It's All About the Warfighter

ATIP

Advanced Technology Investment Plan

2017 - Volume VIII

PEO LAND SYSTEMS

ACQUISITION EXCELLENCE

IT'S ALL ABOUT THE WARFIGHTER

PROGRAM EXECUTIVE OFFICER LAND SYSTEMS MARINE CORPS ADVANCED TECHNOLOGY INVESTMENT PLAN 2017

Executive Summary

This 2017 edition of the Program Executive Officer Land Systems (PEO LS) Advanced Technology Investment Plan (ATIP) provides an update to 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 emphasizes our continued commitment to "Focus the Future Faster" by leveraging available Science and Technology (S&T) venues to provide gap-closing capabilities to the Warfighter.

The overarching focus of this plan is to support concept aligned, capability-based technology transitions into Programs of Record (PORs). 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.

By developing and publishing this plan on an annual basis, PEO LS is committed to playing an active role within the Three Circles framework that consists of the Combat Developer, S&T Developer and Materiel Developer. The 2017 ATIP is an informative resource that highlights the importance of this collaboration and provides critical insight into technology solutions to program specific S&T challenges. 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.

Andrew D. Bianca
Program Executive Officer
Land Systems Marine Corps, Acting

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PROGRAM EXECUTIVE OFFICER
LAND SYSTEMS
ADVANCED TECHNOLOGY
INVESTMENT PLAN 2017

Bottom Line Up Front

This eighth edition of the ATIP identifies and prioritizes the Program's Top Technical Issues within PEO LS with the goal of informing, influencing, and aligning S&T investment to resolve program technical issues and support transition of critical capabilities to the warfighter.

The ATIP serves as a guide to how industry/Warfare Centers can best support PEO LS Program Managers and their associated technology needs.

Each Program's Top Technical Issues were vetted through the appropriate S&T Representative, Lead Engineer, Deputy Program Manager, and Program Manager to ensure an accurate representation of their highest priority technology needs.

The PEO LS ATIP uses a repeatable process focused to inform all key stakeholders of Top Technical Issues within PEO LS Programs with the goal of leveraging available S&T venues to "Focus the Future Faster" for the warfighter.

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

As always, we welcome any comments or suggestions to improve the utility of this investment plan. Please forward any suggestions or comments to me at michael.d.halloran@usmc.mil.

Michael D. Halloran
Director, Science & Technology
Program Executive Officer Land Systems

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Section 1.0

INTRODUCTION

"We must capitalize on innovation that realizes how to leverage the capabilities of all new systems ….at a pace that maintains the advantage over our adversaries."

—General Robert B. Neller, 37th Commandant of the U.S. Marine Corps

In this eighth edition of the Program Executive Officer Land Systems (PEO LS) Advanced Technology Investment Plan (ATIP), the top technical issues for each program are identified and prioritized within the organization. The goal of this ATIP is to inform, influence and align Science and Technology investments to help resolve technical issues, transition advanced technology and to bring greater capability to the warfighter as rapidly as possible. The methodology used to develop the ATIP is the focused and repeatable Concept to Capability process (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 this process is stakeholder engagement within the S&T enterprise, industry, and academia. The concept developer must understand the 'realm of the possible' when it comes to developing concepts and requirements. Once developed, requirements become the backbone of program capabilities. Together, these efforts support the ultimate transition of critical and affordable capabilities to the warfighter.

This year's ATIP theme is **Autonomy**. The Commandants Planning Guidance 2015, written by the former Commandant, General Joseph F. Dunford Jr, and amended in FRAGO 01/2016, Advanced to Contact, by the current Commandant, General Robert B. Neller, clearly states that the Marine Corps will pursue technologies that enhance our warfighting capabilities through Manned Unmanned Teaming (MUMT), such as unmanned aerial systems (UAS) and robotics, artificial intelligence, and autonomous technologies that provide tactical and operational advantage. PEO LS is looking for innovative solutions and game-changing technologies that will empower our Marine Corps to be dominant in defending our nation on the future battlefields.

Published annually, the PEO LS ATIP is much more than an information source for the PEO LS technology efforts. It is a catalyst for opening communication and collaboration between "3 Circle" partners (Combat Developer, Materiel Developer, and the S&T Developer) and to other DoD and Non-DoD organizations. This year's ATIP was developed in direct collaboration with the Office of Naval Research (ONR), Army Tank Automotive Research, Development and Engineering Center (TARDEC), Defense Advanced Research Projects Agency (DARPA), Marine Corps Warfighting Lab (MCWL), Naval Warfare Centers 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 DoD to propose solutions that might otherwise be missed.

As today's fiscally austere budgets continue to decrease, 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 are advertised in the ATIP to alert and assist industry and government regarding the S&T needs of major ACAT programs within PEO LS.
2. **Resolving capability gaps and technical issues** by identifying and publishing the technical challenges, PEO LS is delivering input and assistance to the S&T enterprise, industry, and academia.
3. **Informing, influencing, and aligning S&T investment** by identifying the S&T needs of PEO LS and **supporting the technology insertion and transition into Programs of Record**.

The overall technology requirements for PEO LS programs remain consistent from previous years and are as follows:

- Reliable and efficient electrical power generation to supply energy for our modern force.
- Increased survivability while maintaining mobility.
- Government-owned and operated modeling and simulation capability that can accurately predict cost and performance of systems.
- Open plug-and-play communications architecture in Marine Corps vehicles.

PEO LS Organization

Program Executive Officer Land Systems—located at historic Hospital Point, Building 2210, Marine Corps Base Quantico, Virginia—is the Corps' first Program Executive Office. PEO LS is a separate command that reports directly to the Assistant Secretary of the Navy for Research Development and Acquisition (ASN (RDA)). PEO Land Systems' integral relationship with the Marine Corps Systems Command (MCSC) leverages infrastructure, competencies, and technical authority. The mission of PEO LS is to meet warfighter needs by devoting full-time attention to Marines Corps weapon systems acquisition, while partnering with MCSC to develop, deliver, and provide life-cycle planning for all assigned programs. Figure 1-1 illustrates the current organization of Program Executive Officer Land Systems.

PEO LS is responsible for managing multiple Acquisition Category (ACAT) I, II, III & IV programs, which are critical to the support of the warfighter. These programs include: the Marine Corps' #1 ground program, the Amphibious Combat Vehicle (ACV); the Assault Amphibious Vehicle (AAV7A1); the Joint Light Tactical Vehicle (JLTV); the Mine Resistant Ambush Protected (MRAP) family of vehicles; the Common Aviation Command and Control System (CAC2S); the Ground Based Air Defense (GBAD); the Ground/Air Task Oriented Radar (G/ATOR); the Lightweight 155 M777 Howitzer; the Medium Tactical Vehicle Replacement (MTVR); and the Logistics Vehicle System Replacement (LVSR). The monetary value of these programs across the Future Years Defense Program (FYDP) is approximately $8 billion.

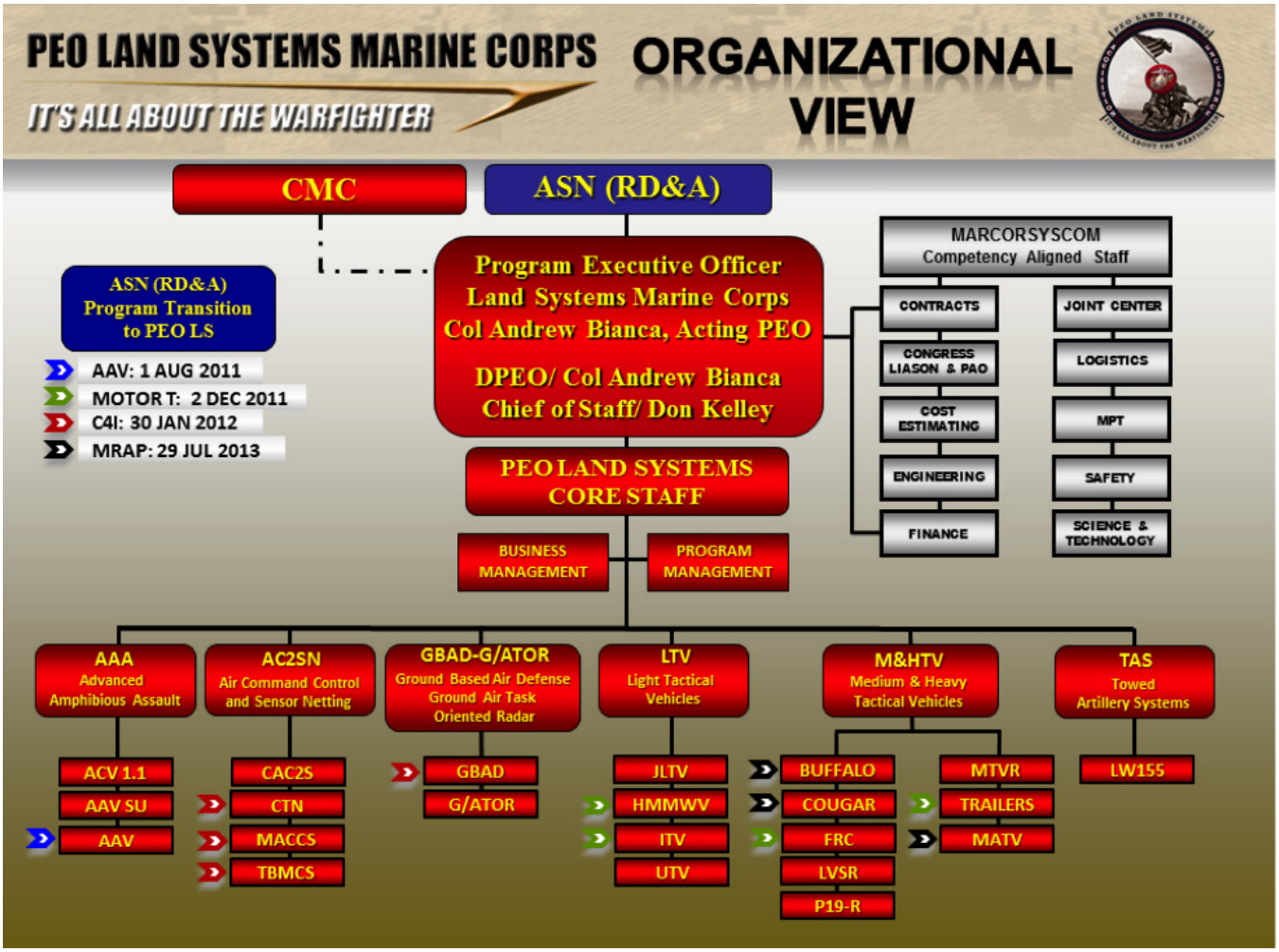

Figure 1-1. Program Executive Officer Land Systems Organization

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Section 2.0

S&T COLLABORATION AND ENGAGEMENT

Concept-to-Capability Process

The Concept–to–Capability process, depicted in Figure 2-1, provides the Program Executive Officer Land Systems (PEO LS) with a focused and repeatable process that has proven essential for facilitating effective interaction with Science and Technology (S&T) stakeholders within the S&T Community.

The PEO LS 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 Commandants 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.

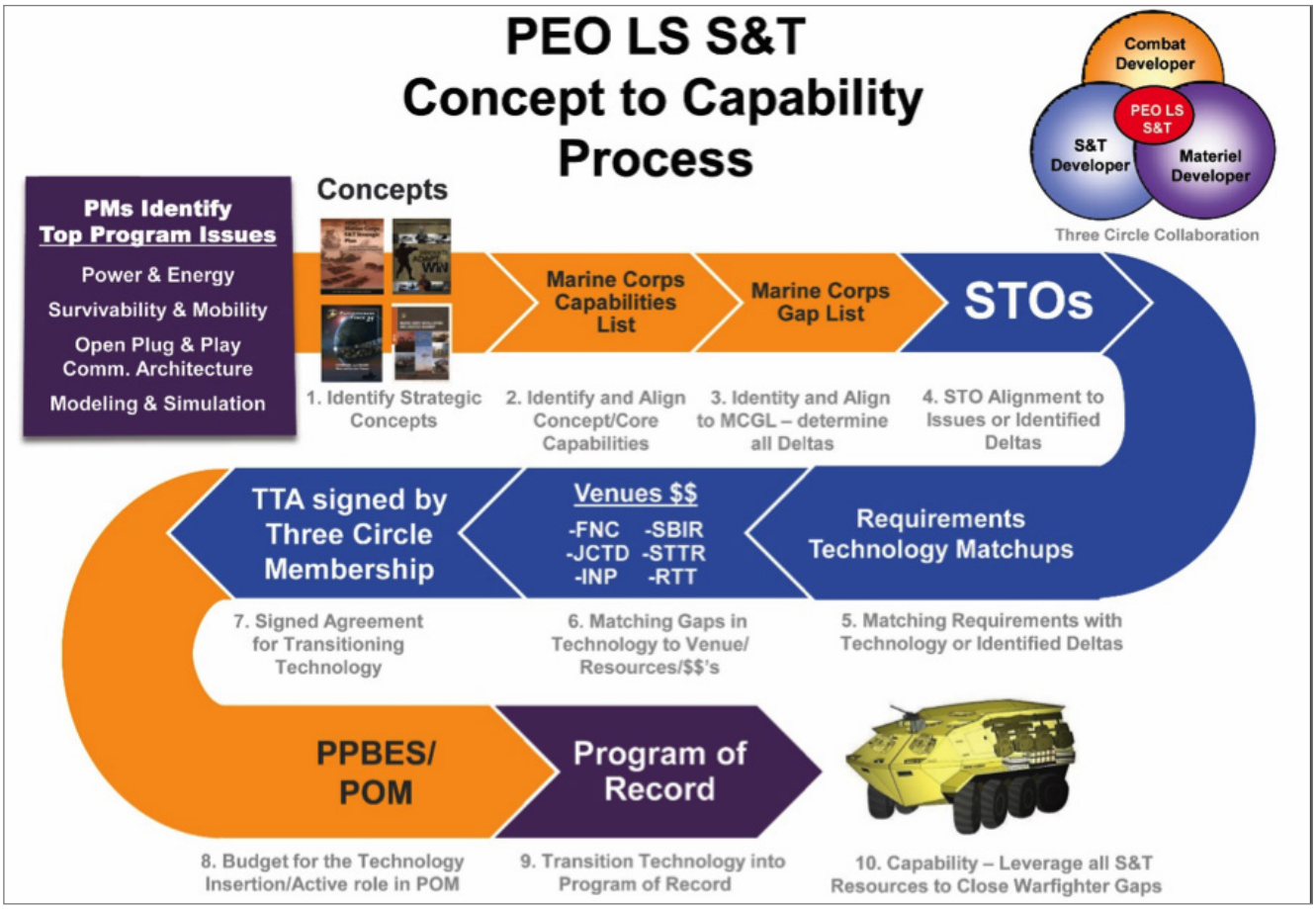

Figure 2-1. PEO LS Concept to Capability Process

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 as well as 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 (PPBE) process. Once a matching requirement/S&T initiative capable of lessening the effect on a Marine Corps gap, 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 Three 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 Program of Record (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 and 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, the 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 USMC S&T

Commanding General (CG), Marine Corps Combat Development Command (MCCDC) tasked the Director, Futures Directorate/ CG, Marine Corps Warfighting Laboratory (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 USMC 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 roundtables to identify USMC S&T requirements.

Science and Technology

Within DoD, Science and Technology 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 USMC 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 has a unique and pivotal role in the S&T process within the Three Circle S&T Community. 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 as depicted in Figure 2-2 on the following page.

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 USMC 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 Three Circle relationship is depicted in Figure 2-3 on the following page.

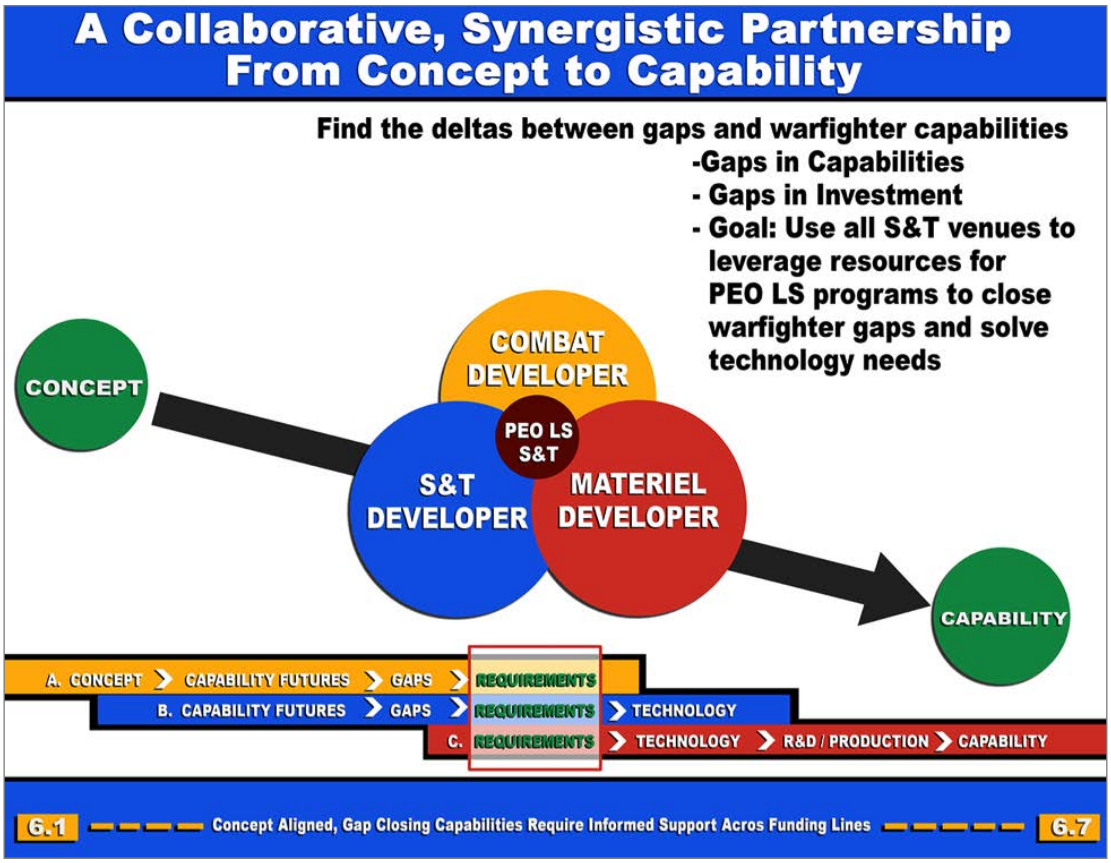

Figure 2-2. A Collaborative, Synergetic Partnership from Concept to Capability

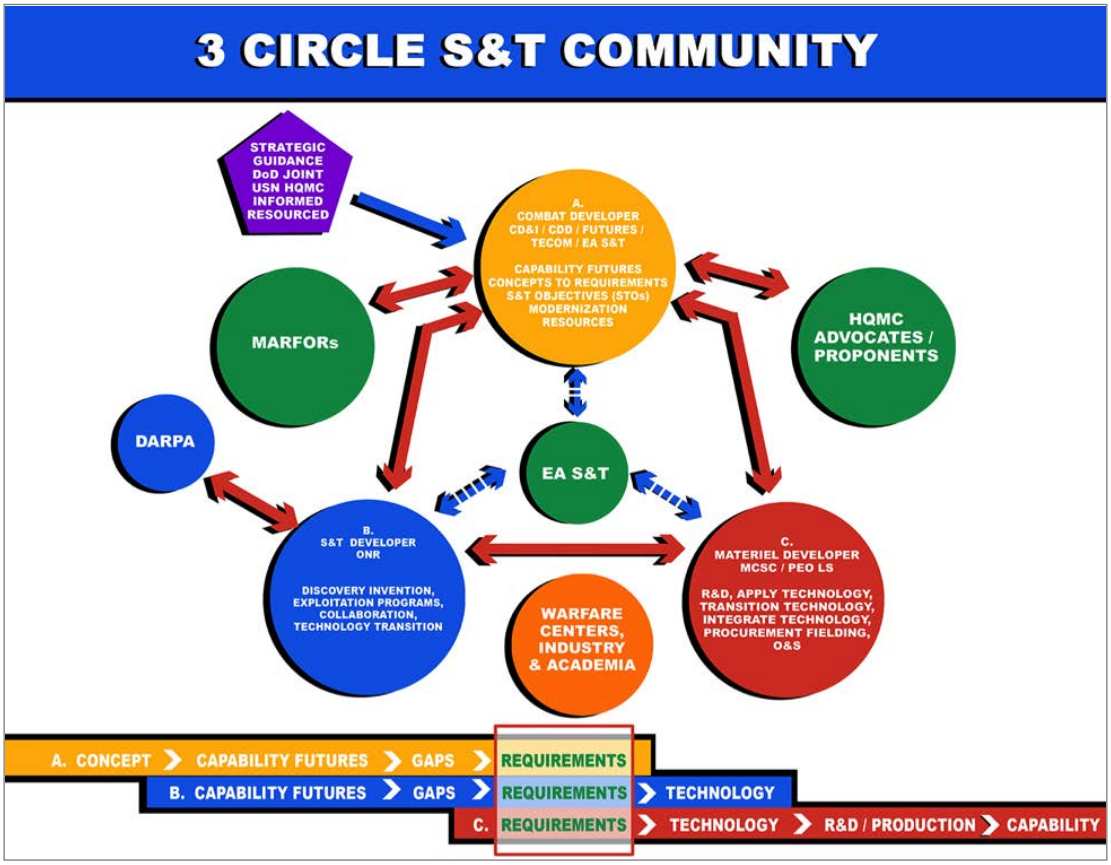

Figure 2-3. The 3 Circle S&T Community

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

- **Director, Capabilities Development Directorate** develops warfighting capabilities and requirements. The Director, Capabilities Development Directorate accomplishes this through the Marine Corps Capability Based Assessment (MC CBA) resulting in the Marine Corps Enterprise Integration Plan (MCEIP). The MCEIP is produced annually, is approved by the Marine Requirements Oversight Council (MROC), and signed by the Assistant Commandant of the Marine Corps (ACMC). 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 Marine Corps Capabilities List (MCCL), which are prioritized and measured against MROC approved scenarios, guidance and event task, condition and standards. The gaps in the MCCL are identified and further prioritized to create the Marine Corps Gap List (MCGL), which feeds in to 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 (DOTMLPF-P) pillars with identified actions, to include initiatives that implement the solutions. Formulation of the Enterprise Capabilities Management Plan (ECMP), which 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 Science and Technology Integration** is tasked with implementing the Director, Futures Directorate/CG, MCWL S&T responsibility as the USMC Commandant's EA for S&T. OSTI coordinates S&T within the combat development life cycle from 'requirement to transition.' Through coordination with the Three Circle S&T Community, OSTI develops the vision, policies, and strategies needed to exploit scientific research and technical development. A Defense Advanced Research Projects Agency (DARPA) Transition Officer is assigned to OSTI to stay abreast of DARPA's ongoing efforts and to ensure MCWL's ability to incorporate relevant technologies into future experimentation. OSTI provides technical oversight of proposals submitted to 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 U.S. Marine Corps S&T Strategic Plan. Within the U.S. Marine Corps S&T Strategic Plan are S&T Objectives (STO), which are products of the MC 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, 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 (VCNR). The below listed organizations 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.
- **Expeditionary Maneuver Warfare & Combating Terrorism Department (Code 30)**, one of ONR's S&T departments, develops and transitions technologies to enable the Navy-Marine Corps team to win and survive on the battlefield both today and tomorrow. In addition to supporting the Marine Corps, Code 30 also supports the Marine Corps Special Operations Command (MARSOC), Naval Special Warfare Command (NSWC), and Navy Expeditionary Combat Command (NECC).

Other S&T Stakeholders

- **DARPA's** singular and enduring mission is to make pivotal investments in breakthrough technologies for national security. DARPA explicitly reaches for transformational change instead of incremental advances by working within their innovation ecosystem that includes academic, corporate and governmental partners. DARPA's scientific investigations range from laboratory efforts to creation of full-scale technology demonstrations in the fields of biology, medicine, computer science, chemistry, physics, engineering, mathematics, materiel

sciences, social sciences, neurosciences, and more. As the DoD's primary innovation engine, DARPA undertakes projects that are finite in duration but that create lasting, revolutionary change. The Marine Corps maintains awareness of DARPA's initiatives by assigning a Marine Corps Operational Liaison to DARPA and assigning a DARPA Transition Officer to MCWL (OSTI).

- **Tank Automotive Research, Development and Engineering Center (TARDEC)** develops, integrates, and sustains the right 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 our 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 the majority of the DoD's S&T investment, some service-specific investments are not included in these groups. COIs were established in 2009 as a means 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 and technology opportunities, jointly planning programs, measuring technical progress, and reporting on the general state of health for specific technology areas. The COI that PEO LS is most interested 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

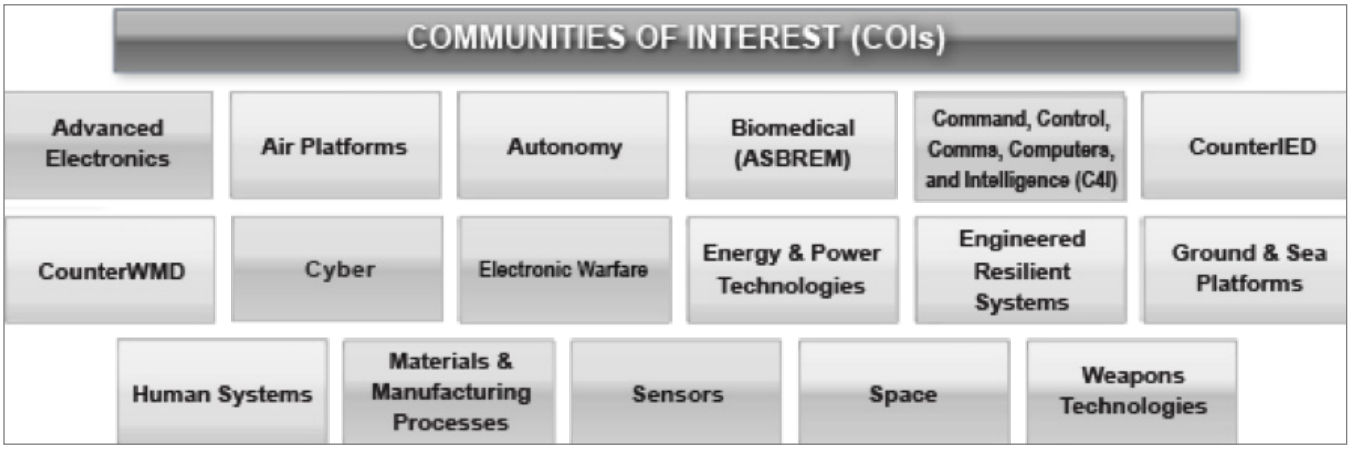

Figure 2-4. Communities of Interest

logistics burden, increases reliability, and provides timely support of ground and sea platforms. Areas of research include structural health monitoring, sustainment analysis tools, networked 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 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 (MPRI); Human/Autonomous Systems Interaction and Collaboration (HASIC); Scalable Teaming of Autonomous Systems (STAS); and Test, Evaluation, Validation, and Verification (TEVV).
- **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 research and development (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 (NSWCs):** Part of the Naval Sea Systems Command (NAVSEA) 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 Research, Development, Test and Evaluation (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. NSWC consists of nine sites or locations (Section 6 provides a detailed description regarding each of the following Warfare Centers):

  - Carderock Division of the Naval Surface Warfare Center, Maryland
  - Naval Surface Warfare Center Crane Division, Indiana
  - Naval Surface Warfare Center Dahlgren Division, Virginia
  - Naval Surface Warfare Center Dam Neck, Virginia
  - Naval Surface Warfare Center, Indian Head Explosive Ordnance Disposal Technology Division, Indian Head, Maryland
  - Naval Surface Warfare Center Panama City, Florida
  - Philadelphia Division of the Naval Surface Warfare Center, Pennsylvania
  - Naval Surface Warfare Center Port Hueneme, California
  - Naval Surface Warfare Center Corona, California

- **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 (JNLWD)** was established in 1996 with the Commandant of the Marine Corps (CMC) 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 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/Science and Technology 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/Events to better inform Independent Research and Development (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 2017 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.

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.

Figure 2-5. The Defense Innovation Marketplace Homepage

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Section 3.0

FUTURES

"Everything changes so fast and the rules are against us… But I am confident enough in the intellect and advice, that we will come up with the right solution, even if it is only 80 percent. If we do nothing, we lose. I am willing to take risk."

—General Robert B. Neller, 37th Commandant of the Marine Corps CMC, Innovation Symposium 23 February 2016

Introduction

The Marine Corps' 2015 Force Development Strategic Plan stated that the Marine Corps must innovate and adapt to a fast, unpredictable moving future to remain ahead of our adversaries. The Commandant reinforced these ideas when he spoke at the Marine Corps Warfighting Lab's Innovation Symposium stating,

"The system is broken. The Pentagon can't fix itself, let alone these emerging issues. There are an increasing number of hot spots around the world; no two are alike, and the circumstances are ever changing and increasingly complex. Technologies that could help have often evolved before older technologies are even fielded."

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 recent guidance documents have proven to be especially impactful in this effort. In November 2014, 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 Department of Defense 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 recently conducted wargames designed to examine aspects of the Marine Corps' new Expeditionary Force 21 (EF 21) capstone concept, which included: Ground Warrior 2015, Expeditionary Advanced Base Operations 2015, and MAGTF Warrior 2016 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

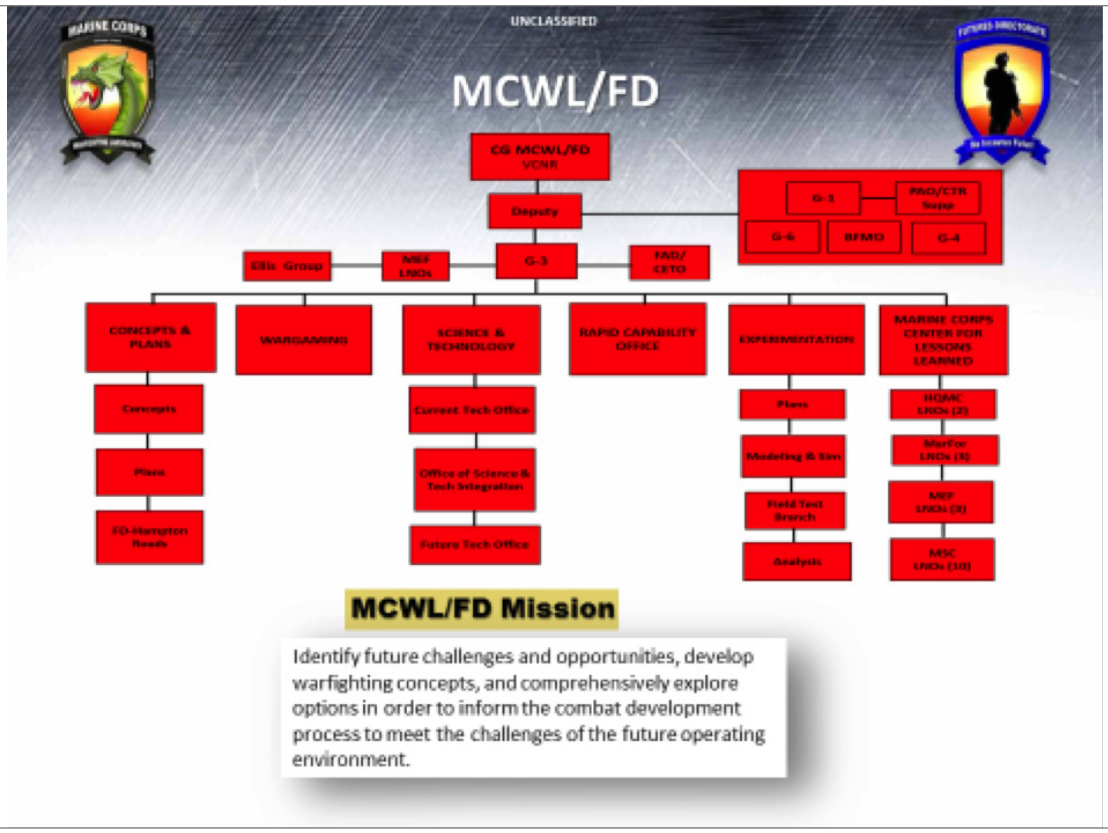

Figure 3-1. Futures Directorate Organizational Chart

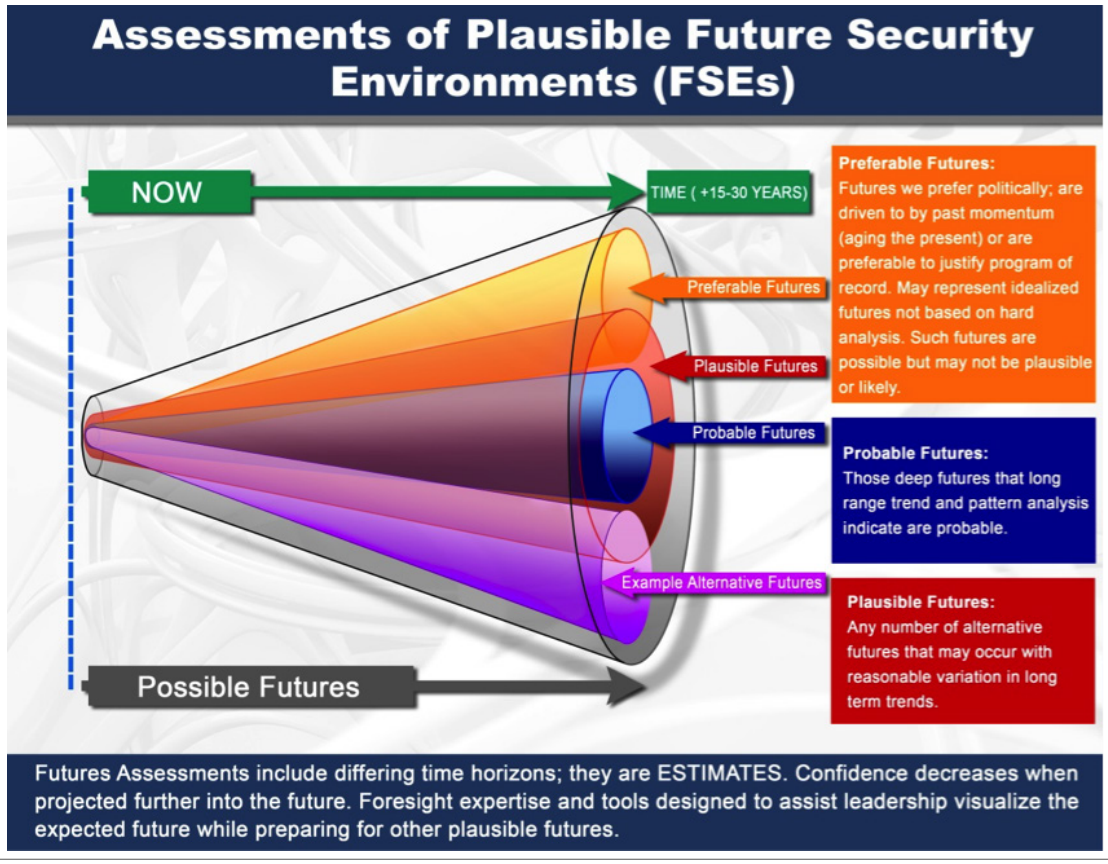

Figure 3-2. Assessments of Plausible Future Security Environments (FSEs)

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 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 2014).
- *The Defense Innovation Initiative* (*Secretary of Defense memo*, 2014).
- *36th Commandant's Planning Guidance* 2015.
- *Wargaming and Innovation* (*Deputy Secretary of Defense memo*, 2015).
- *The National Military Strategy of the United States of America 2015* (NMS).
- *Naval S&T Strategy: Innovations for the Future Force* (ONR 2015).
- *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.

"The future requires Marines to embrace change to leverage the rapid advancements in technology at the pace of the 21st Century in order to gain an operational advantage over any potential adversary we may face in the future."

—General Robert B. Neller,
37th Commandant of the Marine Corps CMC PB17 Posture Written Testimony

- 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

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 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 the 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. Drs. 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".

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's 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. 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. Drone warfare is merely the leading edge of a broader worldwide trend toward more autonomous methods of warfighting. Evidence of this trend can be seen in 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 which are just a few examples of the versatility that these automated systems provide. 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. 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. 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.

3.1.1 Manned-Unmanned 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 anti-access/area denial (A2/AD) environment.

3.1.2 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.

3.2 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)

"The proliferation of low cost, tactical unmanned aerial systems demand we think about this potential threat now… We must understand the threat these systems present to our joint force and develop the tactics, techniques, and procedures to counter the problem."

—General James Mattis, USMC (Ret)

- Artificial Intelligence/Deep Learning
- Condition Based Maintenance (CBM)

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

TOP TECHNICAL ISSUES

The identification and prioritization of Program Executive Officer Land Systems (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 Science and Technology (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 technical issue (see Figure 4-1).

This process assists S&T representatives from all PEO LS programs to work through the

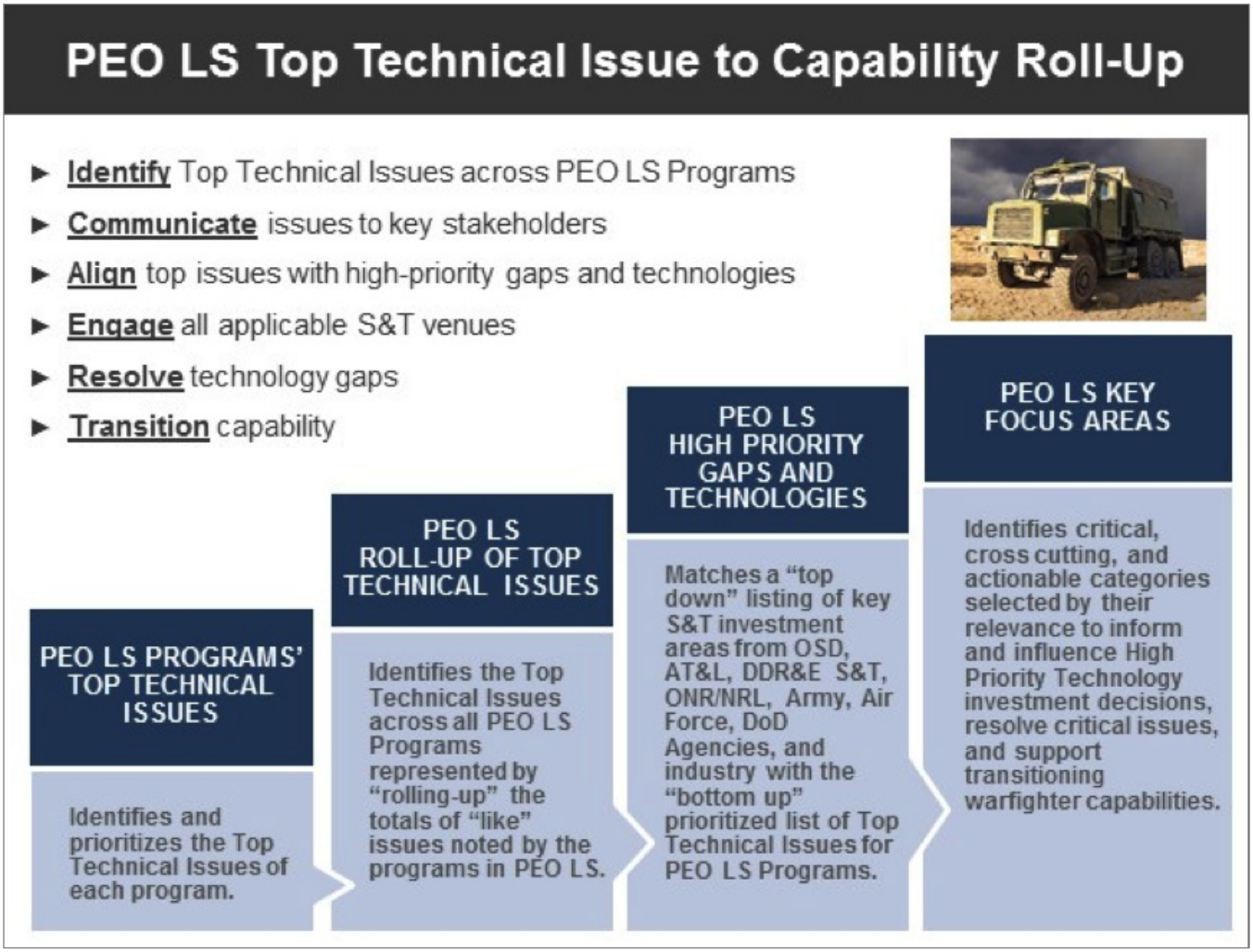


Figure 4-1. PEO LS Technical Issues to Capability "Roll-Up"

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.

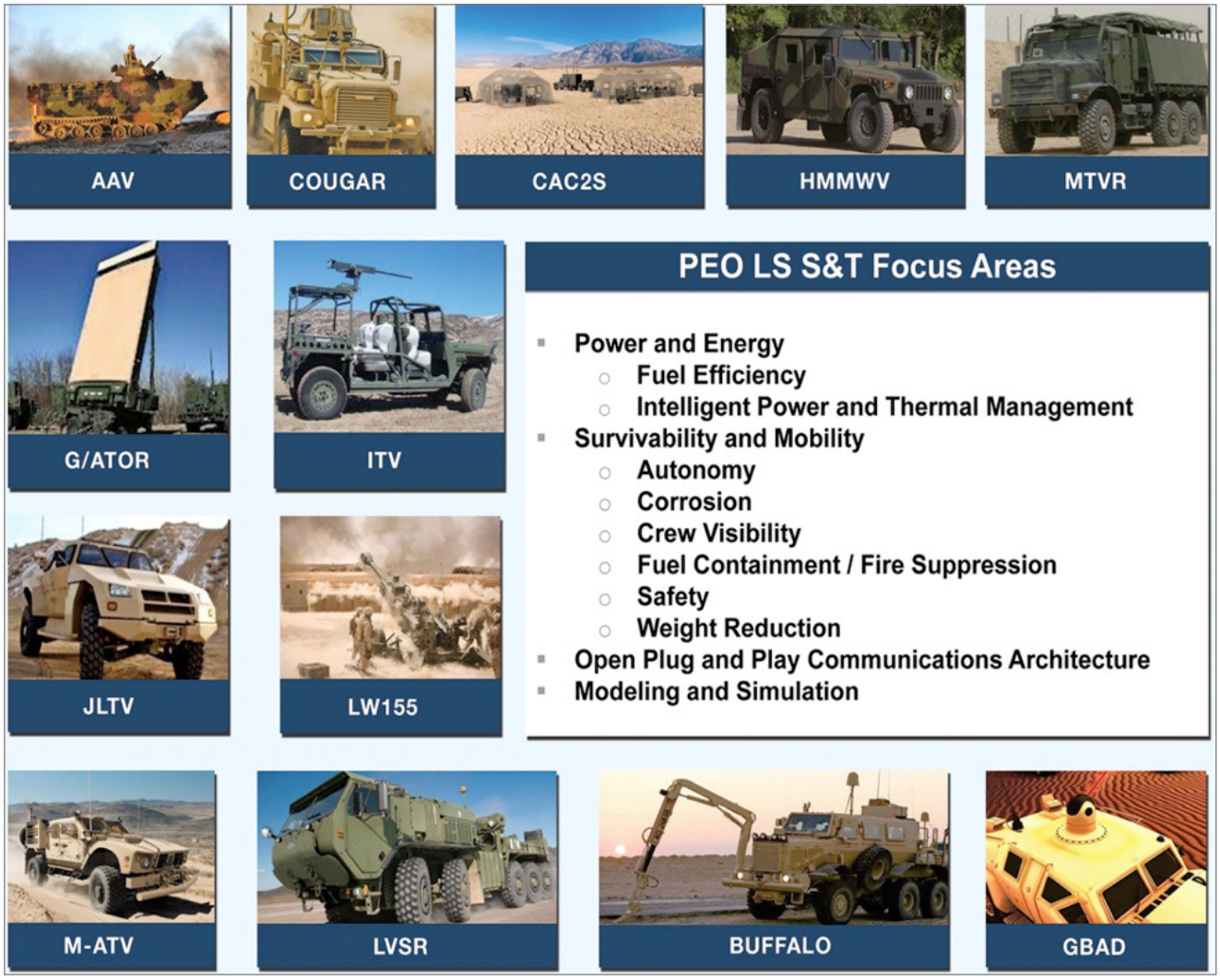
PEO LS Programs' Top Technical Issue Roll-Up

Program	Technical Issues
Assault Amphibious Vehicle (AAV)	➤ Survivability ➤ Weight/Buoyancy Management ➤ Reliability/Sustainment
Amphibious Combat Vehicle Phase 1 Increment 1 (ACV 1.1)	➤ 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) ➤ Stinger Night Sight Replacement
Ground/Air Task Oriented Radar (G/ATOR)	➤ Lowering Manufacturing Costs ➤ Increased Dynamic Range ➤ Advanced Electronic Protection
Joint Light Tactical Vehicle (JLTV)	➤ Weight/Protection ➤ Vehicle Network ➤ JLTV-Close Combat Weapons Carrier (CCWC) Missile Reloading Improvements
Logistics Vehicle Systems Replacement (LVSR)	➤ Fuel Consumption ➤ Increased Survivability ➤ Safety
Medium Tactical Vehicle Replacement (MTVR)	➤ Fuel Consumption ➤ Increased Survivability ➤ Safety
Mine-Resistant Ambush Protected (MRAP) Family of Vehicles: Buffalo, Cougar, and M-ATV	➤ Stress cracks in welded construction and monolithic hulls both using high hard steel ➤ Transparent Armor ➤ Reduction in occupant accelerations with minimal stroke distance availability
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

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

Section 5.0

PEO LS S&T FOCUS AREAS



Program Executive Officer Land Systems (PEO LS) Science and Technology (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, S&T investments, and support 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 Marine Air-Ground Task Force (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, as well as other areas on the platform to maintain equipment and crew comfort. Ideally, an effective power/thermal management system will improve electrical system efficiency and improve heat rejection by linking power/thermal management strategies into a single onboard architecture. Advanced power/thermal management tools are a critical step in the development of reliable and efficient vehicle platforms.

5.2 Survivability and Mobility. Survivability (5.2.1) consists of Fuel Containment/Fire Suppression and Safety; Mobility (5.2.2) consists of Crew Visibility, Corrosion, Autonomy 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.

5.2.1.1 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.

5.2.1.2 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.

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

5.2.2.4 Weight Reduction. This area develops modular, scalable, lightweight, and affordable components/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/technology trade-offs for tactical wheeled vehicles. These trade-offs will address performance, payload, crew protection, lifecycle costs, survivability, reliability, availability, and maintainability.

5.4 Open Plug-and-Play Communications Architecture. This technology focuses on the development of an affordable, scalable, and operationally flexible Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance architecture for use on new and legacy platforms.

Section 5.1 Focus Area

POWER AND ENERGY

PEO LS continues to address the challenge of increasing energy and fuel efficiency of Marine Corps vehicles. As the vehicles today are being equipped with a greater number of electronic devices, there is an increase in the demand for onboard power. Vehicle dependence on a common towable power generator only adds to the logistics burden and increases fuel consumption. The benefits of optimizing energy and fuel efficiency are:

- Lightening the load of the Marine Air- Ground Task Force (MAGTF).
- 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 they use.

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.

PEO LS is actively engaged with other agencies and technology partners to address the Marine Corps' current and future power and energy challenges. Working with ONR, MCSC, US Army Research Development and Engineering Command, Tank and Automotive Research, Development and Engineering Center (TARDEC), as well as various industry partners, PEO LS S&T representatives continually 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) with less fuel. The existing tactical vehicle fleet and associated fossil-fuel-consuming end items will be in the Marine Corps inventory for quite some time. Multiple 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

PEO LS Efforts

Fuel Efficient Medium Tactical Vehicle Replacement (MTVR)
This effort (a result of a Future Naval

MTVRs operating in Southwest Asia

Capability) will develop, optimize, integrate, and demonstrate at least a 15% fuel efficiency improvement beyond the existing MTVR and across a set of driving cycles representative of likely operational conditions, while maintaining MTVR affordability, current mobility, transportability, and survivability capabilities.

ONR Efforts

Extreme Power Internal Combustion (EPIC) Engine

This program will conduct feasibility studies, combustion modeling and simulation, and kinematic analyses of a Navy-patented novel rotary internal combustion engine concept that provides high power and torque in a small, lightweight, and fuel-efficient package.

Future Naval Capability (FNC) - ACV 1.X Mobility Enhancements

This FNC project will develop, optimize, integrate, and demonstrate a fuel efficiency improvement beyond the current ACV platform across a set of driving cycles representative of likely operational conditions, while maintaining affordability, mobility, transportability, and survivability capabilities. Additionally, the ACV 1.X Fuel Efficient Technology Suite will decrease the fuel consumption of ACV 1.2/1.3 by at least 10% through addressing engine and drive train losses while moving and at idle.

TARDEC Efforts

Advanced Combat Engine

The intent is to design and develop a novel 1000hp Military engine to meet mobility needs for combat vehicles. To meet the Army's need for enhanced protection and fuel efficiency, high power engines (750 – 1500 hp) are needed to offset increasing combat vehicle weights (armor), increased electrical generation needs (onboard and exportable power), improved fuel

economy (cost & range), enhanced mobility (survivability), and reduced cooling system burden (size, heat rejection) in a smaller package (reduce under armor volumes).

Advanced Combat Transmission

This is the development of a high efficient cross-drive transmission for a track vehicle mated to a 1000hp high power dense engine while offering greater fuel economy (↑ 10-15%), improved thermal efficiency (↑ 15%), and lower heat rejection (↓ 20%) for use in future combat vehicles and demonstrated in the CVP platform.

Alternative Fuels Qualification

This project will determine jet fuel specification/purchase requirements needed for approval of alternative jet fuels (ATJ, DSH, CH, AJF) as military ground fuel that enables DLA-Energy to source these fuels when they are commercially available at cost-competitive prices.

Energy Efficient Hydraulic Fluids

This effort will reduce energy (fuel) consumption in CE/MHE equipment by developing an energy efficient hydraulic fluid formulation and hydraulic fluid efficiency models. The EEHF requirements will be documented in a performance specification with qualified products for DLA-Aviation to purchase. Project will verify hydraulic fluid efficiency models developed for CE/MHE to further understand the efficiency gains that can be attributed to hydraulic fluid formulations. Efficiency testing will be conducted via laboratory rig and vehicle level testing.

Fuel Cell In-House

This will maintain and strengthen in-house technical knowledge and competencies through hardware testing, system integrations, collaborations with industry, government and academia and managing technical research efforts that push the state of the art and reduce system cost and complexity.

Fuel Quality Surveillance

The petroleum fuel handlers at all levels (to include Petroleum Groups and Theater and Divisional Sustainment Brigades, and Brigade Support Battalions) lack the ability to rapidly verify the suitability for use of petroleum products prior to issuing. This effort will also develop algorithms and mature technologies that will provide a fuels quality surveillance in minutes. Technologies to be investigated include: Light obscuration, light scattering, and ultrasound for contaminate; and Near Infrared Spectrometry for the portable fuel property monitor.

Small Business Innovation Research (SBIR) Efforts

Fuel Efficiency Improvements for Amphibious Vehicles (Phase I)

The program will develop concepts for fuel efficiency improvements including an estimate of reduced consumption/increased operation time and/or distance for an ACV 1.1 notional vehicle. During the initial phase, the objectives are to demonstrate the feasibility of the concepts in meeting Marine Corps needs and to establish what concepts can be developed into a useful product for the Marine Corps. Feasibility will initially be established by material testing and analytical modeling, as appropriate.

These efforts investigate four possible approaches to improve the fuel efficiency of the ACV system. One approach is energy scavenging technology to maximize the energy obtained from the fuel burned. Second, intelligent mobility technology is being developed to enable the system to self-tune powertrain performance based on the environment in which the system is operating. Third, auxiliary load optimization is being explored to minimize auxiliary component sizing and load on the engine. Finally, weight reduction technologies are being developed to reduce the overall weight and load on the powertrain across the system's operational range.

Variable Speed Accessory Drives (Phase II)
This Phase II research project will develop a variable ratio cooling fan drive for the MTVR. The MTVR currently uses a clutch-style fan drive operated with air pressure. It is believed that the fuel economy of the MTVR can be improved by implementing a variable ratio cooling fan drive and controlling the cooling fan speed as a function of coolant temperature.

RIF Efforts

Amphibious Combat Vehicle Fuel Efficiency Improvement
This effort will address the more than 10% reduction in fuel consumption during the expected ACV driving cycle. The project's major activities are to fabricate retrofit kits for two ACV engine types, conduct dynamometer and durability testing, and to provide the retrofit kits to the Marine Corps for field testing.

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; hotel services; and heating, ventilation, and air conditioning systems in an adaptive operational environment. Thermal management of electronics is vital to the successful tactical operation of a variety of military electronic systems. Vehicle thermal management is important as it can reduce thermal loads, efficiently remove heat, reuse waste heat, and integrate systems within the vehicle. This effort can improve operational effectiveness and have a reduced energy load. It also can extend 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.

Potential Solutions

SBIR Efforts

Lightweight Vehicle Exhaust for Amphibious Vehicles (Phase II)
A major challenge facing designers of exhaust and thermal management systems is the need for increased exhaust transport, heat transfer and dissipation capability, while reducing weight penalties and improving component lifecycle. Currently, the demand for increased exhaust and heat removal in military vehicles is surpassing the performance limits of conventional exhaust and thermal management systems. This is because updated military vehicles include additional armor protection, sensors, firepower, and other advanced capabilities that have added weight and higher performance requirements onto the system components. The Marine Corps experienced exhaust system challenges on the Expeditionary Fighting Vehicle (EFV). The aluminum and composite design developed to meet the exhaust requirements of the 2800 hp diesel engine performed poorly and came at a substantial weight and cost penalty.

As the USMC begins to look at future amphibious assault vehicle (AAV) designs, it is seeking to develop a light-weight, lower-cost vehicle exhaust system that can withstand the repeated heating/cooling cycles under exposure to the aggressive saltwater environment, while minimizing the transfer of heat from engine exhaust to the external surface of the vehicle for improved personnel safety and reduced thermal signature. This program proposes to achieve these objectives

using an exhaust system concept based on a composite wall construction, where each material used in the composite design is selected to perform a specific function. This approach offers the most flexibility with respect to the overall design of the exhaust system, providing multiple ways to address the demanding thermal, structural, and environmental performance requirements.

TARDEC Efforts

Advanced Li-Ion Modular Batteries

This effort will apply recent commercial advances in Lithium-ion based anode, cathode, electrolyte and separator battery materials to electrode, cell, and military specific pack designs to significantly increase energy density vs. lead acid battery baseline from 36Whr/kg to >160Whr/kg while increasing power density by >50% and increase operating temperature range for the Li-ion batteries from (-20°C to +50°C) to (-46°C to +71°C).

Advanced Thermal Management System

The intent is to leverage current investments in combat vehicle cooling technologies to develop, mature and integrate an efficient and effective cooling system for CVP. Also optimize cooling system reducing parasitic power in all modes of vehicle operation for more range & mobility as well as mature advanced technologies into integrated thermal solutions while enhancing performance, decreasing weight, and minimizing cost.

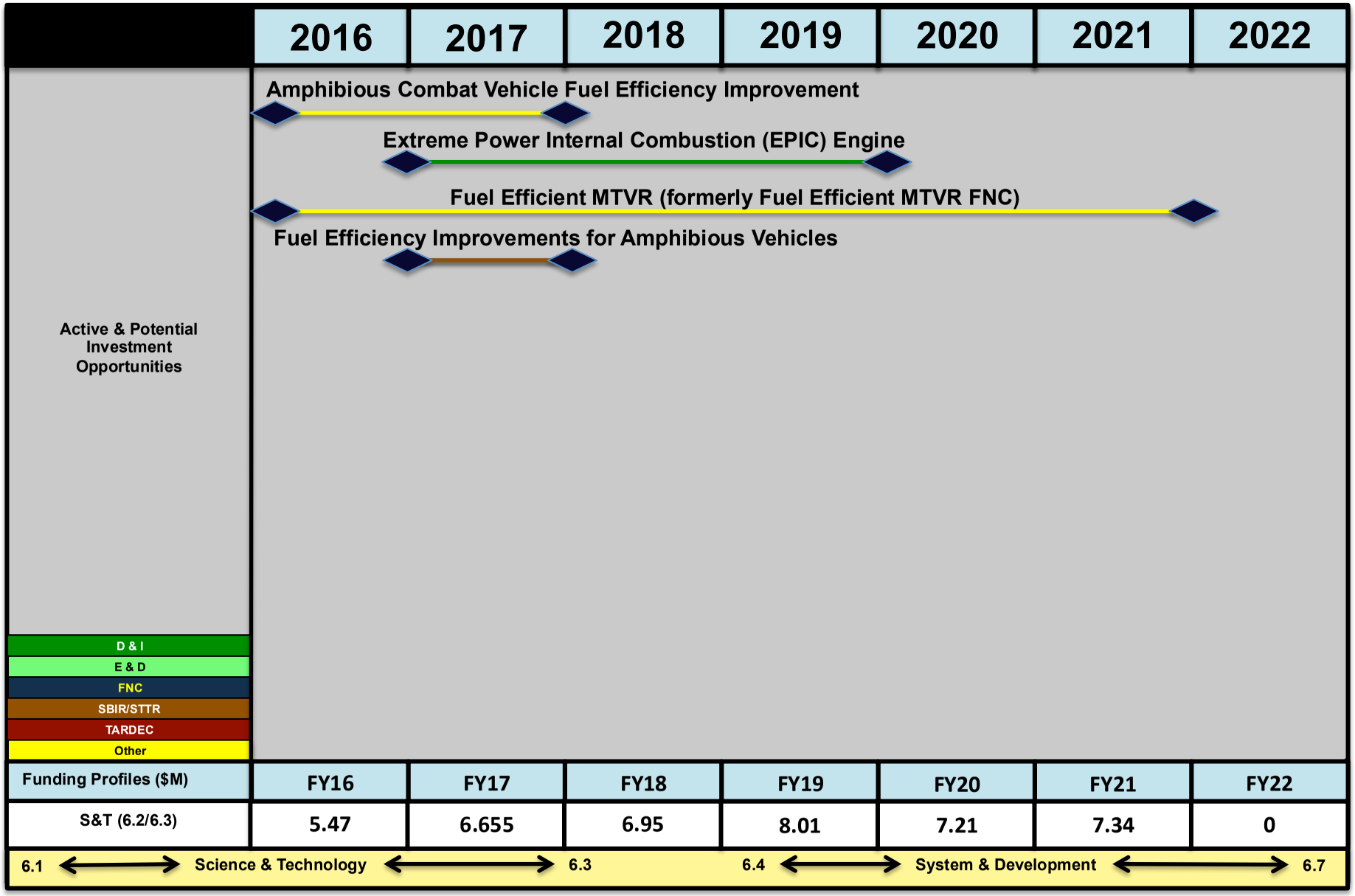
Advanced Vehicle Power Technology Alliance

This will develop advanced technologies that enable military ground vehicles to become significantly more energy efficient. This effort will also collaborate with the U.S. Department of Energy to demonstrate technologies in: advanced combustion engines and transmissions; lightweight structures and materials; energy recovery and thermal management; alternative fuels and lubricants; hybrid propulsion systems; batteries and energy storage; and analytical tools.

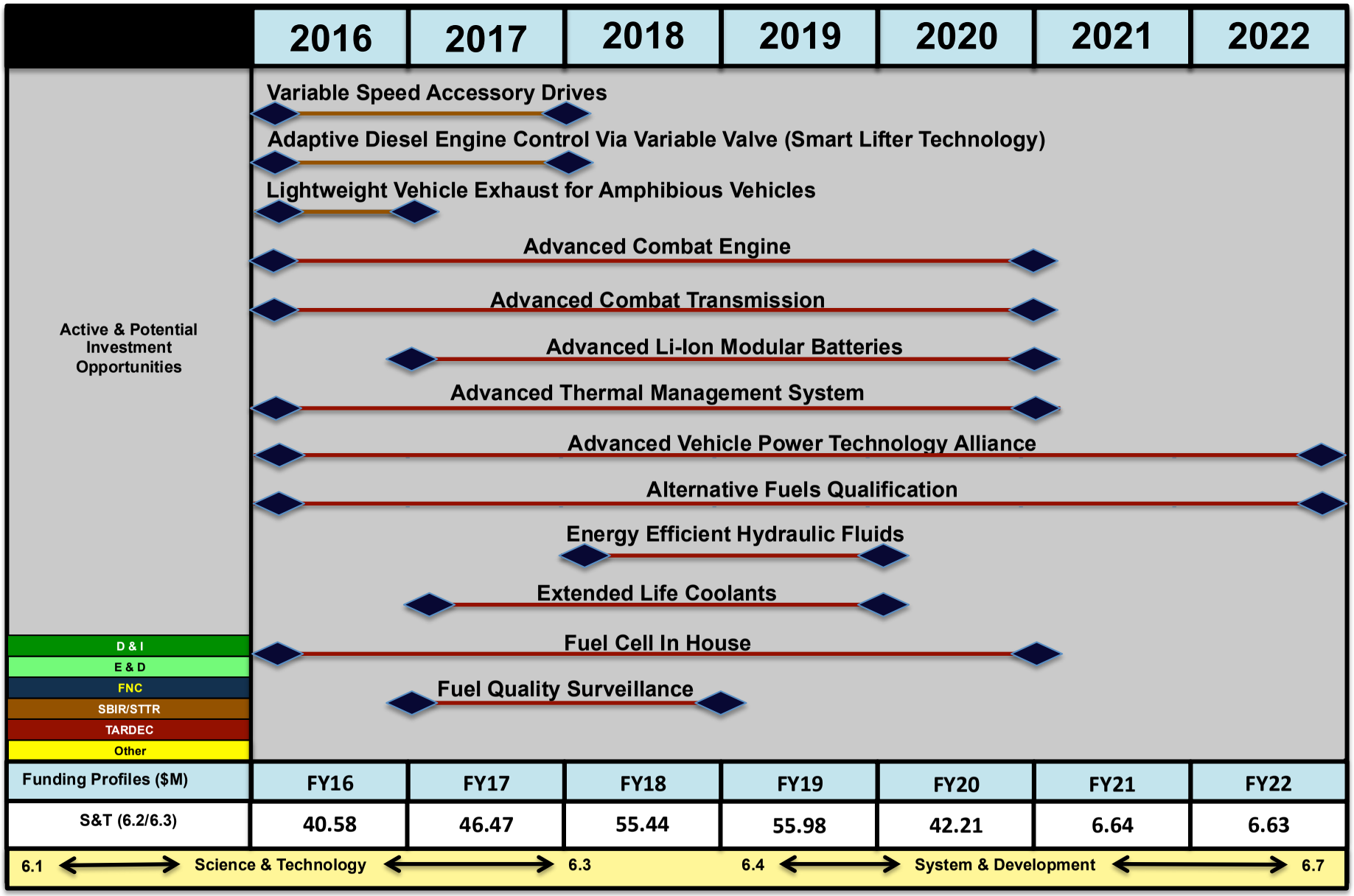
Extended Life Coolants

This project will research and evaluate extended life coolants (ELC) to determine their compatibility to military ground systems without degradations in performance and durability (i.e. that thermal efficiency is not compromised and that new additive technologies in ELC do not cause corrosion in legacy ground systems). The use of ELC can reduce operation and maintenance costs by increasing the intervals between drain and refill (potentially three years plus) as compared to the coolants in use today. This project will complement the current work being funded by the Defense Logistics Agency (DLA) on the investigation of the current life of CID-approved coolants and the properties of ELC when mixed with CID-approved coolants to evaluate compatibilities.

Fuel Efficiency



Power & Energy



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Section 5.2 Focus Area

SURVIVABILITY AND MOBILITY

The Marine Corps will operate in an increasingly complex and uncertain future. Future conflict will be marked by chaos and the proliferation of a variety of threats both conventional and unconventional. The Marine Corps' counter to those threats must be affordable, scalable and a systems-of-systems approach in order to be realized. Improvised Explosive Device (IEDs) will continue to be a challenge in the future battlespace where Marines fight. As an expeditionary force that is concentrating its efforts on re-honing their amphibious skills, the Marine Corps must ensure its tactical vehicle fleet is light, fast, easily transportable and survivable.

In addition, maintaining legacy vehicles and increasing their capability is a challenge, especially in an environment where affordability is crucial. One way to keep development costs low is to use simulation-based design tools that predict performance, survivability and reliability of systems.

Program Executive Officer (PEO) Land Systems (LS) continues to collaborate closely with Marine Corps Systems Command (MCSC), Marine Corps Warfighting Lab (MCWL), Marine Corps Combat Development Command, Office of Naval Research (ONR), Research Development and Engineering Command (RDECOM), Tank Automotive Research, Development, and Engineering Center (TARDEC), and other agencies to address the competing challenges of Survivability and Mobility.

The Survivability and Mobility focus area consists of technologies that increase survivability of both the Marines and vehicles. The two are addressed as a combined S&T Focus Area since what affects one often directly affects the other.

5.2.1 Survivability consists of:

- 5.2.1.1 Fuel Containment/Fire Suppression
- 5.2.1.2 Safety

5.2.2 Mobility consists of:

- 5.2.2.1 Crew Visibility
- 5.2.2.2 Corrosion
- 5.2.2.3 Autonomy
- 5.2.2.4 Weight Reduction

5.2.1 Survivability

The Challenge

The design, development and production of survivable vehicles that adequately protect our warfighters is a highly complex system-of-systems engineering problem. Maintaining legacy vehicles while increasing their capability remains a challenge, especially in an environment where affordability is as important as capability. Additionally, while maintaining survivability, the vehicles must provide the required mobility for the Marine Corps to successfully conduct expeditionary/amphibious operations.

Potential Solutions

PEO LS Efforts

Ground Based Air Defense On the Move (GBAD OTM)
This FNC will demonstrate the capability of a rugged expeditionary high energy laser demonstrator cued by a radar capable

of detecting low radar cross section threats and performing hard kills of unmanned aerial system (UAS) to prevent reconnaissance, surveillance, targeting and acquisition of expeditionary forces.

The Warfighting Payoff:

- Track & engage at greater distances.
- Low cost per engagement.
- On-the-move detection capability to enable maneuver.
- Much lower cost per engagement vs. kinetic weapons.

ONR Efforts

Technologies for Lightweight, Low Profile Active Protection System (APS)

This effort will investigate technologies to advance the state-of-the-science active protection system applicable to vehicles and watercraft for defeat of air-delivered chemical energy threats with minimal fratricide.

Active Protection Technology

The Active Protection Technology initiative investigates novel countermeasures to defeat Rocket Propelled Grenades (RPGs) and Anti-Tank Guided Missiles (ATGMs) inflight.

Lightweight Armor Applications/ Integration

This project will investigate applications of carbon nanotubes (CNTs) in high strain rate using lessons learned from the 6.2 Program for application in hard-armor systems.

Next Generation Lightweight Armor

This effort will investigate methods for inexpensive formation of ceramics (SiC), develop mesostructure mechanical property relationships for CNTs to guide material development, and improve processing methods for ultrahigh strength and stiffness CNT yarn and tape.

Detection Avoidance Material and M&S Development

This initiative will examine materials and develop improved M&S for advanced camouflage application. It leverages funds from the Army Research Laboratory (ARL) and the Defense Advanced Research Project Agency (DARPA) on the development of a capability to evaluate performance of new materials.

Detection Avoidance Technologies

This ONR effort continues development of advanced technologies to reduce vehicle signature.

Directed Energy Weapons Mitigation

This study will investigate Directed Energy Weapons (DEW) threats and develop countermeasure technologies among three mechanisms: obscuration, reduce probability of EM coupling, and EM reflective surfaces. It will leverage Navy experience and ARL/TARDEC investments for mitigation of DEW effects on Marine Corps platform hulls and sensors.

Flawless Glass+P2

This project will further develop the methodology to produce flawless glass as part of a transparent armor system. Reducing surface flaws can increase performance of the transparent armor systems by more than 10%, thereby allowing for a reduced weight armor system.

Functionally Gradient Armor Materials (Additive Manufacturing)

This initiative seeks to use additive manufacturing to fabricate light armor ceramic composite systems with novel geometries and seams.

Golem Protection System

This effort is a collaborative program with ARL and Communications-Electronics Research, Development, and Engineering Center (CERDEC) to develop and demonstrate an RPG/ ATGM defeat system. ONR funding supports

sensor development, fire control system research, software programming, and some experimentation for the Golem Protection System for Marine Corps vehicle needs.

Hybrid Layer Aluminum Composite (HLAC)

This effort explores the response of aluminum-composite structures to underbody blast events.

Multi-DOF Rollover-Impact-Blast Effects Simulator

This project will develop the capability of simulating crew response to an underbody blast in a laboratory setting without the use of explosives. It will also capture complex local structural motion by novel fixturing developed through modeling and simulation.

Scaling Studies in Ballistics

This study will investigate lightweight materials for armor applications for Marine Corps platforms (i.e., Amphibious Combat Vehicle (ACV) and JLTV Objective).

Tandem Threat Defeat and Select ATGM

This effort will continue the technology development to defeat tandem chemical energy threats and ATGM.

Transparent Armor Integration

This project will develop and demonstrate advanced transparent armor systems in a field environment using lessons learned from Flawless Glass, Transparent Armor Small Business Innovative Research (SBIR) project, and Polymeric Material Transparent Armor.

Transparent Armor SBIR (Phase II)

This project will reduce transparent armor for relevant threat by more than 30% and develop ballistic models useful for other programs. Transparent Armor Solutions and Southwest Research Institute have demonstrated a weight savings compared to conventional transparent armor solutions. Improvements to reduce weight along with M&S are ongoing to enable design of a transparent armor for different threats.

DARPA Efforts

Ground X-Vehicle Technologies (GXV-T)

Ground-based armored fighting vehicles and their occupants have traditionally relied on

USMC MRAP

armor and maneuverability for protection. The amount of armor needed for today's threat environments, however, is becoming increasingly burdensome and ineffective against ever-improving weaponry. GXV-T seeks to develop revolutionary technologies to enable a layered approach to protection that would use less armor more strategically and improve vehicles' ability to avoid detection, engagement and hits by adversaries. Such capabilities would enable smaller, faster vehicles in the future to more efficiently and cost-effectively tackle varied and unpredictable combat situations.

The GXV-T program aims to improve the survivability of ground-based armored fighting vehicles by providing physically and electronically assisted situational awareness for crew and passengers. It also will provide semi-autonomous driver assistance and automation of key crew functions similar to capabilities found in modern commercial airplane cockpits to reduce onboard crew and training requirements. The GXV-T program is not a vehicle development program, but rather it is focused on developing core technologies so future vehicles can be more robust and agile. This is done through the provision of innovative protective capabilities, such as real-time movable armor that is instantly responsive to incoming threats and novel drive-train technologies able to provide enhanced mobility and power.

RDECOM & TARDEC Efforts

Advanced Armor

This project will leverage current investments in combat vehicle armor to develop, mature and integrate lightweight base, add-on, and electrified armors. Mature and test Pulse Power system to enable electrified armors. Mature advanced armors into integrated armor solutions while maintaining performance, decreasing weight, and maintaining cost.

Advanced Countermine/IED Payloads Competency

Army Elements lack the ability to conduct mounted and dismounted movement and maneuver on and offroad, in all terrain conditions where the threat of AT mine and IED engagements exist. This effort will capitalize on small incrementally funded activities combined with customer focused efforts to achieve technical capabilities that can ultimately be packaged into a single system adaptable to truck, tracked, and robotic platforms.

Advanced Passive / Active Blast Mitigation

This effort will mature blast mitigation technologies through product development, integration and validation. It will meet the ≥4X underbody blast requirements by integrating interior and exterior blast mitigation technologies on combat vehicle representative blast bucks. It will also fully understand blast load paths through vehicle platforms by decomposing the load paths through each technology and technology interface.

Combat Vehicle Adaptive Armor

The intent is to develop and demonstrate integrated adaptive armor systems comprised of mechanical and electrical subcomponents on a representative combat vehicle platform.

Combat Vehicle Office Program Management Office

The CVP Mission is to execute a five year Ground Vehicle technology development program that delivers a portfolio of leap-ahead technologies at TRL 6 by FY19 to the Army and can be integrated and demonstrated on a prototype platform by FY21. The CVP Vision is to develop ground vehicle leap-ahead technologies that ensure the Warfighter maintains its overwhelming ground combat superiority against any enemy worldwide.

Modular Active Protection (includes MAPS BA4)

This project will develop and demonstrate soft kill/hard kill APS utilizing a modular APS framework that will allow commonality across the vehicle fleet, tailored systems to meet PM needs, and facilitate transition.

Sensor Protection from Lasers
The intent is to improve and adapt sensor protection technologies to a variety of platforms as well as develop new materials/devices/strategies for countering advanced laser threats. Reduction of optical cross-section, minimization of jamming and dazzling, and overall increase in damage thresholds.

5.2.1.1 Fuel Containment/ Fire Suppression

The Challenge

PEO LS Science and Technology representatives continue to investigate all options in potential fuel containment and fire suppression technologies. Addressing fires caused by accelerants and 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.

Potential Solutions

RDECOM and TARDEC Efforts

Fire Protection Competency
This effort will provide legacy and future vehicle programs with improved damage mitigation techniques to protect against current and emerging fire threats.

SBIR Effort

Aqueous Based AFES (Phase II)
This ONR effort will develop an aqueous solution that provides vehicle crew protection against crew cab fires, fire re-flash and also protect occupants from associated hazards. The approach is to identify a breathable foam solution for fire suppression with no harmful/toxic byproducts, and to develop aqueous-based injury criteria. An initial prototype will be developed and tested.

5.2.1.2 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.

Potential Solutions

ONR Efforts

Dynamic Vehicle Center-of-Gravity and Gross Weight Estimation Using Readily Available Sensors – SBIR (Phase II)
This SBIR effort will develop and demonstrate a novel system for estimating vehicle gross weight and center-of-gravity location using an innovative nonlinear real-time filter based method. The proposed algorithm uses known physics-based kinematic relationships between vehicle states for the estimation process, and it requires minimal set of low-cost sensors that can be easily integrated into existing vehicle platforms.

RIF Efforts

Computational Anthropomorphic Virtual Experiment Man (CAVEMAN) Model for Injury Assessment in Kinetic Events
The project's goal is to refine the high fidelity computational physics model to support survivability improvement efforts within the Marine Corps vehicle community. It will use a virtual human body model for crew injury evaluation from underbody IED. CAVEMAN will provide advanced skeletal injury localization and additional injury modalities in damage to soft tissue to help the Marine Corps more effectively design for IED survivability.

MTVR during amphibious operations

5.2.2 Mobility

The Challenge

Mobility is fundamental for providing the agility and flexibility that expeditionary warfare requires. The challenge is to find an affordable balance between payload, protection, and performance mobility.

Potential Solutions

ONR Efforts

ACV High Water Speed Parameter Setting Study
This project will determine the bounds of physics for the three ACV high water speed lanes.

Amphibious Swarming Vessels
This effort will analyze potential mission sets and payload modules and determine system parameters and desired performance capabilities.

Future Naval Capability (FNC) - ACV 1.X Mobility Enhancements
This FNC will design and build a suite of affordable drag reduction, speed enhancing, and affordable fuel efficient technologies to provide at least a 50% increase in water speed and at least a 10% increase in fuel economy of the ACV 1.2/1.3. This effort will also develop a suite of affordable drag reduction and speed enhancing technologies that can be quickly and easily installed and removed from ACV 1.2/1.3 to increase water speed.

Configurable Terrain/Tire Interface
The project's objective is to develop a novel tire material that can adapt its footprint or stiffness to different terrain conditions via stiffness change of a thermoplastic styrene-based polymer around glass transition and phase change of low temperature bi-alloys encapsulated in an elastomer matrix.

Predictive/Adaptive Mobility (PAM)
This effort will predict upcoming environment and terrain characteristics via on-board

databases and remote sensors (e.g., Unmanned Air Vehicles (UAVs), satellites, and lead platforms) and intelligently adapt, in near-real time, platform mobility dynamics systems. The objective is to optimize mobility, agility, and safety, providing just-in-time trafficability.

Trafficability and Mobility Analysis from Remote Sensing
This project will use remote sensing products focused on terrain and soil characteristics to generate the mobility corridors from the modified combined obstacle overlay to improve maneuver planning in the littorals.

Vehicle Agnostic Modularity (VAM)
This effort includes the exploration and creation of modularity concepts for future tactical vehicles.

VAM – Virtual Framework Phases II and III
This project will develop a multi-criteria/ multi-objective optimization methodology for use within a dynamic simulation code. The methodology will estimate system and subsystem benefits, as well as predict effects of module-level design changes on system-level operational capabilities. Application of the developed methodology enables assessment of the efficacy, benefits, and burdens of novel modularity concepts within a realistic operational environment.

RDECOM & TARDEC Efforts

Active Suspension / Lightweight Track
This project will develop an Advanced Running Gear as a system, consisting of an advanced External Suspension Unit (ESU) and Advanced Lightweight Track (ALwT) system that will maximize weight reduction, improve vehicle durability and mobility and augment system survivability. The products will support PM CVP with additional support to the Bradley Family of Vehicles. Track and suspension technologies are historically developed as individual components leading to sub-optimal system performance. The Advanced Running Gear must be developed as an optimized system to achieve optimal performance and durability at minimal weight.

NAC Business Management
This will explore, plan and execute the High Efficiency Truck Users Forum (HTUF) for trucks and off-road equipment. It will also bring stakeholders together to accelerate commercialization of high-efficiency technologies for military and commercial vehicles.

5.2.2.1 Crew Visibility

Crew visibility addresses the tactical vehicle crewman's ability to see the battlefield. Darkness, rain, snow, fog, sandstorms, dust, smoke and obscuration factors caused by weapons firing all have an impact on crew visibility. Navigation, vehicle identification, tactical movement and situational awareness are all important aspects of crew visibility. On the battlefield of the future, it is highly likely that enemies will have access to various types of night vision devices, as well as lasers, and use them to their advantage.

The Challenge

Survivability can inadvertently hinder crew visibility. The cost, weight, and optical limits associated with transparent armor often results in vehicles that are burdened with limited visibility. Increasing visibility for Marine Corps vehicles without imposing a heavy penalty on size, weight, power and cost is the goal, but achieving this goal presents a significant technological challenge.

Potential Solutions

ONR Efforts

Transparent Armor
The goal of this SBIR is to reduce the weight of transparent armor for relevant threat by more than 30%, and then transition the technology to relevant vehicle platforms. In addition,

the Transparent Armor project will develop a ballistic model useful for other programs.

Transparent Armor Integration
This effort will develop and demonstrate advanced transparent armor systems in a field environment using lessons learned from flawless glass, SBIR, and polymeric material TA.

RDECOM & TARDEC Efforts

Future Sensor Protection Research (TBD)
The purpose of the project is to prevent destruction of combat vehicle optical systems from High Energy Laser (HEL) weapons.

Ground Degraded Visual Environment
The purpose of the effort is to increase local situational awareness (LSA) in all conditions and environments, to include degraded visual environments (e.g. dust, smoke) for ground vehicle systems using scalable LSA sensing & immersive intelligence.

5.2.2.2 Corrosion

For Marines, who preserve and maintain thousands of pieces of ground equipment, fighting corrosion is uniquely challenging. Marines operate in very harsh saltwater environments. The Marine Corps has established an effective corrosion-prevention program for all tactical ground equipment. This program intends to reduce maintenance requirements and costs through the development of corrosion prevention and control products, materials, technologies, and processes.

The Challenge

With a reduced national defense budget and the resulting reduction of new equipment procurements, the Marine Corps cannot afford to ignore corrosion issues. Consequently, the Marine Corps will be required to use much of its current gear and its existing vehicle fleet. Enhanced anti-corrosion technologies will extend vehicle-service life, reduce required maintenance, and prolong the operational viability of legacy systems. Enhanced anti-corrosion technologies and future service life extension programs will be required to extend the life of the Marine Corps' equipment, keeping them operationally viable and ready for use.

Potential Solutions

MCSC Efforts

Corrosion Prevention and Control (CPAC)
The goal of this effort is to establish an effective CPAC program to extend the useful life of all Marine Corps tactical ground and ground support equipment. The effort also seeks to reduce maintenance requirements and associated costs through the identification, implementation, and, if necessary, development of corrosion prevention and control products, materials, technologies, and processes. The use of these technologies and processes will repair existing corrosion damage and prevent, or at least significantly retard, future corrosion damage on all Marine Corps tactical ground and ground support equipment.

Recognized by the Office of the Secretary of Defense for its successful corrosion prevention and repair efforts, the Marine Corps CPAC program has become a model for other services. This program continues to deliver best-value return on investment across all phases of Marine Corps' equipment life cycles. Since its inception in 2004, the CPAC Program Management Office has maintained a viable, comprehensive program that is credited with saving the Marine Corps more than $20 million annually. With the expansion of the program and the use of advanced technology, savings are anticipated to continue to grow.

5.2.2.3 Autonomy

Autonomy has the potential of becoming a Marine Corps combat multiplier that will save lives by reducing or removing the human element from the convoy. The Marine

Corps has increased its efforts to develop autonomous unmanned ground systems that will work in union with manned systems and augment Marine Corps capabilities. In addition, autonomous vehicles can free up manpower from logistics missions, making them available for more tactical roles.

Similar to the value UAVs bring to the skies in the form of persistent visibility, Unmanned Ground Vehicles (UGVs) bring benefits to Marines on the ground in standoff capability. These ground vehicles are reducing Marines' exposure to life-threatening tasks. UGVs are largely used in support of counter-IED and route clearance operations, using robotic arms attached to, and operated by, modified Mine Resistant Ambush Protected vehicles and remotely controlled robotic systems.

The Challenge

Because UGVs have been playing a greater role in combat, the need for new capabilities has been steadily increasing. Current UGVs require a person to operate the vehicle remotely. Autonomous vehicles that do not require a man-in-the-loop tend to move slowly and have difficulty traversing terrain, even over minimal obstacles. For autonomous vehicles to be beneficial to the Marine Corps, they must be able to conduct resupply missions with either a "man-out-of-the-loop" or a "man-on-the-loop" (to provide oversight and input when needed). To truly be valuable, future autonomous vehicles should not require Marines for protection, and they must be able to cross rugged terrain quickly and easily without requiring human assistance.

Potential Solutions

ONR Efforts

Cognition for UGV/Warfighter Teaming

This project seeks to develop a cognitive framework to enable intelligent interaction between unmanned autonomous systems and human warfighters. The approach is to develop algorithms that will allow for extended situational comprehension from processing of real-time sensor data without the need to translate objects and features into semantically identifiable symbols.

Collaborative Heterogeneous Autonomous Systems

This work will develop and demonstrate collaborative robotic behaviors involving multiple autonomous vehicle types, including mixed teams of ground and air platforms.

Complex Scene Analysis

This effort will investigate computationally efficient methods for extracting real-time knowledge and understanding from visual scenes. The approach will focus on merging bottom-up and top-down processes, moving beyond pixel-level analysis, to provide deeper understanding of objects and relationships within a scene. The intent is to exploit vision-based systems to achieve enhanced automated perceptual understanding in a dynamic, complex environment, providing a sufficient level of comprehension to enable advanced autonomous navigation and the development of tactically relevant behaviors.

Coordinated Tactical Behaviors

This project will develop, implement, and demonstrate multi-vehicle autonomy enabling multiple unmanned ground vehicles to perform collaborative behaviors in support of various expeditionary military missions (e.g., force resupply, convoy protection, and route reconnaissance).

Expeditionary Wingman Navigation

The Wingman concept envisions mobile autonomous systems that are fully integrated with small-unit Marine ground forces. Wingman will provide added operational capability, load bearing, and security for multiple mission profiles, environments, and conditions. This project will develop and demonstrate advanced navigation and path-planning algorithms that will allow a robotic

wingman to maintain position and pace with a dismounted squad, while autonomously traversing complex terrain and obstacles.

Intelligent Autonomy Architectures

This project seeks to develop, mature, and advance an architectural framework for integrating technology components and subsystems of unmanned autonomous ground vehicles. It will facilitate the use of open, modular hardware and software development, while fostering science and technology innovation, multi-developer participation, and interoperability.

ITV Autonomy Conversion - Autonomy Integration

This effort will facilitate transition, integration, and maturation of autonomous capabilities for a full- system demonstration and limited military utility assessment at the Autonomous Logistic Connecter Mission in FY16/FY17.

Natural Interaction between UGV and Squad

This project will develop and demonstrate technologies that will enable Marines to communicate with autonomous machines, and autonomous machines to communicate with Marines, using the same familiar methods humans commonly use to communicate with each other. Focus areas include: two-way voice communication, two-way visual sign usage, understanding of intent, implementation of rehearsed coordinated action, and machine interpretation of text, tactical graphics, maps, and overlays.

Neural Perception and Cognition

This project will explore artificial means of replicating the cognitive and perceptual performance of biological systems in a context relevant to the use of unmanned autonomous systems in expeditionary war fighting. The approach targets sensing and perceptual processing that leads to knowledge acquisition and understanding.

Night Ops with Electro-optical Perception System

This initiative seeks to enable autonomous night operations. It will develop and quantitatively demonstrate a low-cost electro-optical perception system to perform stereo camera-based navigation during night operations and a localization solution (sensors + algorithms) with less than 1% error (2D) during one hour in GPS-denied environments at 20 mph.

Perception Under Adverse Conditions

This project will focus on developing and demonstrating advanced perception capabilities that will enable the continued operation of autonomous systems when optical sensor performance is degraded by photonic absorption or scattering due to rain, snow, fog, smoke, dust, or other visual obscurants.

Robust Traversability in Complex Terrains

This effort will demonstrate that a path planner using high-fidelity terrain, kinodynamic vehicle models, and nonholonomic trajectories will enable navigation to be 20% faster and with 25% less interventions through complex, cluttered environments.

Scene Comprehension and Representation

This project builds on previous efforts to develop and ultimately demonstrate advanced cognitive robotic perceptual capabilities. The objective is to create the ability for a machine to process streaming sensor data into actionable information and knowledge. The approach encompasses advances in scene comprehension, symbolic representation, attention allocation, anticipation, probabilistic expectation, contextual reasoning, learning, and adaptation.

Sensor Fusion for Robust Perception

This initiative will demonstrate a low-cost perception system ($10k–$20k) for an autonomous ITV-sized vehicle that can

provide 20cm X/Y spatial resolution at ranges to 40 meters; surface normal data; classify environmental material with an accuracy > 75%; and perform nighttime perception with a perception distance > 63% of daylight requirements.

Squad Level Tactical Behaviors

Autonomous robotic vehicles interacting with human teammates as part of an integrated squad will need to be able to perform tactical movements and behaviors that support the team's overall mission while enhancing its effectiveness. The objective of this project is to develop and demonstrate a functional set of tactically relevant responses and behaviors that will enable a robotic team member to perform mission-related tasks in close proximity to humans and in accordance with the squad's tactics, techniques, and procedures.

Terrain and Object Perception

This effort will develop perception algorithms for recognition and representation of operationally relevant objects and features in the environment. The approach will use multi-modal sensing, both passive and active, to enable discernment of specific features from within a complex dynamic environment, including: terrain and landscape features, roads/pathways, people, vehicles, structures, and other features to enable improved autonomous navigation, actions, intelligent decision-making, and behavioral learning.

Warfighter/UGV Team Intent Reasoning and Adaptation

This effort is motivated by the need for autonomous systems to make inferences and apply reasoning based on the dynamic information being continuously received from sensors observing the environment and specifically warfighters with which the system is interacting. The project objective focuses on the use of advanced perception capabilities to support reasoning about friendly and adversarial activities and intent in dynamic situations with evolving context.

Wingman Platform and Mission Packages

This project will design and develop an autonomous test bed vehicle platform for use in testing, maturing, and demonstrating new autonomy-enabling technologies and payloads related to the wingman robotic squad member concept.

World Modeling and Tactical Path Planning

This effort will investigate the potential to extract higher-level knowledge elements from World Model datasets. It will use segmentation and clustering techniques to identify distinct regions, paths, and objects for use in advanced navigation and reasoning solutions.

RDECOM & TARDEC Efforts

Autonomous Ground Resupply

The purpose of Autonomous Ground Resupply Program is to develop and demonstrate an improved and optimized distribution system that integrates new and emerging technologies across the full spectrum of operational and tactical supply movement operations.

Autonomous Robotics for Installation & Base Operations

The purpose of the project is to accelerate the adoption and use of intelligent ground vehicle systems for military and commercial applications by linking technology with real-world operational settings in semi-controlled environments.

5.2.2.4 Weight Reduction

Weight reduction is an aspect of lightening the Marine Air-Ground Task Force. This is a significant challenge and every pound counts. Equipping trucks with auxiliary power sources, for instance, can save a generator and potentially reduce the load by 300 pounds. More efficient engines would help reduce fuel demands.

The Challenge

Successful weight-reduction efforts will generate benefits including expanded range, superior mobility, increased energy efficiency, and greater speed. The challenge is to implement weight- reduction measures that are affordable and that will not degrade survivability nor reduce reliability.

Potential Solutions

ONR Effort

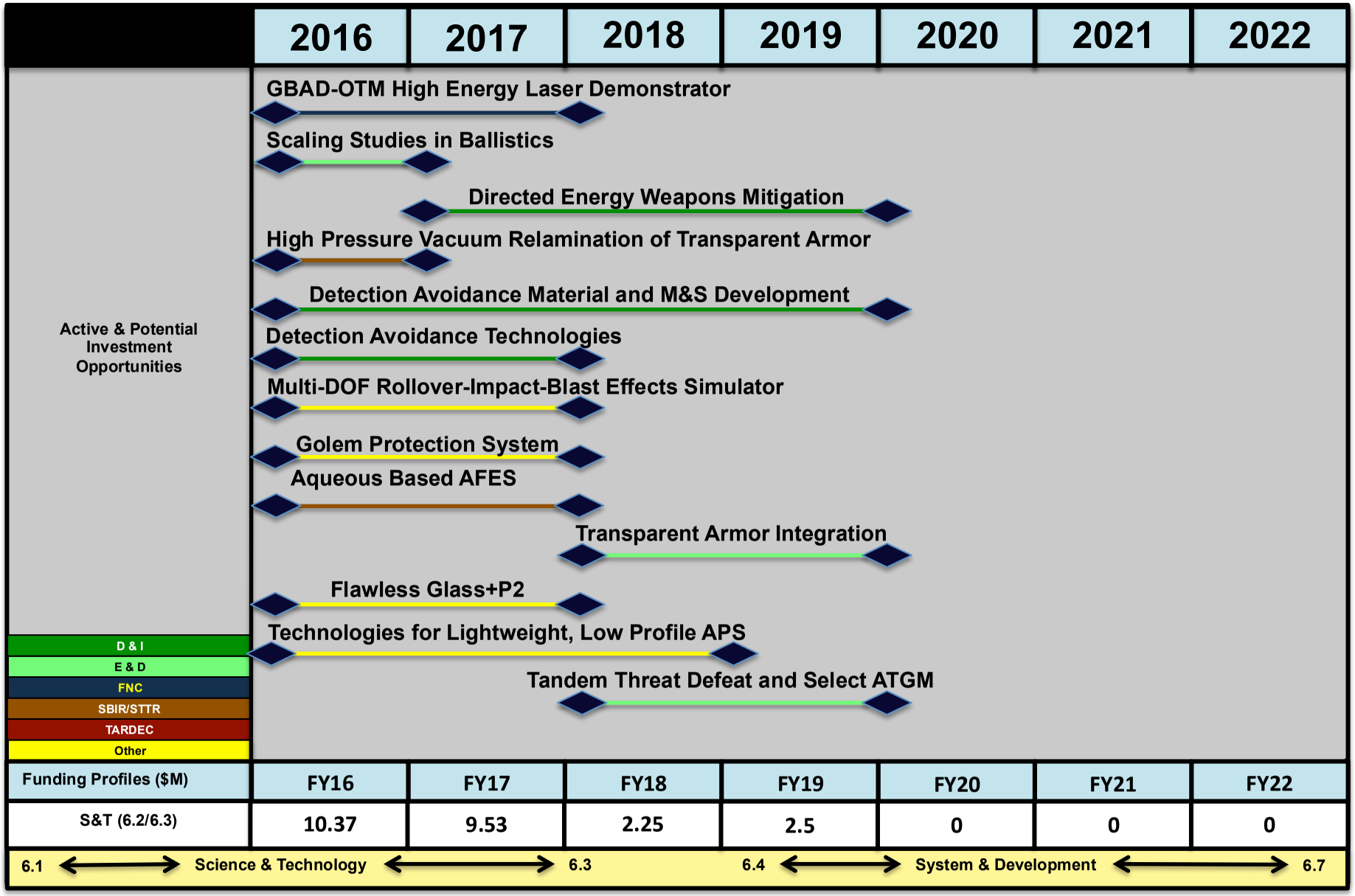
Flawless Glass

This initiative will further develop the methodology to produce flawless glass as part of a transparent armor system. Reducing surface flaws can increase performance of the transparent armor systems by more than 10%, thereby allowing for a reduced-weight armor system.

Lightweight Vehicle Exhaust for Amphibious Vehicles

This SBIR will evaluate the exhaust systems for Amphibious Vehicles and develop a lightweight alternative.

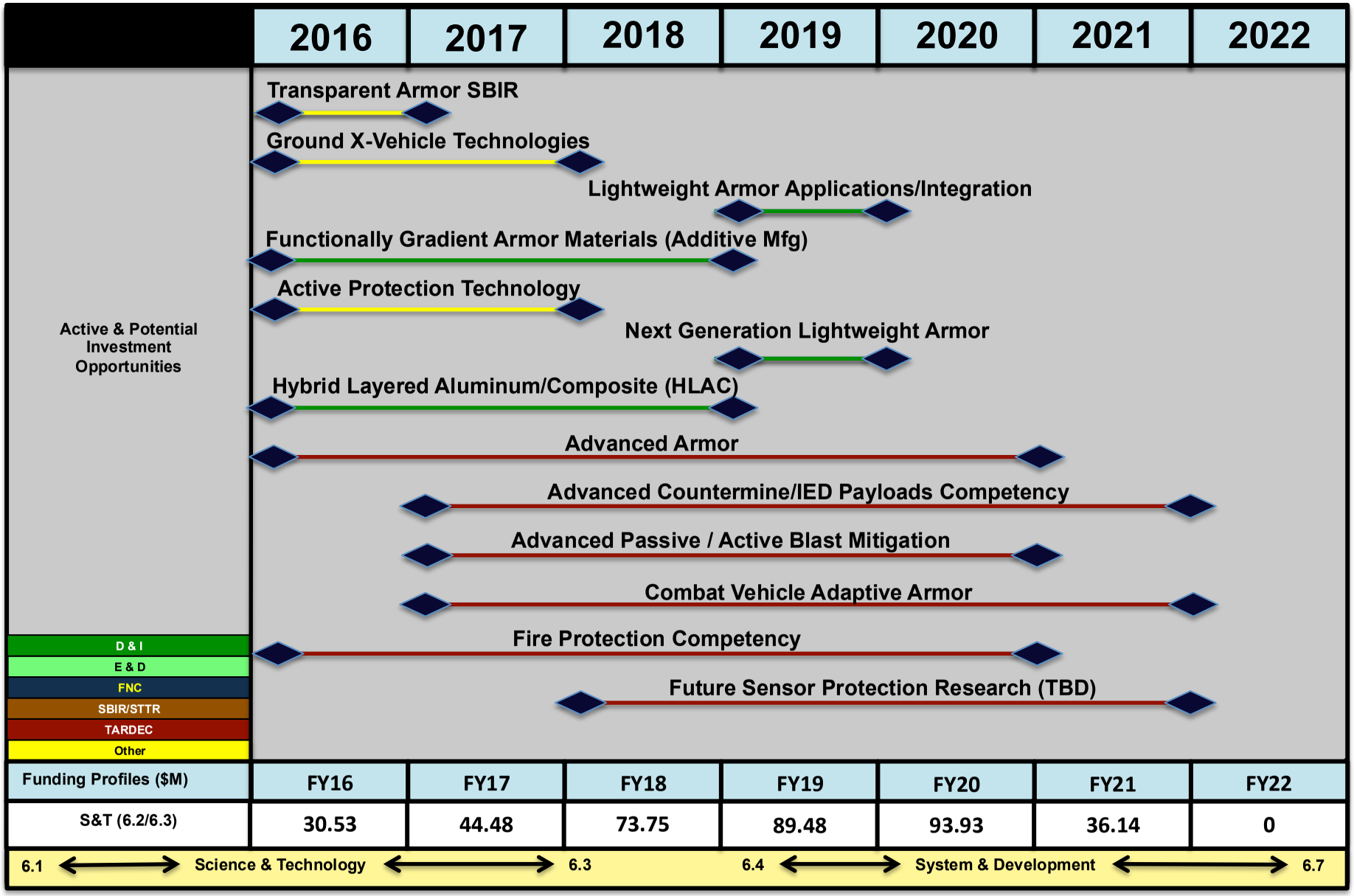
Survivability



Funding Profiles ($M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22
S&T (6.2/6.3)	10.37	9.53	2.25	2.5	0	0	0

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

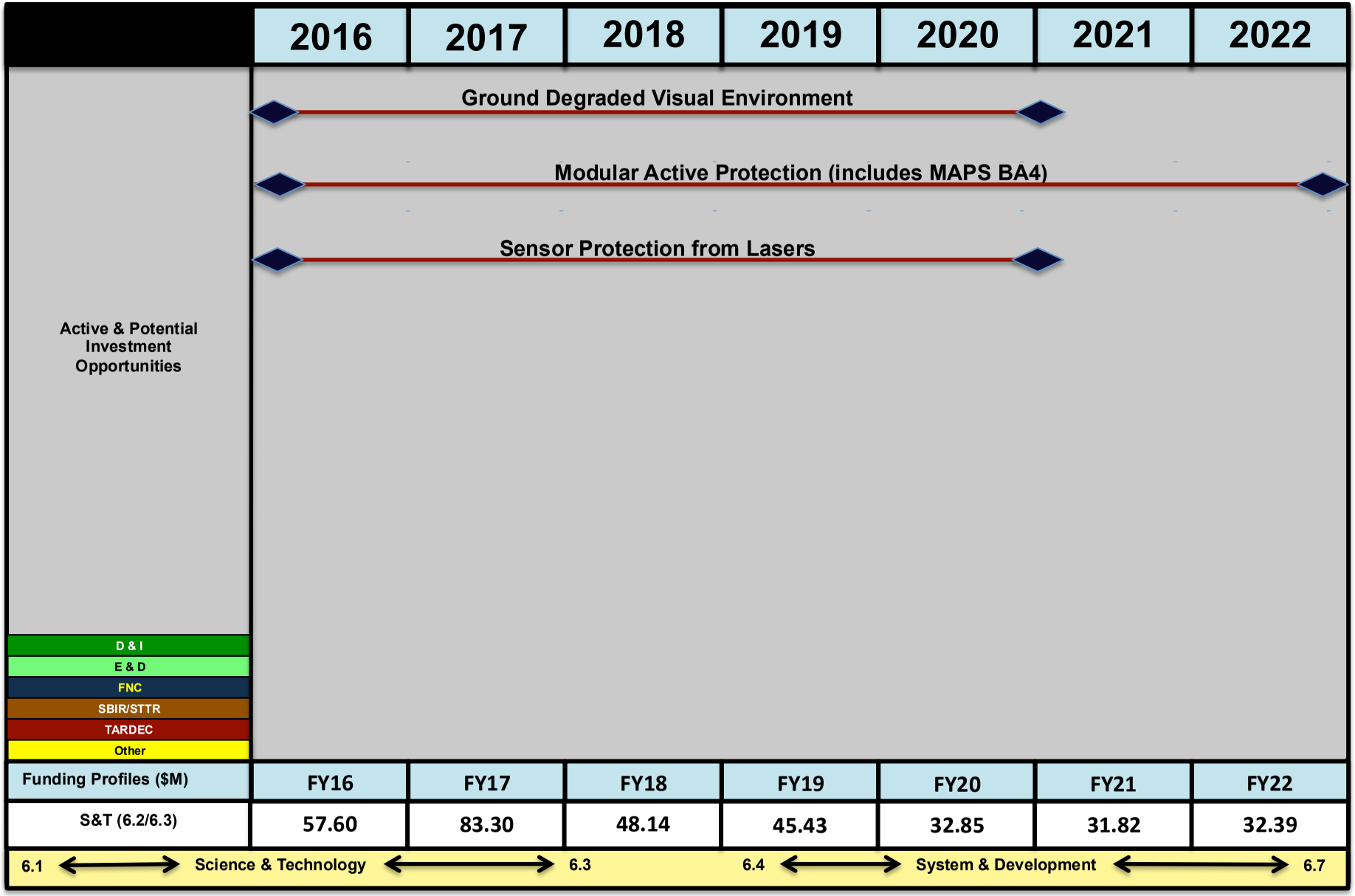
Survivability



Funding Profiles ($M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22
S&T (6.2/6.3)	30.53	44.48	73.75	89.48	93.93	36.14	0

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

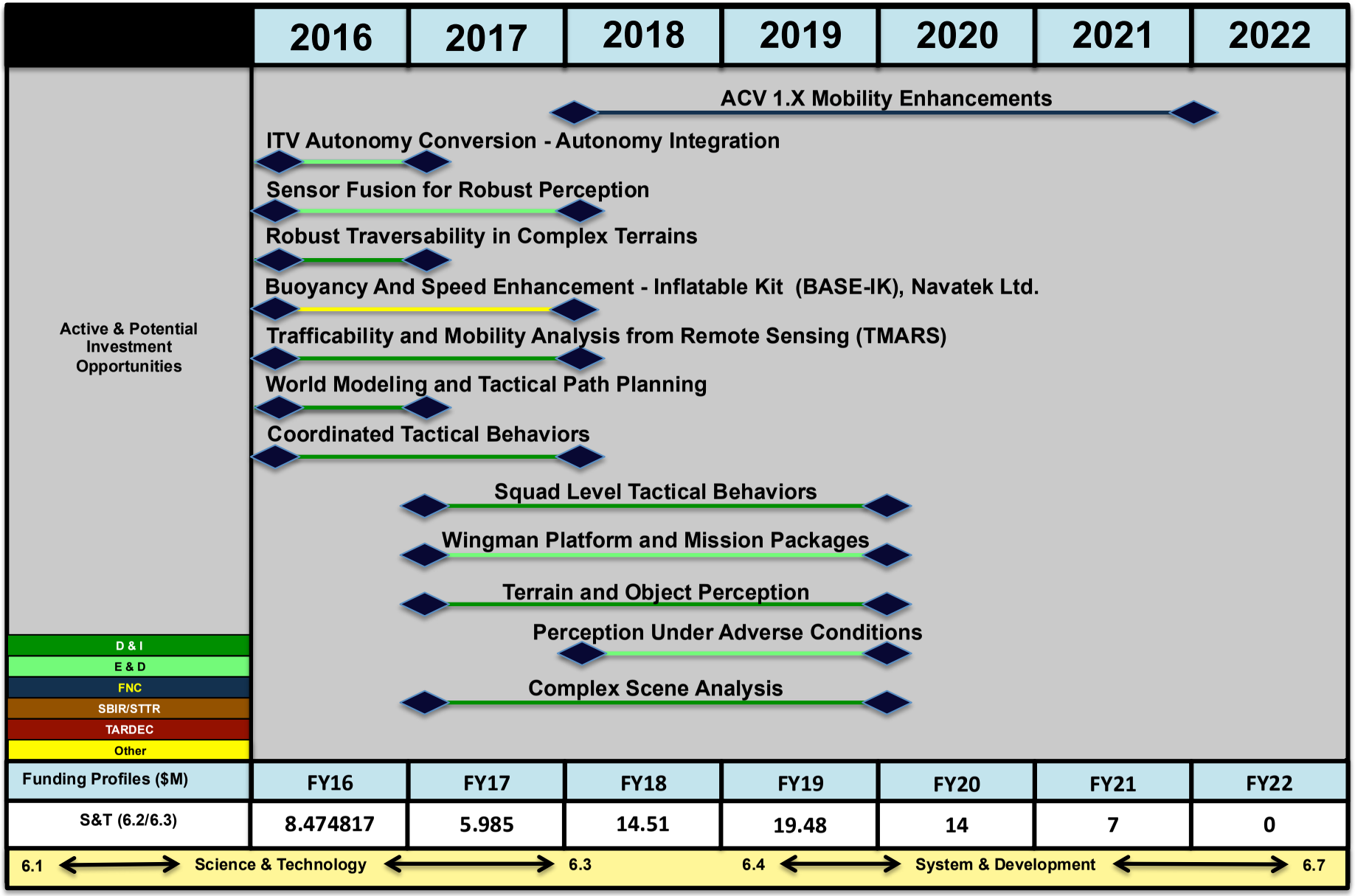
Survivability



Funding Profiles ($M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22
S&T (6.2/6.3)	57.60	83.30	48.14	45.43	32.85	31.82	32.39

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

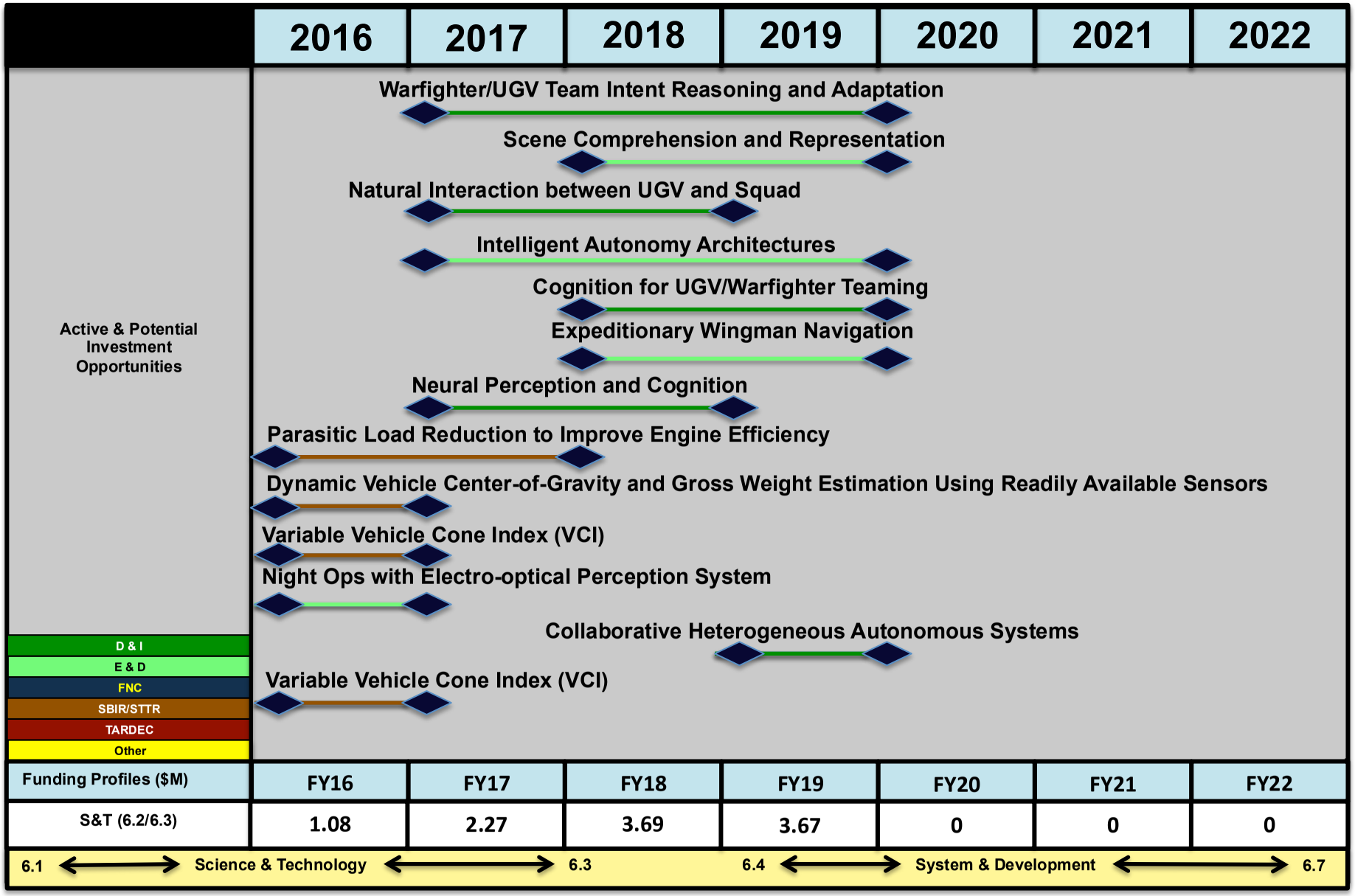
Mobility



Funding Profiles ($M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22
S&T (6.2/6.3)	8.474817	5.985	14.51	19.48	14	7	0

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

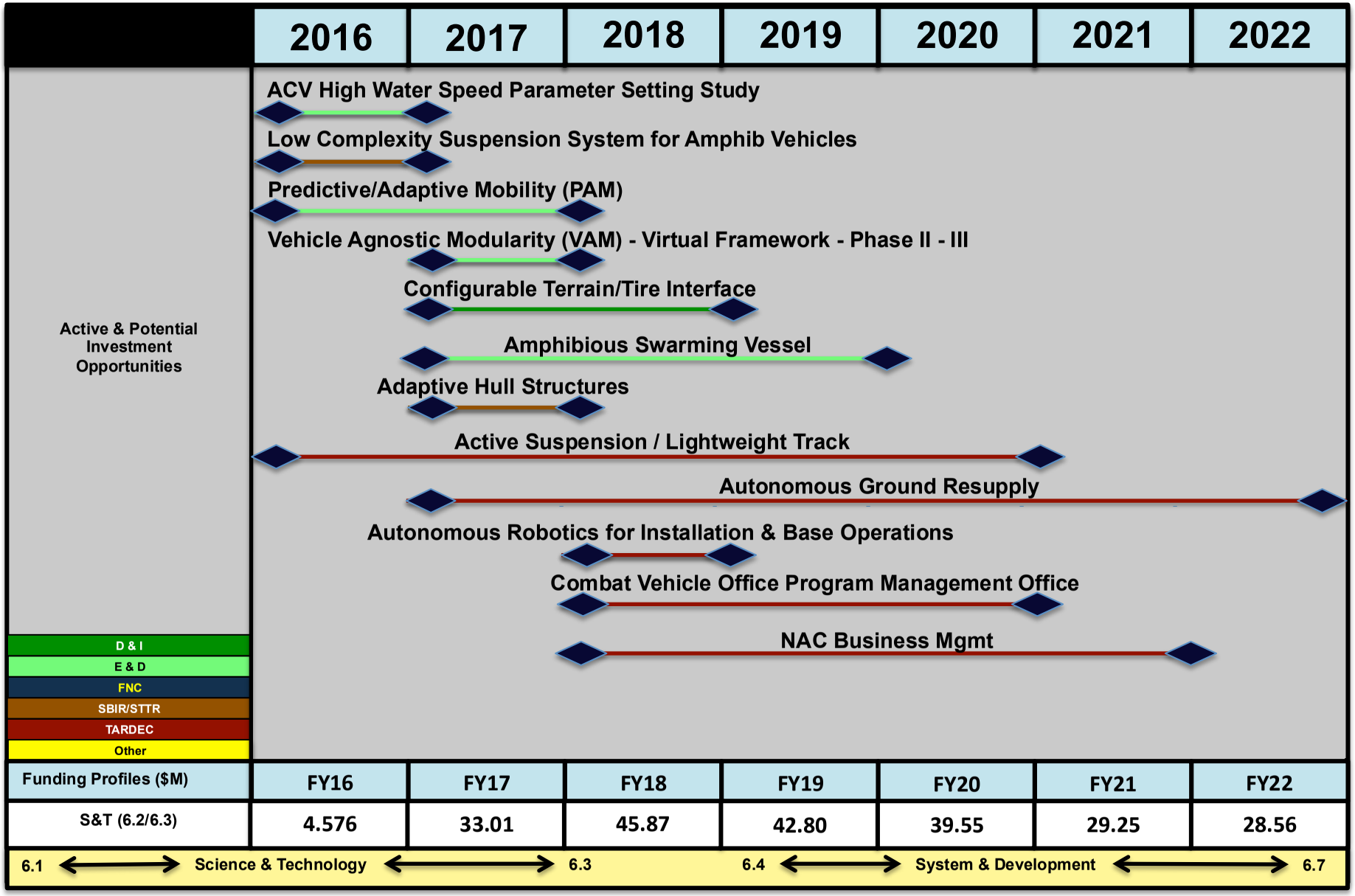
Mobility



Funding Profiles ($M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22
S&T (6.2/6.3)	1.08	2.27	3.69	3.67	0	0	0

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

Mobility



Funding Profiles ($M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22
S&T (6.2/6.3)	4.576	33.01	45.87	42.80	39.55	29.25	28.56

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

Section 5.3 Focus Area

MODELING AND SIMULATION

PEO Land Systems Marine Corps has a continuing requirement for the development of an integrated suite of non-proprietary multi-variable Modeling and Simulation (M&S) tools. These tools must leverage existing ground vehicle simulation tools and enable M&S-based acquisition and lifecycle management of tactical ground vehicles to include cost data. 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.

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

- Enable 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, as well as test and evaluation costs.
- Allow high-fidelity requirements trade-offs with accurate predictions of costs, schedule, and performance (CSP).
- Evaluate potential new technology insertions and their effects on CSP.

5.3.1 PEO LS Future M&S Vision

The Challenge

PEO LS has a need for a universal M&S aggregation tool that is verified, validated and has a high degree of fidelity. This tool will collect and aggregate industry component and platform data for various vehicle systems/platforms, assess 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 (See Figure 5.3-1).

The development of a universal modeling and simulation aggregation tool will provide:

- Streamlined and standardized approach for assessing CSP of future Ground Combat Vehicles (GCVs) and proposed upgrades/modifications.
- Single integration tool capable of assessing multiple platforms and multiple configurations.
- Plug-and-play capability for upgrade or alternative component comparison, as well as future modernization programs.
- Requirements-based scenarios to assess total LCC and performance for each platform/configuration and upgrade.
- Standardized interfaces for industry

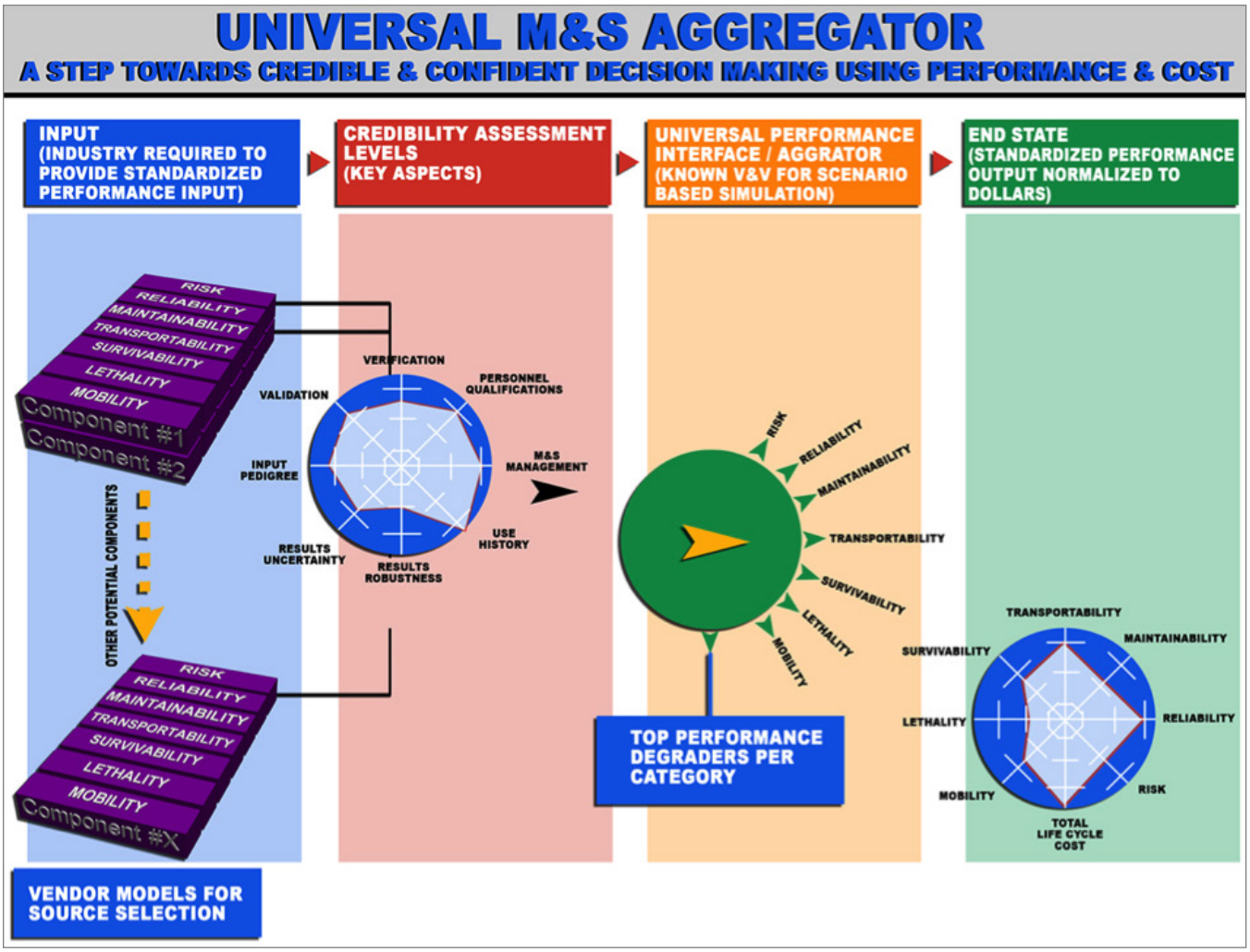


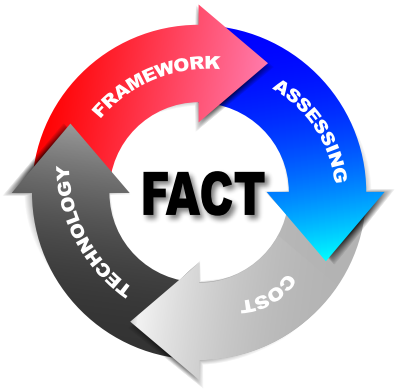
Figure 5.3-1. Universal M&S Aggregator

to design component models, as well as establishes acceptable credibility assessment levels for key design aspects.

- Decision-making tools for acquisition leadership with a known confidence level.
- Reduced total ownership costs, while maximizing limited S&T resources.

5.3.2 Shaping the Future of M&S

Framework Assessing Cost Technology (FACT)



The United States Marine Corps Systems Command (MCSC) sponsored the development of the Framework for Accessing Cost and Technology (FACT) with Georgia Tech Research Institute (GTRI) to enable investigators to visualize a system's potential costs alongside the systems performance, reliability and other factors deemed important. FACT is a modeling

and simulation framework, enabling real-time collaboration in a web environment, primarily geared towards conducting real-time trade space analysis for complex systems-of-systems. FACT uses Systems Modeling Language (SysML) to define complex systems. SysML expands upon the Unified Modeling Language (UML) and goes beyond software-centric design to include hardware components. The specification provides a formal means to describe a system, most notably the decomposition and organization of the system components as well as the parametric relationships between value properties distributed throughout the systems.

5.3.3 Ongoing M&S Efforts

Human Body Model

Current Anthropomorphic Test Dummies (ATDs) used to predict human injury risk in live-fire blast testing have several limitations due to a lack of biofidelity and limited injury assessment capability. The ATD is composed of metals, rubbers, and plastics, and the majority of injury metrics associated with the ATD were developed under automotive crash loading scenarios.

Development of a human body model is underway; leveraging the recent advances in high-fidelity computational physics-based M&S of explosive events against armored vehicles. This major advancement in the ability to accurately predict human injury risk will enable vehicle designers and evaluators to predict risk of injuries across the severity spectrum experienced in the real world, supplement ATD results with prediction of injuries beyond fracture, expand injury risk assessments beyond the 50th percentile, support theater event reconstruction, and deliver injury causation determination. Beyond the scope of the PEO LS focus on injury prediction in Improvised Explosive Device (IED) events, this model could be used in ballistic protection, blast overpressure, burn injuries, and non-lethal munitions.

Post IED Damage Small Business Innovative Research (SBIR)

Two companies are currently in Phase II of SBIR contracts to develop the capability to systematically gather and store Post IED damage data from the vehicle and scene and process this data into a format that allows the vehicle PMs to assess the risk of repair vs redeployment.

Survice Engineering Company is developing an integrated, low-cost, ruggedized, and portable tablet-based 3D capture tool kit to guide and facilitate the assessment of battle damage to combat vehicle platforms. The plans for the tool includes:

- Development and integration of ruggedized, low-cost indoor/outdoor 3D scanning technology.
- Procedural forms and checklists.
- Photo and video documentation.
- Expandable framework to incorporate other Non-Destructive Inspections (NDI) technologies.

Corvid Technologies is developing Battle Damage Assessment Visualizer (BDAV) software which is run on ultra-portable devices and allows quick time access to a database incorporating hundreds of IED and multi IED-event scenarios. By comparing the damage produced by the incident to a database of simulated vehicle damage, the software determines the closest match and calculates the risk of redeploying vs repairing the vehicle structure. The tool will also support event-reconstruction, identifying the most likely threat scenario that led to the damage. Additionally, as an alternative to visual-only inspection, BDAV provides a more data driven, consistent way to determine vehicle repair levels required, lowering risk to the warfighter while simultaneously reducing unnecessary vehicle downtime. BDAV software relies on robust surface

capture and data storage capability being developed under this same SBIR topic.

Joint Light Tactical Vehicle (JLTV) Blast M&S

The objective of this effort is to develop and execute a physics-based model that is able to account for both soil/structure interaction and gross vehicle response. Corvid Technologies has prepared high- fidelity models for the Marine Corps JLTV Program Office. The Under Body Blast (UBB) M&S efforts will:

- Provide Joint Project Office (JPO) insight into force protection levels (initially from a structural standpoint and evolving to a crew-response standpoint).
- Support engineering design analyses and modifications.
- Provide supplemental information to support key performance parameter analyses. The JPO also plans to use M&S for future evaluations of vehicle design modifications and Engineering Change Proposals (ECPs).

Mitigation of Blast Injuries

The objective of the JLTV Blast Modeling and Simulation (M&S) effort is to develop and execute a physics-based model that can account for both soil/structure interaction and gross vehicle response. Corvid Technologies is developing high-fidelity models for the JLTV programs. The underbody blast M&S efforts will: 1) provide the Joint Project Office (JPO) insight into force protection levels (initially from a structural standpoint and evolving to a crew response standpoint); 2) support engineering design analyses and modifications; and 3) provide supplemental information to support key performance parameter analyses. The JPO also plans to use M&S for future evaluations of vehicle design modifications and engineering change proposals. Funding and timeline information can be found in the M&S section.

Additional M&S projects supporting PEO LS include:

- **Material Characterization of Energy Absorbers (EA)** focuses on material for blast modeling, which is being tested to determine models used to define EA component response. Components to be modeled include seat EAs, cushions and blast mats.

Potential Solutions

Tank Automotive Research, Development and Engineering Center (TARDEC) Efforts

Light Weight Systems & Technology (LWS&T)

This effort will develop a weight informed vehicle design optimization process / architecture for the Army. LWS&T will utilize, develop, and evaluate tools, advanced materials, manufacturing, and assembly technologies to optimize component/sub-system/system weight while maintaining or improving performance. Finally, it will demonstrate best practices in a cost-conscious system design to reduce ground vehicle weight.

Vehicle Electronics and Architecture (VEA) Mobile Demonstrator

The purpose of the project is to mature the open data and power architecture as well as the system designs to TRL 6 that were implemented as part of the VEA Research SIL at TRL 5 by integrating those subsystems onto a combat vehicle platform. This effort will also validate the power and data capabilities required for the future infantry or combat vehicle modernization efforts while increasing vehicle performance & decreasing SWAP over current implementations. Finally, it will build the TARDEC bench on in-house vehicle integration of these systems.

Virtual Proving Ground

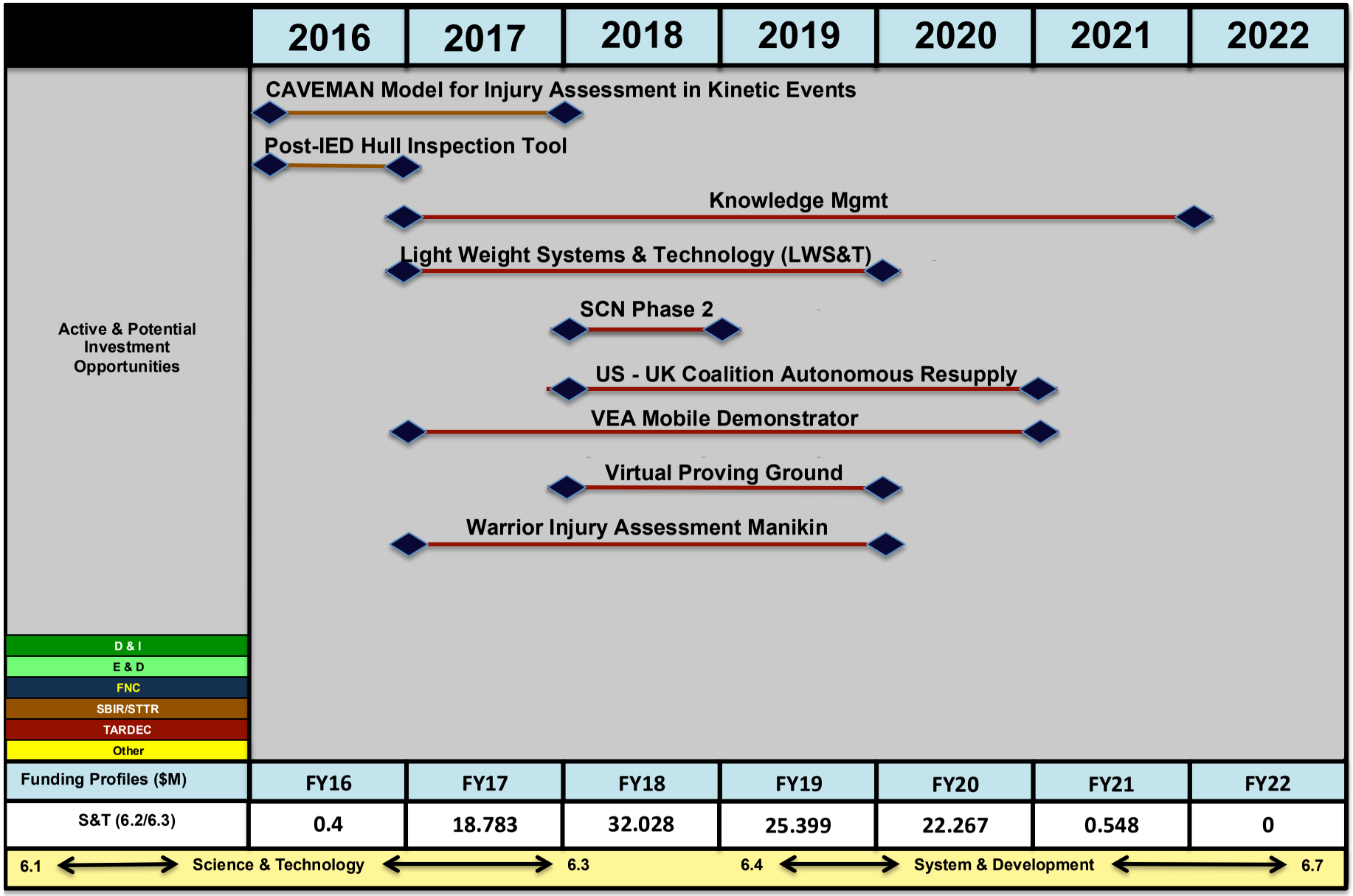
The purpose is to develop a comprehensive and integrated Autonomy M&S toolkit strategy, positioning TARDEC to lead the push for more unified / interoperable M&S capabilities.

This project will also engage with on-going M&S tool development efforts (e.g. Autonomy in Operational Energy (AiOE), TARDEC Virtual Experimentation Capability (TVEC), etc.), identify the best-of-breed M&S tools available, and perform a gap analysis to identify areas for future tool enhancement. Other efforts include:

- Develop and extend M&S tools to address shortcomings identified in the gap analysis. (e.g. integrate best-of-breed tools together, expand functionality/robustness, etc.).
- Manage the integration of existing/ future M&S tools into the toolkit to reduce duplication of effort and maximize the value of M&S outputs.

Warrior Injury Assessment Manikin (WIAMan)
The purpose of this effort is to establish the feasibility of the WIAMan injury assessment concept and advance to prototype fabrication.

M&S



Funding Profiles ($M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22
S&T (6.2/6.3)	0.4	18.783	32.028	25.399	22.267	0.548	0

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

OPEN PLUG-AND-PLAY COMMUNICATION ARCHITECTURE

Open plug-and-play architecture provides vehicle platforms the capability to add a new communication, sensor, and data component to a system and have it integrate seamlessly without changing the architecture or technical configuration of the vehicle. Adapting such architectures for the tactical vehicle fleet has great potential to improve tactical and operational flexibility for commanders. Consequently, the Marine Corps continues to develop a standardized approach to Command, Control, Communications, Computers, and Intelligence (C4I) and Electronic Warfare (EW) integration. PEO LS continues to work with Marine Corps Systems Command, Tank Automotive Research, Development and Engineering Command, Marine Corps Combat Development Command and the broader research community to integrate these systems through a coordinated development and acquisition process. Critical to this process is a shift to common resources accessed through open architecture systems. This change will reduce or eliminate a large number of duplicative and proprietary solutions that were procured under pressure of combat operations.

The Challenge

Many of the fielded vehicle-mounted C4I/EW systems in the inventory, which were primarily driven by urgent operational needs, are standalone solutions integrated onto tactical vehicles in bolt-on applications that come with separate power, processing, clock,

Figure 5.4-1. M-ATV

and location functions. Some current tactical vehicles were not designed to support radios at all, and certainly not the multiple new technologies that have been added to enhance combat effectiveness. The development of modular, scalable, open-system architectures, which enable a plug-and-play mission flexibility across all tactical vehicles, will enable rapid vehicle modernization and shared-resource allocation. It will also eliminate duplicate equipment for both legacy and future vehicle programs and ease shipboard operations.

Potential Solutions

SBIR

Artificial Intelligence (AI)-based C2 Digital Assistant

The Marine Corps seeks to employ advanced artificial intelligence (AI) technologies for its CAC2S program to reduce information overload, improve situational awareness (SA) and collaboration, and aid in Commander decision-making. Leverege will use its unrivaled subject matter expertise in CAC2S and its deep experience with cutting-edge machine learning techniques to research and test the optimal algorithms for the AI-based digital assistant. The research and development will identify the areas that need to be addressed, propose and study alternative solutions, and provide simulated but relevant input to test our hypotheses against known CAC2S use cases.

Leverege intends to address the following quantitative commercialization metrics and achieve increased maturity in the following areas: Multi-level neural network approaches to speech tokenization, deep machine learning, and contextual understanding, Conversational bot technology that remembers 0x9D context between individual queries, Autonomous big data 0x9D architectures and implementation strategies that can be embedded into disconnected systems and meet stringent performance and security requirements, and Improved data presentation and user experience methodologies for digital assistants.

TARDEC Efforts

Vehicular Integration for Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4/ISR)/ EW Interoperability (VICTORY)

In FY-15, Marine Corps Systems Command and PEO LS have approved the VICTORY standard in future Marine Corps vehicles. The current version (as of the date this document was published) of the standard is 1.6.1, which will be critical for future development of modular C4/ISR systems, is a required characteristic for new vehicle systems.

The VICTORY open plug-and-play architecture is being developed as a solution to operating forces applying solutions to identified C4ISR capability short falls through short term solutions quickly bolted on to ground vehicles, which inhibits functionality, negatively impacts the vehicle's size, weight and power, and limits crew space. VICTORY will reduce these issues by embedding the systems directly into the platform. It provides a framework for architecture, standard specifications, and design guideline input.

VICTORY is developing a framework for integration of C4ISR/EW and other electronic equipment on Army ground vehicles. The framework is composed of:

- An architecture that defines common terminology, systems, components, and interfaces.
- A set of standard technical specifications for the items identified in the architecture.
- A set of reference designs that provide guidance for how the architecture and standards can be used to create designs against various types of requirements and environments.

The architecture is documented in VICTORY Architecture - Version A2, which identifies the

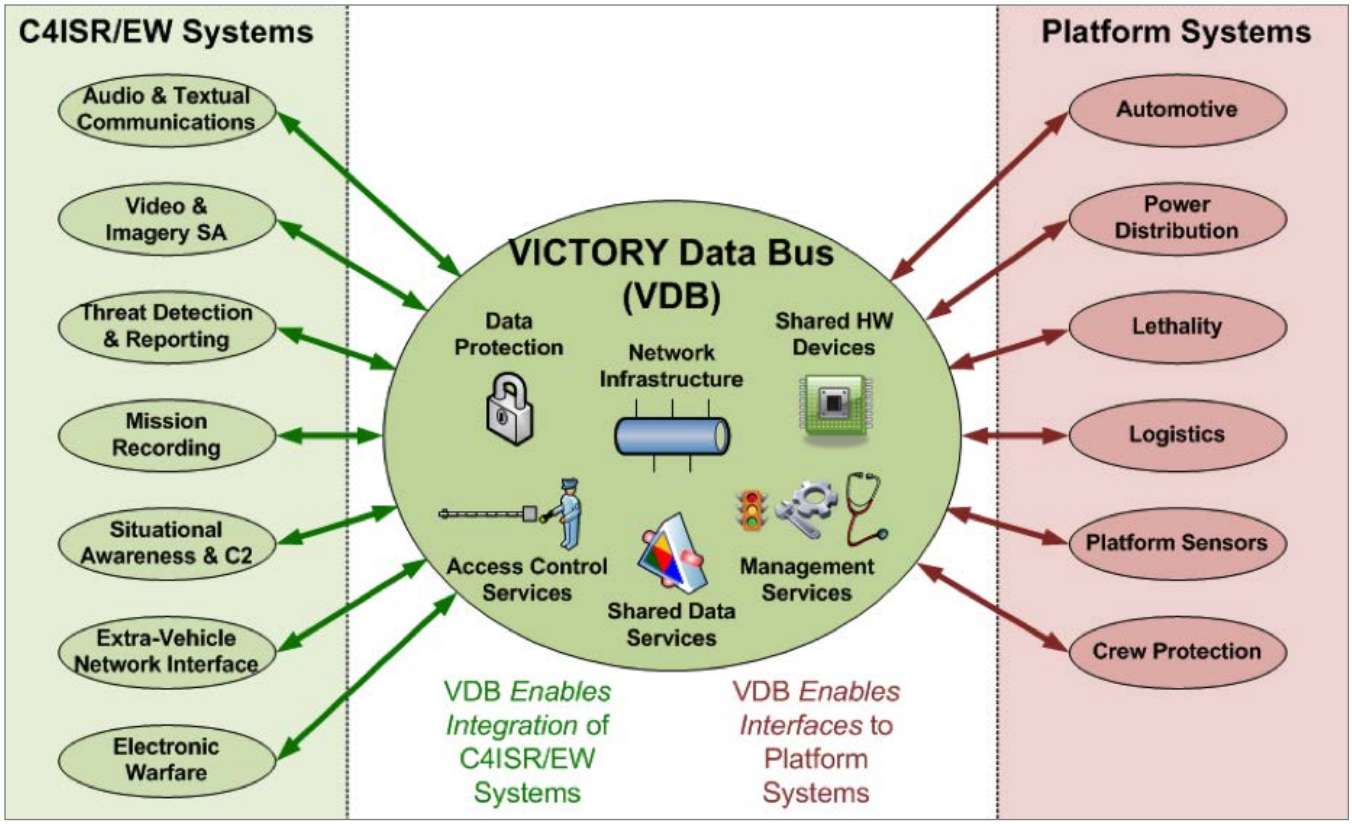


Figure 5.4-3. Core Concept: VICTORY Data Bus (VDB)

systems, components, and interfaces, but does not provide technical details. The technical details are specified in the VICTORY standard specifications, and are intended for the system acquisition and S&T communities to use as a citable reference in new procurements, modernization activities, and engineering change proposals.

The VICTORY standard specifications do not specify system design or the specific hardware and software components that will be used to implement the VICTORY standard specifications. In addition, these specifications do not specify the hardware configuration or the mapping of software to hardware.

The designs must be developed to meet the operational, functional, and performance requirements of the platform or product. VICTORY provides example designs to aid the community in understanding the options for deploying the specifications. These examples are documented in VICTORY reference design documents:

- **VICTORY Standards Maturation (VSM)** Maintain, develop, and adopt future capabilities to continue to enhance the Vehicular Integration for C4ISR/EW Interoperability (VICTORY) Specifications. Enhance existing Systems Integration Lab (SIL) capabilities to perform validation and verification for the updated standards. Continue to provide new capabilities that can be added to Military Ground Vehicle platforms as a part of Army Force Generation block upgrades or modernizations.

- **VICTORY Enabled Company Transformation (VECTOR)** Transition and demonstrate TARDEC's VICTORY investment from its current Technology Readiness Level (TRL) 4 Lab Components to TRL 6 vehicle systems applicable to all platforms. This will reduce Program Managers' risks for transitioning VICTORY components and systems onto their vehicle platforms by providing an accredited information assurance

solution, aiding in the integration of legacy components, and providing a common vehicle integration package for VICTORY.

➤ **VICTORY System Integration Laboratory (VICTORY SIL)**
The VICTORY SIL was developed to help facilitate verification and validation of the VICTORY standards in support of near-term PEO Ground Combat System Engineering Change Proposal efforts. It also provides a facility where vendor components are independently verified to VICTORY standards. The VICTORY SIL has a representative vehicle cabin to demonstrate the VICTORY standards in a system-level vehicle environment.

➤ **Capabilities**
The VICTORY SIL offers contractors the ability to bring hardware and software solutions to be tested and verified at VICTORY standards. The testing would be performed via a test service agreement between the contactor and TARDEC.

➤ **Benefits**

- Provides an independent implementation of VICTORY proposed standards.
- Advances VICTORY standards through the process from proposed standards to draft. standards.
- Identifies and clarifies issues with the VICTORY proposed standards.

Radio Frequency (RF) Convergence

The intent is to leverage CERDEC's RF Convergence project outcomes to define and build a flexible framework to readily adapt and allow insertion of existing and new C4ISR/EW technologies. Define A-Kit & B-Kit Specifications, Common Interfaces and Reference implementations for Electronics Chassis, RF Distribution network and Power Distribution network.

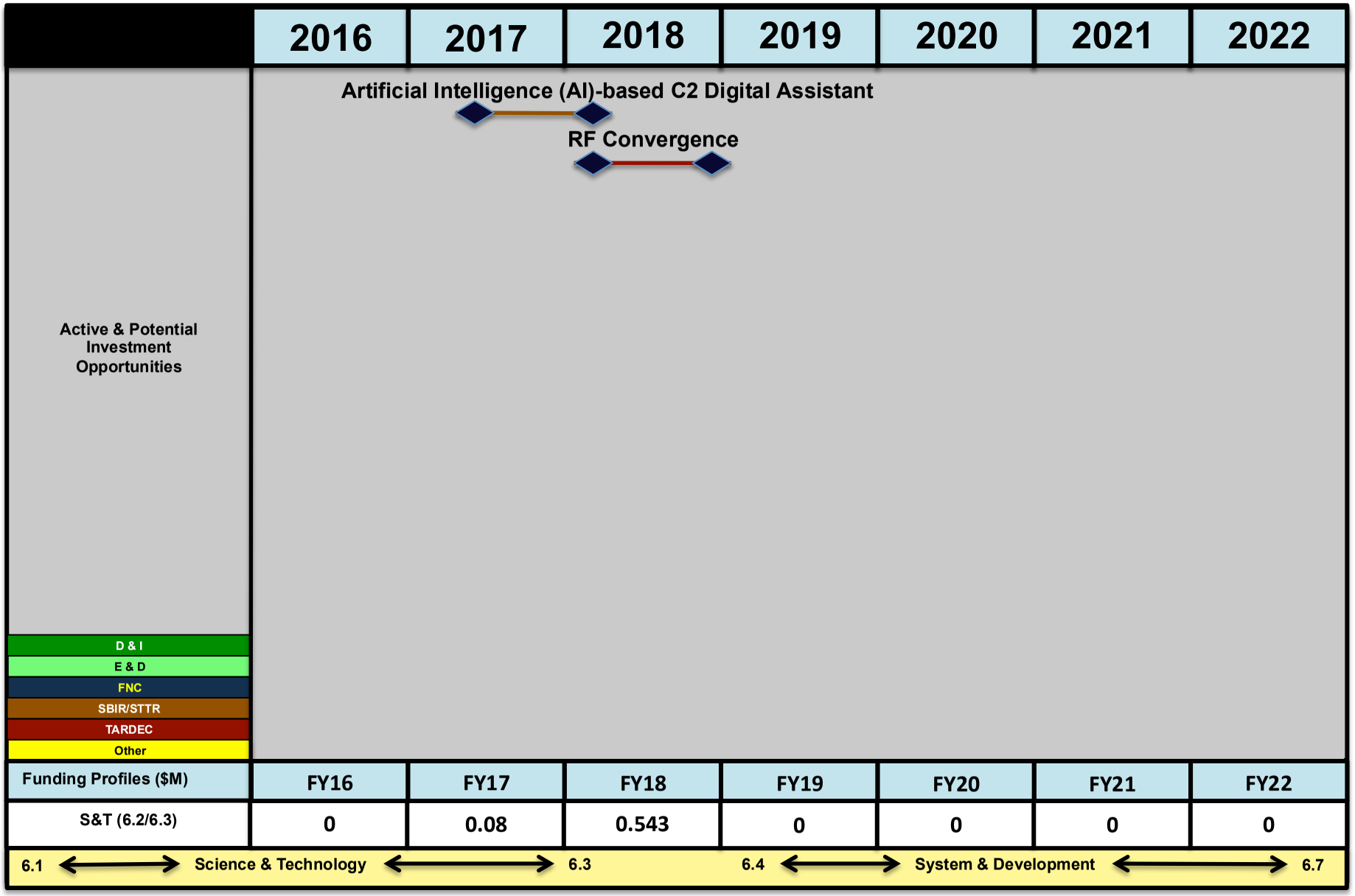
Vehicle Electronics & Architecture Research SIL (VRS)

The Army faces considerable challenges when integrating electronics into ground vehicles, compounded by the need to reduce cost and redundancy across multiple platforms. The VRS project will create a complete reference architecture to address the power, vetronics, and C4ISR integration challenges facing the modernization of the ground vehicle domain. This architecture and the associated SIL (as a TARDEC test asset) will support experimentation with future architectural concepts and implementations. This effort also includes the power management technologies for the VRS project.

Virtual Experiments Capability (VEC)

The VEC will develop a process for modeling innovative TARDEC technologies and inserting them into the Army Capabilities Integration Center (ARCIC)-led Early Synthetic Prototyping (ESP) environment. ESP is an ARCIC-led effort to develop a persistent video game environment Soldiers want to play and researchers can use to evaluate emerging military technologies.

Open Plug and Play Comms Architecture



Funding Profiles ($M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22
S&T (6.2/6.3)	0	0.08	0.543	0	0	0	0

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

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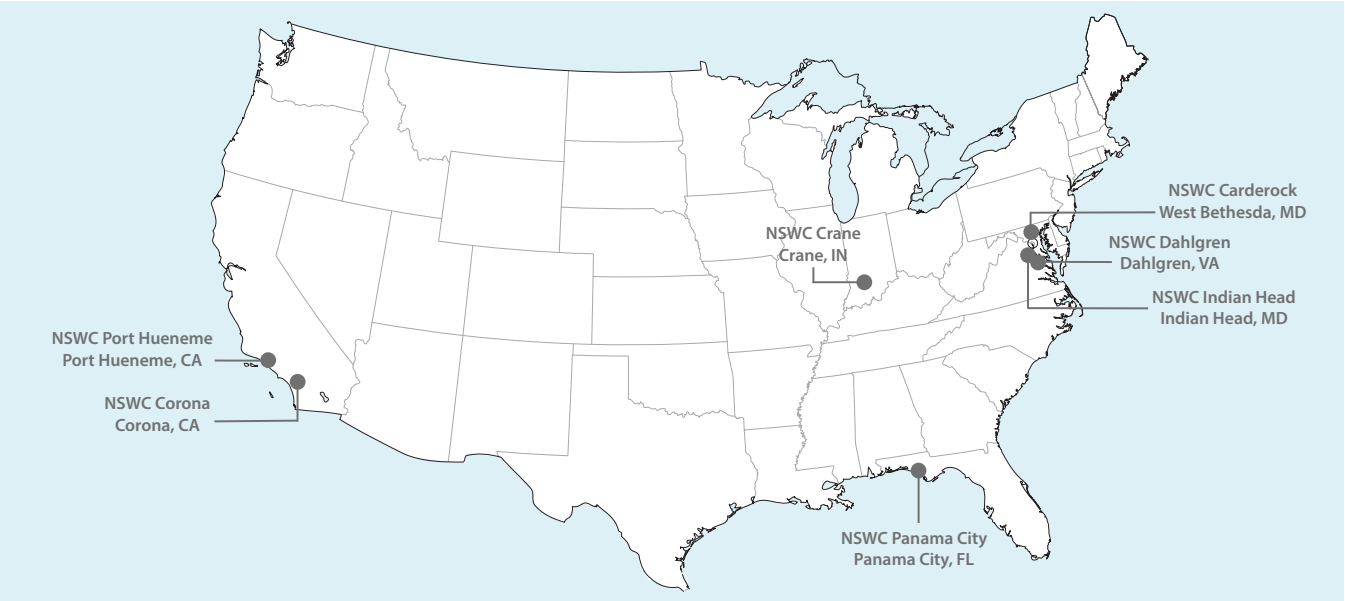
Section 6.0

WARFARE CENTERS



Naval Sea Systems Command Naval Surface Warfare Centers Map

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.

The mission of the NSWC is to operate the Navy's full-spectrum research, development, test and evaluation, engineering, and fleet support center 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 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. The CT is a readily available resource to facilitate Marine Corps stakeholder engagement with the Warfare Center Divisions.

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

NSWC Carderock Division (NSWCCD)

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

- CD04 Surface and Undersea Vehicle Machinery Systems Integration
- CD05 Combatant Craft and Expeditionary Vehicles
- CD07 Hull Forms and Fluid Dynamics
- CD09 Surface and Undersea Vehicle Mechanical Power and Propulsion Systems
- CD10 Surface and Undersea Vehicle Electrical Power and Propulsion Systems
- 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 Laboratories
- 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

PM-AAA

- AAV Hydrodynamics
- AAV Corrosion
- ACV 1.0/2.0 Hydrodynamics
- ACV Human Factors

PM-JNLW

- Polymer Kelp Program (Small Boats/Craft)

PM-MRAP

- Live Fire Testing and Evaluation (LFT&E)/Survivability

AUTOCELL

- Survivability

Marine Corps Systems Command

SIAT (Systems Interoperability and Architecture Technology)

- SBIR Program Manager
- Corrosion Prevention and Control (CPAC Program)
- Expeditionary Power

PMM-115 (PM-Combat Support Systems)

- Power/Energy (MEHPS; GREENS, etc...)

USMC Headquarters Expeditionary Energy Office (E20)

- Power/Energy

NSWC Dahlgren Division (NSWCDD)

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 established itself as the major testing area for naval guns and ammunition. Today, it continues to provide the military with testing and certification by utilizing its Potomac River Test Range in Dahlgren, VA, and provides Fleet support at Combat Direction Systems Activity in Dam Neck, overlooking the Virginia Capes Fleet Operations Area, Virginia Beach, VA.

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

- A Strategic and Computing Systems
- B Electromagnetic & Sensor Systems
- E Gun & Electric Weapon Systems
- H Weapons Control & Integration
- R Readiness & Training Systems
- V Warfare Systems Engineering & Integration
- ME Mission Engineering & Analysis Directorate

Facilities

NWWCDD occupies four geographic locations, the Naval Observatory in DC and Dahlgren, Wallops Island, and Damn Neck in Virginia. The NSWCDD Headquarters at Dahlgren is near Quantico and the Pentagon. The Damn Neck facility 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 such as: sensors, unmanned systems, fire control systems, integrated warfare systems, directed energy, railgun, chem-bio defense, and electromagnetic environmental effects.

Current Marine Corps Support Areas

- Vehicle 3-D Modeling and Laser Scanning drawing development, configuration management and sustainment
- Vehicle Capability Insertions design, integration, fielding and sustainment
- Expeditionary Command and Control design, integration, and testing
- Energy Modeling, Analysis, and Testing
- Expeditionary Analysis, Modeling and Simulation
- Human Systems Integration
- Safety Engineering
- Directed Energy Weapons
- Advanced Sensor Development
- Autonomous and Unmanned System Development
- Chem-Bio Sensors and Defense Development

Current Marine Corps Programs Supported

Combat Development and Integration (CD&I)

- Engineering Support to Seabasing Integration Division

Marine Corps Warfighting Laboratory (MCWL)

- Engineering Support

PEO Land Systems

PM-AAA

- AAV Emergency Egress Lighting
- AAV Electrical Upgrade
- AAV ARVCOP (Funded by PMS 495)
- Habitability

PM-*Aviation Command & Control and Sensor Netting*

- CAC2S Software Integration and Management
- CAC2S Test & Evaluation

PM-*Medium and Heavy Tactical Vehicles*

- LVSR 3-D Modeling
- MTVR 3-D Modeling
- Vehicle Capabilities Insertions

PM-G/ATOR

- Engineering and Acquisition

Marine Corps Systems Command

PM-*MAGTF Command, Control, and Communications* (MC3)

- Combat Operations Center (COC) Engineering
- Joint Battlespace Viewer sustainment
- E3 Hazards Engineering
- Composite Tracking Network (CTN)

PM-*Ammo*

- 40mm Ammunition
- Anti-Personnel Obstacle Breaching System (APOBS)
- 120mm Ammunition, Missiles & Rockets

PM-*Infantry Weapons Systems* (IWS)

- Follow on to SMAW (FOTS)
- Raids and Recon Depot Support
- Anti-Armor
- M40A5 Rifle Improvement Project

PM-*Armor and Fire Support Systems* (AFSS)

- Ordnance Qualification
- Weapon System Integration
- M1A1 Weapon System Upgrades
- Ground Weapon Radar Support

PM-*Light Armored Vehicle* (LAV)

- Anti-Tank Modernization

PM SIAT

- Systems Engineering
- Energy
- CIED
- Expeditionary M&S and FACT Support

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. Seventy-three 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-Air Command and Control and Sensor Netting (AC2SN)

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

PM-Ground Based Air Defense (GBAD) *and Ground / Air Task Oriented Radar* (GBAD & G/ATOR)

- G/ATOR
- Advanced Man-Portable Air Defense System (AMANPADS)

- Counter – Unmanned Arial Systems (C-UAS)

PM-Light Tactical Vehicles (LTV - Legacy)

- HMMWV
- ITV
- UTV

Marine Corps Systems Command

PM-MAGTF Command, Control, and Communications (MC3)

- Ground Based Operational Surveillance System (G-BOSS)
- USMC Counter Radio-Controlled Improvised Explosive Device Electronic Warfare (CREW)

PM-Marine Intelligence (MI)

- Topographic Production Capabilities (TPC)
- Target Material Production (TMP)
- Tactical SIGINT Collection System (TCSC)
- Technical Control and Analysis Center (TCAC)

PM-Infantry Weapons Systems (IWS)

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

PM-Armor and Fire Support Systems (AFSS)

- AN/TPS-59 and AN/TPS-63 Long Range Radars

PM-Combat Support Systems

- Mk-154 Land Mine Clearance
- TMDE Systems

PM-Ammunition

- Ammunition Programs and Inventory Management

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, CA; Search Radar Engineering at Virginia Beach, VA; and Live Fire Testing at White Sands, NM.

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-Air Command and Control and Sensor Netting (AC2SN)

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

PM-Ground Based Air Defense (GBAD) *and Ground / Air Task Oriented Radar* (G/ATOR)

- G/ATOR T&E, Production Monitoring, Program Management, Contracting Officers Representation, Reliability Maintainability and Availability (RM&A) Engineering, ILS Support

PM-Advanced Amphibious Assault (AAA)

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

Marine Corps Systems Command

PM-Armor and Fire Support Systems (AFSS)

- AN/TPS-59 and AN/TPS-63 Long Range Radars T&E, Systems Engineering, CM support
- AN/TPQ-49 Lightweight Counter Mortar Radar Sustainability Study, In-Service Review for USMC Primary Inventory Control Activity (PICA), Diminishing Manufacturing Sources and Material Shortages (DMSMS) analysis

PM- SIAT

- In-Service Engineering (ISE), Guidebook development & Training

NSWC Indian Head Explosive Ordnance Disposal Technology Division (IHEODTD)

Mission

Provide research, development, engineering, manufacturing, test, evaluation and in-service support of energetic systems and energetic materials (chemicals, propellants and explosives) for ordnance, warheads, propulsion systems, pyrotechnic devices, fuzing, electronic devices, Cartridge Actuated Devices and Propellant Actuated Devices (CAD/PADs), Packaging, Handling, Storage, and Transportation (PHS&T), gun systems and special weapons for Navy, Joint Forces and the Nation. Develop and deliver Explosive Ordnance Disposal (EOD) technology, knowledge, tools and equipment and their life-cycle support through an expeditionary work force, which meets the needs of the DoD, combatant commanders and our foreign and interagency partners. Support the Executive Manager for EOD Technology and Training. Execute other responsibilities as assigned by the Commander, Naval Surface Warfare Center.

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 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-Advanced Amphibious Assault (AAA)

- Amphibious Assault Vehicle (AAV)

PM- Light Tactical Vehicle (LTV)

- LTV System Safety

Marine Corps Systems Command

PM AMMO

- Multi Point Initiator (MPI)
- MK22 Mod 4 Rocket Motor
- MK154 Line Charge Release

PM Combat Support Systems (CSS)

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

PM Infantry Weapon Systems (IWS)

- PdM Anti-Armor
- PdM Non-Lethal & Optics

PM-MAGTF Command, Control, and Communications (MC3)

- Joint Battle Command – Platform (JBC-P)

PM Armor & Fire Support Systems (AFSS)

- PdM TANKS System Safety

Systems Engineering Interoperability, Architecture & Technology (SIAT)

- System Engineering (SE) Division
- Developmental Test & Evaluation (DTE) Division
- Safety (00T) Division

Joint Non-Lethal Program Office

- Indirect Fire Munition Engineering/ Technical Support
- BAA & Contract

NSWC Corona Division

Mission

NSWC Corona provides the Navy and Marine Corp independent analysis and assessment, with 1375 scientists, engineers, and support staff, and more than 1200 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."

Description

Using a rigorous, disciplined independent assessment process, NSWC Corona, located in Corona, CA, provides the fleet, program managers and acquisition community with the objective assessment needed for the Navy to gauge warfighting capability of ships and aircraft, assess warfare training and analyze new defense systems - even those systems in the concept phase. This commitment to independent assessment allows the Navy to achieve the greatest value for acquisition, material readiness and lifecycle management programs - for Today's Navy, the Next Navy, and the Navy After Next. As the Navy's metrology and calibration authority, Corona also sets the measurement science and calibration standards to support proper weapons operation, interoperability and peak readiness for the fleet. Corona uses innovation and automation to also reduce burdensome workload for Sailors, while reducing maintenance costs and increasing readiness for the Navy.

Technical capabilities and unique expertise - ranging from missile defense assessment to range and test instrumentation to setting measurement standards - enable Corona to support in-service and emerging weapons and combat systems for key customers in critical areas.

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

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 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 GBAD/GATOR

- G/ATOR Block 1, Analysis and Assessment
- G/ATOR Block 1, DT&E Test Director

MARCORSYSCOM

AC/ALPS

- Item Unique Identification (IUID) Engineering

PM Ammunition

- Total Life-Cycle Assessment:
- In-Service Systems Engineering
- T&E Technical Agent for Operational Reliability and Predictive T&E for Surveillance
- Technical Agent for Fleet Malfunction Investigations
- Global Inventory Supply Chain Management and Pre-Positioning
- Knowledge and Information Management
- Joint Services Production Readiness Assessments and Quality Engineering

PM CSS

- 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

PM ISI

- Emergency Response System (ERS) Development and Maintenance
- Public Safety Network (PSNet) Engineering
- Secure Operational Network Infrastructure and Communications (SONIC) Analysis

PM IWS, PdM AAS

- T&E Technical Agent for Javelin
- T&E Technical Agent for Tube-launch Optically-tracked Wire-guided (TOW)

PM MAGTF C3 I2SA

- Joint Battle Command Platform (JBC-P) T&E
- MAGTF Common Handheld (MCH) T&E
- Military GPS User Equipment (MGUE) T&E

PM TRASYS

- Training Assessment Program Development
- Tactical Warfare Simulation Certification and Accreditation (C&A)
- Tactical Training Ranges (TTR) Development and Maintenance
- Virtual Battlespace Two (VBS2) C&A

SIAT

- Global Positioning System (GPS) Liaison

MCICOM

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

MCB Camp Pendleton Environmental Security Division

- Geographic Information Systems (GIS)
- Knowledge and Information Management and Accreditation
- SharePoint Support

MCOTEA

- Ocular Interrupter (OI) OT&E
- Assault Amphibious Vehicle Survivability Upgrade Program (AAV SUP) Initial Operational Test and Evaluation (IOT&E)
- G/ATOR, CAC2S, and CTN OT&E support.

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

Located in Panama City, FL, the division is the technical center of excellence for Littoral Warfare and Coastal Defense.

NSWC PCD 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, we perform amphibious operations and have developed an Expeditionary Maneuver Test Range for vehicle testing.

Current Marine Corps Support Areas

- Combat Engineer Route Reconnaissance and Clearance (R2C) and Mobility/ Counter-Mobility design, integration, testing, fielding, and sustainment
- Vehicle 3-D Modeling and Laser Scanning drawing development, configuration management and sustainment
- Vehicle Capability Insertions design, integration, fielding and sustainment
- Expeditionary Command and Control design, integration, testing, fielding, and sustainment
- Energy Modeling and Analysis and Testing
- Expeditionary Analysis, Modeling, and Simulation

Current Marine Corps Programs Supported

PEO-Land Systems

PM-AAA

- AAV Emergency Egress Lighting
- AAV Electrical Upgrade
- AAV ARVCOP (Funded by PMS 495)
- Habitability

PM-Medium and Heavy Tactical Vehicles

- LVSR 3-D Modeling
- MTVR 3-D Modeling
- Vehicle Capabilities Insertions
- Cougar Configuration Management

Marine Corps Systems Command

PM-MAGTF Command, Control, and Communications (MC3)

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

PM-CSS

- NSWC PCD is the Technical Agent (TDA, ISEA, AEA, and SSA) for systems of the USMC Engineering Systems Route Reconnaissance and Clearance and Mobility/ Counter-Mobility missions.
- CSE Enhanced Tray Ration Heating Sink System engineering and testing support

PM-Infantry Weapons Systems (IWS)

- Raids and Recon Depot Support

PM- SIAT

- Energy
- CIED
- Expeditionary M&S and FACT Support

CD&I

- Engineering Support to Seabasing Integration Division

SPAWAR Systems Center (SSC) Atlantic – SSC

Atlantic Strategic Guidance-Work together as a high performing organization delivering timely capabilities at the right cost. Rapidly provide information warfare capabilities that exceed expectations.

Land Systems Integration (LSI) Mission

Provide design, engineering, prototyping, and full scale integration of C4ISR capabilities into tactical ground vehicle platforms. Improve USMC readiness through the integration of mission equipment on vehicle platforms. Provide fielding, post-production, and sustainment support.

SSC Atlantic LSI Technical Capabilities

Rapid integration and fielding of new capability into tactical vehicle platforms.

Complete System engineering data management approach. The Amphibious Combat Vehicle (ACV) and Assault Amphibious Vehicle (AAV) program offices invested in a suite of tools and SSC Atlantic LSI has integrated them into a systems engineering tool set. The tool set includes the following applications and their supporting function:

- System Architect-Enterprise Architecture (DoDAF)
- Rational DOORS & DOORS Next Gen-Requirements Development, Requirements Management, Requirements Traceability, and Requirements Verification/Validation Reporting
- Rational Team Concert-Configuration Mgmt., Risk Mgmt., Task Mgmt., Defect Mgmt., etc
- Rational Quality Management-Manage Test: Process, Plans, Cases, Scripts
- Rational Asset Management-Enterprise Class Data Storage for COTS / GOTS applications
- Open Services for Lifecycle Collaboration (OSLC) Integration -Link to other non-IBM applications (PTC Windchill-Product Lifecycle Management, supporting Technical Data Packages)

Open Technical Data Package (TDP) development utilizing a wide range of technology from 3D scanning, 3D modeling, and 3D printing, as well as expanding their capabilities in the realm of mechanical and electrical simulation.

Software and Hardware Tool Set:

- 2D & 3D Modeling, Scanning and Simulation Software
- AutoCAD Professional
- SolidWorks Professional (2013-2016)
- SolidWorks Electrical (2013-2016)
- PTC Creo 3.0
- GEO MAGIC DESIGN X
- ANSYS Mechanical
- ANSYS HFSS
- 3D modeling and scanning hardware

Rapid and dynamic MAGTF test environment architecture engineering.

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

Shock and Vibration test and analysis capabilities.

Proactive collaborative teams utilizing Government Quality Assurance Processes and Procedures utilized.

Facilities

24,000 square foot Digital Integration Facility (DIF) is reconfigurable to support multiple concurrent platform systems design and testing.

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

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.

USMC Programs Supported

PEO - Land Systems

- Advanced Amphibious Assault (AAA)-AAV SW sustainment / 3-D Modeling / COMMS upgrade
- Amphibious Combat Vehicle
- Light Tactical Vehicles (LTV) -Joint Light Tactical Vehicle /GB-GRAM-M integration and testing
- Medium and Heavy Tactical Vehicles (M&HTV)-LVSR & MTVR Integration / MRAP Integration

Marine Corps Systems Command

- Light Armored Vehicle (LAV) -Win 10 Fielding / C2 SW Sustainment / JBC-P / 117-G
- MAGTF Command, Control, and Communications (MC3)-Networking On-The-Move (NOTM) into MRAP / M-ATV / KC-130 / HMMWV
- Digital Fires Situational Awareness (DFSA)- Mobile Tactical Shelter (MTS)
- Force Protection Systems- CVRJ Support
- Expeditionary Power Systems
- Engineering Systems–Route Reconnaissance & Clearance

Marine Corps Logistics Command

- MRAP

Section 7.0

MCWL/DARPA 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 the Marine Corps Warfighting Lab (MCWL) and Defense Advanced Research Projects Agency (DARPA). 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 a number 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 MCWL and 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.

Marine Corps Warfighting Lab (MCWL)

The mission of the Marine Corps Warfighting Laboratory is to conduct concept-based experimentation for the identification, development, and integration of operational concepts with tactics, techniques, procedures, and technologies in order to improve the naval expeditionary warfighting capabilities across the spectrum of conflict for current and future operating forces.

The Science & Technology (S&T) Division supports the MCWL Commanding General in carrying out his responsibilities under Deputy Commandant for Combat Development & Integration (CD&I) as the Executive Agent for Marine Corps S&T and experimentation to develop advanced warfighting concepts and capabilities. The S&T Division works in conjunction with Office of Naval Research (ONR), Defense Advanced Research Projects Agency (DARPA), Department of Defense (DOD), Marine Corps Systems Command (MCSC), Program Executive Office, Headquarters Marine Corps (HQMC) and industry partners to develop the vision, policies, and strategies needed to exploit scientific research and technological development in support of USMC combat development and experimentation.

The following MCWL programs have been identified as most relevant to the PEO LS portfolio and demonstrate the potential to support the future direction of the PEO.

Unmanned Tactical Autonomous Control and Collaboration (UTACC)

There is a perceived problem in Marine Corps tactical units regarding technological advancements and cognitive load; specifically, the almost infinite flow of new information on the modern battlefield is overtaxing the human brain. The development of Unmanned Tactical Autonomous Control and Collaboration (UTACC), an alternative warfare concept, could clarify the relationship between technological advancements and cognitive load. UTACC's purpose is to enhance mission accomplishment while simultaneously reducing the cognitive load on the Marine through collaborative autonomy. Initially, UTACC could be employed as a scalable decision support tool, automating routine planning processes and improving the efficiency of the small tactical unit. Additionally, future efforts could automate much of the processes needed to develop and manage a common operational picture automating the fusion of multiple sensors and multiple across a dispersed battle space.

Specifically, the UTACC is a C2 framework that enables unmanned systems (UxS) to act collaboratively, and team with manned formations. UTACC accepts mission-type orders for automated mission planning, and executes the mission within the operator defined parameters. UTACC chooses how to best leverage the capabilities of each of a variety of UxS's, and dynamically re-plans in response to battlefield conditions. This is all done with only occasional user prompts, reducing the operator workload and allowing one-to-many control, putting Marines back into the fight.

The end-state capability will allow a unit to conduct a multi-UxS mission with minimal operator input. One operator will control many UxS's – w/out cognitive overload. It will recognize and queue the operator to intelligence requirements and assist with mission planning and execute RSTA tasks in support of the mission.

Robotic Vehicle Modular (RV(M))

Robotic Vehicle Modular (RV(M)) is a squad multi-purpose Unmanned Ground Vehicle (UGV) hosting modular payload architecture providing the ability to rapidly change out payloads for a variety of missions. In its current configuration the RV(M) weighs approximately 800-pounds and is suitably sized to carry weaponized payloads that include the Javelin anti-tank missile, M2 or M134 Minigun. Additional modular payloads include (but are not limited to) remote target acquisition and designator, reconnaissance, communications and logistics. The RV(M) also capitalizes on the Marines' Ground Unmanned Support Surrogate (GUSS) autonomy package for command and control which integrates well with the Marine Corps future Unmanned Ground Vehicle (UGV) concept. This capability will provide an Expeditionary Landing Team (ELT) with a highly mobile, MV-22 transportable, multiple payload, squad-level infantry support UGV capable of supporting a multitude of missions.

Autonomous Littoral Connector (ALC)

The Enhanced MAGTF Operations Limited Objective Experiment #2 (logistics) identified Autonomous vehicles as effective tools for the provisioning of logistics. Additionally, fast-moving Unmanned Surface Vessels could

lower risk, while increasing efficiency for a large number of missions, to include supply, weapons transport, and amphibious assaults. The ALC program will look to capitalize on potential to reduce risk and increase efficiency to conduct littoral staging and autonomous resupply. The ALC will autonomously provide operational and tactical maneuver from seabases in alignment with the Marine Operating and Expeditionary Advanced Base Operations Concepts. Additionally, the ALC will be used to develop and incorporate existing navigation and sensor perception capabilities (e.g. ACTUV, USV, Riverine, CARACaS), testing of autonomous systems (which are integrated into a LCM-8), and development of autonomous surface craft CONOPS and TTPs. The goal of the ALC program is to develop a surrogate autonomous litoral connector to deliver equipment, fuel or supplies from ship-to-shore and throughout the littoral environment in support of distributed operations and / or SPMAGTF operations.

Counter Unmanned Systems (C-UxS)

As the barrier for entry in to the construction of sophisticated unmanned systems has fallen, many of these commercial off the shelf (COTS) technologies are now within reach of third world militaries as well as terrorist organizations. In addition, the explosive growth of unmanned systems (air, land, surface or subsurface) UxS the threat from these unmanned and soon to be autonomous systems increases. MCWL's C-UxS effort involves the employment of multiple networked and fused sensors capable of providing detection, identification, tracking and defeat capabilities to counter their effects. The goal of the C-UxS will be to develop an integrated, expeditionary suite of networked capabilities to detect, identify, and track, cue and kinetically or non-kinetically prosecute enemy unmanned air, ground, and surface/sub-surface systems. The project is currently exploring a comprehensive suite of technologies integrated onto a light MV22 transportable vehicle to demonstrate the ability to execute an end-to-end C-UAS killchain in a distributed operational environment.

Ground Unmanned Support Surrogate (GUSS)

The Ground Unmanned Support Surrogate (GUSS) project developed a system of sensors, controllers and CONOPS to experiment with autonomous support vehicles at the lowest levels. Fitted with electro-optics, lasers, and navigation sensors, GUSS provides navigation and obstacle sensing for autonomous missions. The system is controlled by GPS-guided pre-determined waypoints, a "follow me" mode in which it shadows a warfighter, direct tele-operation or can be man driven. GUSS can navigate through wooded areas, urban or open-terrain and has a cruising range of 482km without refueling and carry 1,700lbs of cargo, (2) passengers and (1) litter patient.

The GUSS vehicle moves at the speed of a troop on foot, or about five miles per hour. The multi-purpose systems are designed to operate on off-road terrain, day or night in all weather conditions, and will support dismounted troops with point-to-point resupply, thereby reducing the loads manually carried by Marines and providing a means for immediate casualty evacuation. GUSS can navigate through wooded areas, urban or open-terrain and provide dismounted infantry platoons with semi-autonomous or fully autonomous logistic resupply and casualty evacuations capabilities. The project consists of development and testing of an infantry support Unmanned Ground Vehicle to support multiple resupply, CASEVAC, and

reconnaissance type missions. Additionally, the autonomous science and technology developed for GUSS is being applied as the basis for the autonomy incorporated into RV(M).

HEIT (Hybrid Energy ITV Trailer)

Hybrid Energy ITV (Internally Transportable Vehicle) Trailer (HEIT) provides a Company Landing Team Landing Team with a highly mobile, MV-22 Osprey transportable electric power solution that is matched to energy demands and provides the flexibility to operate with a variety of energy sources with the ability to generate, scavenge, condition, store, manage and distribute power. HEIT is a MRZR Trailer reconfigured with a Tactical Quiet Generator, battery bank and a power distribution system capable of providing 3.5 kW/5kW of power. HEIT is also capable of scavenging power, harvesting energy for renewable sources such as solar, shore power, or conventional energy provided by the on-board generator. The intent of the HEIT is to provide a Company. The current concept-demonstrator is a two-wheeled trailer attaches to the back of a vehicle, giving Marines a versatile, transportable source of electricity.

Defense Advanced Research Projects Agency (DARPA)

Established in 1958 as part of the U.S. Department of Defense, DARPA is designed to pursue opportunities for transformational change rather than incremental advances. Its mission is to make the pivotal early technology investments that create or prevent strategic surprise for U.S. National Security. 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.

The following DARPA programs have been identified as most relevant to the PEO LS portfolio and demonstrate the potential to support the future direction of the PEO.

High Assurance Cyber Military Systems (HACMS)

Develop formal methods and tools to enable the synthesis and verification of high-assurance cyber-physical systems.

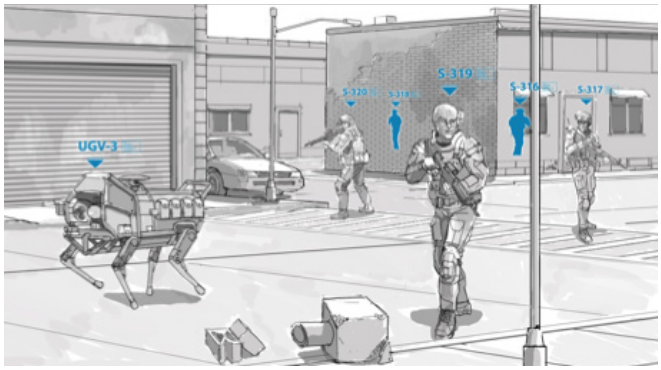
The goal of the HACMS program is to create technology for the construction of high-assurance cyber-physical systems, where high assurance is defined to mean functionally correct and satisfying appropriate safety and security properties. Achieving this goal requires a fundamentally different approach from what the software community has taken to date. Consequently, HACMS adopts a clean-slate using a formal methods-based approach to enable semi-automated code synthesis from executable, formal specifications. In addition to generating code, HACMS is developing a synthesizer capable of producing a machine-checkable proof that the generated code satisfies functional specifications as well as security and safety policies. Technologies are prototyped on a research quadcopter and a USA TARDEC-developed Ground Vehicle Robot (GVR-bot) before being transitioned to the Boeing Unmanned Little Bird (ULB) and the TARDEC Autonomous Mobility Appliqué System (AMAS) Heavy Equipment Transporter (HET).

- High-assurance OS components and control systems
- Suite of program synthesizers and formal-methods tools
- Architectural analysis workbench

The goal of the final program demonstration is to show DoD requirements and accreditation policy makers the feasibility and broad applicability of the HACMS approach to high assurance software.

Squad X Experimentation

Design, develop, and validate system prototypes for a combined arms squad – Squad X. Squad X would overmatch its adversaries through the synchronization of fire and maneuver in the physical, electromagnetic spectrum, and cyberspace domains.

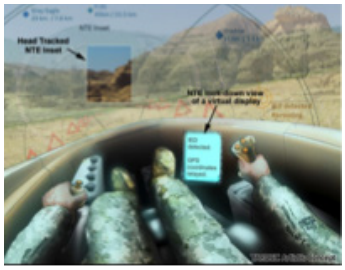


DARPA's Squad X Core Technologies (SXCT) program aims to develop novel technologies that could be integrated into user-friendly systems that would extend squad awareness and engagement capabilities without imposing physical and cognitive burdens. The goal is to speed the development of new, lightweight, 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. DARPA's SXCT capability objectives are:

- Extend and enhance the situational awareness of the Squad to their entire operational environment.
- Increase the Squad's maneuver time and space through optimized use of their physical, cognitive, and material resources.
- Enable the Squad to shape and dominate their operational environment through synchronization of fire and maneuver in the physical, electromagnetic spectrum, and cyberspace domains.

Ground Experimental Vehicle Technologies (GXV-T)

Develop next generation ground platform technologies that improve expeditionary mobility, combined factors of tactical and strategic, without sacrificing survivability.



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 U.S. 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 Ground X-Vehicle Technologies (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 U.S. ground forces to more efficiently and cost-effectively tackle varied and unpredictable combat situations.

The GXV-T program seeks to develop advanced technologies in the following four technical areas:

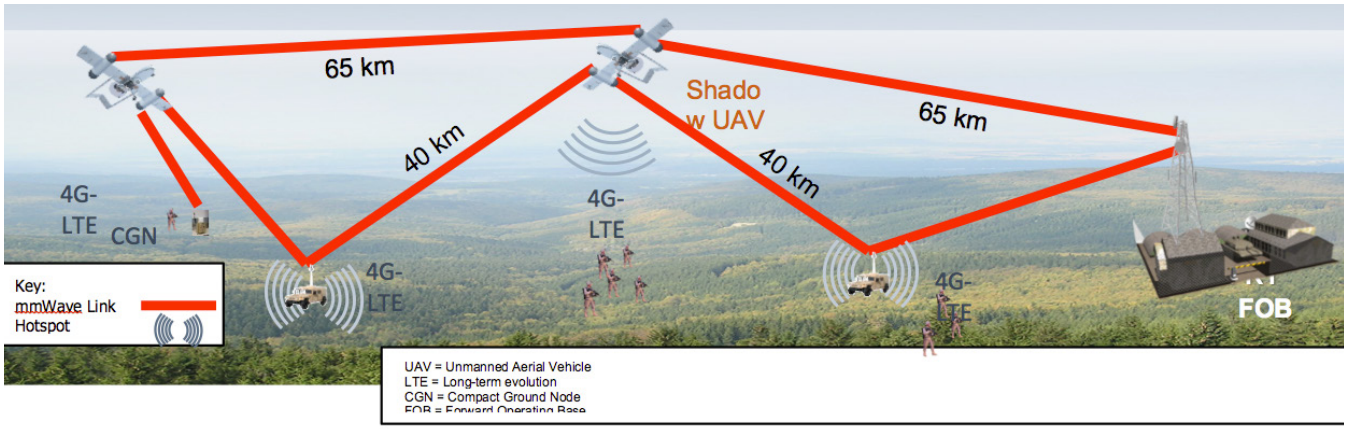
- Enhanced Platform Mobility — Ability to traverse diverse off-road terrain, including slopes and various elevations.
- Enhanced Platform Agility — Autonomously avoid incoming threats without harming occupants through technologies that enable, for example, agile motion and active repositioning of armor.
- Crew Augmentation — Improved physical and electronically assisted situational awareness for crew and passengers; semi-autonomous driver assistance and automation of key crew functions similar to capabilities found in modern commercial airplane cockpits.
- Signature Reduction — Reduction of detectable signatures, including visible, infrared (IR), acoustic and electromagnetic (EM).

Mobile Hotspots

The program's goal is to provide high-bandwidth communications for troops in remote forward operating locations.

The Mobile Hotspots program intends to develop and demonstrate a scalable, mobile, millimeter-wave communications backbone with the capacity and range needed to connect dismounted warfighters with forward-operating bases (FOBs), tactical operations centers (TOCs), intelligence, surveillance and reconnaissance (ISR) assets, and fixed communications infrastructure. The backbone should also provide reliable end-to-end data delivery between hotspots, as well as from ISR sources and command centers.

The program envisions air, mobile and fixed assets, most of which are organic to the deployed unit, that provide a gigabit-per-second tactical millimeter-wave backbone network extending to the lowest-echelon warfighters. To achieve this capability, the program seeks to develop advanced millimeter-wave pointing, acquisition and tracking (PAT) technologies that are needed to provide high connectivity to the forward-located mobile hotspots. Advanced PAT technology is key for connectivity to small UAVs, for example, enabling them to serve as flying nodes on the mobile high-speed backbone. Additionally, the program seeks novel technologies to increase the transmission power of millimeter-wave amplifiers to provide adequate ranges within the small size, weight, and power (SWAP) constraints required for company-level unmanned aerial vehicles (UAVs).



Aerial Reconfigurable Embedded System (ARES)

The program's goal is to demonstrate of a full scale, modular, multi-mission vehicle capable of vertical takeoff and landing (VTOL).

ARES is a vertical takeoff and landing (VTOL) flight module designed to operate as an unmanned platform capable of transporting a variety of payloads. The ARES VTOL flight module is designed to have its own power system, fuel, digital flight controls and remote command-and-control interfaces. Twin tilting ducted fans would provide efficient hovering and landing capabilities in a compact configuration, with rapid conversion to high-speed cruise flight.

It is envisioned that the flight module would travel between its home base and field operations to deliver and retrieve several different types of detachable mission modules, each designed for a specific purpose. Capability objectives include:

- Modular – Rapid reconfiguration
- Multi-mission – Logistics; reconnaissance; strike; force multiplier
- Embedded – Tactical organic warfighter support
- Expanded access – Vertical takeoff and landing

Tern

Long endurance unmanned aircraft system operable from small ships and expeditionary settings. Capable of generating persistent orbits at long radius and high sea state operations.

Tern is an advanced technology development program with the goal to design, develop, and demonstrate a medium-altitude long-endurance (MALE) unmanned aircraft system and related technologies that enable future launch, recovery, and operations from small ships. Additionally, the program seeks to enable on-demand, ship-based unmanned aircraft system (UAS) operations without extensive, time-consuming, and irreversible ship modifications. It would provide small ships with a "mission truck" that could transport ISR and strike payloads long distances from the host vessel. A modular architecture would enable field-interchangeable mission packages for both overland and maritime missions. It would be able to operate from multiple ship types in elevated sea states.

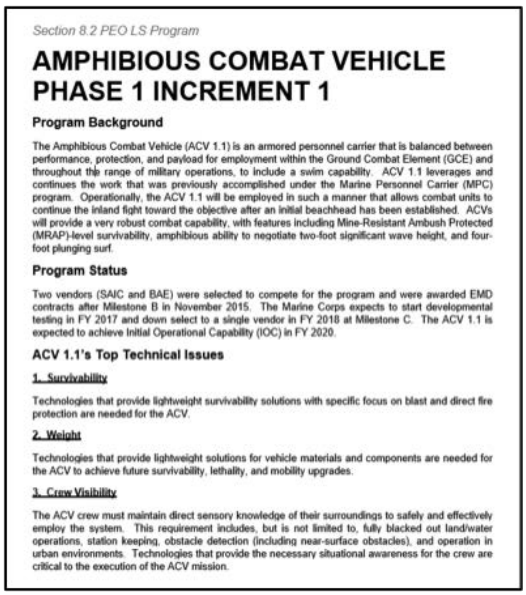
Program objectives include:

- Develop objective system design with operational radius from 600+ nm with a modular 500+ lb payload capability that can operate from small ships
- Develop high sea-state-capable launch and recovery approaches and technologies for air vehicles capable of higher-speed, long-endurance flight
- Flight Demonstrate Tern demonstration system with launch and recovery capability from a small ship footprint
  - Precision approach and controllability
  - Reliability and operational safety

PEO LS PROGRAMS

Program Executive Officer Land Systems (PEO LS) consists of six program offices overseeing 22 programs. The following sections discuss the ATIP for each of the pertinent PEO LS programs. Each selected 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 (Figure 8-1) describes the program's background, status, and Top Technical Issues.



Section 8.2 PEO LS Program

AMPHIBIOUS COMBAT VEHICLE PHASE 1 INCREMENT 1

Program Background

The Amphibious Combat Vehicle (ACV 1.1) is an armored personnel carrier that is balanced between performance, protection, and payload for employment within the Ground Combat Element (GCE) and throughout the range of military operations, to include a swim capability. ACV 1.1 leverages and continues the work that was previously accomplished under the Marine Personnel Carrier (MPC) program. Operationally, the ACV 1.1 will be employed in such a manner that allows combat units to continue the inland fight toward the objective after an initial beachhead has been established. ACVs will provide a very robust combat capability, with features including Mine-Resistant Ambush Protected (MRAP)-level survivability, amphibious ability to negotiate two-foot significant wave height, and four-foot plunging surf.

Program Status

Two vendors (SAIC and BAE) were selected to compete for the program and were awarded EMD contracts after Milestone B in November 2015. The Marine Corps expects to start developmental testing in FY 2017 and down select to a single vendor in FY 2018 at Milestone C. The ACV 1.1 is expected to achieve Initial Operational Capability (IOC) in FY 2020.

ACV 1.1's Top Technical Issues

1. Survivability

Technologies that provide lightweight survivability solutions with specific focus on blast and direct fire protection 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 are critical to the execution of the ACV mission.

Figure 8-1. Part One

Part Two (Figure 8-2) describes 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.

Part Three (Figure 8-3) graphically addresses the Top Technical Issues for each program.

Each technical issues and related S&T projects are aligned to the current program schedule. It 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.
- TRL 3 - Analytical and experimental critical function or characteristic proof-of-concept.

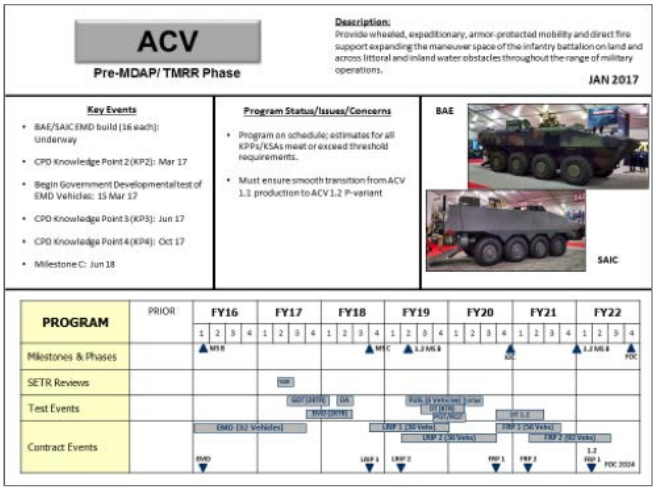


Figure 8-2. Part Two

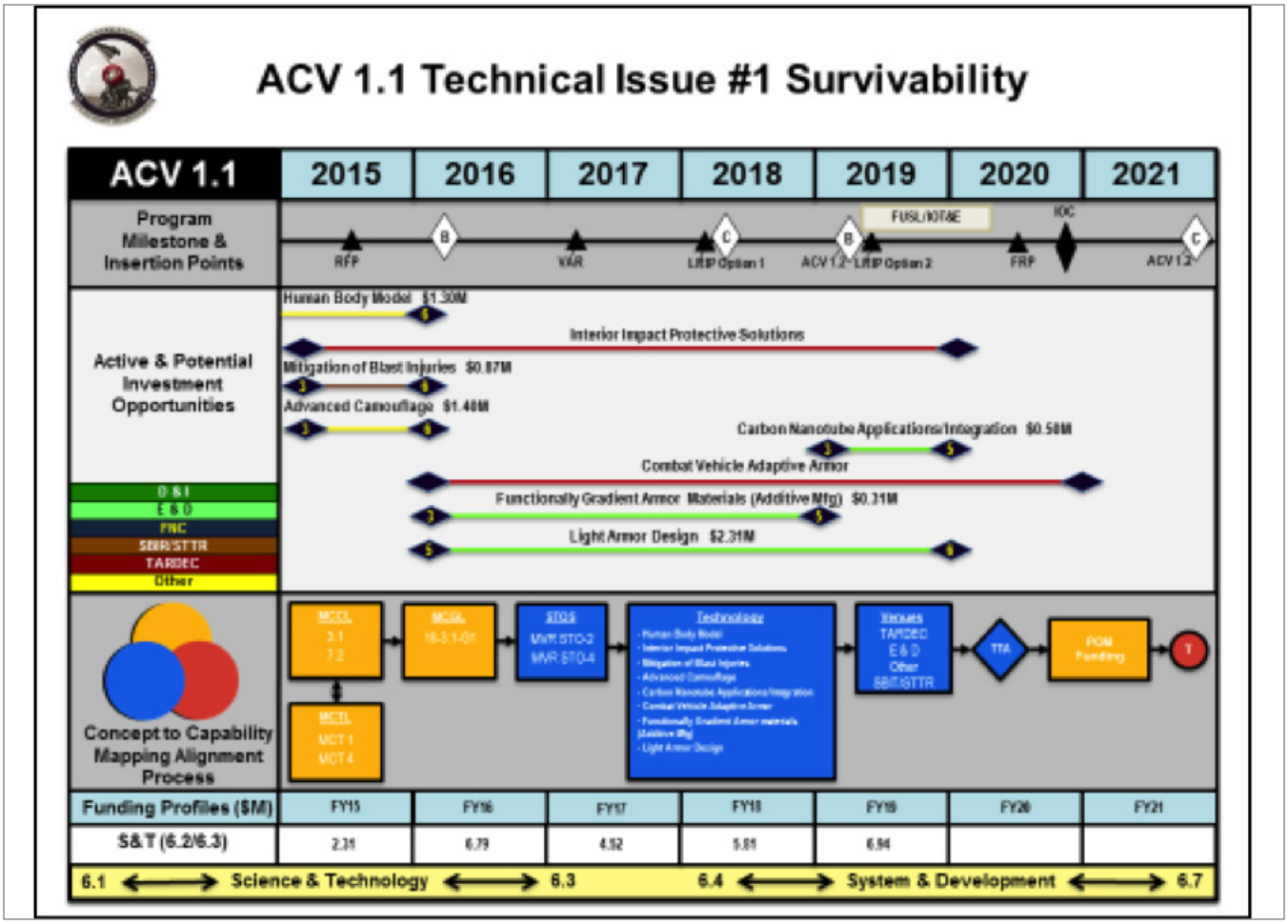


Figure 8-3. Part Three

- 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) provide the best technology solutions to formally defined capability gaps and usually leverage past D&I and E&D successes.

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 U.S. Armed Forces' research and development facility for advanced technology in ground systems. It is part of the Research, Development and Engineering Command (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 8 for a detailed list of applicable S&T venues.

Row three traces the issue from the originating Marine Corps Capabilities List (MCCL), through the identified gap via the Marine Corps Gap List (MCGL), to the Science and Technology Objectives (STOs) 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 ACV Technical Issue #1, Survivability as an example, MCCL 3.1 (Maneuver Forces) identifies the capability that is associated with the technical issue. Applicable tasks identified from the Marine Corps Task List (MCTL). MVR STO-2 addresses the Maneuver (MVR) STO addressing the functional area of ground vehicle mobility. 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, this edition of 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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ASSAULT AMPHIBIOUS VEHICLE

Assault Amphibious Vehicle (AAV)

Program Background

The Assault Amphibious Vehicle (AAV) 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; and it was upgraded to the AAV7A1 RAM/RS (Reliability Availability Maintainability/Return to Standard) 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 Family of Vehicles 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 2035, requiring upgrades as a bridge to the planned Amphibious Combat Vehicle Phase 1 Increment 1.

Program Status

The AAV Survivability Upgrade Program entered the acquisition cycle at Milestone B during FY14 and began the engineering, manufacturing, and development phase. The program improves force protection and platform survivability by integrating mature technologies into the AAV. These upgrades include belly and sponson armor, blast-mitigating seats, spall liners, and expected automotive and suspension upgrades. Currently slated for 361 AAV personnel and 44 AAV Command variants, the upgrades will provide Marine Corps operational forces with four battalions of lift plus some additional support capabilities. The program's

developmental testing is currently ongoing. Milestone C, authorizing entrance into the production and deployment phase, is scheduled for FY17, with an Initial Operating Capability slated for FY19.

Upcoming efforts will focus on numerous subsystems and components that will require technology refresh and/or upgrades; they include fuel tanks, fire suppression, radios and intercoms, suspension, and driver's display. The requirements of the AAV Survivability Upgrade Program and legacy sustainment may be met with non-developmental items and mature technology. The following areas, however, may offer opportunities where advanced technology could benefit the AAV.

AAV's Top Technical Issues

1. Survivability

Technologies that provide advances in ceramic and layered armor, blast seats, and spall liner to improve survivability and reduce weight would benefit the AAV Survivability Upgrade.

2. Weight/Buoyancy Management

Enhancing survivability will likely add weight to the AAV. Alternative lightweight, economical materials, along with design improvements to increase and protect buoyancy, would benefit the AAV Survivability Upgrade.

3. Reliability/Sustainment

The AAV is a 40-year-old platform that will remain in service for years to come. 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 reduces operation and maintenance support costs, which could include advances in weapon station technology (single and dual mount systems) that specifically address operation in an amphibious environment. Advances in diagnostics and modernized maintenance management would also benefit the AAV fleet.

AAV Survivability Upgrade

ACAT III / MS B

Description: The Assault Amphibious Vehicle (AAV) Survivability Upgrade is an ACAT III program initiated to increase AAV7A1 force protection while maintaining required land and water mobility performance. This upgrade is derived from the need for an operationally effective amphibious armored personnel carrier capability bridge until the future amphibious portfolio of vehicles reaches full operational capability.

Key Events

Operational Assessment: 10 Apr–15 Jun 17

Milestone C: Aug 17

LRIP Option award: Aug 17

IOC: 2QFY19

FOC: 2QFY23

Program Status/Issues/Concerns

Acquisition Status: Engineering Manufacturing Development

Acquisition Objective: 405/466

- CPD will add AAV-C7 and 61 additional vehicles to receive partial SU (39 AAV-R7 & 22 AAV-P7 MCM / 466 total)
- Change to 361 P7 and 44 C7 for a total of 405

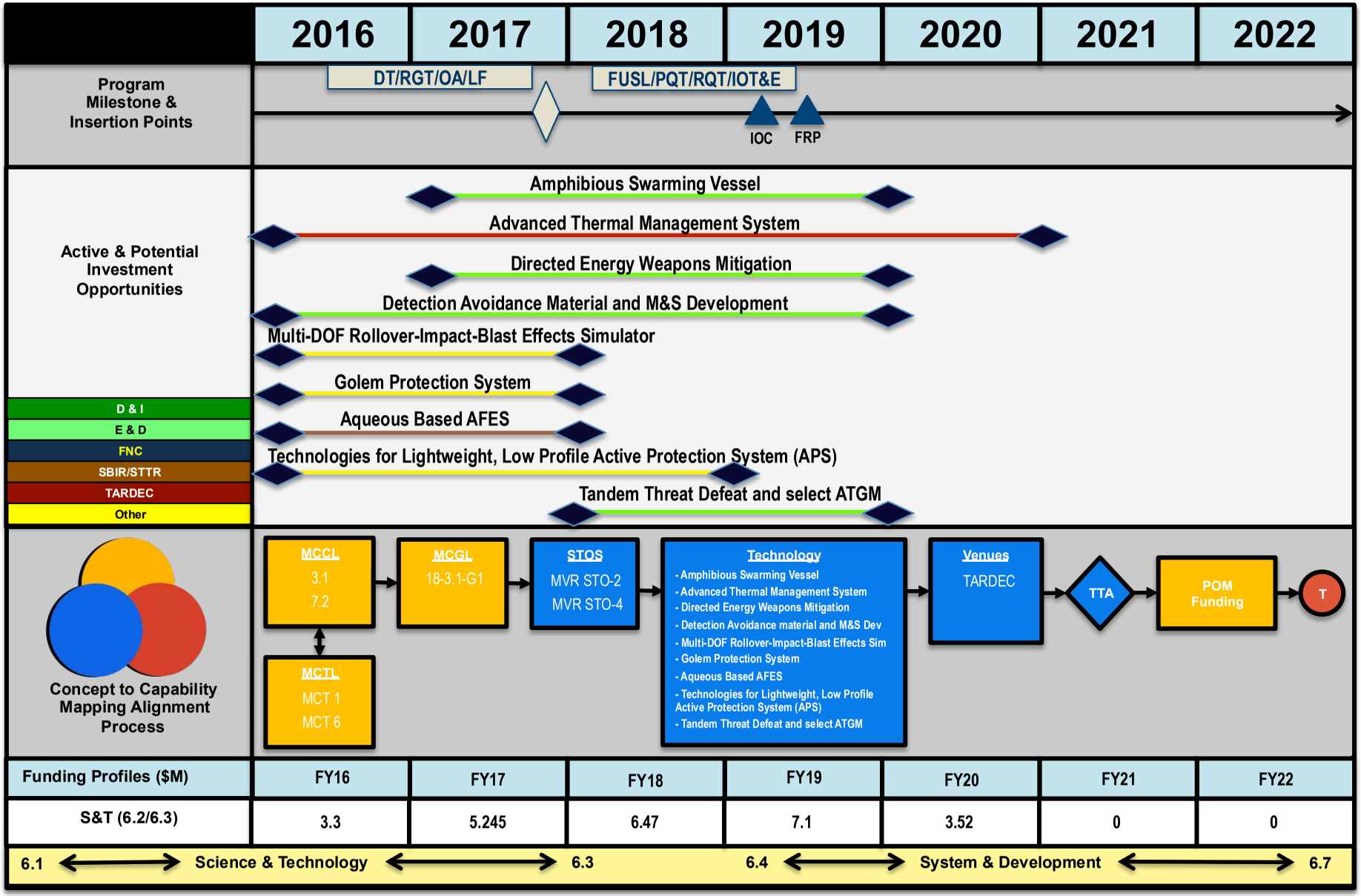
Approximate Unit Cost: $1.65M (FY12$)

Comments:

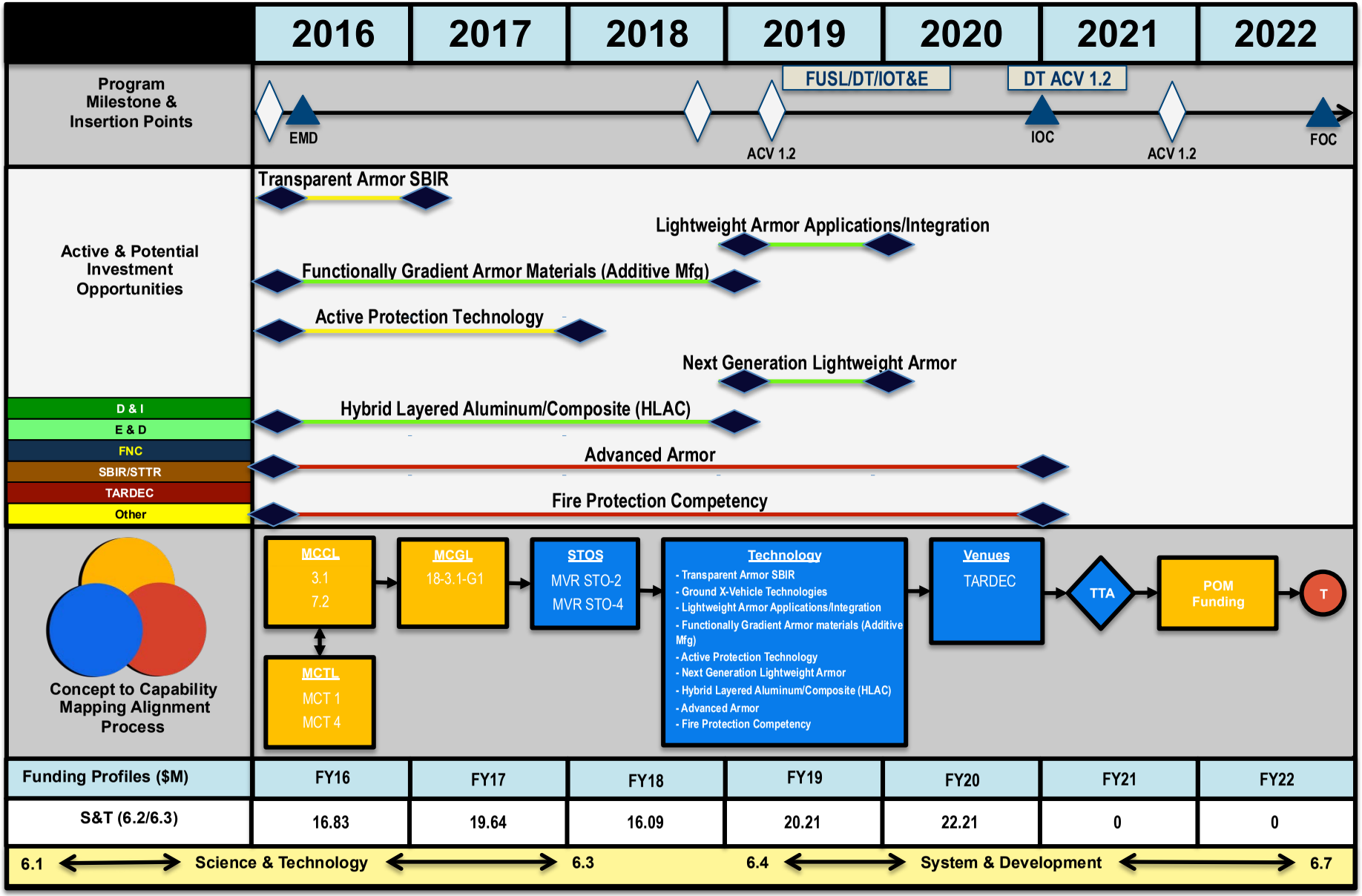
- Prototypes delivered / testing began 2Q FY16
- MS C planned for 4Q FY17

PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases									▲ MS C						▲ IOC														
															▲ FRP														
SETR Reviews																													
Test Events			DT/RGT/OA/LF								FUSL			IOT&E															
											PQT/RQT																			
Contract Events										LRIP								FRP											
									▼ LRIP						▼ FRP														

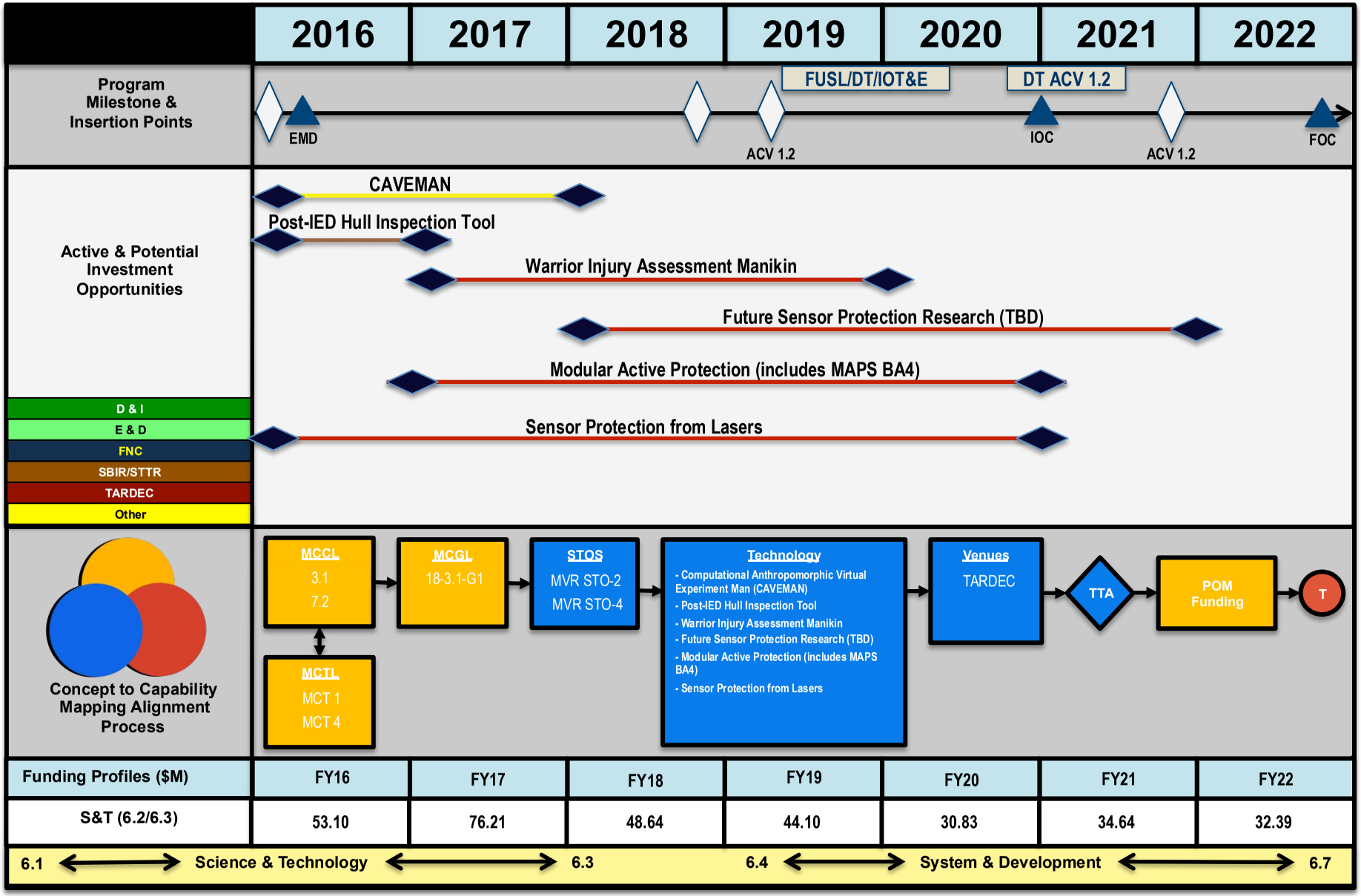
AAV Technical Issue #1 Survivability



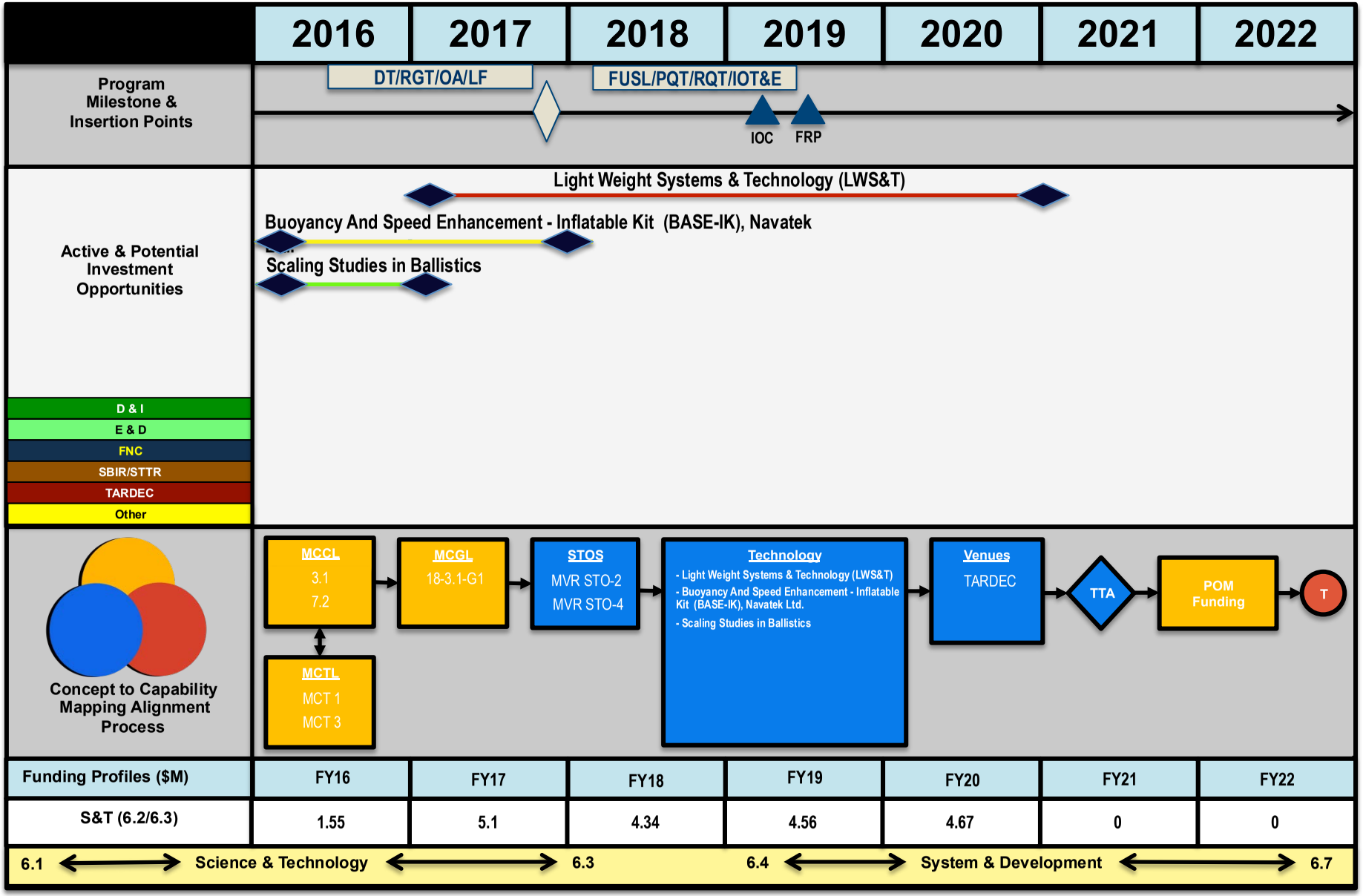
AAV Technical Issue #1 Survivability



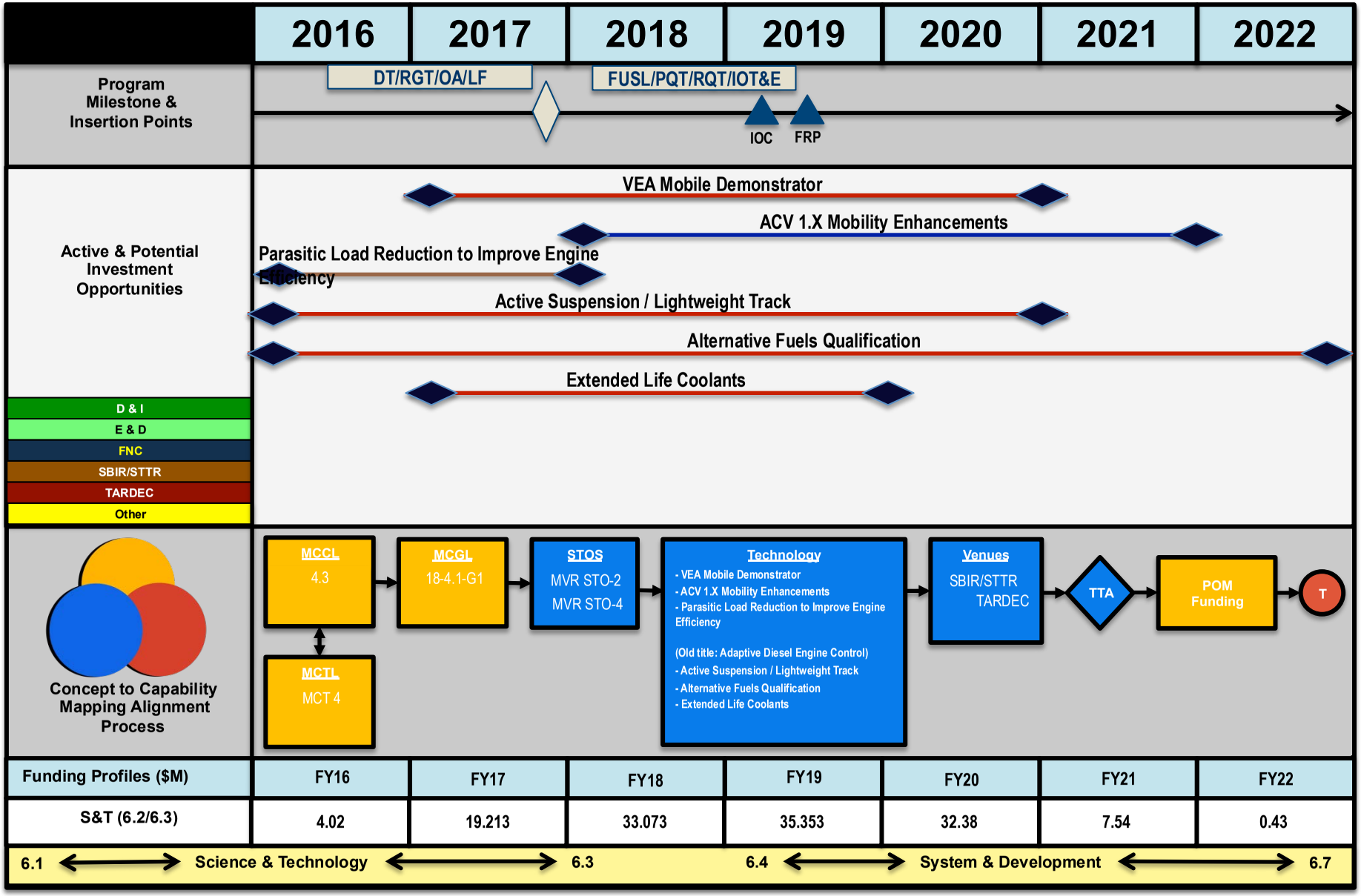
AAV Technical Issue #1 Survivability



AAV Technical Issue #2 Weight/Bouyancy Management



AAV Technical Issue #3 Reliability/ Sustainment



AMPHIBIOUS COMBAT VEHICLE PHASE 1 INCREMENT 1

Amphibious Combat Vehicle (ACV 1.1)

Program Background

The Amphibious Combat Vehicle (ACV 1.1) is an armored personnel carrier that is balanced between performance, protection, and payload for employment within the Ground Combat Element (GCE) and throughout the range of military operations, to include a swim capability. ACV 1.1 leverages and continues the work that was previously accomplished under the Marine Personnel Carrier (MPC) program. Operationally, the ACV 1.1 will be employed in such a manner that allows combat units to continue the inland fight toward the objective after an initial beachhead has been established. ACVs will provide a very robust combat capability, with features including Mine-Resistant Ambush Protected (MRAP)-level survivability, amphibious ability to negotiate two-foot significant wave height, and four-foot plunging surf.

Program Status

Two vendors (SAIC and BAE) were selected to compete for the program and were awarded EMD contracts after Milestone B in November 2015. The Marine Corps expects to start developmental testing in FY 2017 and down select to a single vendor in FY 2018 at Milestone C. The ACV 1.1 is expected to achieve Initial Operational Capability (IOC) in FY 2020.

ACV 1.1's Top Technical Issues

1. Survivability

Technologies that provide lightweight survivability solutions with specific focus on blast and direct fire protection 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 are critical to the execution of the ACV mission.

ACV

Pre-MDAP/ TMRR Phase

Description: Provide wheeled, expeditionary, armor-protected mobility and direct fire support expanding the maneuver space of the infantry battalion on land and across littoral and inland water obstacles throughout the range of military operations.

Key Events

- BAE/SAIC EMD build (16 each): Underway
- CPD Knowledge Point 2 (KP2): Mar 17
- Begin Government Developmental test of EMD Vehicles: 15 Mar 17
- CPD Knowledge Point 3 (KP3): Jun 17
- CPD Knowledge Point 4 (KP4): Oct 17
- Milestone C: Jun 18

Program Status/Issues/Concerns

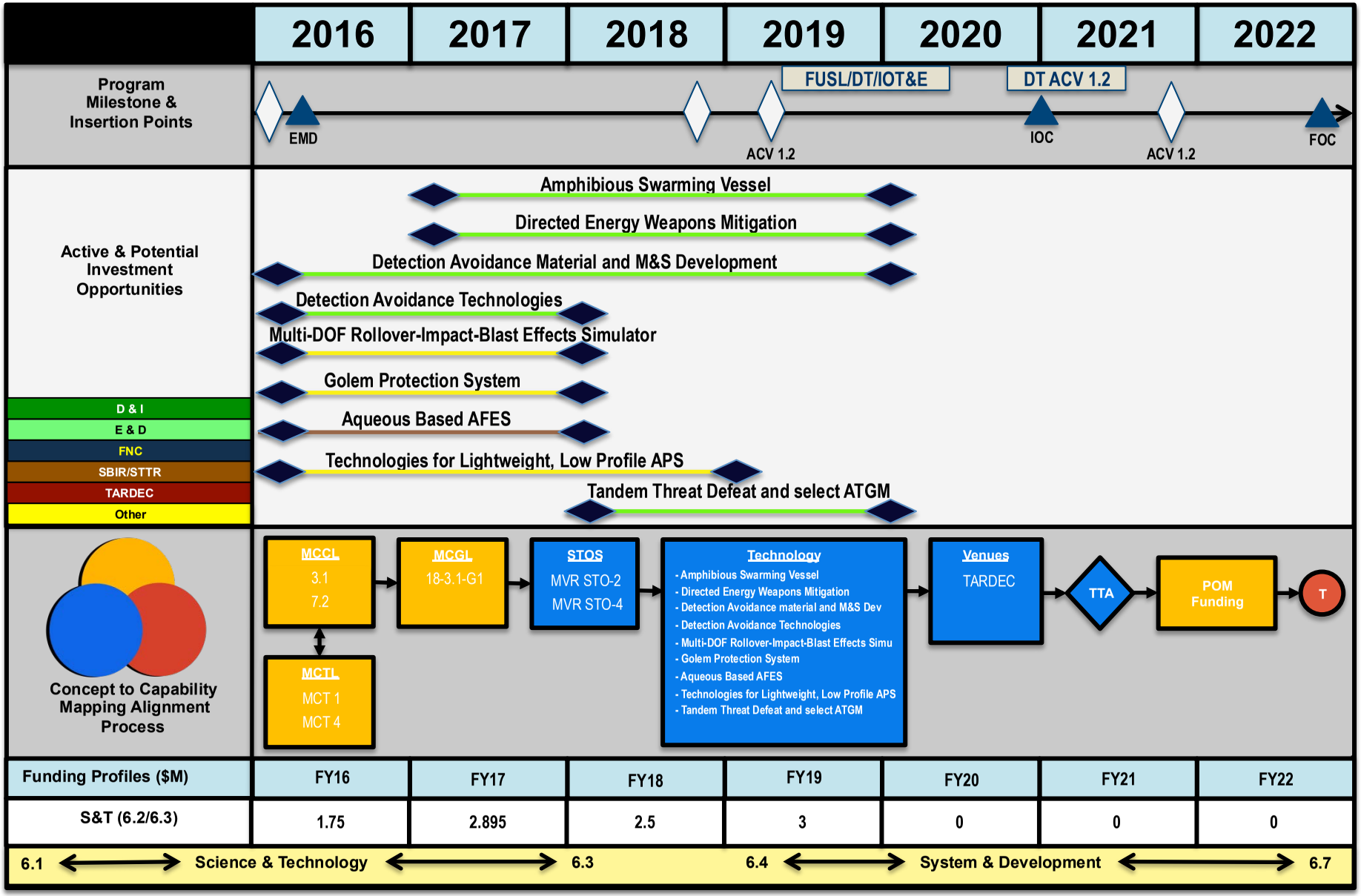
- Program on schedule; estimates for all KPPs/KSAs meet or exceed threshold requirements.
- Must ensure smooth transition from ACV 1.1 production to ACV 1.2 P-variant

BAE

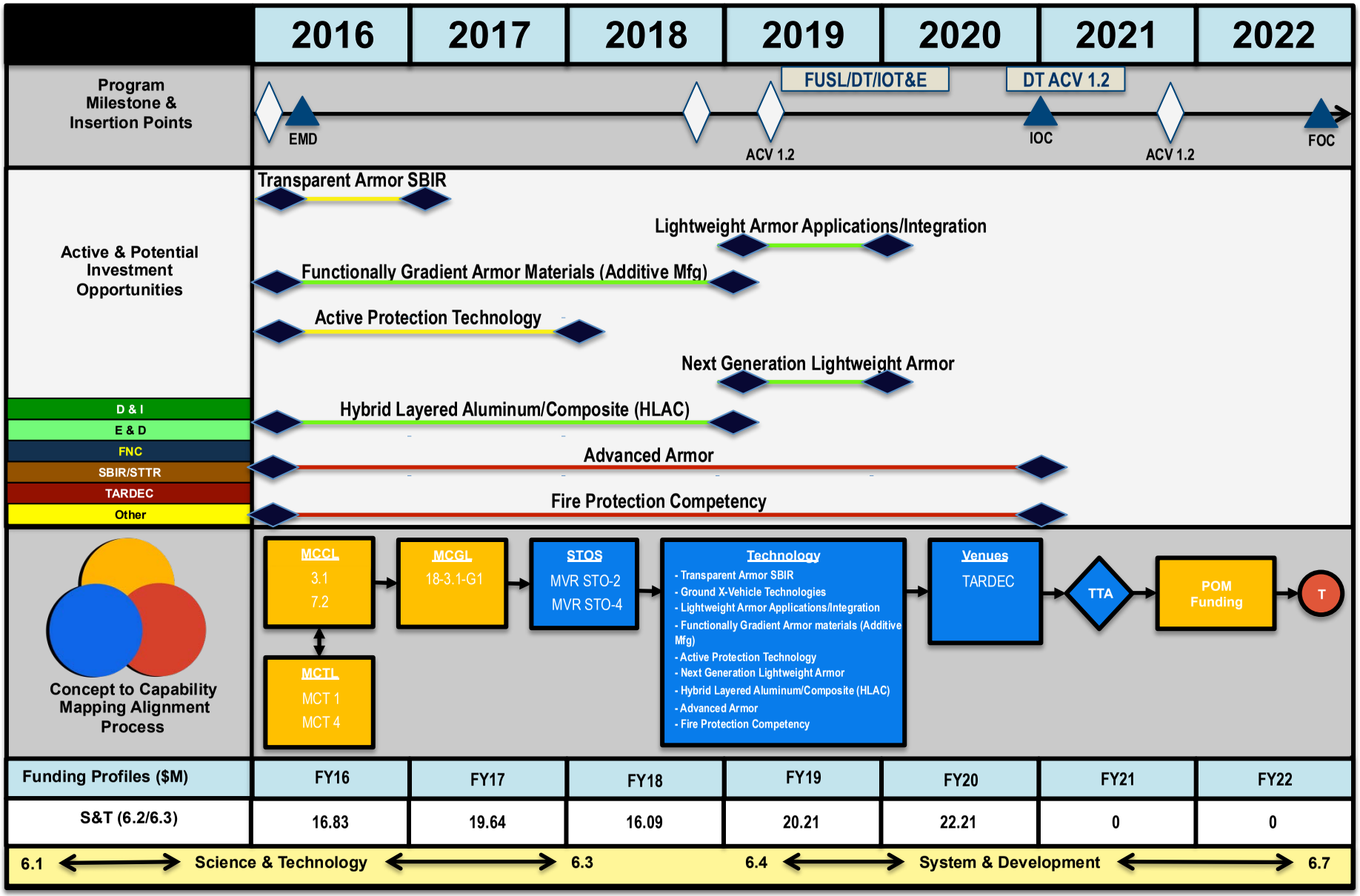
SAIC

PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases		▲ MS B											▲ MS C		▲ 1.2 MS B						▲ IOC								▲ 1.2 MS C			▲ FOC
SETR Reviews							VAR																						
Test Events								GDT (2KTR)		OA						FUSL (4 Vehicles)		IOT&E												
									EMD (2KTR)							DT (KTR)						DT 1.2								
																PQT/RQT													
Contract Events		EMD (32 Vehicles)											LRIP 1 (30 Vehs)								FRP 1 (56 Vehs)								
															LRIP 2 (30 Vehs)										FRP 2 (92 Vehs)				
		EMD											LRIP 1		LRIP 2						FRP 1			FRP 2				1.2 FRP 1	

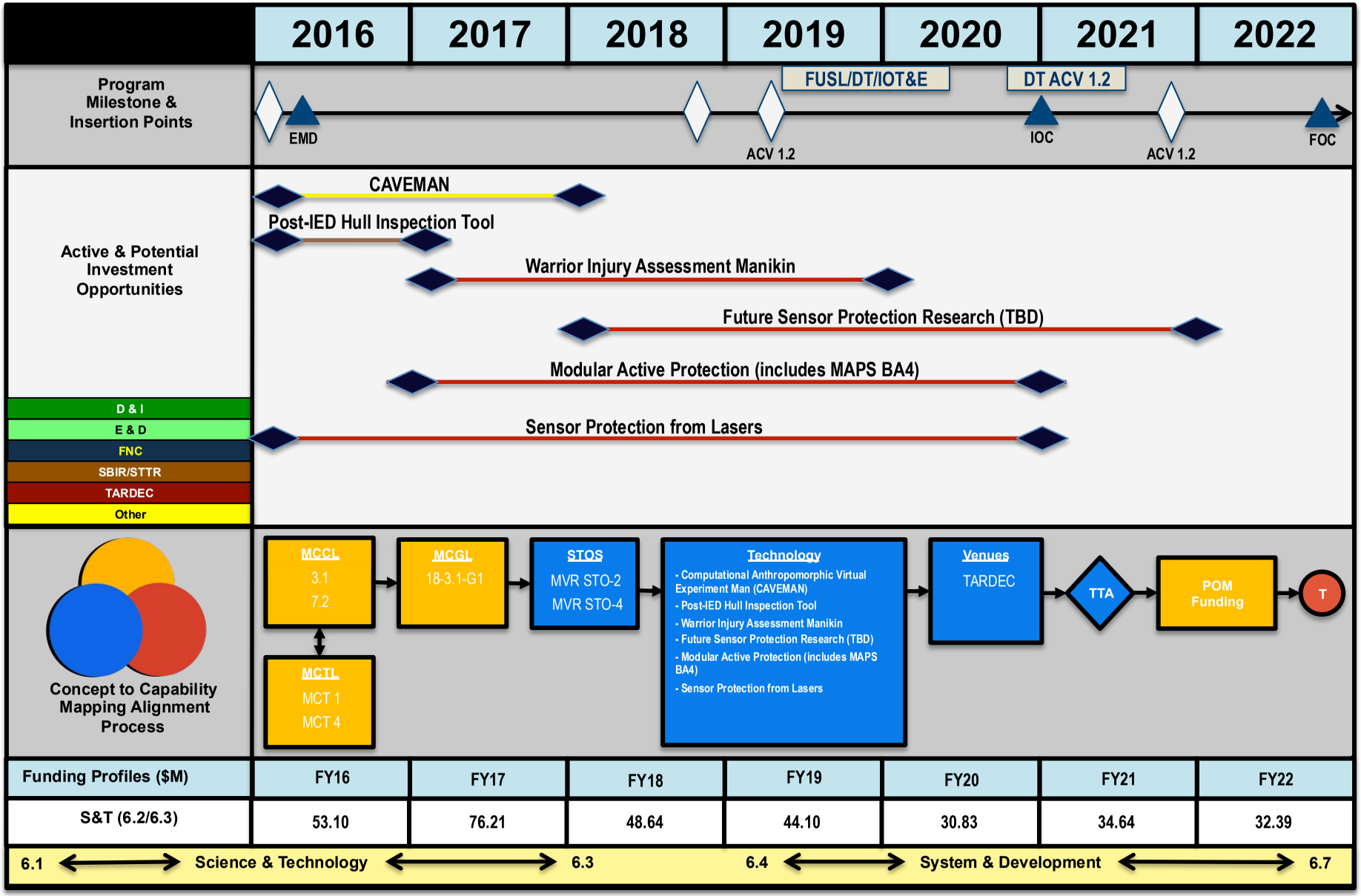
ACV Technical Issue #1 Survivability



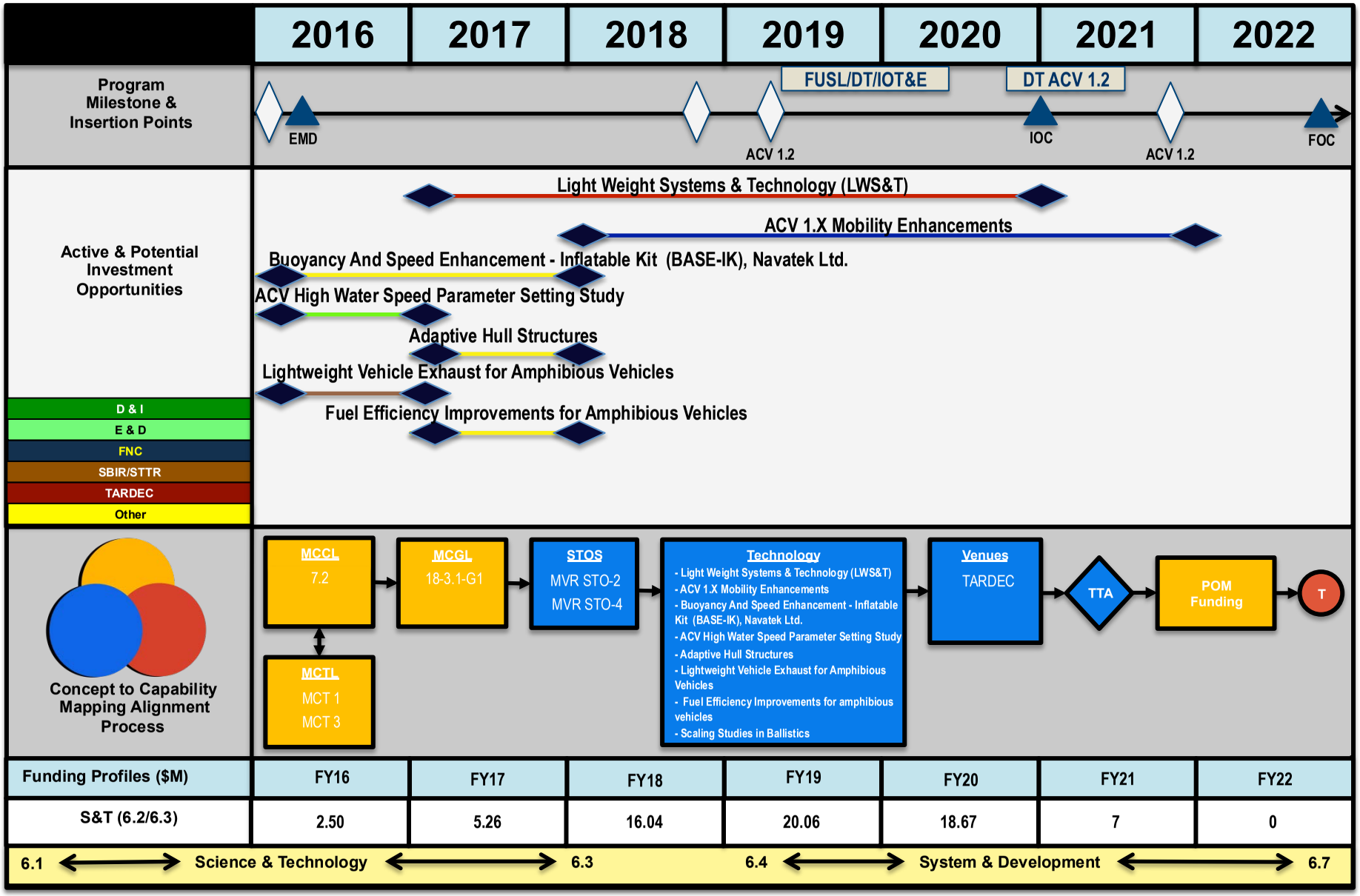
ACV Technical Issue #1 Survivability



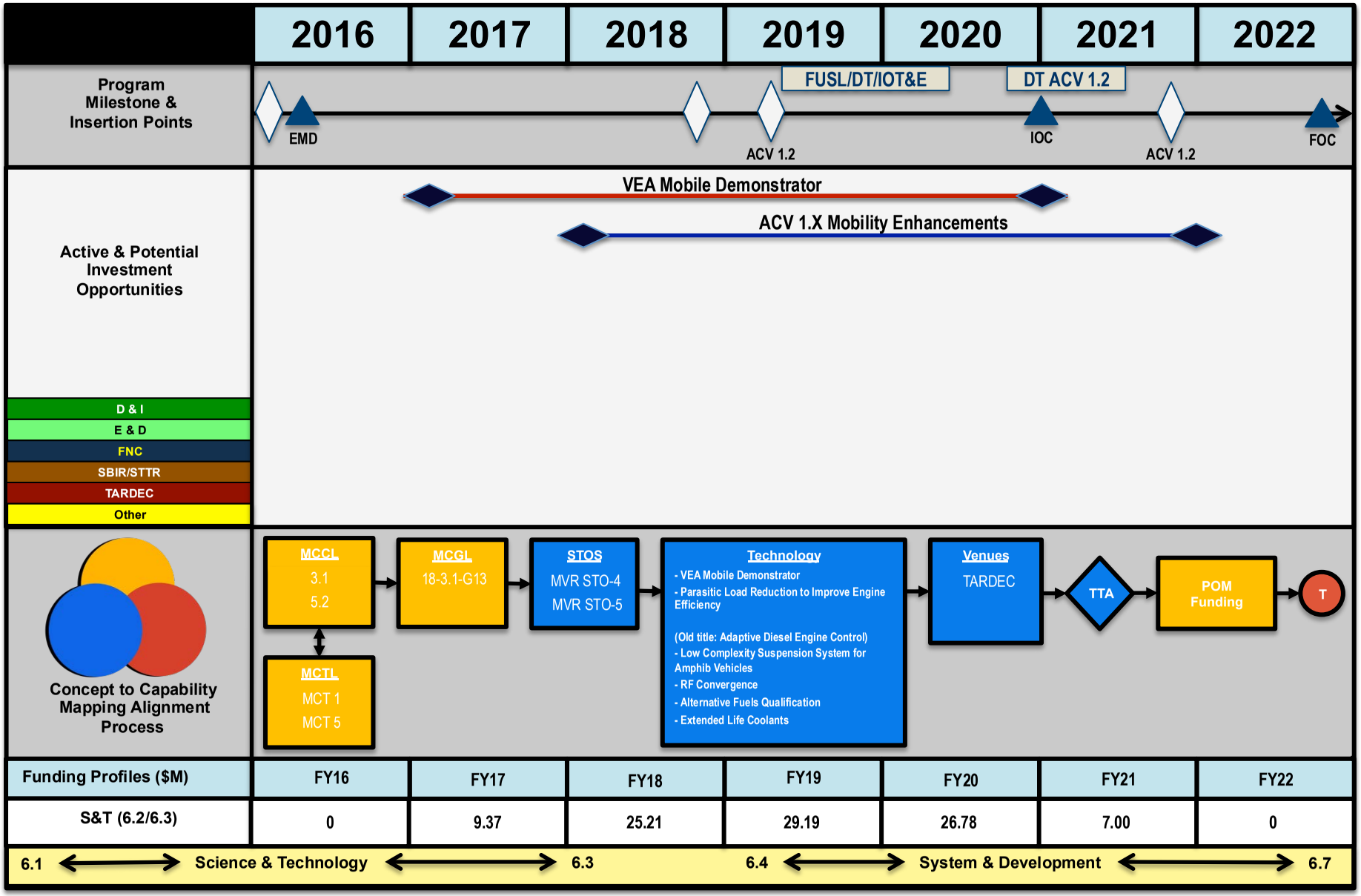
ACV Technical Issue #1 Survivability



ACV Technical Issue #2 Weight



ACV Technical Issue #3 Crew Visibility



COMMON AVIATION COMMAND AND CONTROL SYSTEM

Common Aviation Command and Control System (CAC2S)

Program Background

The Common Aviation Command and Control System (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 will provide 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 with 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 will support the core competencies of all Marine Corps warfighting concepts. CAC2S, in conjunction with MACCS 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 to achieve the full requirements of 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. The CAC2S

PMO structured Phase 1 to accommodate rapid fielding of operationally relevant capabilities, to 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, and it established an initial product baseline for a Processing and Display Subsystem (PDS) and Communications Subsystems.

Phase 2 addresses the requirements for remaining ACE Battle Management and Command and Control requirements and implements the Sensor Data Subsystem to fuse input from expeditionary sensors as well as 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 for 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, and full deployment fielding will begin 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; follow-on increments will be 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 29 Palms, CA.

The Government successfully completed Initial Operational Test and Evaluation of the Phase 2 systems in 2QFY16 and is preparing for full rate production. The Government released a Request for Proposal on 7 October 2016 and expects to award a contract by 3QFY17. 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 USMC air surveillance radars using high bandwidth, Local Area Networks (LANs) that are connected by tactical fiber optic cables. This approach limits radar emplacement to locations within relatively close proximity to CAC2S, which may not allow optimal surveillance coverage. This limitation will also preclude CAC2S from receiving air surveillance data directly from the Ground Weapons Locating Radar (GWLR) version of the G/ATOR. Connectivity between CAC2S and USMC radars using fielded data radios/wireless communications systems or a Wide Area Network is preferred, however this approach must consider bandwidth limitations of the supporting communications systems and architectures. The 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, Local Area Networks (LANs) that are connected by tactical fiber optic cables. This approach limits CS (and associated radio antennas) emplacement to locations within relatively close proximity to CAC2S, which may not provide optimal tactical voice radio line-of-site / coverage. Additionally, the CS lacks the ability for remote users to access the tactical voice radios contained within a CS. 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 Wide Area Network (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. Meanwhile, CAC2S operates on SIPRNet as its primary data network for information exchanges, while most coalition systems and users operate on CENTRIX. Although some information that CAC2S processes could potentially be exchanged with coalitions forces; system, network and data security considerations prevents CAC2S from exchanging information on SIPRNet and CENTRIX concurrently. 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 size, weight and power (SWAP / footprint) of the equipment that these detachments can deploy.The PMO seeks solutions that minimizes 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.

CAC2S

ACAT IAC (MAIS)
Phase 1- Operations & Support
Phase 2- Production & Deployment

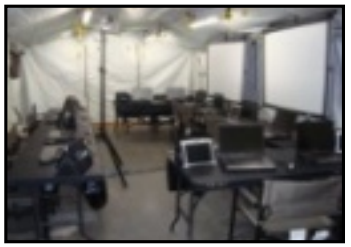
Description: Common Aviation Command and Control System (CAC2S) is a modernization effort to replace existing Marine Air Command and Control System (MACCS) equipment. Phase 1 has fielded a product baseline Processing and Display Subsystem (PDS) and Communications Subsystem (CS). Phase 2 is the integration of sensor capabilities and will provide an Air Command and Control Subsystem (AC2S). Fielding of Phase 2 will complete CAC2S Increment I.

Key Events

- AC2S production & software maintenance source selection activities are in progress
  - Proposals received 6 December 2016
  - Evaluations progressing as scheduled
  - CA planned 3QFY17
- Software updates to address IOT&E OSur findings are underway
  - 3.0 R2 September 2016 addressed 10 of 11 OSur Vulnerabilities
  - 3.0 R3, addresses remaining OSur Vulnerability, two test events, MCTSSA, March 2017 & NCSW Crane, Apr 2017

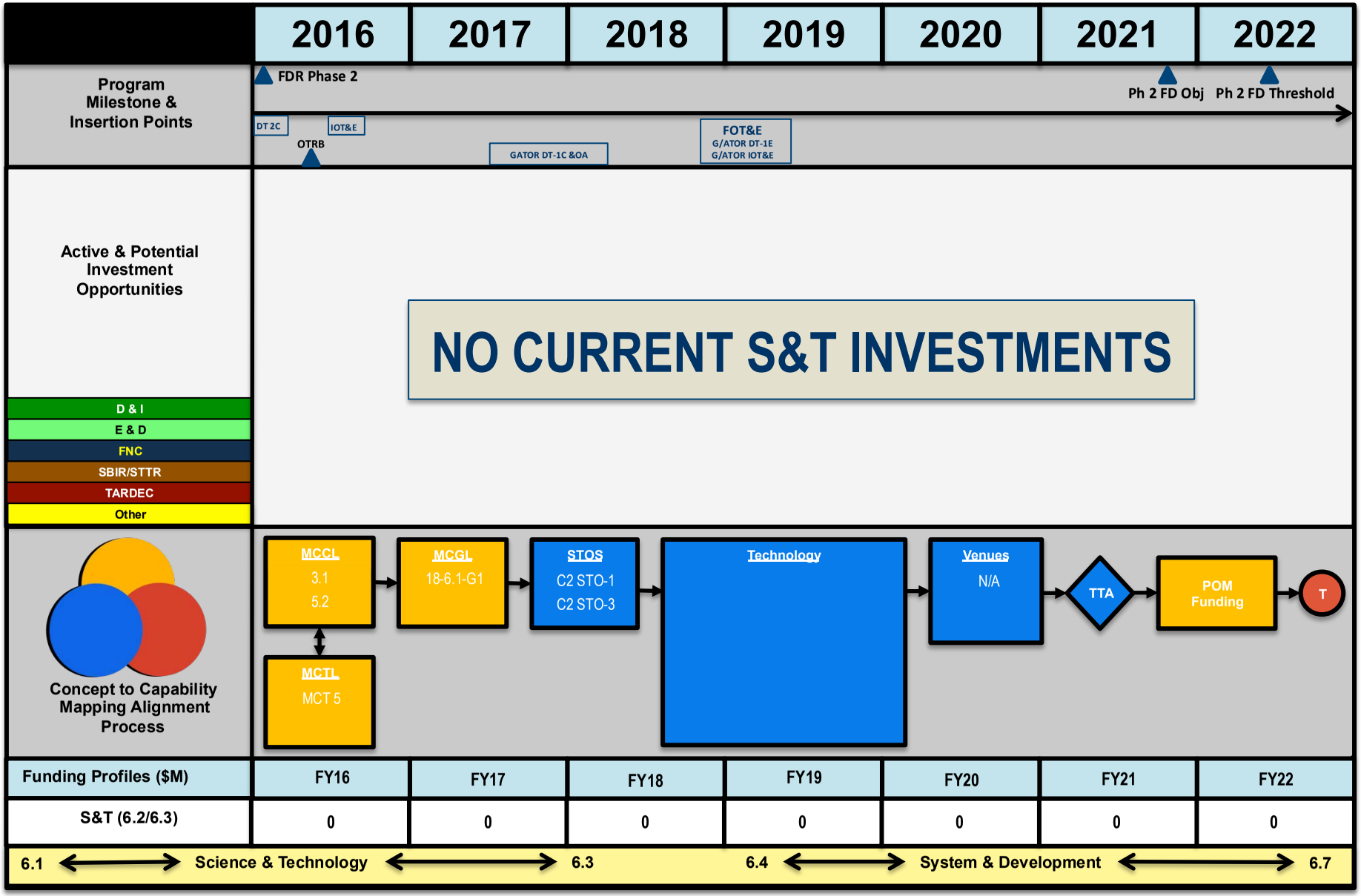
Program Status/Issues/Concerns

- Phase 1 Processing and Display Subsystem (PDS) & Communication Subsystem (CS)
  - Fielded 23 PDS and 75 CS

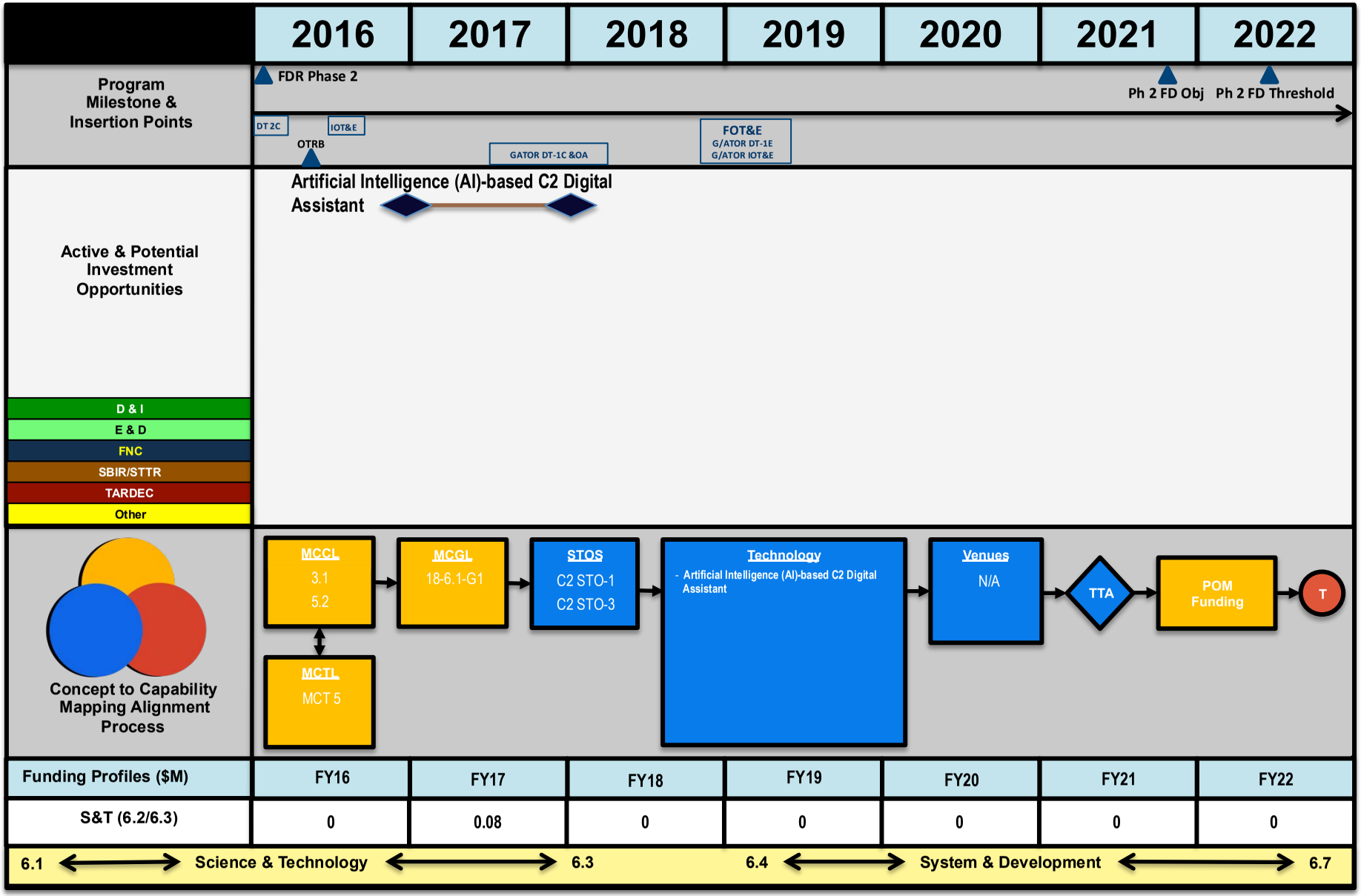


PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases					▲ FDR Phase 2																				▲ Ph 2 FD Objective				▲ Ph 2 FD Threshold
SETR Reviews											CS Refresh																		
Test Events		DT 2C		IOT&E				GATOR DT-1C &OA							FOT&E G/ATOR DT-1E G/ATOR IOT&E														
			▲ OTRB																										
Contract Events											Full Production: 41 AC2S & SW Main Supt Contract																		
				LDU Option #2-5 AC2S																										

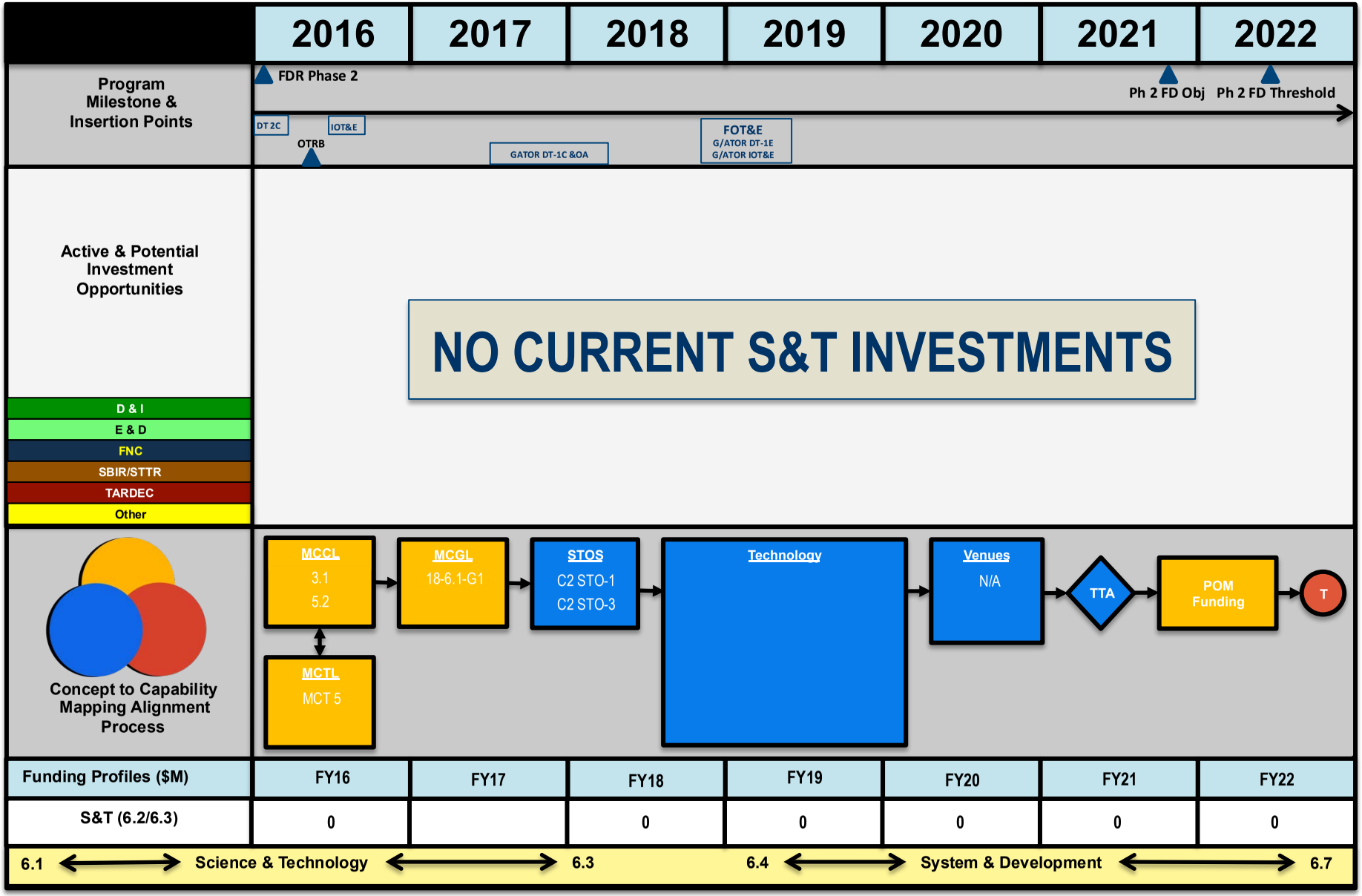
CAC2S Technical Issue #1 Future Data Link Receiver & Processor



CAC2S Technical Issue #2 C2 Command Tools



CAC2S Technical Issue #3 Marine Transportable CAC2S



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GROUND BASED AIR DEFENSE

Ground Based Air Defense (GBAD)

Program Background

The Marine Corps' organic Ground Based Air Defense (GBAD) capabilities are centered on the Low-Altitude Air Defense (LAAD) Battalions of Marine Air Wings. LAAD battalions currently use the 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 Next Generation Weapon System (NGWS) has recently completed and will result in a Capability Development Document by the end of fiscal year (FY) 2017. In addition to the AoA, there is the GBAD On-the-Move (OTM) FNC project. This program seeks to develop an agile and cost-effective, detect and-engage 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 Increments 0 & 1
- Stinger Night Sight Replacement
- Identification Friend or Foe (IFF) Mode IV Replacement
- GBAD NGWS

Program Status

Stinger Missile SLEP

A Stinger Missile SLEP began in FY14 and is scheduled to complete delivery in FY18. 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 – Missile System to prolong the life of the Stinger Missile by replacing aging components such as the flight motors and missile energetics.

Advanced Man-Portable Air Defense (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 (COTS) and NDI subsystems. The concurrence to pursue the full Approved Acquisition Objective for Increment I of 38

Section Leader Vehicles (SLV) and 143 Fire Unit Vehicles (FUV) was received in 2015. A-MANPADS Increment I vehicles contains 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 supported by a Joint Range Extension Sustainment contract that was awarded in September 2013 for five years. An Engineering Change Proposal (ECP) has been approved for all A-MANPADS FUVs, which will be transitioning to a HMMWV Prime Mover platform to rectify obsolescence and operational deployability of the current chassis. Included in this ECP is the replacement solution for the Harris Communication secure tactical wireless capability, SECNET-11, which has reached obsolescence and is being replaced with the AN/PRC-152A radio. A follow on ECP is planned to transition the current SLV capability to the same HMMWV Prime Mover platform.

Stinger Night Sight Replacement

The AN/PAS-18 Stinger Night Sight is being replaced in a joint acquisition with the Army through the Army's Family of Weapon Sights – Crew Served development and production efforts. The future optic will be replaced with a state-of-the-art, high-definition Focal Plane Array (FPA), providing greater target resolution and detection capability against the full spectrum of threats to include UASs.

IFF ModeV

GBAD plans to procure a replacement IFF system in a joint acquisition with the Army to meet a Joint Requirements Oversight Council requirement to be Mode V capable and compliant by 2020. The effort will replace the current AN/PPX-3B analog interrogator with a new digital Mode V interrogator, which can operate with Stinger Missile or Army Avenger system. Efforts will include AIMS box level and platform integration testing.

GBAD

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, VA. This effort is investigating the feasibility of hosting a directed energy solution on tactically relevant vehicles such as the Joint Light Tactical Vehicle (JLTV) or High Mobility Multipurpose Wheeled Vehicle (HMMWV).

GBAD's Top Technical Issues

1. Counter Unmanned Aircraft System (UAS)

Based on the proliferation of inexpensive Low, Slow, and Small (LSS) Unmanned Aircraft System (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. Three technologies are currently being sought after to counter UASs.

- Missile System: A small, low cost missile that is capable of countering UAS threats.
- Radio Frequency Jammer: A lightweight integrated detect, track, identify, and defeat capability that can react to emerging technologies to address new threat sets. The system should either allow the user to reconfigure the defeat capability to address varying threats or do it automatically.
- Laser: A more stable beam director and a better dual axis gimbal are required to concentrate the amount of power on target. An improved tracking software that eliminates or compensates for the cone of confusion within the radar capability.

To compliment a lower cost per shot defeat system, a miniaturized radar that is capable of being mounted onto a lightweight tactical vehicle which provides azimuth, elevation, and

distance while on the move is necessary to better detect and track UAS systems.

2. 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, rotary/fixed aircraft) at ranges suitable for man-portable air defense operation. Technologies required are 1) lightweight, quiet, and efficient micro chiller that can be incorporated into a hand held Mid Wave IR (MWIR) thermal sight; 2) High Density Focal Plane Array (FPA) (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 (FOV) for missile engagement and narrow FOV for target identification.

GBAD

Description: A-MANPADS provides low altitude air defense against fixed/rotary wing, cruise missile and emerging UAS threats. It utilizes the Joint Range Extension Application Protocol (JREAP) capability to provide a tactical air picture for the LAAD gunner's defense of MAGTF High Value Assets (HVAs). The Fire Unit Vehicle (FUV) and Section Leader Vehicle (SLV) comprise primary mobile platforms for the system.

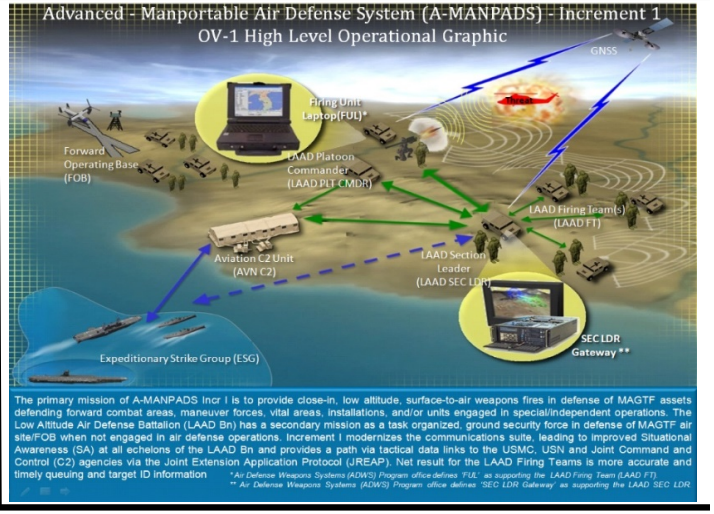
Key Events

- Designated an AAP in 2005
- IOC DEC 2012
- Tracking Head Trainer initial production 2QFY17
- FUV PCA 3QFY17
- Delivery of first M1114 FUV production systems 4QFY17
- STINGER SLEP missile delivery FY18
- FOC 1Q FY20

Program Status

Status

- **FUV:** Meeting performance metrics and NSWC Crane meeting the adjusted M1114 FUV fielding schedule. Schedule was adjusted to incorporate ECPs.
- **SLV:** M1114 SLV development schedule delayed 10 months as a result of adjustments to the FUV fielding schedule.
- **Stinger Missile:** Stinger Blk I missiles undergoing Army sourced Service Life Extension Program (SLEP) to bridge the gap in assets until a more capable GBAD Future Weapon System is fielded.



PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases																													
SETR Reviews		A-MANPADS FUV/SLV Prime Mover Design																											
		FNC ATD																											
Test Events						▼																							
Contract Events										Datalink								Datalink											
				Stinger SLEP																									
					A-MANPADS FUV/SLV																								
		Aerial Targets																											
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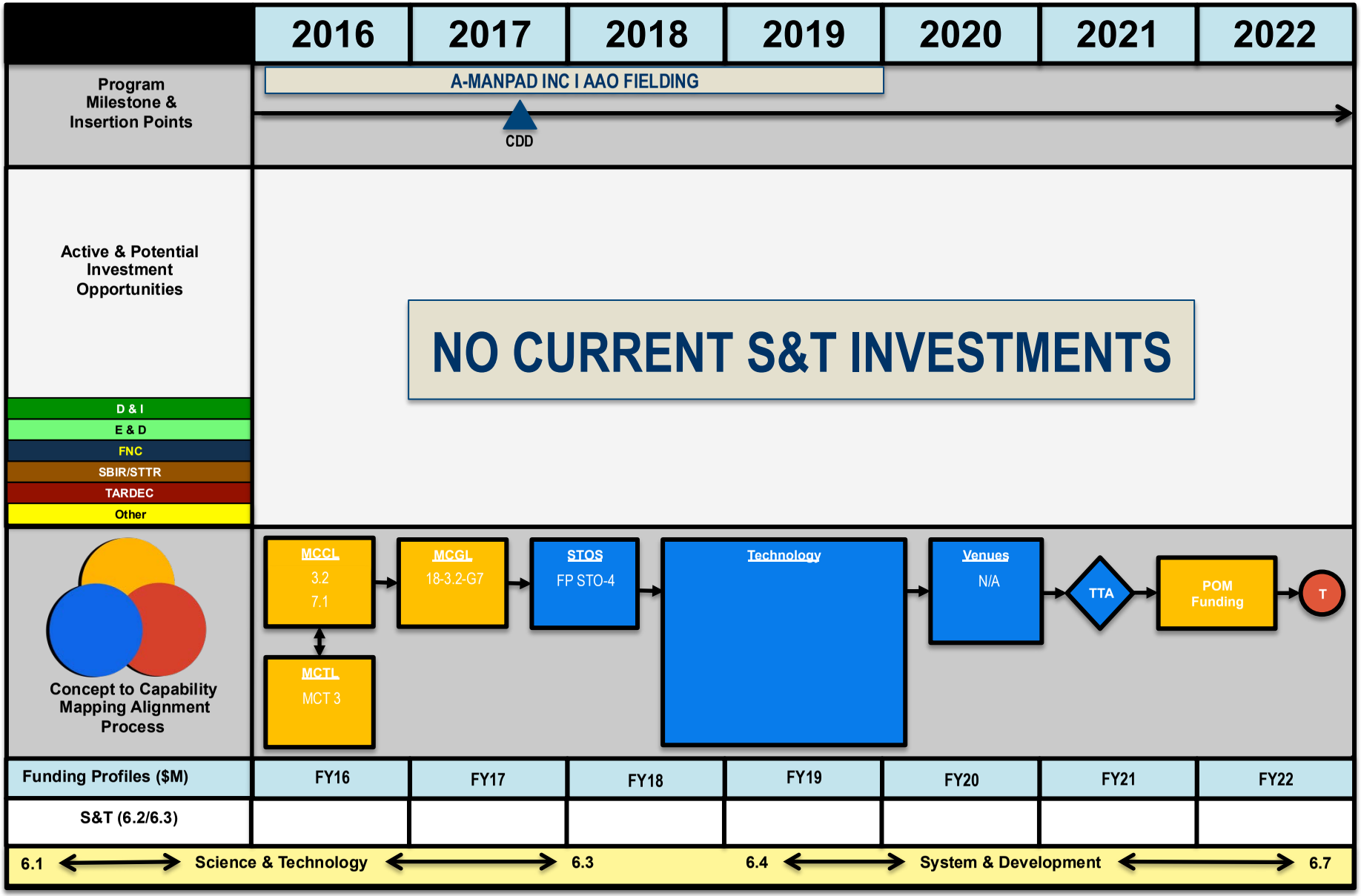
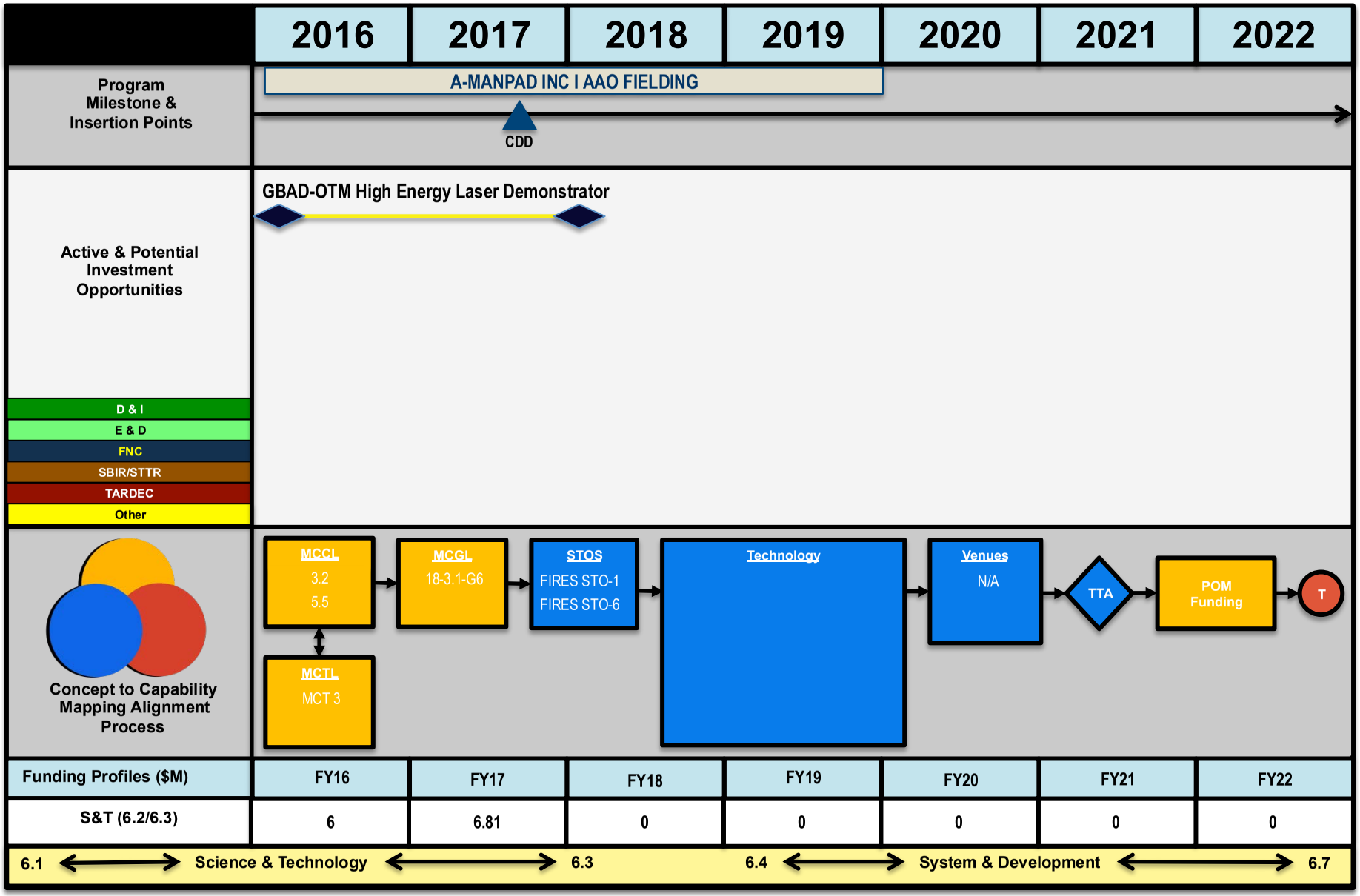
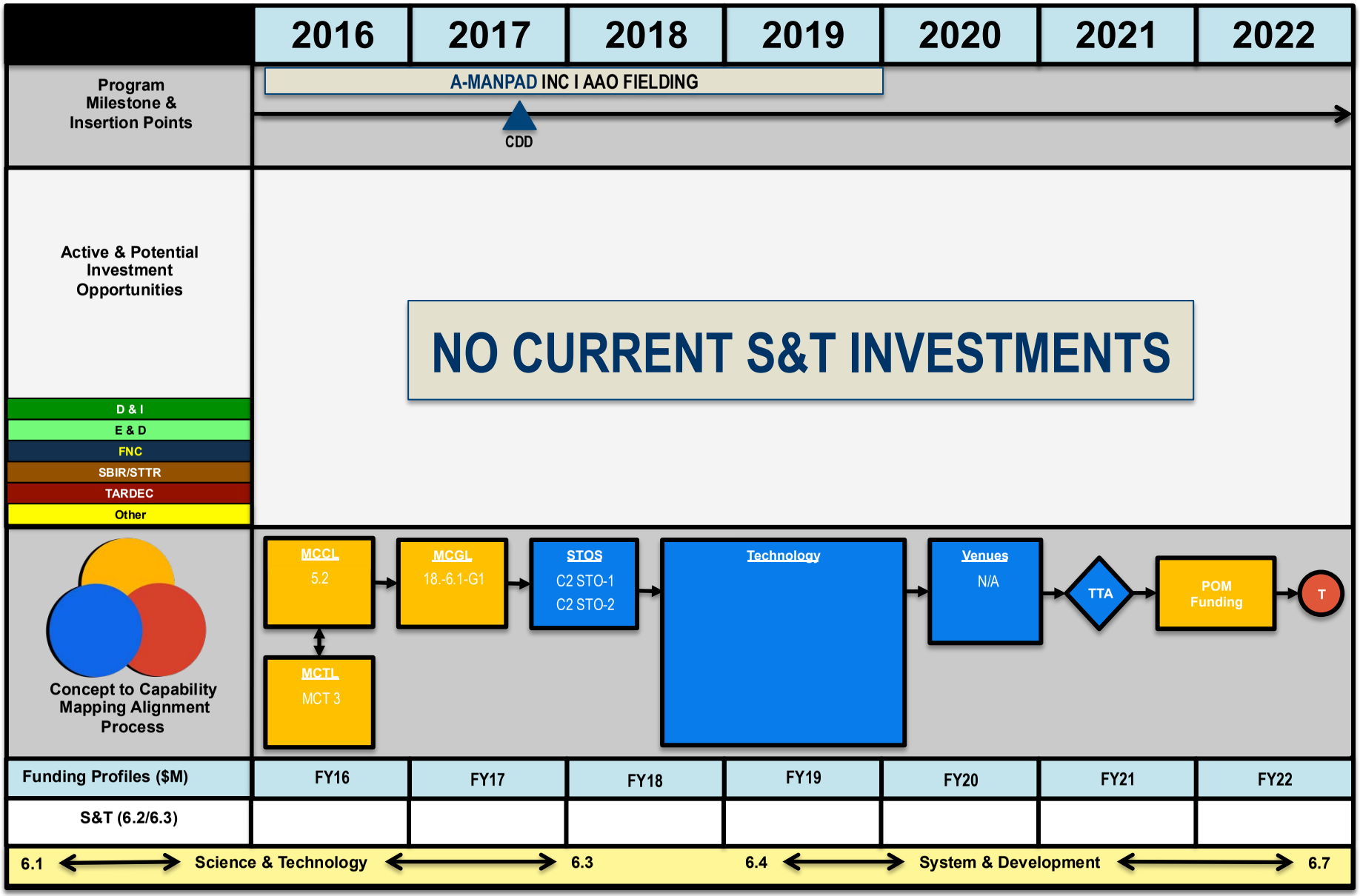
GBAD Technical Issue #1 Stinger Night Sight Replacement



GBAD Technical Issue #2 Counter Unmanned Aircraft System (UAS)



GBAD Technical Issue #3 Secure Wireless Communication



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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 Marine Air Ground Task Force (MAGTF). The Marine Corps will operate G/ATOR in both global and regional conflicts in support of operations ranging from low-intensity deterrence to conventional high-intensity conflicts. G/ATOR will be forward deployed and employable from the Marine Expeditionary Unit (MEU) to the Marine Expeditionary Force (MEF). G/ATOR will provide the MAGTF with the operational flexibility and speed of employment necessary for enhanced situational awareness in support of Expeditionary Maneuver Warfare, Operational Maneuver from the Sea, ship-to-objective movement, prolonged operations ashore, Sea-Basing, Sea Shield, Sea Strike, and FORCE Net.

G/ATOR Block 1 (GB1) will provide radar measurement data to the Common Aviation Command and Control System (CAC2S) and the Composite Tracking Network (CTN). GB1 will replace the legacy Marine Air Command and Control System (MACCS) AN/TPS-63, AN/UPS-3, and AN/MPQ-62 radars. G/ATOR Block 2 (GB2) will provide radar-determined launch and impact point data to the Advanced Field Artillery Tactical Data System (AFATDS) in the Fire Support Coordination

Center (FSCC) and Fire Direction Center (FDC) in the Marine Artillery Regiments. GB2 will replace the legacy Marine Artillery Regiment Ground Counter-Battery/Counter-Fire radar, which is the AN/TPQ-46.

The G/ATOR hardware consists of three major subsystems: the Radar Equipment Group (REG), the Communications Equipment Group (CEG) and the Power Equipment Group (PEG) with pallet assembly. The REG and its transport trailer are designed as an integral package. The CEG is mounted on one M1152 High Mobility Multi-purpose Wheeled Vehicle (HMMWV) and the PEG is mounted on one AMK23 Medium Tactical Vehicle Replacement (MTVR). Both vehicles are government-furnished equipment (GFE). These vehicles are the prime movers within the G/ATOR system configuration. In addition, one GFE Mobile Electric Power (MEP) 1070 60kW generator and GFE radio communications components are included in the PEG and CEG design. The GFE radios are the AN/VRC-110 and the AN/VRC-114.

Program Status

The AN/TPS-80 G/ATOR system received a successful Milestone C on 24 January 2014 from the Assistant Secretary of the Navy (Research, Development and Acquisition). Northrop Grumman was awarded the Low-Rate Initial Production (LRIP) Option 1 contract in October 2014 for four LRIP systems. In March 2015, the G/ATOR LRIP contract was modified to add LRIP Option Period 2 for two additional LRIP systems. In August 2015, Northrop Grumman was also awarded the G/ATOR Block 2 development contract to produce the Ground Weapons Locating Radar (GWLR) software that will enable the common G/ATOR hardware to perform the counter-battery radar mission. Delivery of the first LRIP system is scheduled for the 2nd Quarter of FY17 and Developmental Testing will begin in the 3rd Quarter FY17.

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) Circulator Isolator Radiator Filter (CIRF) boards, which are required for the T/R modules and which require a multi-step, medium yield manufacturing process.

2. Increased Dynamic Range

Under certain adverse conditions, G/ATOR needs additional dynamic range. Dynamic range is limited by the Third Order Intercept 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 development techniques/technologies to negate or defeat them.

GATOR

ACAT 1C/Production & Deployment

Description: G/ATOR is a 3D, short/medium range multi-role radar designed to detect unmanned aerial systems, cruise missiles, air breathing targets, rockets, artillery and mortars. The system satisfies expeditionary needs across the MAGTF and replaces five legacy radar systems with a single MAGTF solution.

Key Events

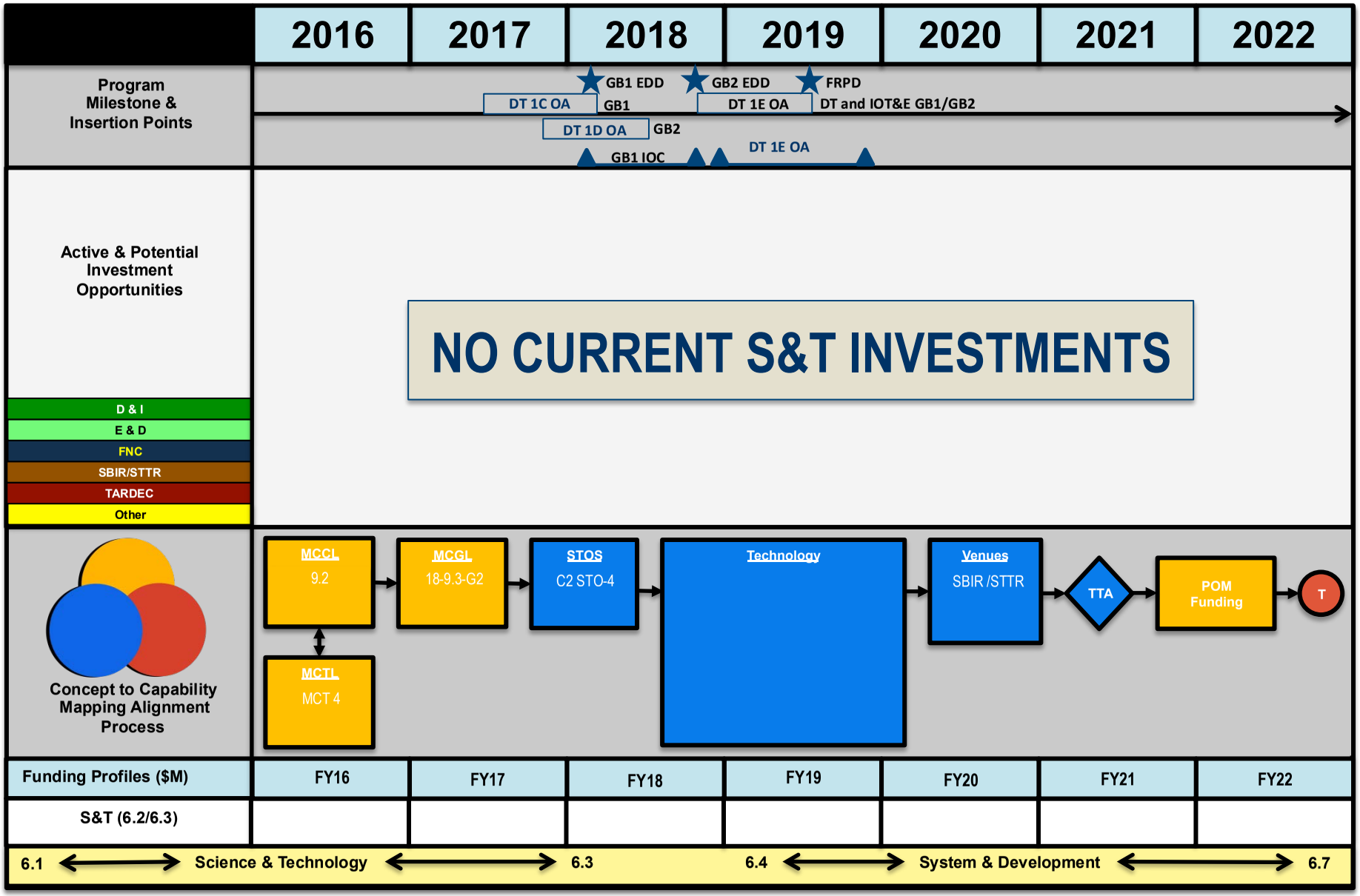
- GB1 DT1C/OA in FY17/18
- GB2 DT1D/OA in FY17/18
- GB1 & GB2 IOC in FY18
- GB1 & GB2 DT1E/IOT&E in FY18/19
- FRPD in FY19

Program Status

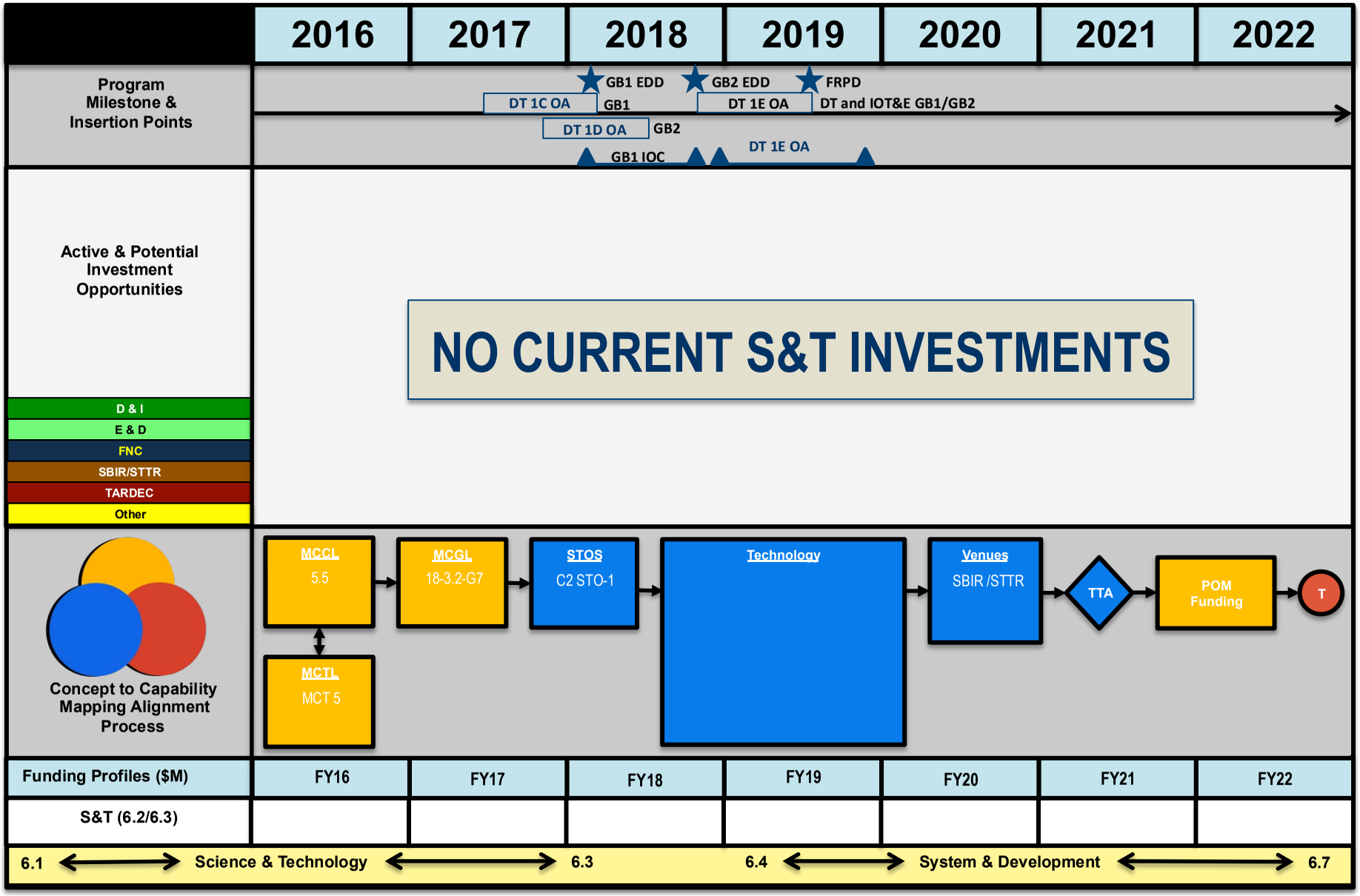
- 15 LRIP systems under contract
- First delivery 2Q FY17
- Preparing for DT1C, EDD and Fielding

PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases											GB1 EDD		GB2 EDD			FRPD														
								GB1 IOC							GB2 IOC															
SETR Reviews																													
Test Events								DT 1C OA		GB1				DT 1E OA		DT and IOT&E GB1/GB2													
								DT 1D OA		GB2																					
Contract Events		GaAs LRIP (6 units /Lots 1 & 2)																											
										LRIP GaN Lot 3				LRIP GaN Lot 4				LRIP GaN Lot 5				FRP	GaN LRIP (9 units /Lots 3 – 5)						
																							GaN FRP (30 units / 4 Lots)						FOC 2024

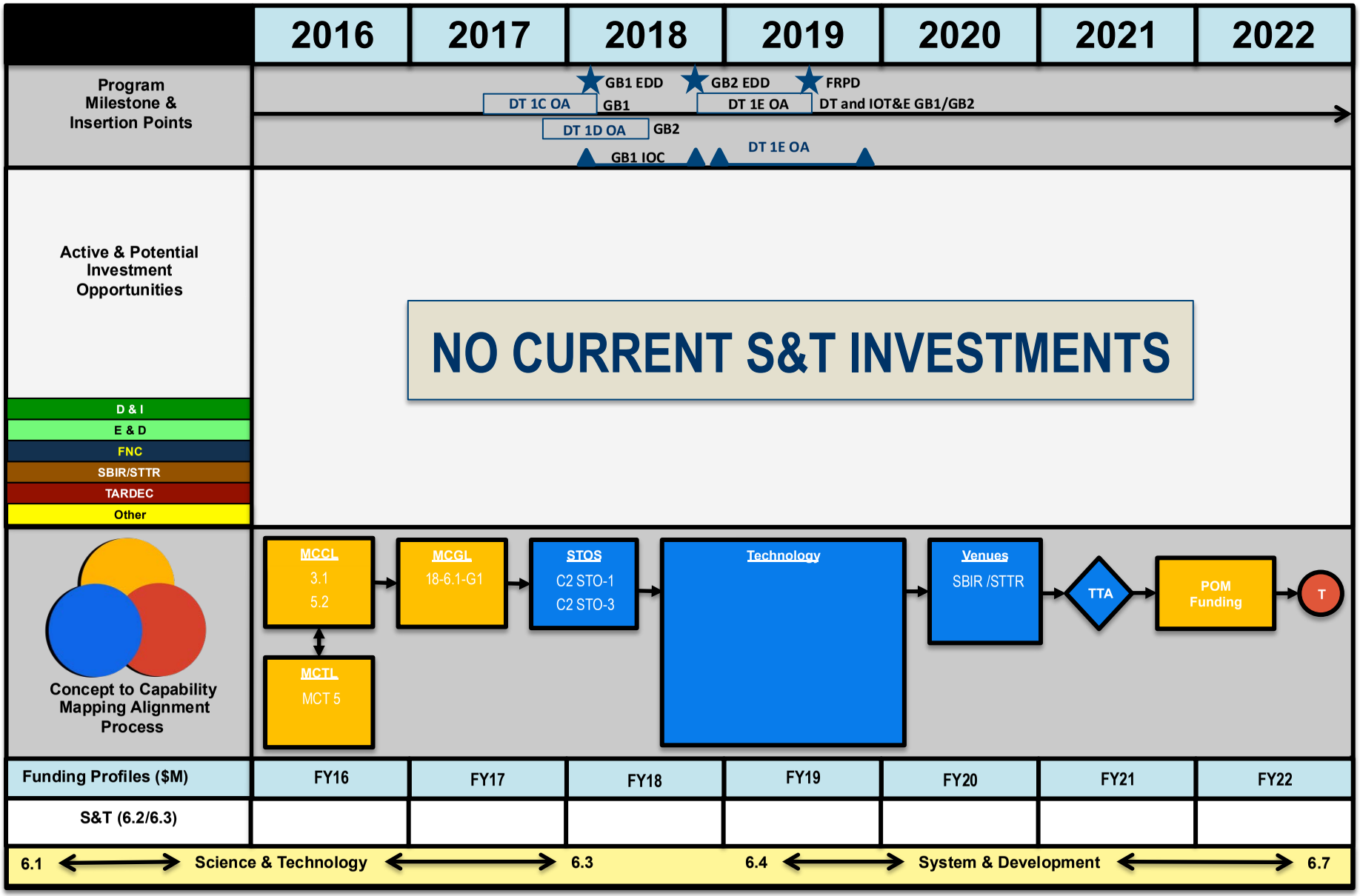
G/ATOR Technical Issue #1 Lowering Manufacturing Costs



G/ATOR Technical Issue #2 Increased Dynamic Range



G/ATOR Technical Issue #3 Advanced Electronic Protection



JOINT LIGHT TACTICAL VEHICLE

Joint Light Tactical Vehicle (JLTV)

Program Background

The Joint Light Tactical Vehicle (JLTV) is an ACAT IC Army-Marine Corps defense acquisition program that addresses a new generation tactical wheeled vehicle to replace a portion of the services' High Mobility Multipurpose Wheeled Vehicle (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 HMMWVs currently support. 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 strive to 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, 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 Low Rate Initial Production (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, with production qualification and reliability qualification testing scheduled to begin during the 1st quarter of Fiscal Year 17 (FY17), live fire test events scheduled to begin during the 2nd quarter FY17 and the Multi-service Operational Test and Evaluation (MOT&E) set to begin in the 2nd quarter FY18. The program is currently on schedule for Initial Operational Capability (IOC) in the 1st quarter of FY20. The Marine Corps' approved acquisition objective (AAO) is for 5,500 JLTVs, while the Army will procure 49,099 vehicles. The Marine Corps will reach Full Operational Capability (FOC) by the 4th quarter of FY22.

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, 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 support 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 through the use of a network switch that can adapt to multiple vehicle configurations, thus avoiding future payload challenges. 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.

3. JLTV-Close Combat Weapons Carrier (CCWC) Missile Reloading Improvement

The JLTV-CCWC is the mission package configuration for employment of the TOW/SABER. The system design includes a securable rear cargo box capable of accommodating TOW/SABER weapon system components, missiles, and loading/reloading capabilities in accordance with the JLTV system specifications. The program office is interested in solutions that will continue to improve the CCWC loading/reloading capabilities to enhance the warfighter's ability to employ, engage, and redeploy the TOW/SABER system safely.

JLTV

ACAT I D / LRIP

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

- Integration / Interdependencies: Interdependencies identified in regard to components include: CSDU, GPS, intercom system, NOTM and GPK for TOW variant.

Key Events

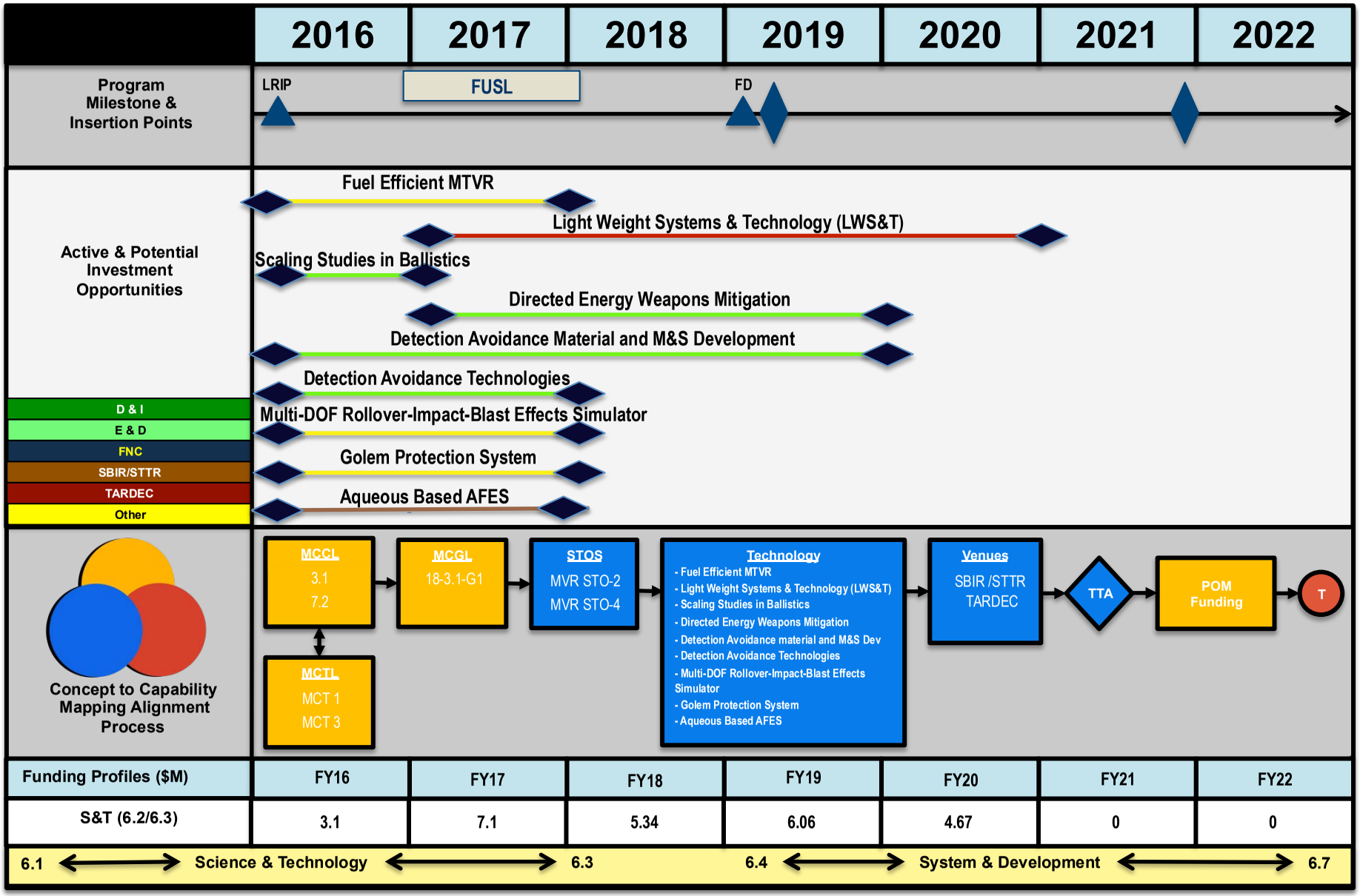
- 2QFY17: PMO begins visits to MEFs (JLTV Road Show)
- 3QFY17: Logistics Demo
- 2QFY18: Multi-service Operational Test & Evaluation (MOT&E)
- 1QFY19: Full Rate Production (FRP) Decision (MDA)
- 2QFY19: USMC Fielding Decision
- 1QFY20: USMC Initial Operational Capability
- 4QFY22: USMC Full Operational Capability

Program Status/Issues/Concerns

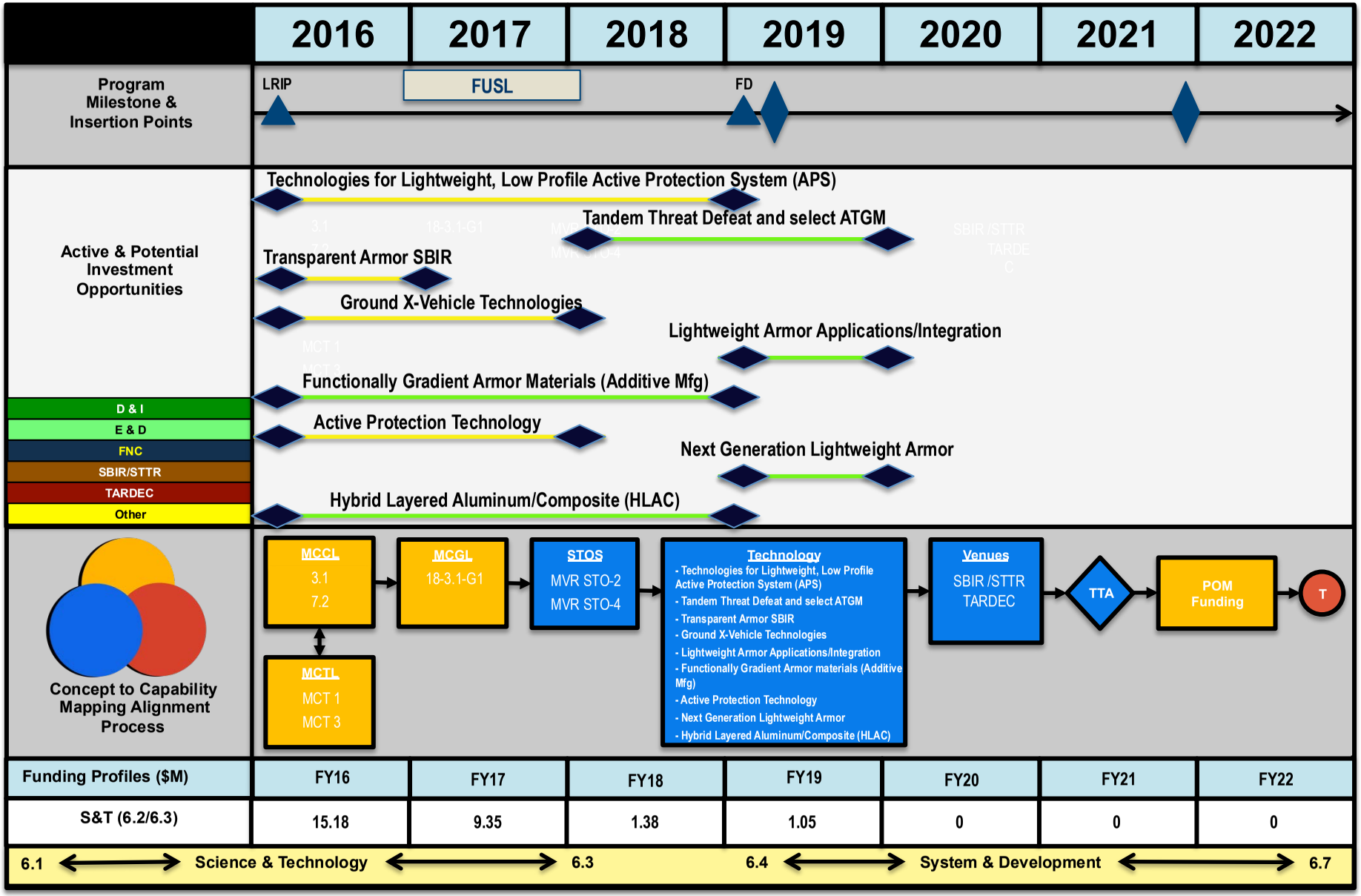
- Option Year 2 was awarded for $44.994M FY17 PMC, $1.855M FY16 PMC, and $6.308M FY16 RDT&E (test support).

PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases		MS C																IOC											FOC
SETR Reviews																													
Test Events						PQT/RQT				MOT&E																			
						FUSL																							
Contract Events		LRIP																											
		LRIP												FRP				FRP 2 (92 Vehs)											

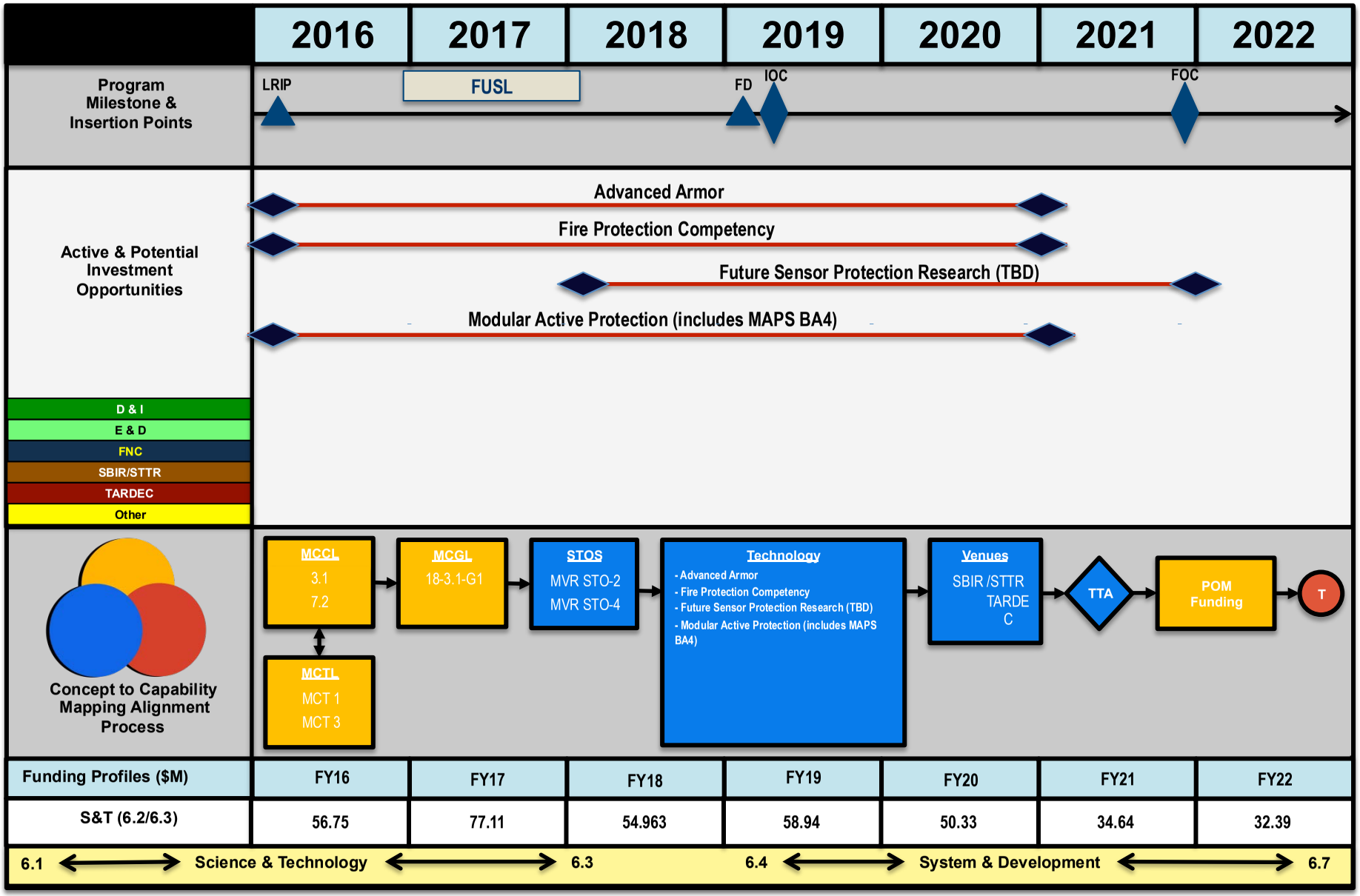
JLTV Technical Issue #1 Weight/Armor



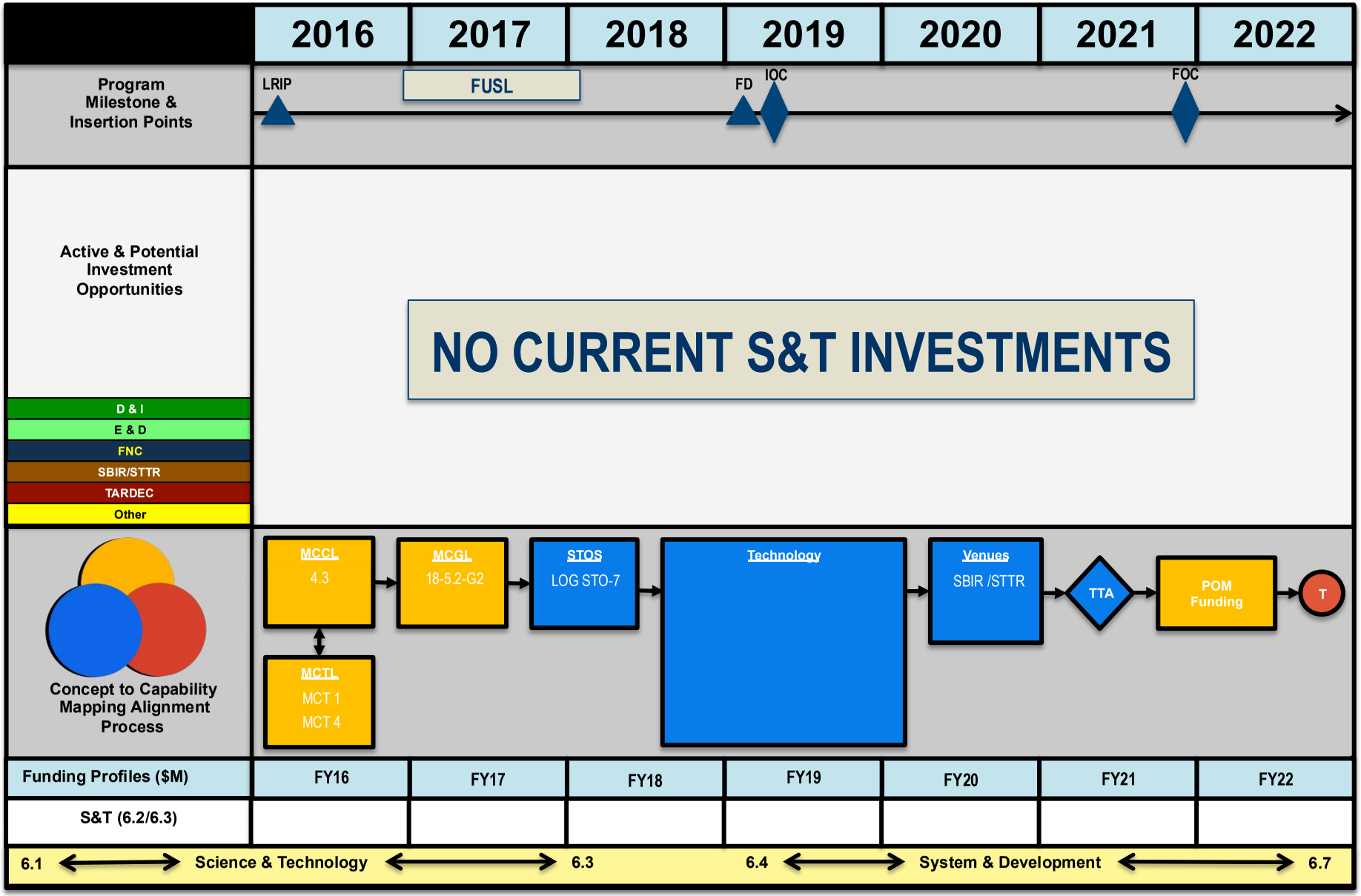
JLTV Technical Issue #1 Weight/Armor



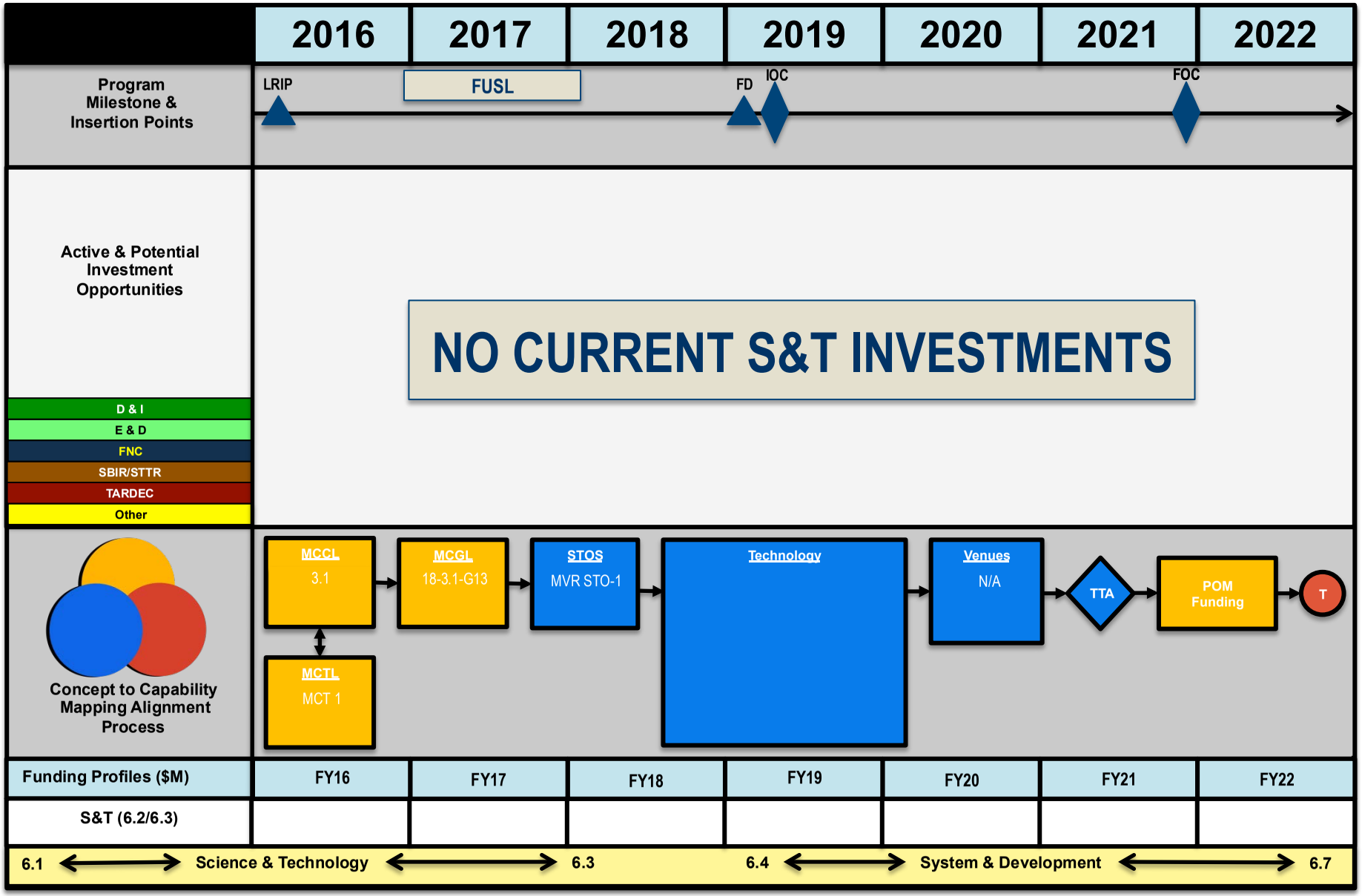
JLTV Technical Issue #1 Weight/Armor



JLTV Technical Issue #2 Corrosion Resistance



JLTV Technical Issue #3 JLTV-CCWC Missile Reloading Improvement



LOGISTICS VEHICLE SYSTEMS REPLACEMENT

Logistics Vehicle Systems Replacement (LVSR)

Program Background

The Logistics Vehicle Systems Replacement (LVSR) system 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 5 axle vehicle 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.

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. Built by Oshkosh Corporation, 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 Oshkosh's TAK-4™ independent suspension system for improved mobility and off-road maneuverability. The acquisition objective of 2,246 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. 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.

LVSR

ACAT II/P&D

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

Key Events

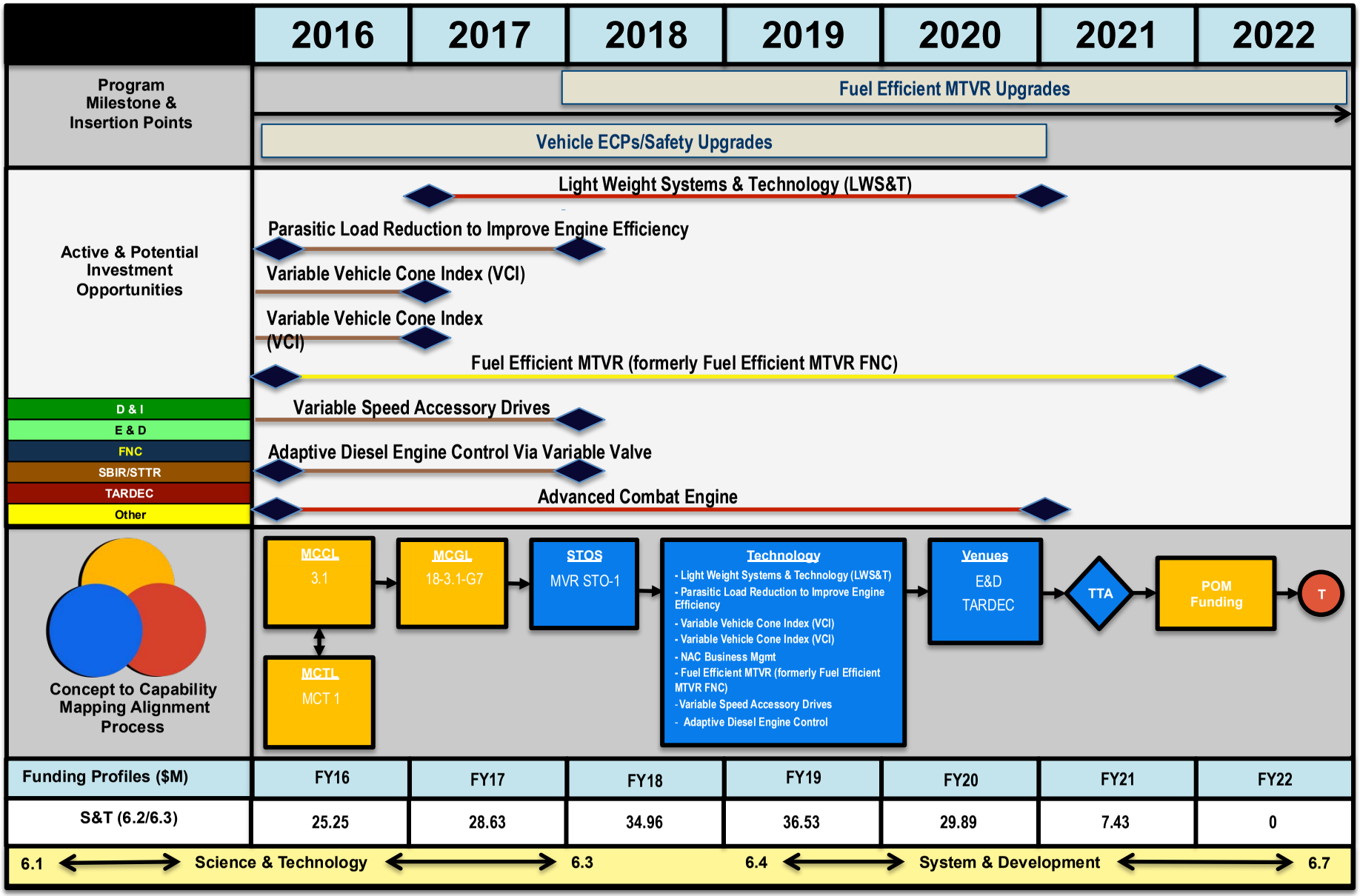
- Brake corrosion ECP with Nevada Automotive Test Center (NATC) is on schedule with a completion date scheduled for 3QFY17
- LRIP of the Brake Corrosion ECP is scheduled for 3QFY17
- Improved Armored Door Lock production scheduled for 3QFY17
- Retesting of Rock Island Arsenal (RIA) armor coupons have been scheduled for 4QFY17

Program Status/Issues/Concerns

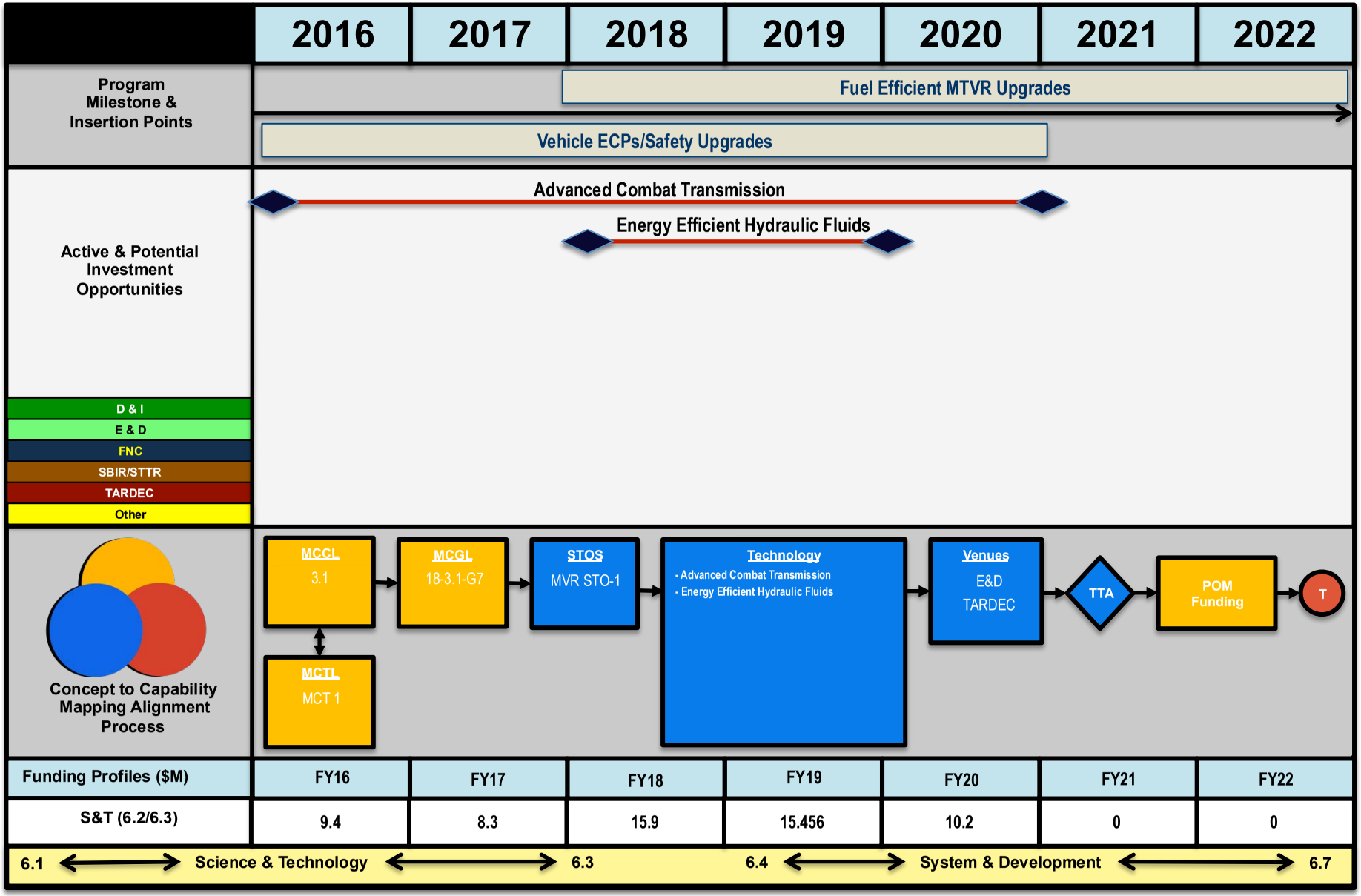
- Logistics
  - Program in sustainment

PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases																													
SETR Reviews		In Sustainment																											
Test Events																													
Contract Events																													

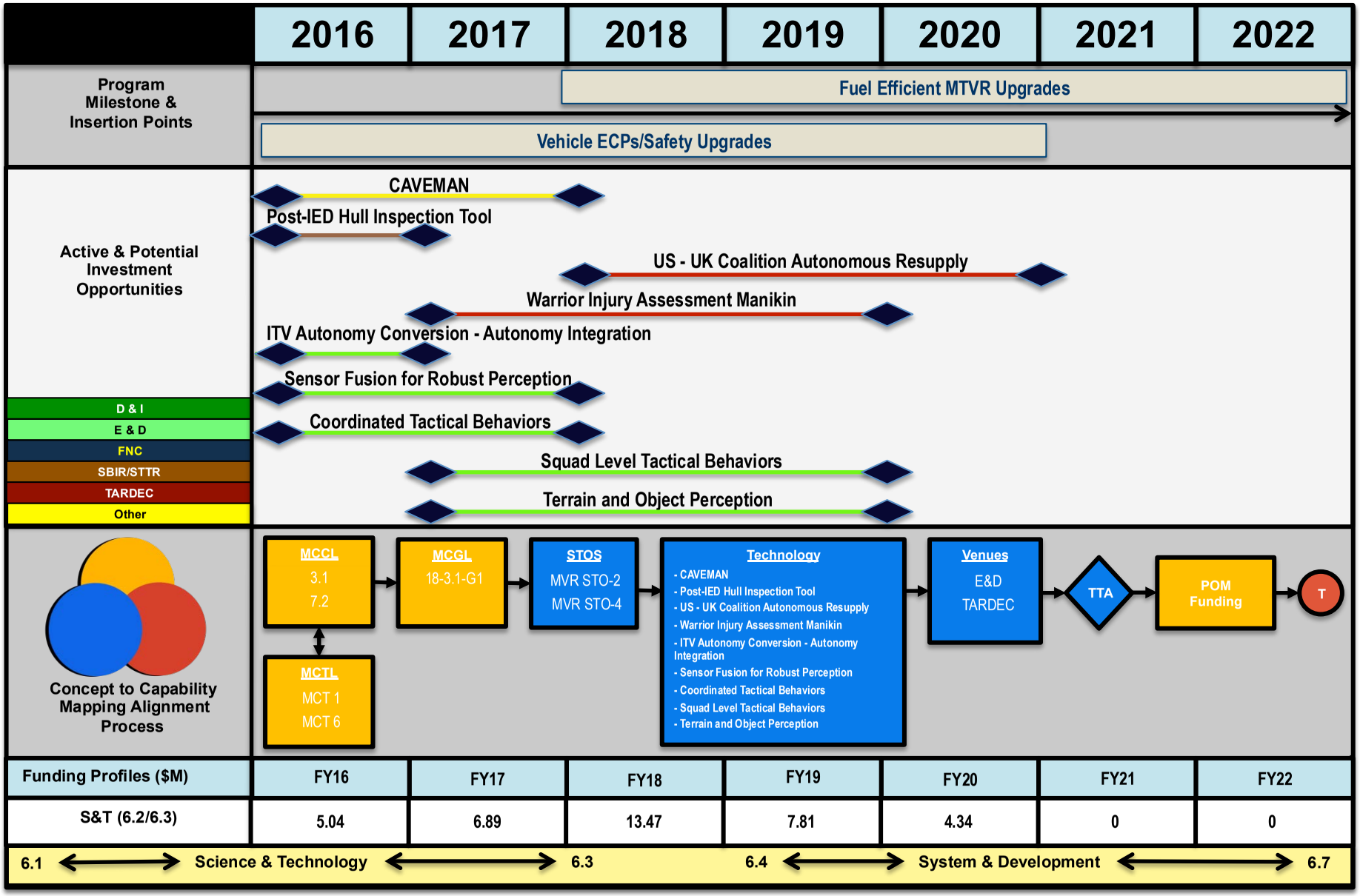
LVSR Technical Issue #1 Fuel Economy



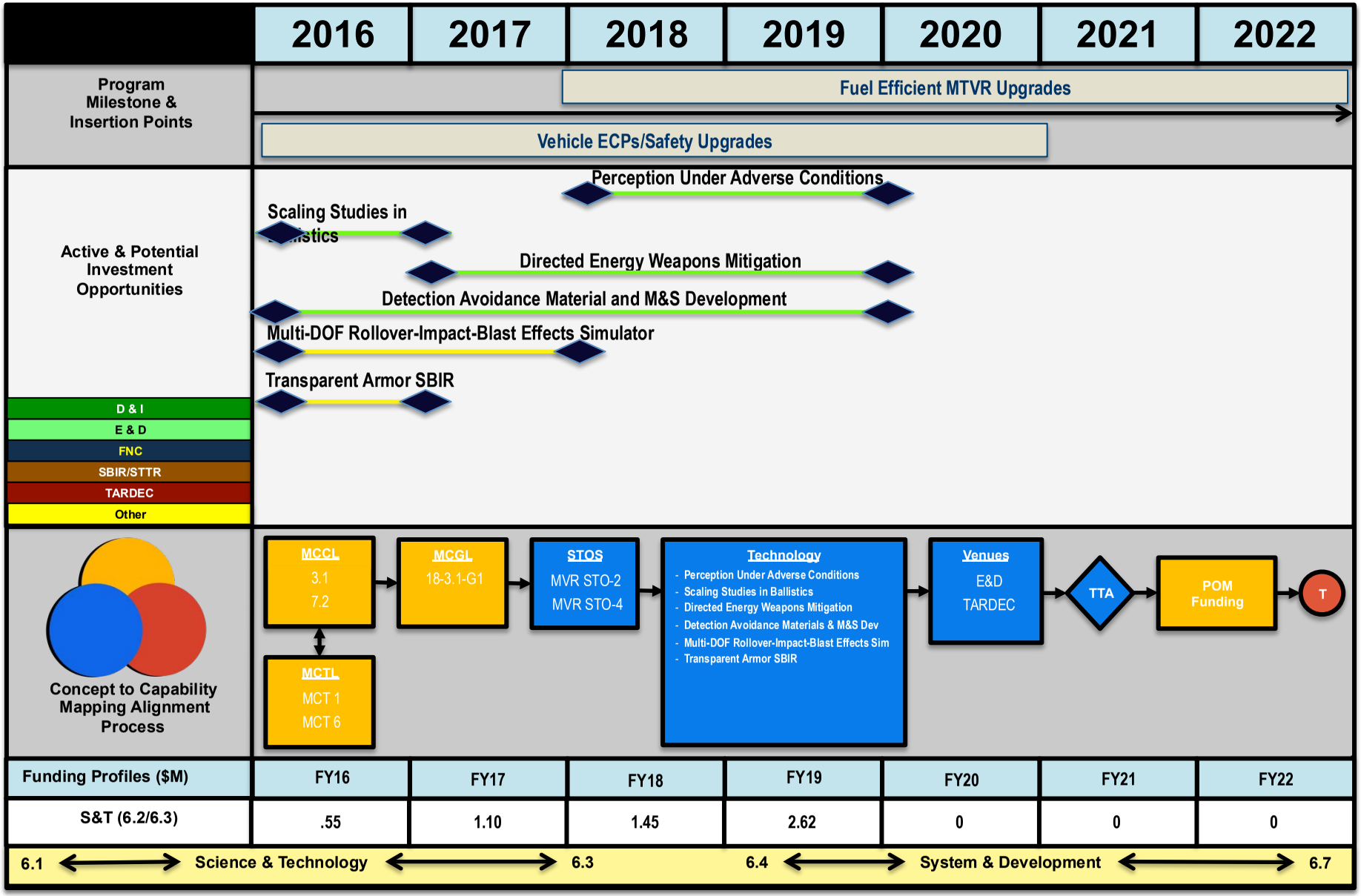
LVSR Technical Issue #1 Fuel Economy



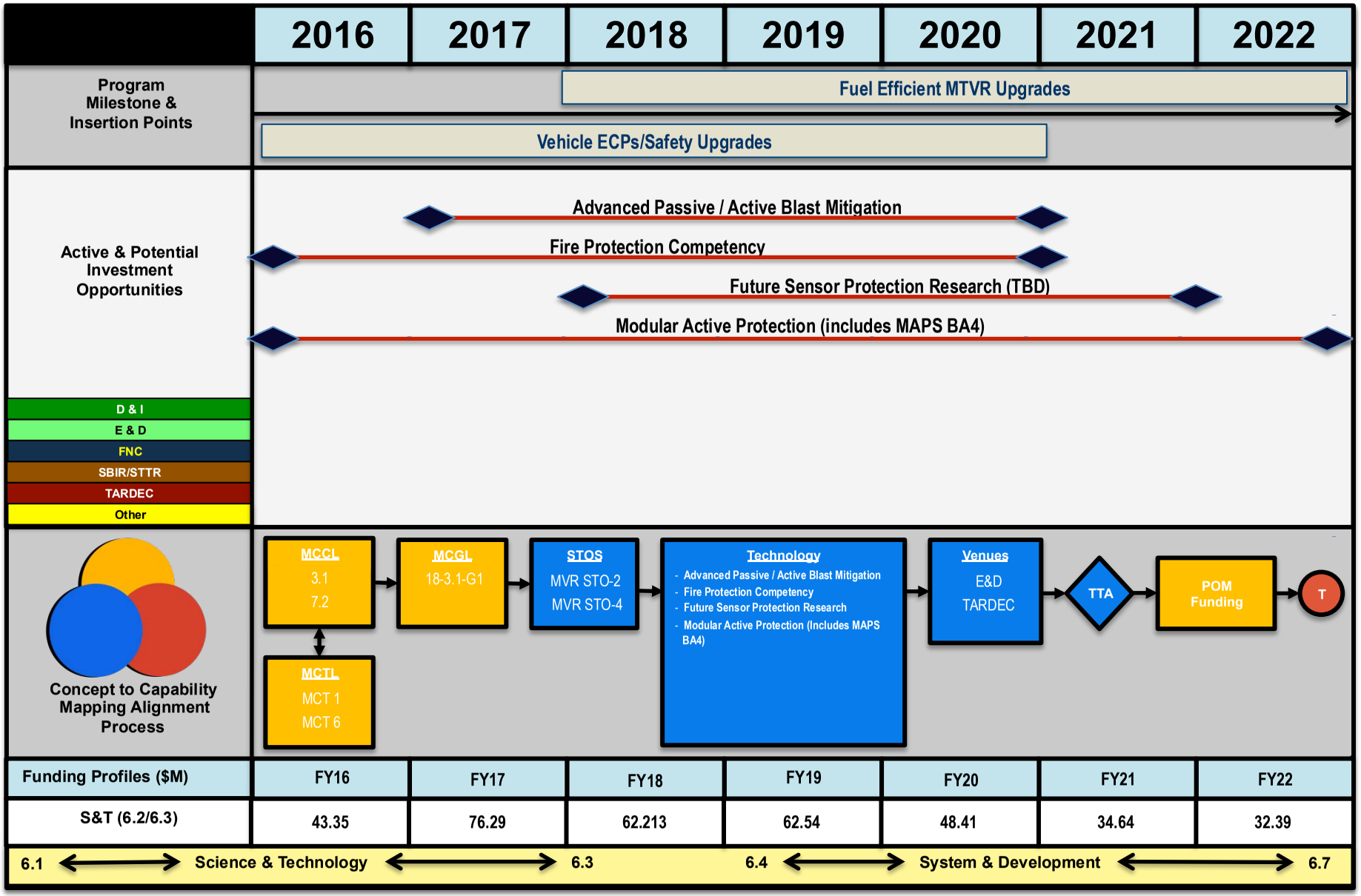
LVSR Technical Issue #2 Increased Survivability



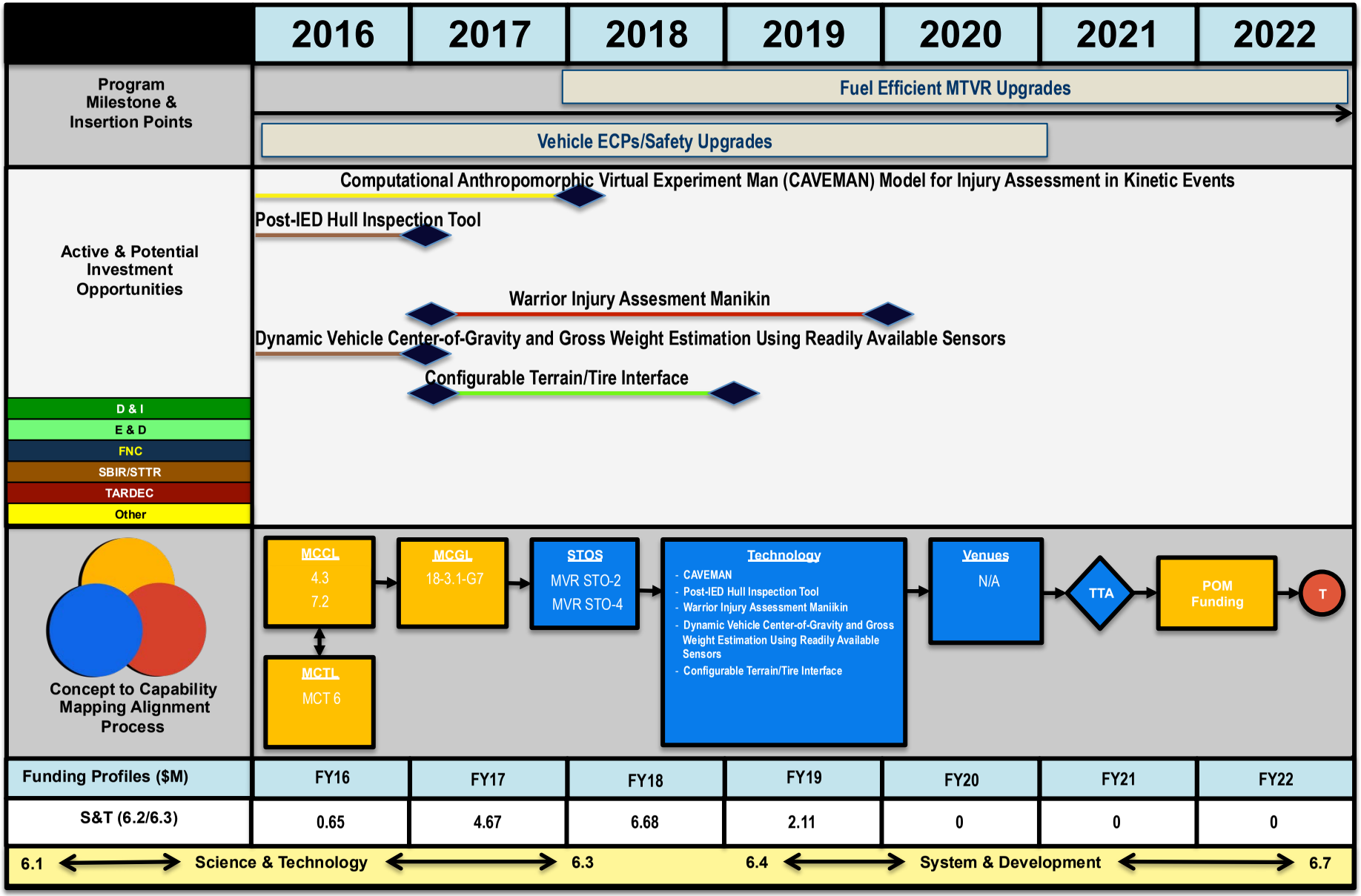
LVSR Technical Issue #2 Increased Survivability



LVSR Technical Issue #2 Increased Survivability



LVSR Technical Issue #3 Safety



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MEDIUM TACTICAL VEHICLE REPLACEMENT

Medium Tactical Vehicle Replacement (MTVR)

Program Background

The Medium Tactical Vehicle Replacement (MTVR) family of 6-wheel, 7-ton, all-terrain multi-purpose vehicles serves as the Marine Corps' key means of moving supplies and equipment across severe environments. Manufactured by Oshkosh Corporation, 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 Oshkosh 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 8,900 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 IEDs, 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, and neither a Service Life Extension Program nor a modernization upgrade is currently scheduled.

Program Status

The MTVR has been in service since 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. Fuel Consumption

Given the MTVR's fuel consumption rate and the fully burdened cost of fuel, even moderate increases in the fuel efficiency of the MTVR can potentially save lives and millions of dollars. Practical, cost-effective technologies are required to increase the fuel efficiency of the MTVR 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 MTVR fleet.

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.

MTVR

ACAT 1C/SUST

Description: The Medium Tactical Vehicle Replacement (MTVR) is a medium lift tactical vehicle capable of transporting 7.1-ton off-road, 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.

Key Milestones / Events

- **2QFY17**
  - MTVR DMSMS
  - MTVR IUID Plan
  - MTVR LCCE
  - MTVR LCSP
  - MTVR LRFS
  - MTVR PESHE
  - FE CARD / LCCE
  - FE LRFS
- **3QFY17**
  - MTVR Zonal Maintenance
- **4QFY17**
  - MTVR 5-yr ILA
  - FE ADM
  - FE Baseline Testing
- **1QFY18**
  - FE MTVR CDR
- **3QFY18**
  - FE MS C
- **TBD (Funding Required)**
  - MTVR Wheel Slings Test
  - MTVR Transportability ECP

Contract Data - FFP/IDIQ
Contractor Oshkosh
Start – Complete May '12 – May '16

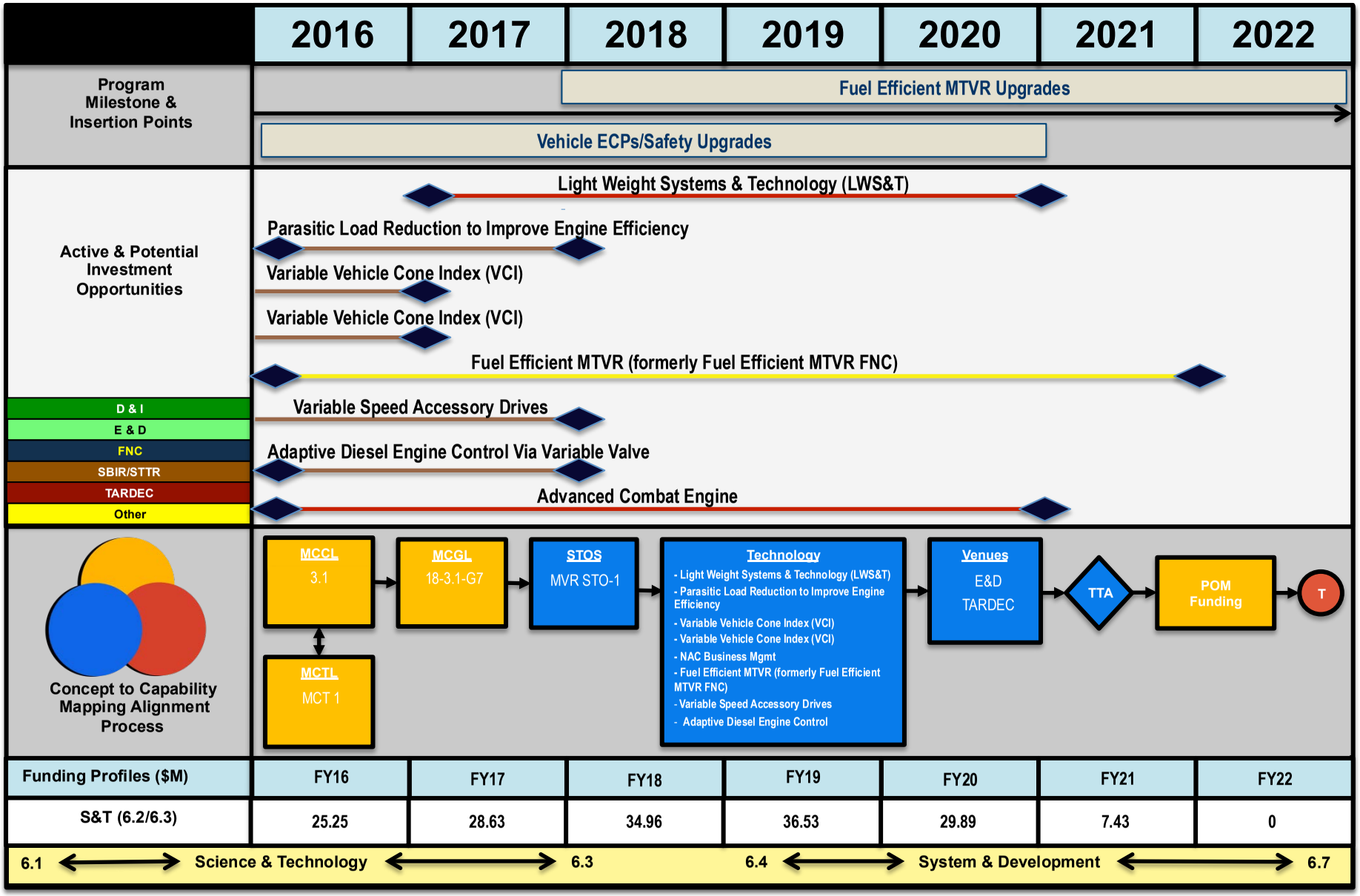
Next Contract: Engineering & Logistics Support & Services (ELSS)

CPI = N/A SPI = N/A EAC = N/A

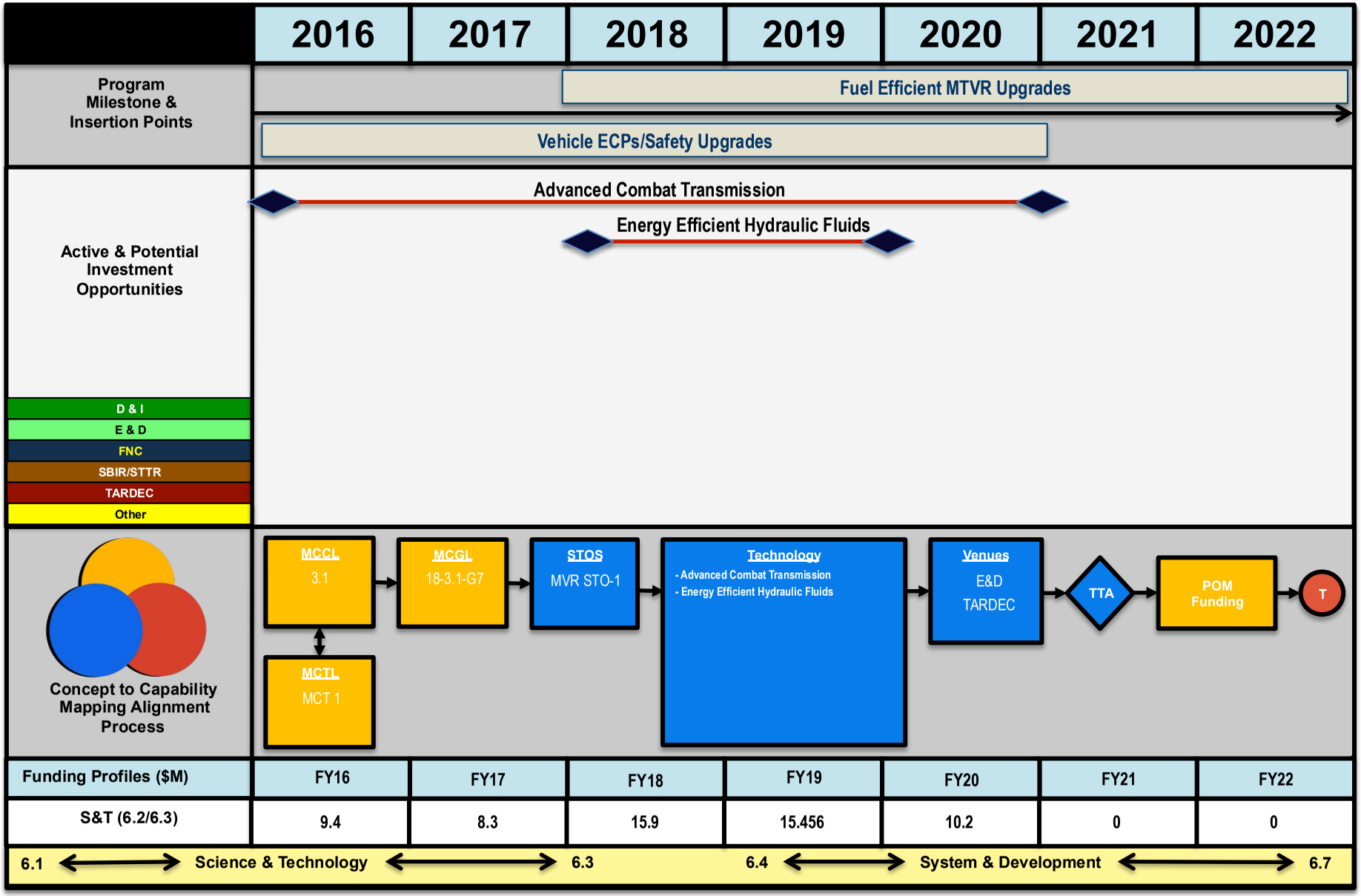
Issues: OEM responsiveness, Integration Plan, Class IX Parts Block Procurement, ECP Integration

PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases																													
SETR Reviews																													
Test Events			IROAN T&E																										
Contract Events	MTVR Prod Contract									MHTV ECP Contract																			
										MHTV Production Contract																			

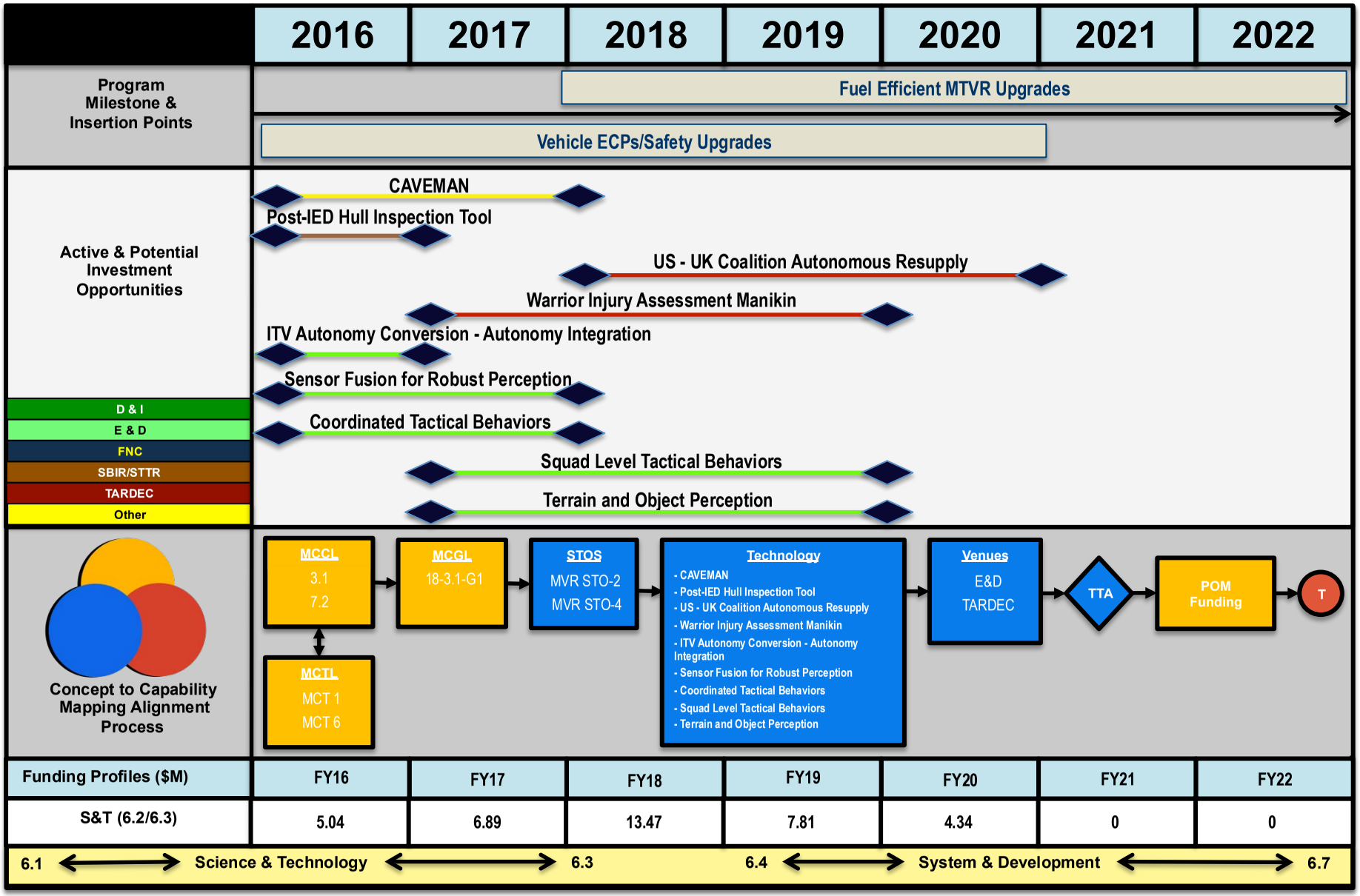
MTVR Technical Issue #1 Fuel Economy



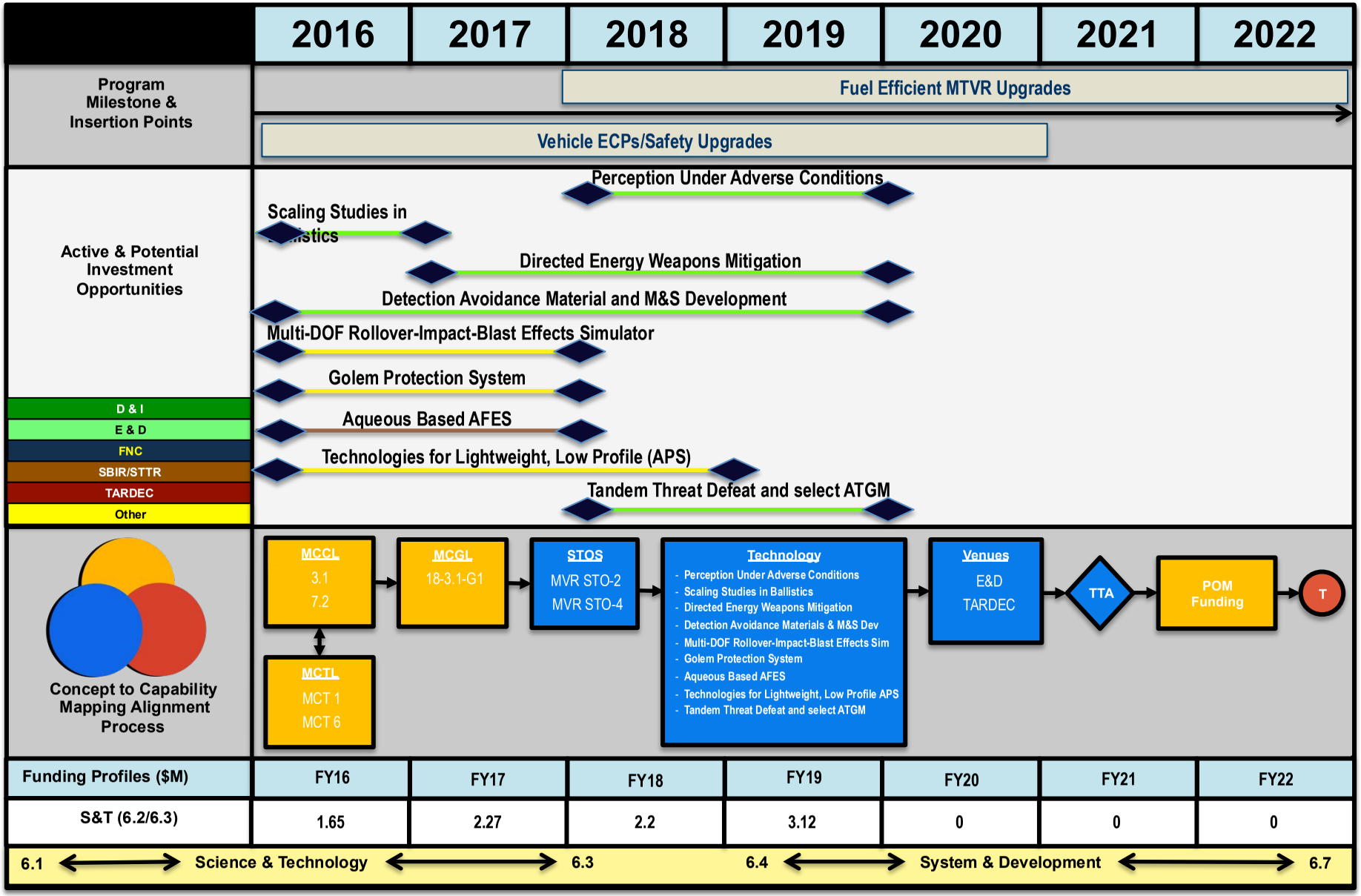
MTVR Technical Issue #1 Fuel Economy



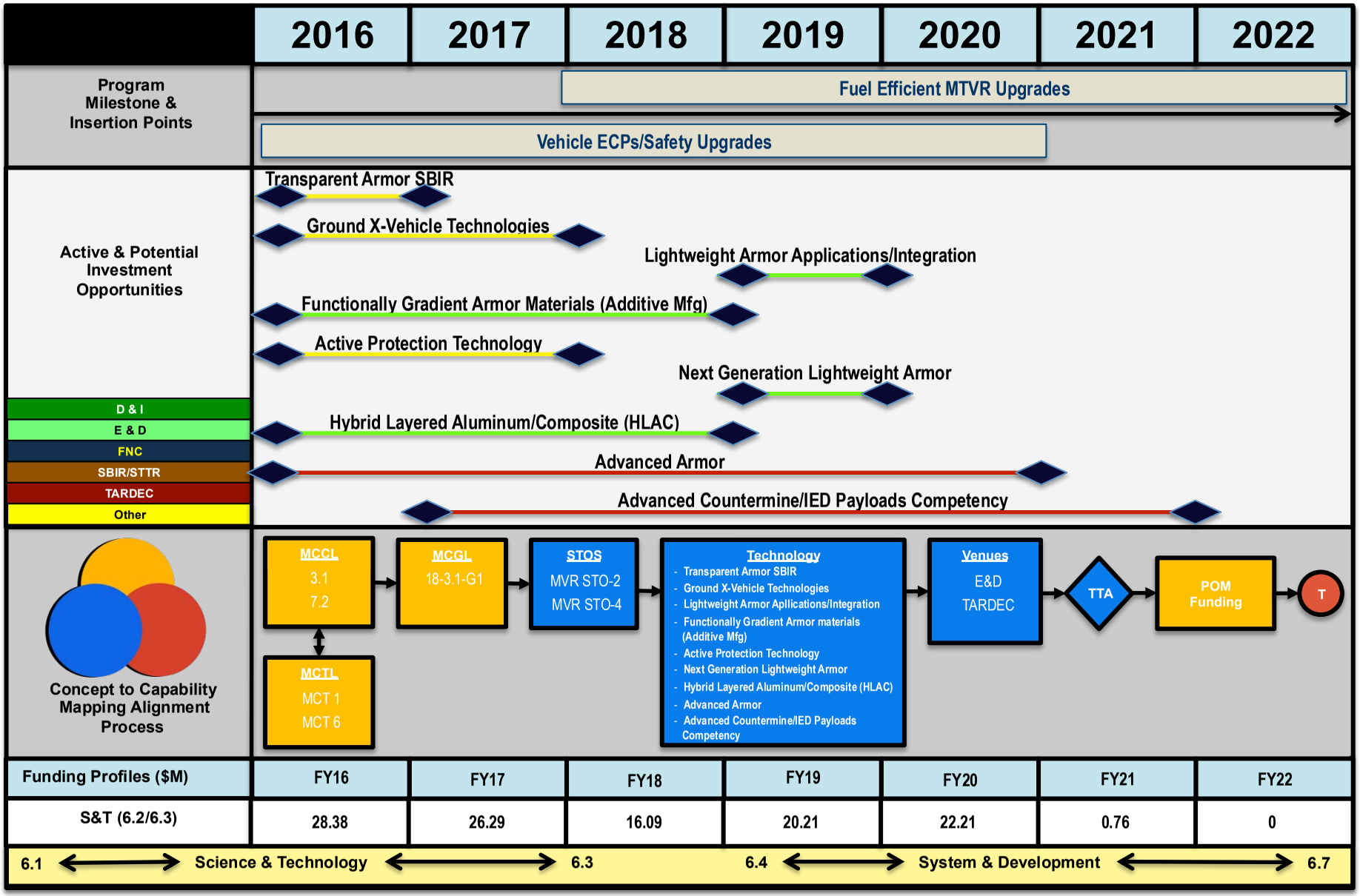
MTVR Technical Issue #2 Increased Survivability



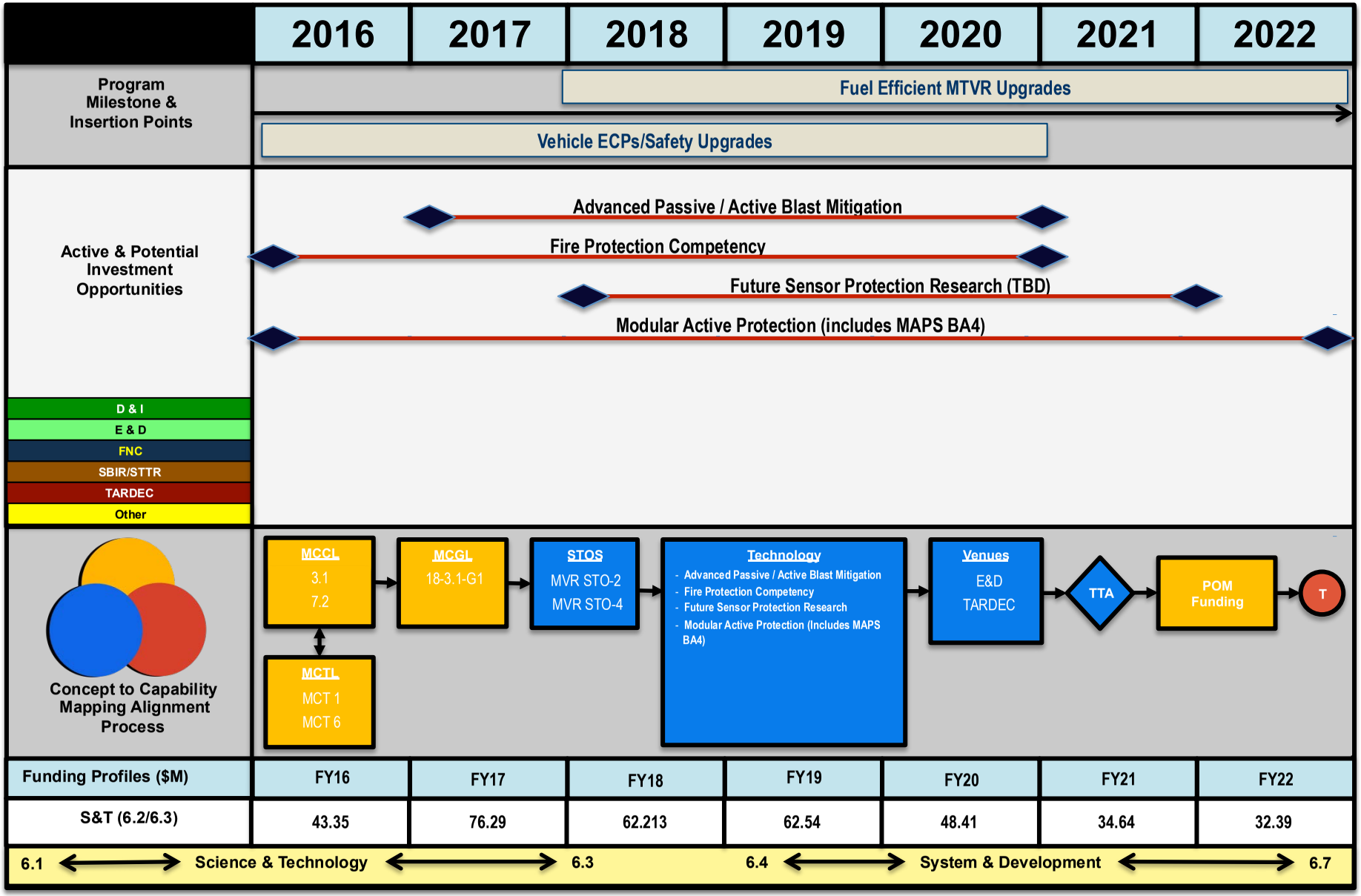
MTVR Technical Issue #2 Increased Survivability



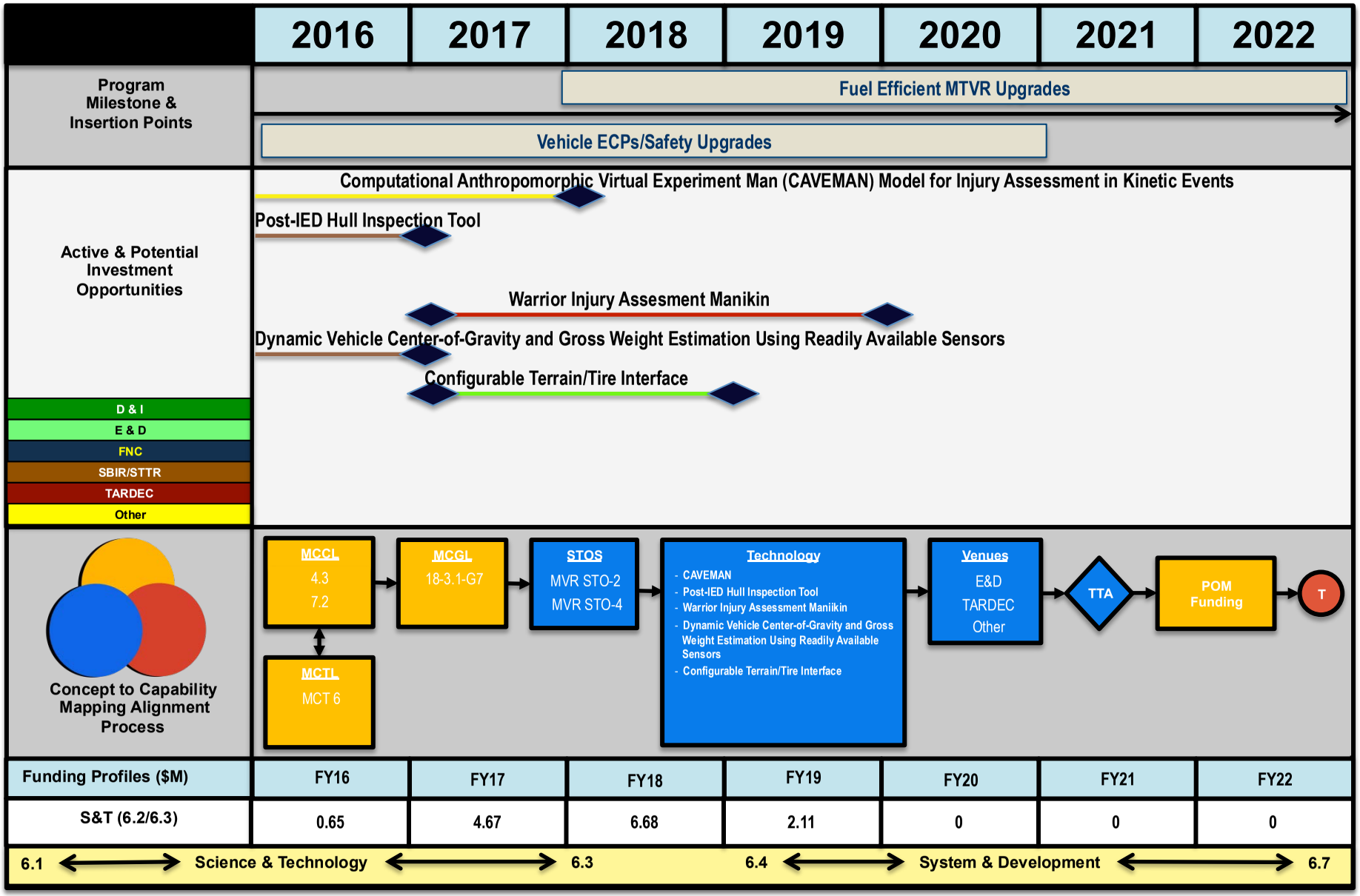
MTVR Technical Issue #2 Increased Survivability



MTVR Technical Issue #2 Increased Survivability



MTVR Technical Issue #3 Safety



Section 8.9

M-ATV/COUGAR/BUFFALO




Left to right, top to bottom: Buffalo; Cougar 4x4; Cougar 6x6; M-ATV

Program Background

The Marine Corps' MRAP All-Terrain Vehicle (M-ATV), Category (CAT) I and CAT II Cougar variants, and the CAT III Buffalo are designed to reduce casualties and increase the survivability of personnel subjected to mine explosions, Improvised Explosive Device (IED) detonations, and Small Arms Fire (SAF). These vehicles were designed under the Mine-Resistant Ambush Protected (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 (MROC) in October 2014.

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 (UIK) 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 (ISS). 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 Tube-launched, Optically tracked, Wire-guided (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 (MEFs). A total of 2,017 of the 2,510 Enduring Requirement (ER) vehicles are scheduled to receive a maintenance reset at Marine Corps and Army depots and a commercial repair facility through calendar year 2018.

Top Technical Issues

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

The fleet is currently going through reset at various depots and commercial locations CONUS. As hulls are stripped and inspected, stress cracks are being discovered throughout the welded high-hard construction of Cougars and in high hard panels of M-ATVs. The reset lines are being delayed and significant cost is being added to the process due to the extensive repair of cracks, replacement of high hard panels. It is critical that the types of cracks be characterized, the root causes discovered, and depot-level repair procedures established that will maintain structural integrity, reduce future cracking, and provide required ballistic protection.

2. 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.

3. Reduction in Occupant Accelerations with Minimal Stroke Distance Availability

The ground vehicle survivability community and vendors have developed high performing blast attenuating occupant seats that protect against significant mine blast charge weights over the last 10-15 years. Many of these seats function by allowing the seat to stroke downwards while an energy attenuating mechanism absorbs the accelerative load. Finding improved seating systems that can provide blast attenuation with minimal downward stroke while allowing components or stowage under the seat is optimal for supporting the Marines and their internal vehicle load plan.

M-ATV

ACAT III / SUSTAINMENT

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 (SAF).

Key Events

- MROC Decision Memorandum 03-2017 published 4 January 2017 maintains AAO of 705
- Reset production line at Red River Army Depot nearing completion Feb/Mar 2017 time frame
- Redistribution of reset vehicles to prepositioned locations will continue through FY18
- 17 January- 14 February: Logistics Demonstration of Operators Manual being conducted in Oshkosh, Wisconsin

Program Status/Issues/Concerns

- AAO 705
- Army is PICA
- Program is in sustainment
- Reset activities are ongoing at Red River Army Depot, Maintenance Center Barstow
- Redistribution of reset vehicles to the MEFs is complete

PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases																									MROC Decision Service Life 2024				
SETR Reviews				Fuel Efficiency																									
						A-Kit Upgrades																							
Test Events						ECM																							
			Trailer Test																										
Contract Events			Rear Wall/Door Sill Kits																										

Buffalo

ACAT III / SUSTAINMENT

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 B0035K and assigned to Combat Engineer units. Since the vehicle has no weapon systems it cannot operate in a combat environment alone.

Key Events

- Windshield Cracking
  - Root cause analysis/testing – 27 Jan 17
  - Design./procedure changes - 01 Mar 17 - 30 Apr 17
  - Solution to Depot – 01 May 17
- Emergency Egress Lighting Product Improvement
  - Prototypes - 15 Mar 17
  - Testing - 30 Mar 17 - 30 Apr 17
  - Receive production kits - 15 Jul 17

Program Status/Issues/Concerns

- Programmatic
  - Block III Upgrade Effort includes over 60 individual improvements to the Buffalo (EEL, 3rd Plane of Egress, Electrical System Mitigation, etc.)
- Logistics
  - Windshield frame Production and Integration
  - Complete Block III Upgrade at LOGCOM at Production Plant Albany (PPA)
  - Complete MIs for IETM Integration and EMSS Software Update

PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases		★ TAU WC Production	★ Electrical Mitigation																										
SETR Reviews		FOV ECPS (Cougar, Buffalo)																											
		ECP 3D CAD Mod &TPD																											
		ECP 51 TPD																											
Test Events			EEL																										
				Rebaseline																									
					Product Improvement Plan Testing Events																								
Contract Events		FSR	FoV FSR																										
			EEL Dev& Prod																										
		IETM		Final IETM																									

Cougar

ACAT III / SUSTAINMENT

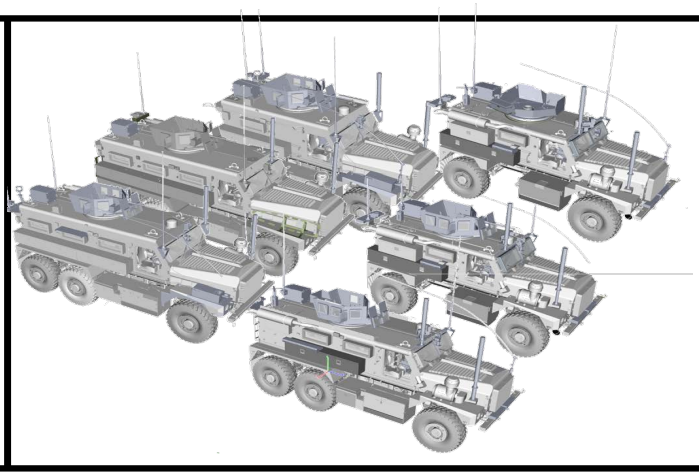
Description: The Cougar FoV is an infantry mobility vehicle designed to resist anti-vehicle mines, IED detonations, and small arms fire. The Cougar FoV is comprised of a four-wheel (4x4 CAT I) version and a six-wheel (6x6 CAT II) version. The Cougar FoV is used for small unit combat operations in urban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

Key Events

- Egress Test Events – (End of Test 17 Mar 17)
  - 360-Degree Rollover Event: 15 Mar 17
- Egress Installs – Organic Site Visits – mid-Feb 17
- Egress FRPD - Egress SVR/PRR – mid-Mar 17
- Egress FRPD – mid-Apr 17
- Egress First Rate Production delivery – Aug 17

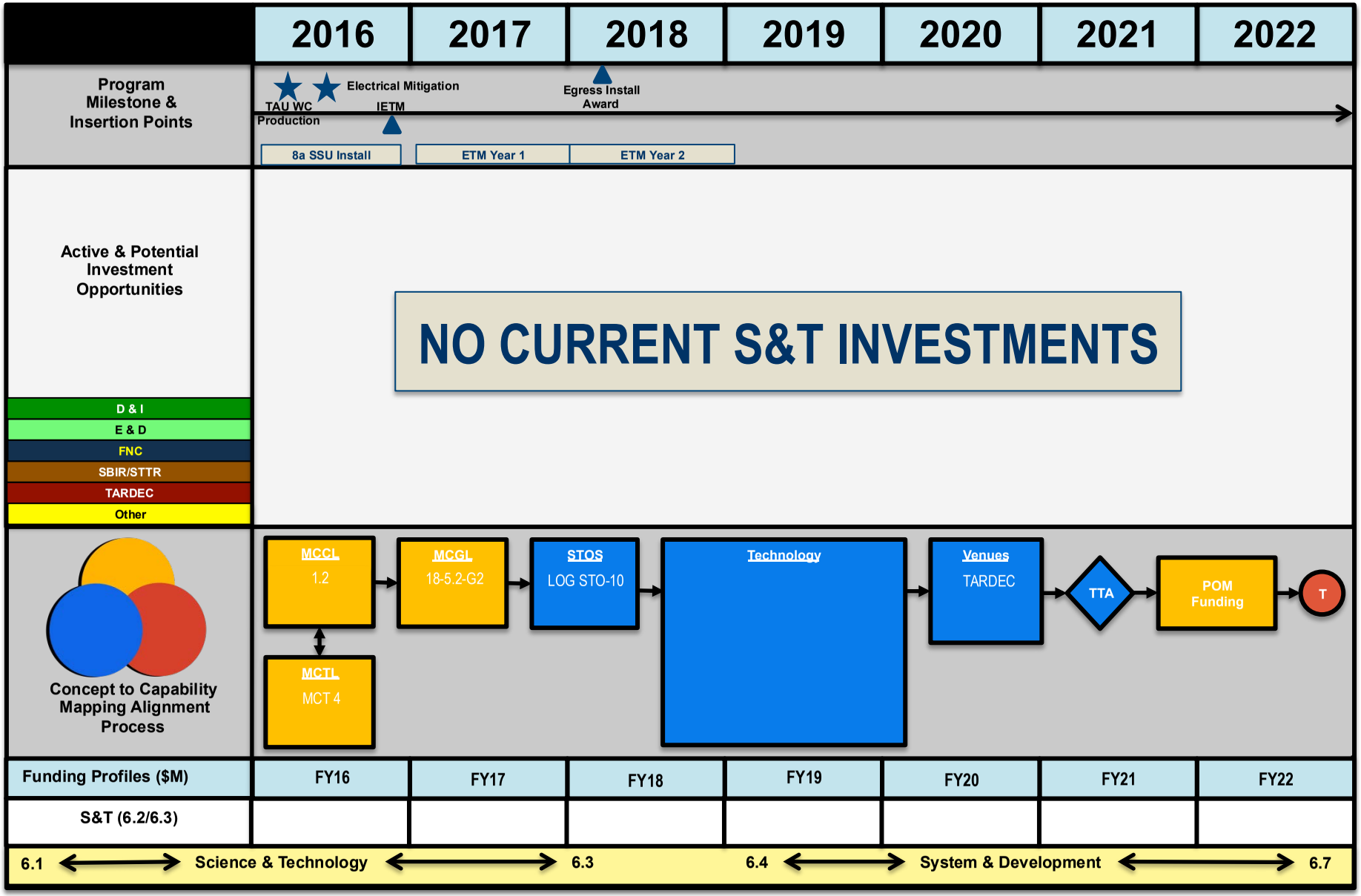
Program Status/Issues/Concerns

- Logistics
  - Post Reset ECP Installation
  - ETM development
  - Transparent Armor supply

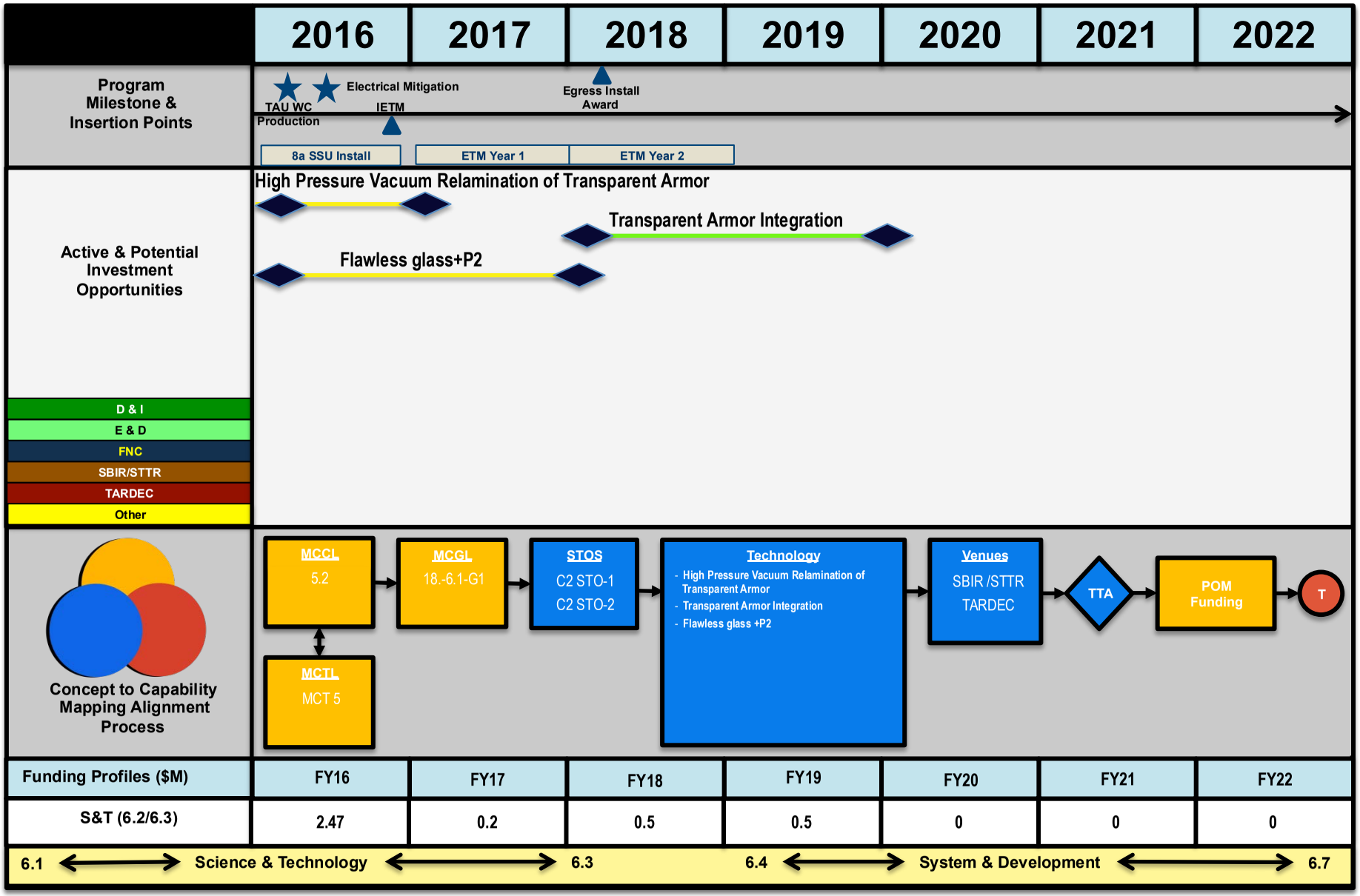


PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases			TAU WC Production			Electrical Mitigation																							
SETR Reviews			Cougar FOV ECPS																										
			Cougar Model Development																										
			Cougar Master Model Complete																										
			A-Kit Upgrades																										
Test Events			CRVJ V2			ECM				Rebaseline																			
			Egress Test			Trailer Test				A-Kit Upgrade Test																			
						Cougar FL																							
Contract Events			FSR	FoV FSR						Egress Install Award																			
			8a SSU Install																										
			IETM			ETM Year 1				ETM Year 2																			

MRAP Technical Issue #1 Stress Cracks in Welded Construction and Monolithic Hulls Both Using High-Hard Steel



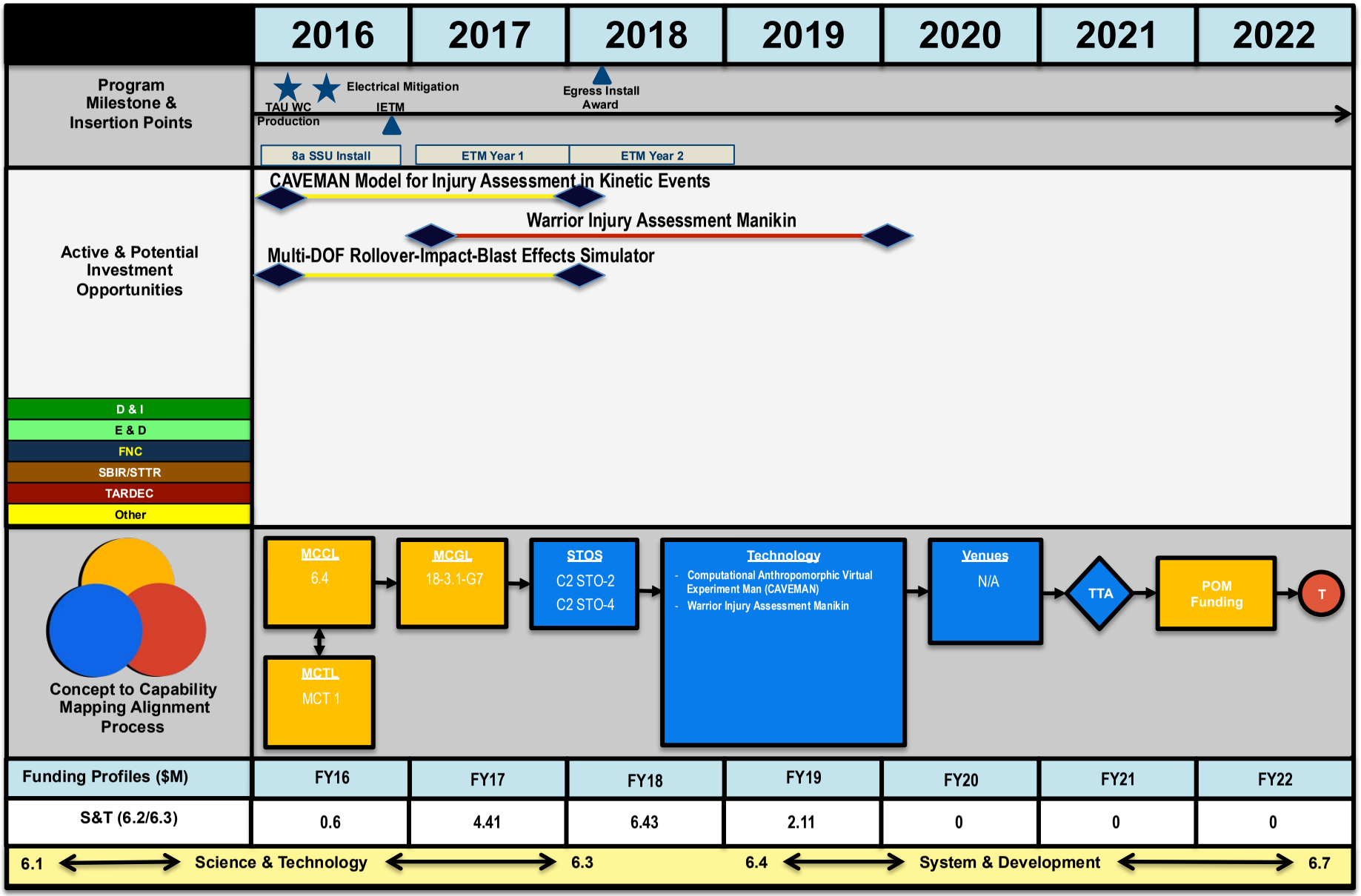
MRAP Technical Issue #2 Repair of Delaminated Transparent Armor



Funding Profiles ($M)	FY16	FY17	FY18	FY19	FY20	FY21	FY22
S&T (6.2/6.3)	2.47	0.2	0.5	0.5	0	0	0

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

MRAP Technical Issue #3 Reduction in Occupant Accelerations with Minimal Stroke Distance Availability



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LIGHTWEIGHT 155MM HOWITZER

Lightweight 155mm Howitzer (LW155)

Program Background

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

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 world's first artillery weapon to make widespread use of titanium and aluminum alloys, 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

There are currently 1,090 M777A2 howitzers: 481 for the Marine Corps and 518 for the Army, with the balance for foreign military sales customers Canada and Australia. To date, more than 1050 of these systems have been fielded, with the

remaining quantity supporting ongoing Army fielding. The final USMC M777A2 was fielded in April 2014 with Full Operational Capability achieved in June 2011.

The M777 Program has commenced activities to "refresh" the system's digitized fire control system. Described as 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 and Assistant Gunners Display (GD/AGD) commenced fielding in 2014. 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, and power supply.

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 SWaP 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, which 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 significant development efforts (at significant expense) to design and qualify "system specific" power packs. To mitigate this, PMs request 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.

LW155

ACAT II Sustainment

Description: M777A2 (LW155) Provides direct, reinforcing, and general support fires to maneuver forces. Replaces the M198 howitzer as the general support artillery for light forces in the Army. Replaces all howitzers in all missions in the USMC.

Key Events

- Jan 2017: India FMS Contract Awarded to BAE
- Feb 2017: Software Material Release for v4.1.3R anticipated
- Mar 2017: PBLCS Option Year 4 Award
- Mar-Apr 2017: 2-146FA WA ARNG fielding
- Apr 2017: Army Prepositioned Stock 3 (APS-3) IBCT fielding
- May 2017: 1-107FA PA ARNG IBCT fielding
- Jun 2017: 1-194FA IA ARNG IBCT fielding

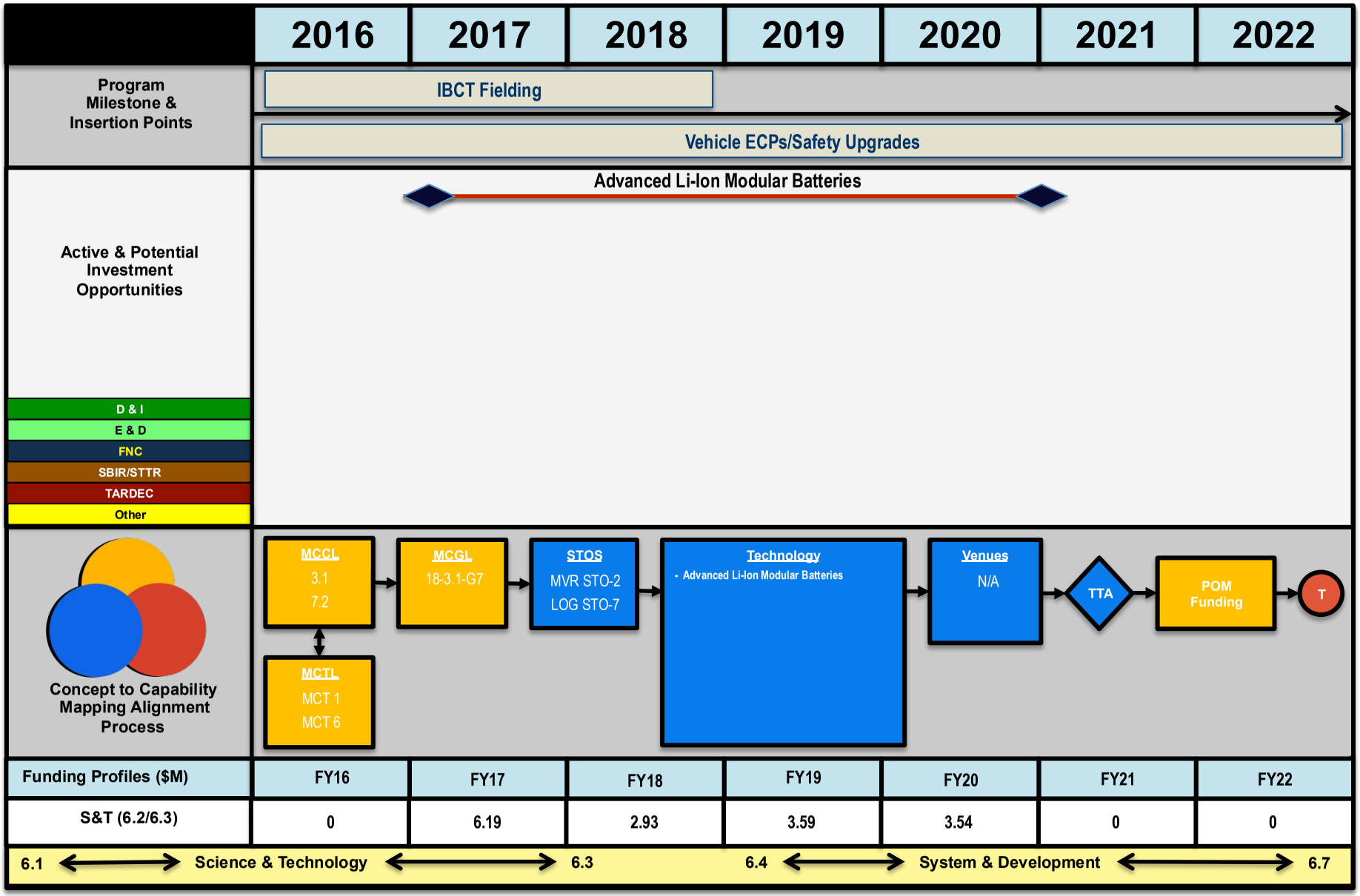
Program Status/Issues/Concerns

Status:

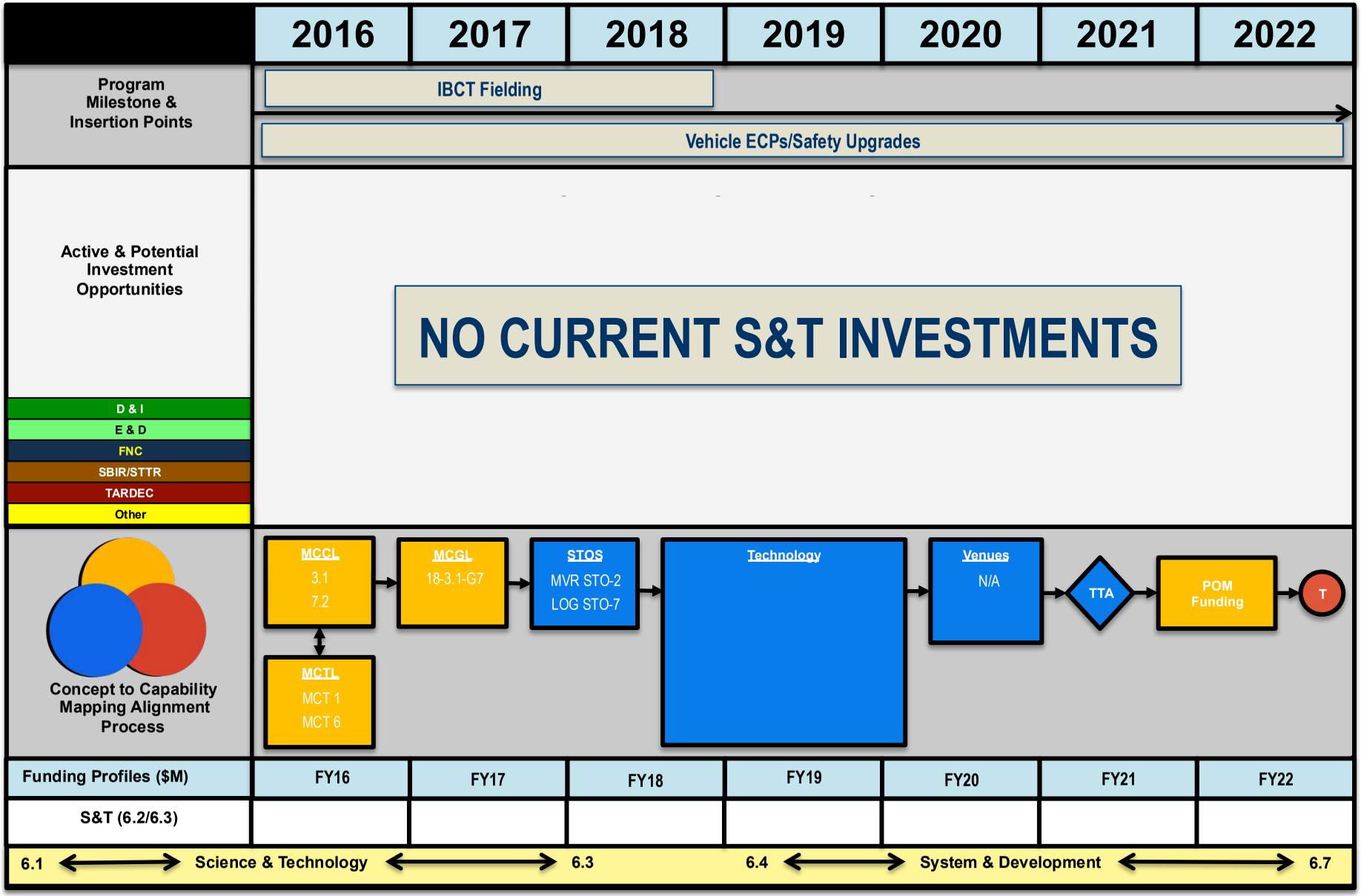
- Program in Sustainment, supported by Performance Based Lifecycle Support – FFP Contract with BAE Systems until May 2023 (based on meeting on time delivery metrics)
- FMS to Canada (37), Australia (54), India (145 on order)
- Upgrades to Digital Fire Control System components to begin this year.

PROGRAM	PRIOR	FY16				FY17				FY18				FY19				FY20				FY21				FY22			
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Milestones & Phases																													
SETR Reviews		In Sustainment																											
Test Events																													
Contract Events																													

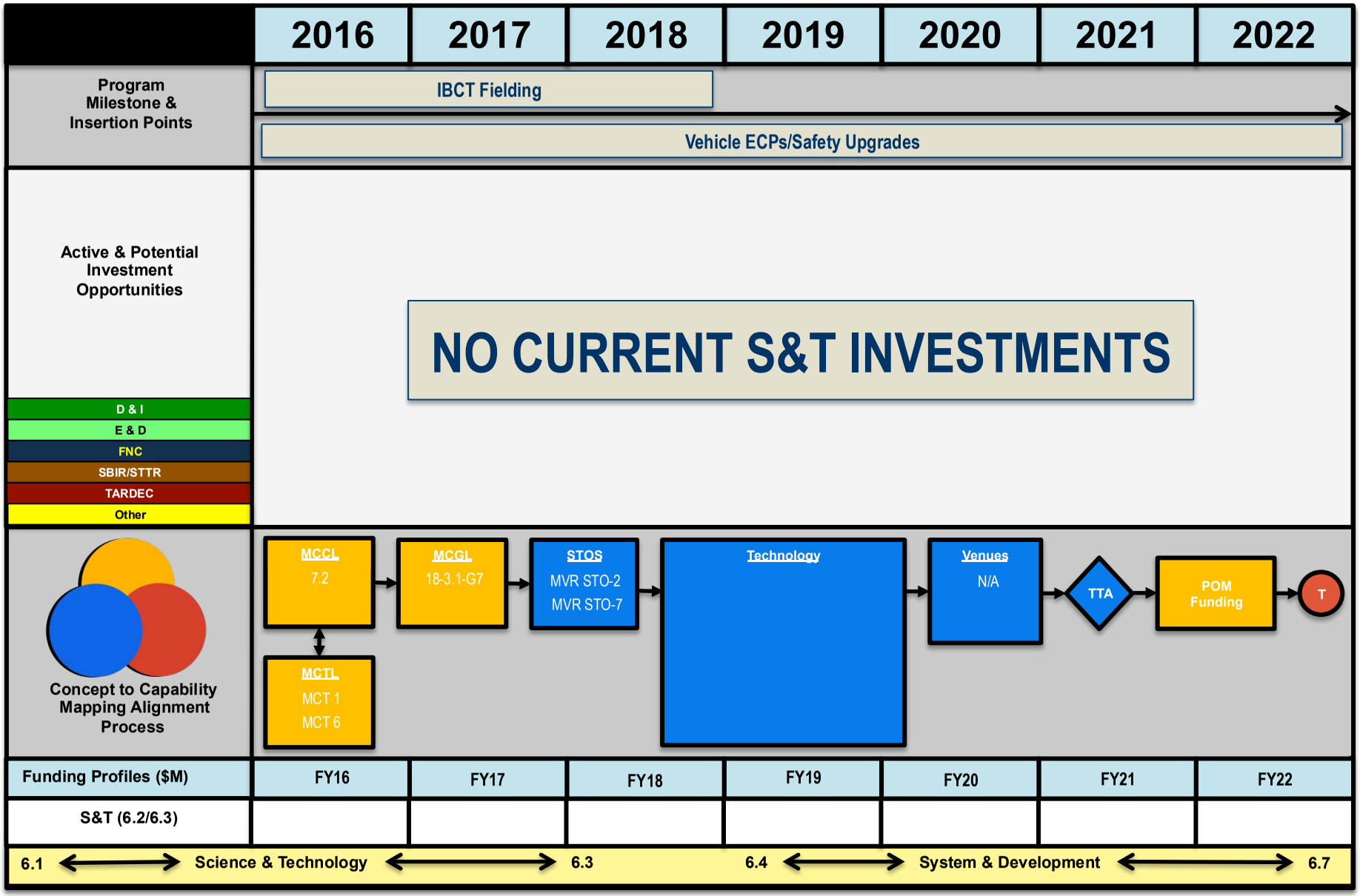
LW155 Technical Issue #1 Safe and Transportable Battery High Capacity Technology



LW155 Technical Issue #2 Secure Wireless: Ruggedized/ Low Energy



LW155 Technical Issue #3 Navigation in a GPS Denied Environment



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 and POC 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	METHODOLOGY	TRL	SERVICE/OSD POC	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 http://www.onr.navy.mil/Science-Technology/Directorates/Transition/Technology-Transfer-T2/Partnership-Options/CRADA-handbook.aspx
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	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	Technologists in US and partner country develop specific list of mutual interests according to Navy International Program Office (NIPO guidelines). NAVAIR recommends a Technical Program Officer for NIPO following the DEA Annex guidelines which specify: • the scope • classification • authorities • channels • correspondence • establishments	2 to 4	**Michael Locke** NIPO (202) 443-6032 michael.locke@navy.mil	http://www.secnav.navy.mil/rda/nipo/Pages/FAQs.aspx
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	ONR Departments issue planning letters soliciting white papers via a Broad Agency Announcement (BAA) or yearly calls for: • University Research Initiatives (URI) • In-House Laboratory Independent Research (ILIR/IAR) • Defense Research Science (DRS)	1 to 4	**Dr. Lang Schuette** Acting, Director of Research, ONR (703) 696-6769	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	_	_	_	Case by case negotiation	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	ONR issues the call to each major Navy/Marine Corps Systems Command (SYSCOM); NAVSEA NAVAIR SPAWAR Marine Corps OSD creates a prioritized list in early June	7 to 9	**ONR FCT Program Manager** DoN_FCT_Contact@onr.navy.mil OSD (571) 372-6803 FCT@osd.mil	http://www.onr.navy.mil/en/Science-Technology/Directorates/Transition/Foreign-Comparative-Testing-FCT.aspx https://cto.acqcenter.com/osd/portal.nsf

VENUE	PURPOSE	WHO	WHEN	DURATION	FUNDING	ELIGIBILITY	METHODOLOGY	TRL	SERVICE/OSD POC	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	A three-star Navy and Marine Corps Board of Directors, the Technical Oversight Group, approves the FNCs based on their contribution to closing S&T capability gaps.	3 to 6	**Mr. Steve Smolinski** ONRA (703) 696-0000 Steven.smolinski@navy.mil Alternative Email: onr.fnc-team@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.	Approved and overseen by the Naval S&T Corporate Board (Assistant Secretary of the Navy for Research, Development and Acquisition (RD&A), Assistant Commandant of the Marine Corps and Vice Chief of Naval Operations) Go-No Go Reviews based on defined technical goals at 2 to 3 year intervals.	5 to 7	**Mr. Craig A. Hughes** Acting, Director of Innovation	http://www.onr.navy.mil/en/Science-Technology/Directorates/Transition/innovative-naval-prototypes.aspx
Joint Capabilty 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 Warfighting Lab	Throughout FY15 and FY16	Aim to be completed within two years, although longer duration projects will be considered.	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.	All JCTD information: • White Papers • updates • briefs • quads Submitted to the Knowledge and Information Management System (KIMS)	6 to 9	**Dan Petonito** (703) 697-4038 daniel.h.petonito.ctr@mail.mil Alternative Email osd.pentagon.ousd-atl.list.jctd-poc@mail.mil	http://www.acq.osd.mil/ecp/PROGRAMS/JCTD.html
Marine Corps Technology Division	To identify future challenges and opportunities, develop warfighting concepts, and comprehensively explore options in order to inform force development	MCCDC Marine Corps	On-Going	–	–	–	–	–	mcwlpao@usmc.mil	http://www.mcwl.marines.mil/
Memorandum of Understanding or Memorandum of Agreement (MOU/MOA)) with other Federal Agency Agreement	MOU/MOA agreement allowing other Federal Agencies (i.e. DARPA) to collaborate with the Navy individually or together on: • research • development • engineering, or other tasks	DoD/Partner	–	0-3yrs	0-$3M Max < $1M per year for up to three years may be extended up to another two years by amendment with appropriate review	Navy with other Federal Agency	Contact the NAWCAD Business & Partnership Office	3 to 6	–	http://corpslakes.usace.army.mil/employees/cecwon/mou.cfm
National Labs (DoE-Los Alamos, Oak Ridge, etc.)	Partnering (MOU), collaboration, in-kind support	Vaious	On-going	Case by case	Case by case	Case by case	–	Varies	–	http://www.dmoz.org/Regional/North_America/United_States/Government/Executive_Branch/Department_of_Energy/DOE_National_Laboratories/ http://energy.gov/offices#Labs%20&%20Technology%20Centers

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Navy Manufacturing Technologies (ManTech)	Provides for the development of enabling manufacturing technology and the transition of this technology for the production and sustainment of Navy weapon systems to support the Fleet	ONR	Annually	0-3yrs	0-$3M Two years	• defense contractors • the Naval Research Enterprise • Navy acquisition Program Offices • academia	http://www.onr.navy.mil/Science-Technology/Directorates/Transition/Manufacturing-ManTech.aspx	5 to 7	**DoD** dodmantech@drc.com **John Carney** ONR Office of Transition ManTech (703) 696-0352 john.u.carney@navy.mil **Adele Ratcliff** Director, OSD ManTech (571) 372-6240 Adele.ratcliff@osd.mil	http://www.onr.navy.mil/Science-Technology/Directorates/Transition/Manufacturing-ManTech.aspx
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 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	ONR	–	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.	–	The Navy ManTech Program is part of the Department of Defense (DoD) ManTech Program, managed by the Office of the Deputy Under Secretary for Defense, Advanced Systems & Concepts, which has oversight of the ManTech programs of the Services and the Defense Logistics Agency (DLA). These organizations, together with the Missile Defense Agency (MDA), coordinate their programs through the auspices of the Joint Defense Manufacturing Technology Panel (JDMTP) consisting of the ManTech directors of the Services, DLA, and MDA with advisory representation from the Office of the Secretary of Defense (OSD), the Department of Commerce's National Institute of Standards and Technology (NIST), the Department of Energy, and industry. The JDMTP is organized to identify and integrate requirements, conduct joint program planning, and develop joint strategies.	5 to 7	–	http://www.onr.navy.mil/Science-Technology/Directorates/Transition/Manufacturing-ManTech/Navy-Mantech-Center-Excellence.aspx
Quick Reaction Fund (QRF)		OSD	Proposals may be submitted any time during the year as opportunities and need arise	0-1yr	$100K- $1M Max	https://epts.dtic.mil/epts/main_qrf.html	QRF takes advantage of technology breakthroughs in rapidly evolving technologies. It provides Components, Combatant Commanders and Force Providers an opportunity to capitalize on emergent technology and to rapidly field-test promising new technology prototypes that can immediately have an impact on military operations. Criteria QRF initiatives are limited to those that will deliver a military prototype application within 6-12 months of being funded. Projects funded thus far are generally in the dollar range from several hundred thousand to several million dollars.	7 to 9	**Pricilla Williams** pricilla.williams.ctr@mail.mil Also, can email QRF_Contact@onr.navy.mil	–
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.	A total of four Broad Agency Announcements (BAA), including one from each Military Department and one from the Office of Small Business Programs (OSBP), will be used to solicit white papers and technical proposals for RIF funding. Upon release, each of these BAAs will remain open for a minimum of 60 days.	5 to 7	**Bob Smith** (703) 696-7954 robertlsmith6@navy.mil	ONR 'BAA list': http://www.onr.navy.mil/Contracts-Grants/Funding-Opportunities/Broad-Agency-Announcements.aspx http://www.defense.... NEED THIS

VENUE	PURPOSE	WHO	WHEN	DURATION	FUNDING	ELIGIBILITY	METHODOLOGY	TRL	SERVICE/OSD POC	WEBSITE
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 to 18 months Capabilites are developed and fielded through a supporting spiral approach	Varies	Varies	Varies	7 to 9	**Pricilla Williams** pricilla.williams.ctr@mail.mil Also, can email QRF_Contact@onr.navy.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	Eligibility Determine topic feasibility and scientific or technical merit in 3 phases. Method Topics: • endorsed by PMAs • reviewed by T-Codes • selected by PEOs, • ontracts created & monitored by SBIR Office	0 to 3	**John Williams** ONR Director, Navy SBIR Programs (703) 696-0342 john.williams6@navy.mil	http://www.navysbir.com/ http://www.onr.navy.mil/Science-Technology/Directorates/Transition/~/media/Files/03T/ONR-SBIR-AWARD-STRUCTURE-2013.ashx
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	**John Williams** ONR Director, Navy SBIR Programs (703) 696-0342 john.williams6@navy.mil	http://www.navysbir.com/ http://www.onr.navy.mil/Science-Technology/Directorates/Transition/~/media/Files/03T/ONR-SBIR-AWARD-STRUCTURE-2013.ashx
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	**John Williams** ONR Director, Navy SBIR Programs (703) 696-0342 john.williams6@navy.mil	http://www.navysbir.com/ http://www.onr.navy.mil/Science-Technology/Directorates/Transition/~/media/Files/03T/ONR-SBIR-AWARD-STRUCTURE-2013.ashx
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.	Topics: • endorsed by PMAs • reviewed by T-Codes • selected by PEOs, • contracts created & monitored by SBIR Office	0 to 9 over the 3 phases	**John Williams** ONR Director, Navy SBIR Programs (703) 696-0342 john.williams6@navy.mil	http://www.navysbir.com/index.html https://www.sbir.gov/about/about-sbir
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	Topics: • submitted by technical community • selected and approved by NAE CTO and S&T IPT team • require PMA statement of interest • no ITAR-restricted or classified topic areas • contracts created & monitored by SBIR Office	2 to 4	ONR STTR Program Manager (703) 696-7830	http://www.navysbir.com/index.html https://www.sbir.gov/about/about-sttr

VENUE	PURPOSE	WHO	WHEN	DURATION	FUNDING	ELIGIBILITY	METHODOLOGY	TRL	SERVICE/OSD POC	WEBSITE
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	ONR STTR Program Manager (703) 696-7830	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	ONR STTR Program Manager (703) 696-7830	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	ONR STTR Program Manager (703) 696-7830	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.	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	**ONR, Office of Innovation** (703) 696-6774 swampworks@onr.navy.mil **Jim Blesse** (703) 696-4037 jim.blesse@navy.mil	http://www.onr.navy.mil/Science-Technology/Directorates/office-research-discovery-invention/swampworks-innovation.aspx
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)	ONR issues a proposal quota for each SYSCOM. The final NAE CTO selections package is sent to ONR. ONR Transition Office staff review all submitted proposals against the required criteria. Those deemed appropriate for source selection get subjected to a technical review panel. Final selections are made by the Executive Review Group (ERG)	Start 6+, End 8+	ONR Office of Transition (Code 03T) **Transition Initiative Program** 3TTX_Contact@onr.navy.mil **TIPS program office** TIPS_Contact@onr.navy.mil	http://www.onr.navy.mil/Science-Technology/Directorates/Transition/Technology-Insertion-Program-Savings-TIPS.aspx
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 Labs Commercial &/or academic partners are common	Request submitted by E4 -O4 Sailor/Marine or ONR Science Advisor to the ONR TechSolutions office	6+ at end	703-696-0616 techsolutions@onr.navy,mil	http://www.onr.navy.mil/techsolutions/ http://www.onr.navy.mil/Science-Technology/Directorates/Transition/tech-solutions-innovation.aspx

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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 (DURIP) DoD Experimental Program to Stimulate Competitive Research (DEPSCOR) Multidisciplinary Research Program of the University Research Initiatives (MURI) The Presidential Early Career Award for Scientists and Engineers (PECASE) Program Young Investigators Program (YIP)	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	**Paula Barden** (703) 696-4111 Paula.barden.ctr@navy.mil	http://www.onr.navy.mil/Science-Technology/Directorates/office-research-discovery-invention/Sponsored-Research/University-Research-Initiatives.aspx

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Advanced Technology Investment Plan

2017 - Volume VIII

PEO Land Systems Marine Corps

It's All About the Warfighter

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