partnered with Research Academia and nonprofit research institutions	2 to 4	**Robert Smith** Robert.L.Smith6@navy.mil (703) 696-7954	http://www.navysbir.com/index.html https://www.sbir.gov/about/about-sttr
STTR Phase I Start up	Feasibility study to evaluate the scientific and technical merit of an idea	ONR	Annual Topic Call June	0-1yr	$150K Max $80K with $70K option 7 months Competitive Solicitation	STTR Partnerships: Small Businesses partnered with eligible Research Institutions	1 to 5	**Robert Smith** Robert.L.Smith6@navy.mil (703) 696-7954	http://www.navysbir.com/index.html https://www.sbir.gov/about/about-sttr
STTR Phase II	Expand on the results of Phase I and develop a prototype product or process.	ONR	At completion of Phase I	0-2yrs	$1,000,000 Max $500K with $250K option 18 months with 9 month option Government Selected	STTR Partnerships with successful phase I completion	2 to 5	**Robert Smith** Robert.L.Smith6@navy.mil (703) 696-7954	http://www.navysbir.com/index.html https://www.sbir.gov/about/about-sttr
STTR Phase III	Commercialization of the results of Phase II	ONR	As Phase III funds are identified	1-3yrs	$3M Max $Unlimited Unlimited time Funding can come from the Government or Private Sector	Any STTR company that has identified non-STTR source of funds; No research institution partnership required	6 to 10	**Robert Smith** Robert.L.Smith6@navy.mil (703) 696-7954	http://www.navysbir.com/index.html https://www.sbir.gov/about/about-sttr
Swamp Works	Explores innovative, high-risk and disruptive technologies and concepts	ONR	Leverages short exploratory studies to examine the maturation of a proposed technology before making substantial investments. Insertion within 1 to 3 years	1-3yrs	$100K-$1M Max Leverages short exploratory studies to examine the maturation of a proposed technology before making substantial investments. Insertion within 1 to 3 years.	Substantial flexibility in planning and execution; The process allows for the shortest possible technology development timeframe; A formal transition agreement is not required; Programs routinely have strong advocacy outside of the ONR either from the acquisition community or the fleet.	2 to 6	**Dr. Michael M. Simpson** naval_STEM@navy.mil	–
Technology Insertion Program for Savings (TIPS)	To increase the rate that new cutting edge technologies are inserted into DoN Acquisition programs in order to significantly reduce operations and maintenance support costs. Structured to rapidly transition applicable commercial off-the-shelf solutions and late-stage development technologies from any source to meet an immediate need.	ONR	NAE CTO call: September Proposals due: October ONR call: November Proposals due from SYSCOMs: 1 Feb	0-2yrs	$2M Max <24 months	Program Office military/civilian (can collaborate with Navy contractors) Requires: Program Office Acquisition Sponsorship OPNAV Resource Sponsorship (responsible for out-year funding)	Start 6+, End 8+	–	–
Technology Solutions	Hot line for meeting current fleet needs Rapid-response S&T solutions to immediate Fleet/Force needs identified by Sailors and Marines; addresses: • New applications of emerging/existing technologies • Well-bounded problems with S&T solutions • Impact to the individual warfighter	ONR	Accepts on-going requests	Maximum 12 months to complete Goal: prototype demo within 15 to 18 months of request	Average project ~ 750K	US Navy and Personnel only Solution developed by Naval Research Enterprise (NRE) or National LabsCommercial &/or academic partners are common	End 6+	ONR_TechSolutions@navy.mil (703) 696-0616	http://www.onr.navy.mil/techsolutions/ http://www.onr.navy.mil/Science-Technology/Directorates/Transition/tech-solutions-innovation.aspx

VENUE	PURPOSE	WHO	WHEN	DURATION	FUNDING	ELIGIBILITY	TRL	CONTACT INFORMATION	WEBSITE
University Research Initiatives (URI)	The University Research Initiative seeks to improve the quality of defense research conducted by universities and supports the education of engineers and scientists in disciplines critical to national defense needs. The initiative is a collection of specialized research programs performed by academic research institutions: • Defense University Research Instrumentation Program • DoD Experimental Program to Stimulate Competitive Research • Multidisciplinary Research Program of the University Research Initiatives • The Presidential Early Career Award for Scientists and Engineers Program • Young Investigators Program	Universities	DURIP (FY2016) : Submit by 25 September MURI (for FY16): White Papers due 08 September 2015 Full Proposals due 07 December 2015	2-5yrs	$50K-$5M Max Varies by Program Typically NTE $50K - $1M per year Funded incrementally or as options NTE 2 to 5 years	U.S. institutions of higher education with degree granting programs in science, math, or engineering	1 to 4	–	http://www.onr.navy.mil/Science-Technology/Directorates/office-research-discovery-invention/Sponsored-Research/University-Research-Initiatives.aspx

ATIP

ADVANCED TECHNOLOGY INVESTMENT PLAN

2020 - VOLUME XI

PEO LAND SYSTEMS MARINE CORPS

IT'S ALL ABOUT THE WARFIGHTER

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