IT'S ALL ABOUT THE WARFIGHTER

PEO LAND SYSTEMS
ACQUISITION EXCELLENCE
IT'S ALL ABOUT THE WARFIGHTER

ATIP

Advanced Technology Investment Plan

2015 - Volume VI

Program Executive Officer Land Systems
Marine Corps Advanced Technology
Investment Plan 2015

EXECUTIVE SUMMARY

The 2015 edition of the Program Executive Officer Land Systems (PEO LS) Advanced Technology Investment Plan (ATIP) provides an update to the Top Technical Issues of PEO LS programs. Each Top Technical Issue has been vetted through the Program Managers to ensure an accurate representation of their highest priority technology needs and highlights science and technology (S&T) investments required to deliver state-of-the-art technologies to the Warfighter.

This sixth edition of the ATIP is consistent with previously published ATIPs and emphasizes our continued commitment to "Focus the Future Faster" by leveraging available S&T venues to provide gap-closing capabilities.

The overarching focus of this plan is to support concept aligned, capabilities-focused technology transitions into Programs of Record. 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. This document is an informative source that highlights the importance of collaboration and communication within the S&T community.

William E. Taylor
Program Executive Officer
Land Systems Marine Corps

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Program Executive Officer Land Systems
Marine Corps Advanced Technology
Investment Plan 2015

BOTTOM LINE UP FRONT

In an environment of fiscal austerity, changing requirements, and rapid technical innovation, collaboration is vital to maximizing opportunities across the Science and Technology (S&T) Enterprise. This sixth edition of the Program Executive Officer Land Systems (PEO LS) Advanced Technology Investment Plan (ATIP) is promulgated with this goal in mind.

The PEO LS ATIP employs a focused, repeatable process that informs all key stakeholders, industry, and academia of Top Technical Issues within PEO LS programs with the goal of leveraging all available opportunities.

The enclosed ATIP identifies and prioritizes Top Technical Issues within PEO LS programs, 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. Each technical issue has been thoroughly vetted through the appropriate S&T representative, lead engineer, deputy program manager, and program manager to ensure an accurate representation of each program's highest priority technology needs.

The ATIP can 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 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 Mike Halloran, PEO LS Director, S&T at michael.d.halloran@usmc.mil.

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

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Program Executive Officer Land Systems
Marine Corps Advanced Technology
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Section 1

INTRODUCTION

"The ATIP is designed to foster collaboration, align S&T investments, and support effective, affordable technology insertion within PEO LS Programs."
—Program Executive Officer Bill Taylor, Marine Corps PEO LS

This is the sixth edition of the Program Executive Officer Land Systems (PEO LS) Advanced Technology Investment Plan (ATIP). As the only Marine Corps Program Executive Office, PEO LS is responsible for managing multiple Acquisition Category (ACAT) I, II, III & IV programs that are critical to the support of the Warfighter. This document identifies and prioritizes the Top Technical Issues for each program within PEO LS. The purpose of this document is to inform, influence, and align science and technology (S&T) efforts and focus investments to resolve issues and transition needed technologies into Programs of Record (PORs) as quickly as possible. The methodology used to develop the ATIP is the focused and repeatable Concept to Capability process, which is designed to encourage communication and stakeholder engagement within the S&T Enterprise, industry, and academia in order to resolve program technical issues and support the transition of critical and affordable capabilities to the Warfighter.

The challenges of today's fiscally constrained environment of the post Operation Enduring Freedom (OEF) era require the Marine Corps to consider different approaches to maintain and modernize its equipment in order to retain its technological edge. With these constraints in mind, the theme of this edition is **Modernization through Modularity**. Modularity is the development of interchangeable system components that are linked through a set of common or standard interfaces to perform specific missions or tasks. Section 4.0, Futures, discusses how this theme applies to PEO LS and how **Modernization through Modularity** could work.

The main focus of the ATIP is to enhance our warfighter capabilities by:

- **Identifying and defining the Top Technical Issues** that must be resolved within each program, some of which remain consistent from year to year. These issues 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.
- **Resolving capability gaps and technical issues.** By identifying and publishing the technical issues, PEO LS is delivering input and assistance to the S&T Enterprise, industry, and academia.
- **Informing, influencing, and aligning S&T investment** by identifying the S&T needs of PEO LS and **supporting the technology insertion and transition into their POR.**

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 solutions
- Open plug-and-play communications architecture in Marine Corps vehicles

The current status of the PEO LS programs can be seen in the Figure 1-1 below, with the following activities anticipated within the next year:

In the second quarter of fiscal year 2015, request for proposals (RFPs) will be released for:

- Amphibious Combat Vehicle 1.1 (ACV 1.1)
- Program Management (PM) Mine-Resistant Ambush Protected (MRAP) Operation and Sustainment Support in Kuwait

In the third quarter of fiscal year 2015, RFPs will be released for:

- Amphibious Assault Vehicle (AAV) Engineering Maintenance Test Support
- AAV Field Service Support
- PM Medium and Heavy Tactical Vehicles (M&HTV) Program Management Office Support Service Contract

In fiscal year 2016, RFPs will be released for:

- PEO LS Engineering and Development Test Support (first quarter)
- Common Aviation Command and Control System (CAC2S) Phase 2 RFP for Full Rate Production (third quarter)

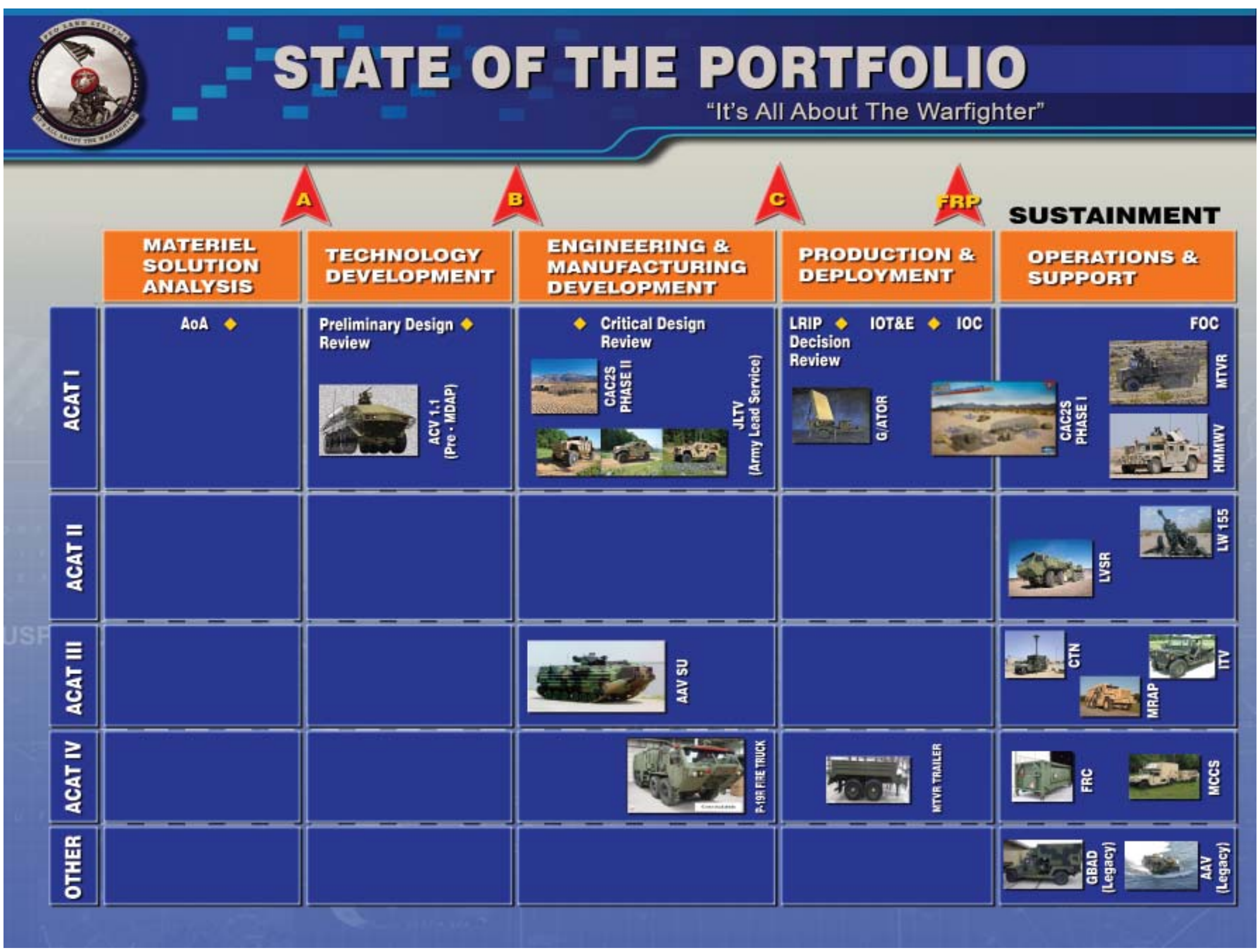

Figure 1-1. Program Executive Officer Land Systems State of the Portfolio

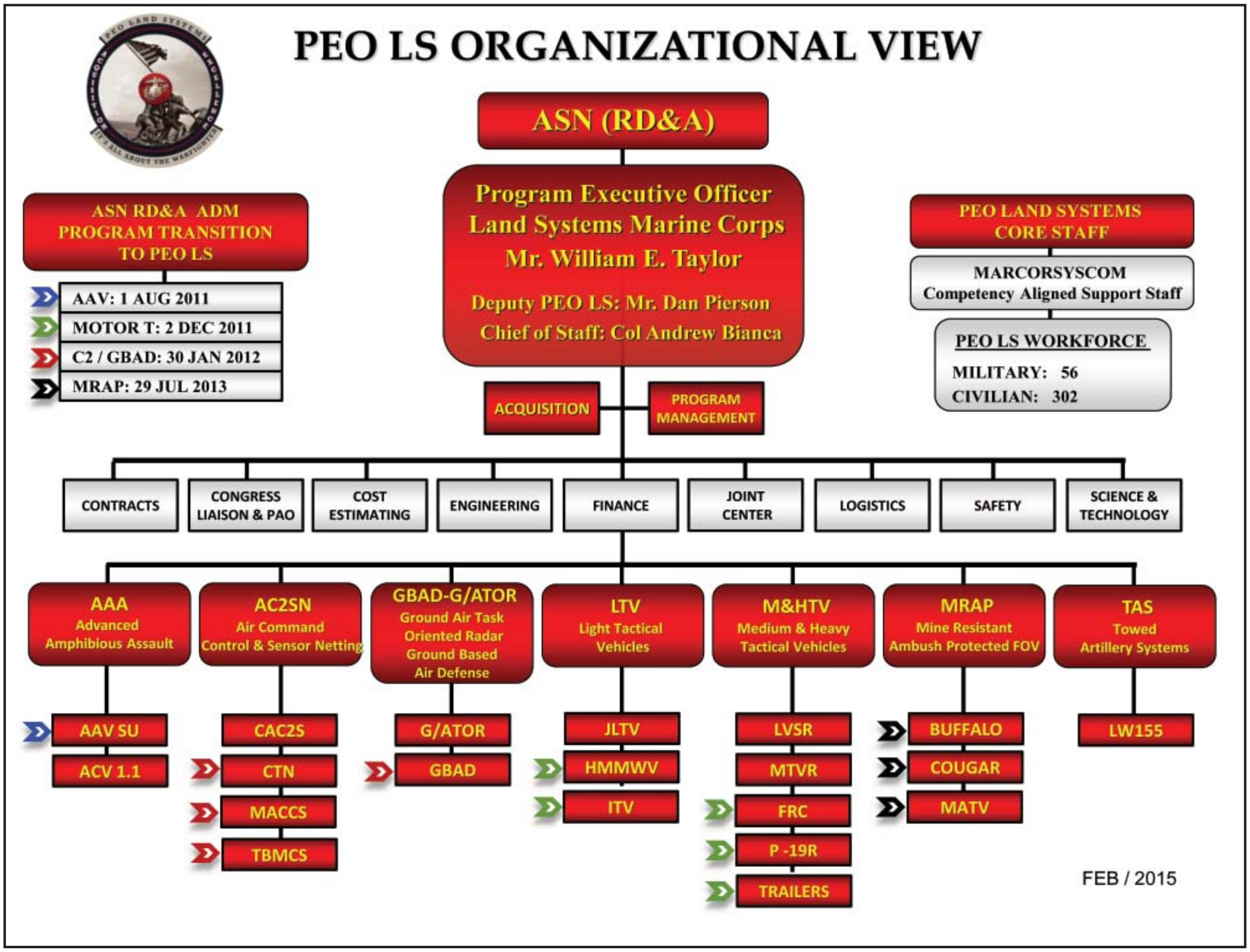

Figure 1-2. Program Executive Officer Land Systems Organization

PEO LS Organization

Program Executive Officer Land Systems—located at historic Hospital Point, Building 2210, Marine Corps Base Quantico, VA—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 security environment changes, the tactics, techniques and procedures change, the threats change, but what won't change is our role as the Nation's crisis response force of choice."*
> **—General Joseph F. Dunford**
> **Commandant of the Marine Corps**

PEO LS Mission

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 1-2 illustrates the current organization of PEO LS.

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Section 2

S&T COLLABORATION AND ENGAGEMENT

Concept to Capability Process

The Concept to Capability process used by PEO LS, depicted in Figure 2-1, is a focused, repeatable process that has proven essential in facilitating effective interaction with S&T stakeholders within the S&T Community.

The PEO LS Concept to Capability process begins with an in-depth understanding and alignment to Expeditionary Force 21 (EF21), the Marine Corps capstone concept, and it's supporting operational concepts. Next, a clear understanding of the core capabilities and technology concepts that support, enable, and underpin the future warfighting concepts. Understanding these top-level strategic and operational concepts as well as their associated issues; particularly those that rely heavily on materiel solutions for resolution is critical. Concepts such as Holistic Modularity and Advanced Force 2020 as

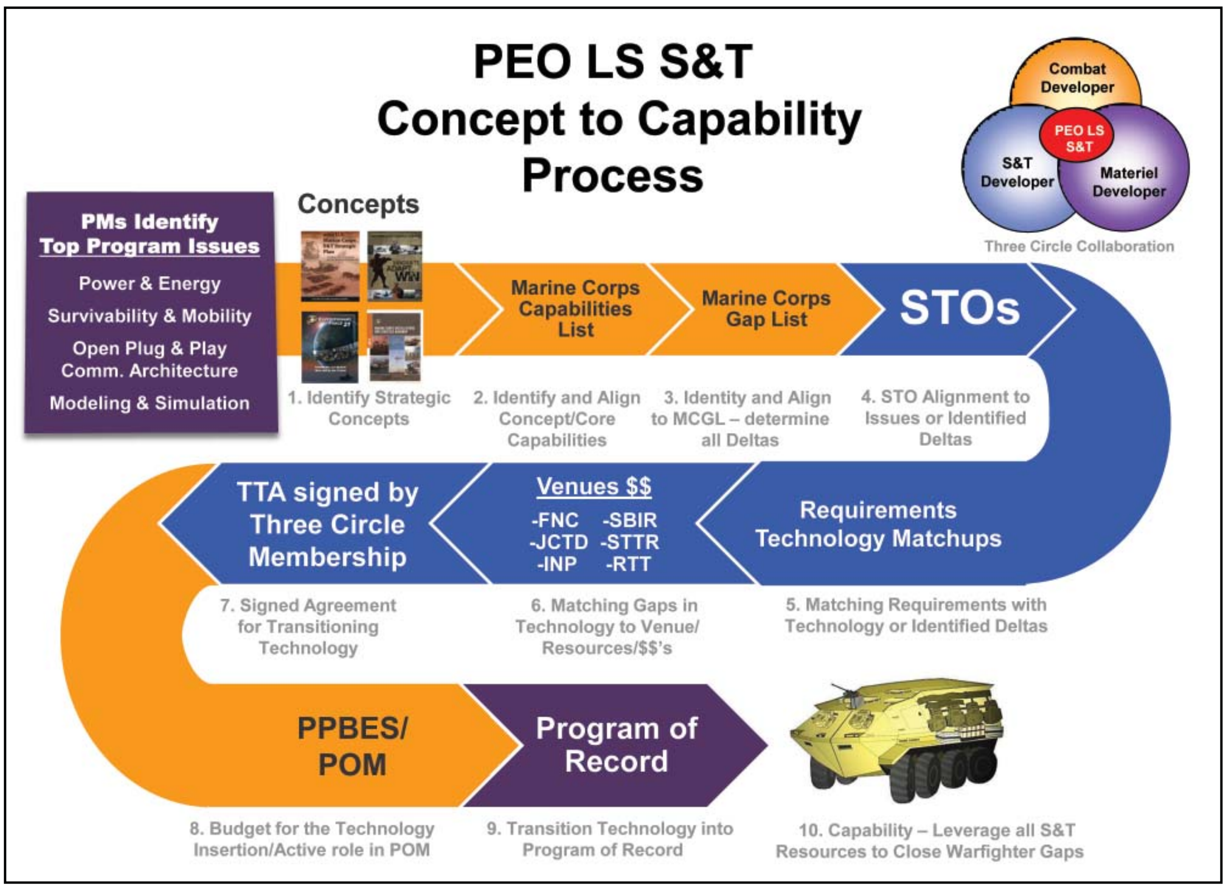

Figure 2-1. Program Executive Officer Land Systems Concept to Capability Process

well as issues 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 will be key to the success of our future warfighters..

Once the operational concepts and capabilities are understood, an analysis is conducted to identify the Marine Corps' capabilities and technology gaps. These capabilities and gaps are categorized in the Marine Corps Capabilities List (MCCL), Marine Corps Gap List (MCGL), Marine Corps Solutions Planning Directive, and the Capability Investment Plan.

The S&T Objectives (STOs) are matched to the technology issue identified by the program office and capability gap. This step is performed to ensure the traceability of S&T investments and to enable stronger support within the Program Objective Memorandum (POM)/Planning, Programming, Budgeting and Execution (PPBE) process.

Once identified, the matching requirement and S&T gap closing initiative, potential S&T Venues are examined and petitioned to fund and mature the needed 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, the S&T representative continues to work closely with the PM to ensure funding support is available (in the POM). POM funding is essential in order to integrate and transition the technology to the appropriate POR and 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 a requirement.

Utilizing the Concept to Capability process enables potential S&T opportunities and solutions to be identified, which allows the S&T representatives to better inform requirements, provide the best value for S&T investment, and transition these needed gap-closing technologies to the POR.

S&T investment is one of the earliest and necessary steps in the process of properly equipping the future force. Applied correctly, it can result in a balanced Marine Corps that is postured for the future with new state-of-the-art equipment that has been 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 United States Marine Corps (USMC) always has an overmatching technological advantage. Preserving technological superiority, a cornerstone of our National Military Strategy, is critically important as high-technology weapons become less expensive and made more readily available to non-traditional adversaries. Additionally, USMC 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;

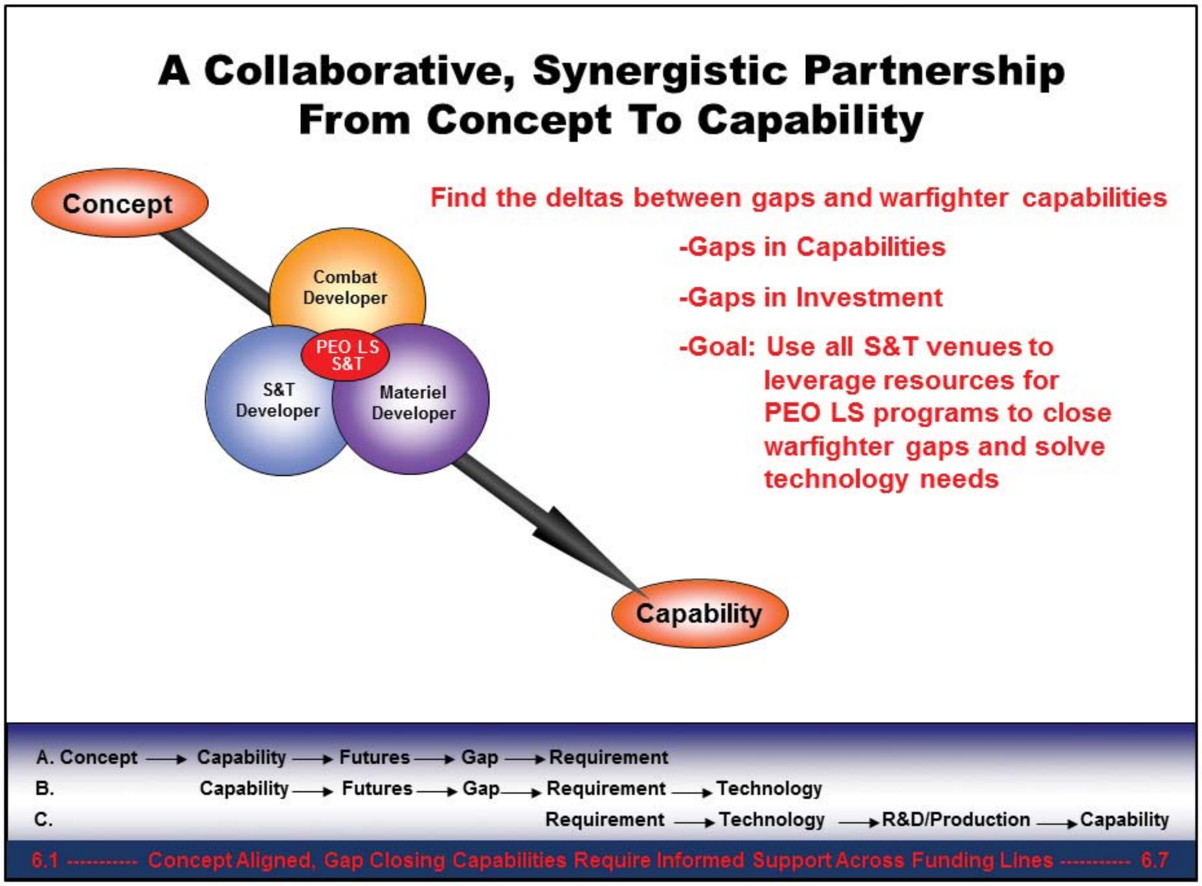

Figure 2-2. The Collaborative, Synergistic Partnership From Concept to Capability

- 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 and coordination to the 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 cosponsoring annual roundtables to identify Marine Corps S&T requirements.

Science and Technology

Science and Technology, within the Defense Department, encompasses the earliest forms of Research, Development, and Test and Evaluation (RDT&E) funding in the Federal Budget. S&T is comprised of three categories: Basic Research, Applied Research, and Advanced Technology Development. It is the path by which new ideas are investigated (Basic Research-Phenomenology), and, if further research shows a military applicability (Applied Research-Connectivity), the process continues until the technology is demonstrated (Advanced Technology Development) at a level where it is transferred to a program office (utility) to finalize the research and development (R&D) process. USMC S&T efforts are assisted by close coordination with the S&T Community, other services, academia, and industry leaders to bring together 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-Circles S&T Community. Although they have overlapping interests and influences regarding the likelihood of the transition, the collaboration, and engagement of these communities is critical for successful transitions (see Figure 2-2).

S&T Developers transition their technology to the Materiel Developers, but the Materiel Developers must first have a requirement from the Combat Developer. Therefore, stakeholder involvement is critical to ensure warfighter priorities are adequately addressed (requirements) and that the technologies being developed are aligned with a 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, Combat Development & Integration, but it also involves the Futures Directorate, MCWL, Office of Naval Research, MCSC, PEO LS, and the EA (CG MCWL) for S&T. This Three-Circles relationship is depicted in Figure 2-3.

Deputy Commandant, Combat Development & Integration

Deputy Commandant, Combat Development & Integration (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 in order 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 through the Marine Corps Force Development System (MCFDS). The Director, Capabilities Development Directorate accomplishes this activity through a Capability Based Assessment (CBA) by refining and validating the MCCL, analyzing and identifying the MCGL, and developing the Marine Corps Solutions Planning Directive to identify possible materiel and non-materiel solutions. This process culminates in creation of the Marine Corps Enterprise Integration Plan, which serves as the long-range plan to integrate capability investments. The STOs articulated in the U.S. Marine Corps S&T Strategic Plan are products of the MCFDS Process and are developed in coordination within the Marine Corps S&T Enterprise.

- The **Director, Futures Directorate/CG, MCWL** determines the future Marine Corps strategic landscape by assessing emerging security

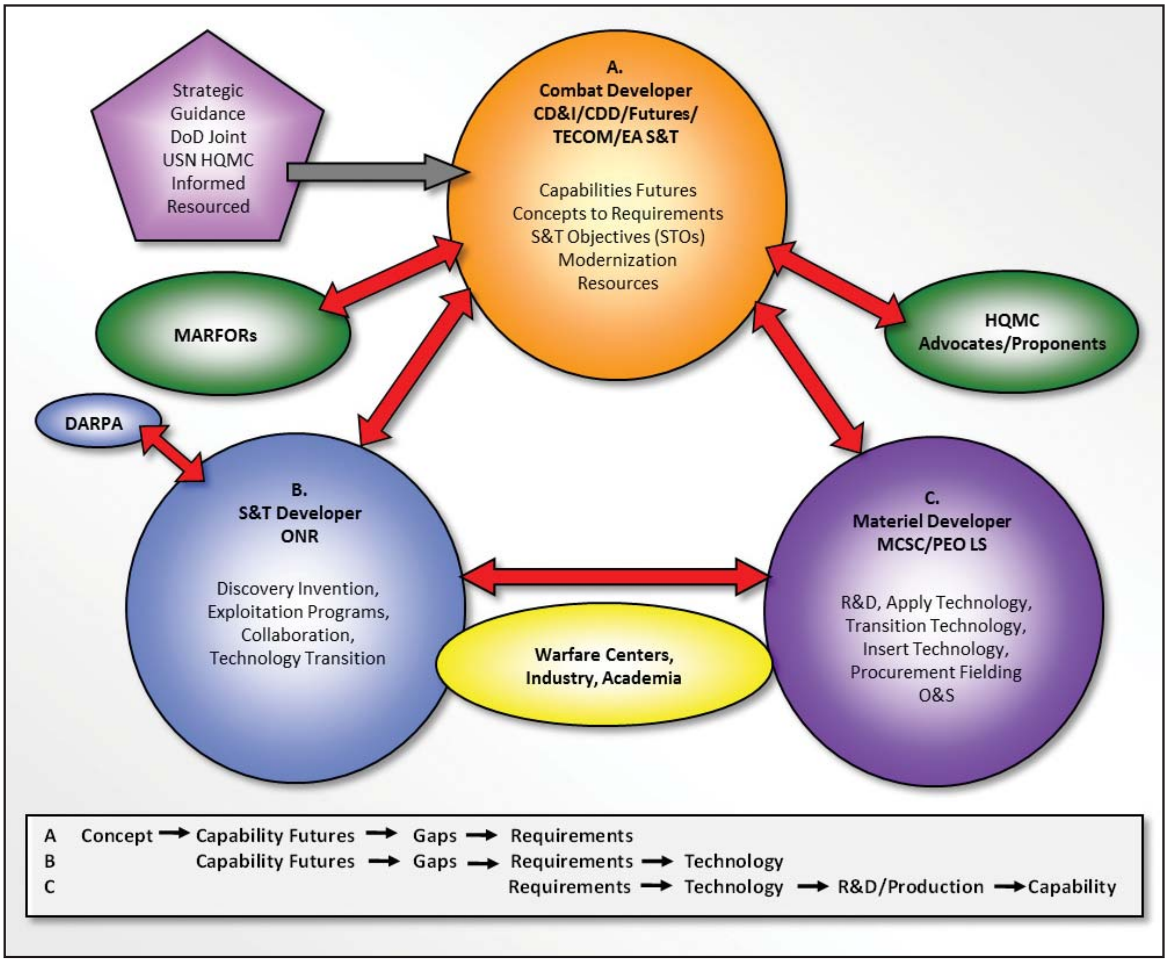

Figure 2-3. The Three-Circles S&T Community

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 functions to coordinate S&T within the combat development life cycle from requirement to transition. Through coordination with the Three-Circles 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 Office of the Secretary of Defense (OSD) and Department of Defense (DoD) and manages/monitors 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.

Marine Corps Systems Command and PEO Land Systems

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 enhanced capabilities 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, defining S&T performance and maturity thresholds, and procuring and fielding the required operational capability.

- **Systems Engineering, Interoperability, Architectures & Technology (SIAT)** is responsible for leading MAGTF systems engineering and integration efforts, ensuring Marine Corps systems interoperability with coalition and Joint forces, and identifying and pursuing S&T transition opportunities for Marine Corps systems. Deputy Commander, SIAT Technology Transition Office develops an S&T Portfolio for MCSC that responds to capability needs with innovative technology solutions.

- MCSC and PEO LS conducts a monthly **S&T Working Group (S&T WG)** to enhance S&T collaboration and to expand technology into PORs. The S&T WG assists in developing S&T processes and S&T transitions, establishing roadmaps, discussing timelines, and enhancing internal and external S&T project awareness.

- The **PEO LS S&T Director** serves as the primary advisor for all S&T policy/process issues and as a conduit for the flow of critical S&T information between all applicable S&T forums and PEO LS, and ensures the timely delivery of technology solutions to the Warfighter. The Director accomplishes this activity by working closely with PEO LS PMs (and S&T stakeholders) to resolve program technical issues, reduce program risk, and deliver state-of-the-art technology via PORs.

Office of Naval Research

The Office of Naval Research (ONR) is the principal agent in the S&T Developer circle. The S&T Developer delivers technologies that enable future warfighters to 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.

- **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. Its primary focus is on the Marine Corps, but it also supports the Marine Corps Special Operations Command (MARSOC), Naval Special Warfare Command (NSWC), and Navy Expeditionary Combat Command.

Other S&T Stakeholders

- **DARPA** relies on diverse performers to apply multidisciplinary approaches both to advance knowledge through basic research and to create innovative technologies that address current practical problems through applied research. 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, material 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. It is the Nation's laboratory for developing advanced military ground vehicle technologies, for process integration expertise, and for system-of-systems engineering solutions for Force Projection Technology, Ground Vehicle Power and Mobility, Ground Vehicle Robotics, Ground Systems Survivability, and Vehicle Electronics and Architecture.

- The **Joint Center for Ground Vehicles (JCGV)** focuses on collaboration and synchronization of portfolios for ground vehicles across the services, leveraging industry and academia to better use resources. This effort provides a key resource for Marine Corps and Army collaboration in vehicle development.

- **Industry.** Independent Research and Development (IR&D) is a program designed to enable superior performance of future United States weapon systems and components by reducing the acquisition and life cycle costs of military systems; strengthening the defense industrial base and the technology base of the United States; enhancing the industrial competitiveness of the United States; promoting development of technologies identified as critical; and increasing the development and promotion of efficient and effective applications of dual-use technologies. IR&D

is a contractor's own investment in basic and applied research and development that DoD may reimburse the company for making.

- **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 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, thereby expanding the possible talent pool for future recruitment.

- **Government Laboratories** execute long-term Government scientific and technological missions, often with complex security, safety, project management, or other operational challenges. Government labs develop unique, often multidisciplinary, scientific capabilities beyond the scope of academic and industrial institutions to benefit the Nation's researchers and national strategic priorities and sustain critical scientific/technical capabilities to which the Government requires assured access.

- The **Joint Non-Lethal Weapons Directorate (JNLWD)** was established in 1996 with the Commandant of the Marine Corps as the DoD Non-Lethal Weapon (NLW) Executive Agent. JNLWD receives ONR funding for developing and advancing the suite of NLW available to U.S. forces. The military services (Army, Air Force, Navy, and Marine Corps) are responsible for NLW procurement and sustainment. Non-lethal weapons provide warfighters with additional escalation-of-force options while minimizing casualties and collateral damage. The JNLWD stimulates innovative solutions to the toughest non-lethal technology challenges and conducts scientific research necessary to understand the risk of injury and build confidence in the effectiveness of emerging technology solutions.

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, college department, 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 chapters of the 2015 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 Enterprise, the following sections in this chapter address the methods and venues and provide a jumping off point 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.

National Advanced Mobility Consortium

There are many ways for industry to engage with PEO LS and one of them is the National Advanced Mobility Consortium (NAMC). PEO LS is in partnership with NAMC which is a non-profit, nation-wide alliance of traditional and non-traditional small businesses, large defense contractors, academic institutions, and other research organizations involved with the translational research and development of the complete range of prototype, ground vehicle and robotics systems and technologies. Via a Section 845 Other Transaction Agreement, the NAMC accelerates the transition of innovative technology into transformative ground vehicles and systems in several important ways:

- readily getting projects under contract,
- enabling technology developers to better understand warfighter needs, and
- empowering Government technical managers to broadly solicit ideas and concepts from industry and academia.

In order to get more information about NAMC please visit their website at http://namconsortium.org/

Defense Innovation Marketplace

The Defense Innovation Marketplace (DIM) [defenseinnovationmarketplace.mil] is a web-based forum that brings together the entire Defense R&D Enterprise to enable successful technology development and transition. Organized and managed by the Assistant Secretary of Defense for Research and Engineering, it is the central resource for DoD investment priorities and capability needs. Government and DoD agencies provide updated strategic documents, congressional testimony, and a list of opportunities for researchers. As a hub of resources, the DIM is a critical resource to enable interested organization to become involved in the R&D Enterprise.

Figure 2-4. The Defense Innovation Marketplace Home Page

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Section 3

MODERNIZATION THROUGH MODULARITY

"We need to do a better job of ensuring that our designs are modular - and that the government is in a position to control all the relevant interfaces…"
—Better Buying Power 3.0

Modular approaches to design in engineering, manufacture, and sustainment have been used in many commercial sectors for years. These approaches have proven useful in reducing life cycle costs and improving the ability to quickly respond to market demands. While the Marine Corps is not driven by market forces, they are challenged with an acquisition system that struggles to keep pace with rapid proliferation of high-tech threats.

Modularity holds great promise for creating the affordability and flexibility that the Marine Corps needs in the future. More importantly, modularity provides the possibility of modernizing our force while increasing tactical agility as well as operational flexibility from the sea base.

Modernization and upgrade of critical systems is a continuing requirement that is driven by the demand to maintain technological advantage and the need to stay ahead of rapidly evolving threats. However, a variety of underlying forces affect the Services' ability to modernize, including more than a decade of continuous land-based warfighting, strategic uncertainty about the future operational environment, and the increasing cost of labor and material in a constrained funding environment that will continue to exist for the foreseeable future. There are many challenges associated with modernizing the force, and if they are to remain effective and relevant, it will be necessary to identify potential solutions that can provide the Marine Corps and the Naval services holistically modular systems that are adaptable, scalable, and interoperable.

A Holistic Modular Approach (HMA) is not just a technology concept or a strategy for developing new systems; it also provides a methodology for modernizing existing systems (see Figure 3-1). The concept relies on a set of standard interfaces, a key component of modular design that provides an opportunity to obtain required future capabilities in a cost-effective manner. Where they are feasible, modular design concepts provide a means of taking advantage of widely supported commercial interface standards to develop required capabilities. Additionally, designing a system for affordable change requires modularity - a concept that is capable of delivering combat systems that are effective, upgradable, affordable, and supportable throughout their planned life cycle. Several examples of the use of modularity exist in products that we use every day. Computers (hardware and software) rely on modular components, and many automakers are building multiple product lines on modular platforms. The auto industry is trending toward fewer chassis designs that are capable of accommodating multiple models to quickly adapt to customer needs and tastes. In regard to the Marine Corps' needs, a HMA provides a means of meeting existing requirements

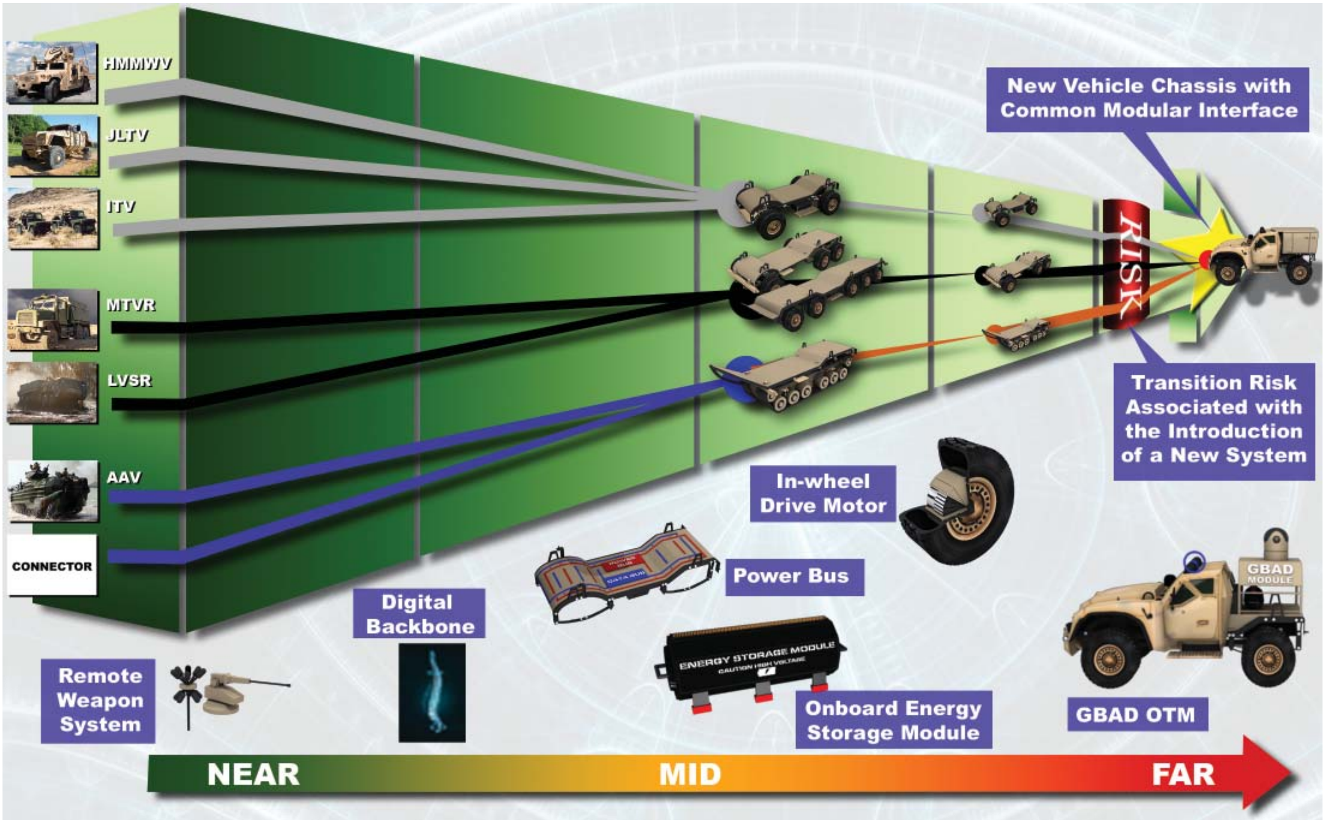

Figure 3-1. Notional Modularity: Incrementally Increasing Modularity

while establishing the foundation needed to meet rapidly evolving threats.

What is Modularity and Why is it Important?

In general, modularity can be described as the development of interchangeable system components, for use with a larger complex system, that are linked together through a set of common or standard interfaces to perform a specific mission or task. A common example of modularity are LEGO® toy sets, which are composed of blocks of varying shapes and sizes that can be linked together through a common structural interface to build a complex item. In 2005 the Naval Research Advisory Committee (NRAC) defined modular as an architecture where system functions are partitioned into elements consisting of various components that have standard/defined interfaces and minimal interdependencies in the overall system (NRAC, p.19). NRAC further defined four types of modularity: capability swapping modularity (mission-package modularity), component sharing modularity, bus modularity, and construction/design modularity (NRAC, 2005).

Since 1990, many within the DoD have begun to view the concept of modularity as having great potential. As shown in Figure 3-2, when a system is "modularized," it is decomposed into manageable components that operate independently and interface with other system components through a set of standardized interfaces. From a functional perspective, modularity has three purposes: to make complexity manageable, to enable parallel work, and to accommodate future uncertainty (Baldwin and Clark, 2006). "Modularity accommodates uncertainty because the particular elements of a modular design may be changed after the fact and in unforeseen ways as long as the design rules are obeyed. Thus, within a modular architecture, new module designs may be substituted for older ones easily and at low cost" (op. cit., p. 175).

Modularity, while not a new concept, continues to grow in its importance to industry. We have seen examples of modularity dating back to 1939, when Baldwin Locomotive Works patented a 4000-horsepower diesel engine with six generator modules (an example of functional modularity), and during World War II with the German shipbuilding industry designing and manufacturing the Type XXI Submarine in sections at various locations and shipping these modules to the Hamburg and Danzig shipyards for assembly (production modularity). A more recent example, one that has transformed logistics within the global business community, is the standard 20-foot cargo container. These containers, with their standard structural interfaces and specifically designed handling equipment, can move easily between "container ships", which are designed specifically to carry these containers, and various semi-trucks with trailers that are specifically designed to haul them.

The broad use of modular systems in industry and some military systems such as air platforms has increased interest in how to apply modularity to naval systems.

Introducing a modular concept into the DoD acquisition model can potentially provide valuable advantages in the design and acquisition of weapons systems and platforms. These advantages can range "from ease of technology refresh to decreased total ownership cost and increased readiness on the battlefield" (The Naval Strike Forum, 2005, p. 6). Numerous studies, including several ongoing studies, have been conducted to analyze modularity for military purposes. PEO LS has supported studies by ONR and Naval Surface Warfare Center Dahlgren Division (NSWCDD) that have indicated the potential for introducing a HMA. One point is clear: the success of this new modular approach is predicated on standardized interfaces and open architecture and an acquisition system that encourages open innovation. Open innovation requires modification of the existing acquisition model to one in which proprietary software/system

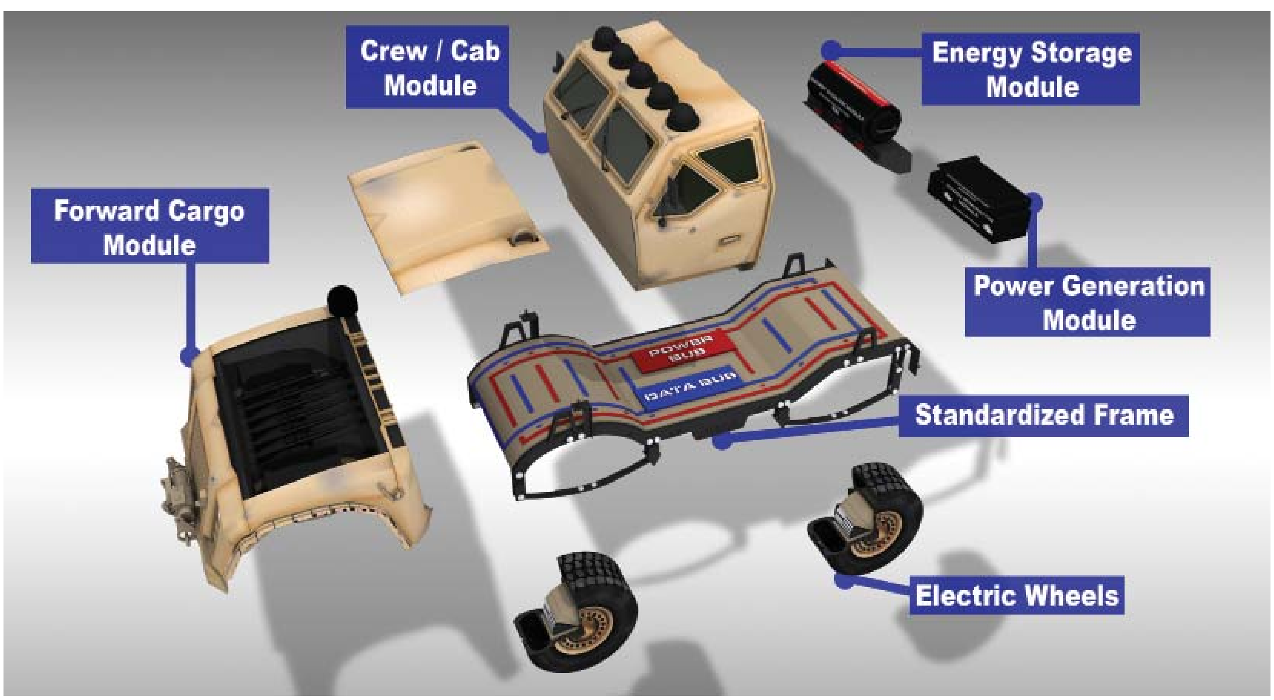

Figure 3-2. Example of Holistic Modularity

interfaces are no longer the norm. Lastly, and most importantly, modularity enables plug-and-play capabilities that will provide the expeditionary warfighter of the future the flexibility to adapt to the dynamic battlefield by enabling rapid reconfiguration of forces to ensure they are optimally configured for the missions at hand.

An ongoing ONR study points out the following potential advantages and disadvantages to Holistic Modularity:

Potential Advantages

- Total structure is more comprehensible.
- Modules can be easily replaced.
- Work division is possible without all participants having an overview of the complete system.
- Effects of changes to one part a of system on other parts are minimized.
- Many different configurations of the system are possible.
- Vendor lock-in is prevented due to standardization.
- Open innovation – enabling external entity innovation input.

Potential Disadvantages

- For very specific modules, the cost of developing interfaces can be high.
- For assemblers (integrators), it can be difficult to assess the quality and interaction of different modules.
- It can be difficult to assemble (integrate) the modules.
- The design creativity of a module designer can be limited because he needs to conform to the interface.
- Less variation in products because of overuse of the same modules.
- Total system performance may be suboptimal.
- Total module replacement costs when a cheaper sub-component has failed.

A modular design enables a system to be expanded or functionally reconfigured by incorporating new modules or replacing others with greater functionality or differing functions. A useful way to think of this concept is to visualize a desktop computer that provides basic functions such as a word processing capability, a graphics application, and spreadsheet software. In this example a modular upgrade could include the addition of a new software module such as database management software. Similarly, expanding a system's functionality can be easily achieved by installing new hardware modules such as a printer or scanner.

Applying the principles of modularity—i.e., maximum cohesiveness; grouping modules by function; low inter-modular coupling, and low intra-modular connectivity—to convert functional architectures to modular system design architectures can result in the same low cost flexibility and reliability that we have come to expect from our computers. Adding functionality is possible because the corresponding system interfaces are clearly defined, which enables designers to develop their individual modules independently.

Developing a modular design for a new system begins with the partitioning of the system into functions and identifying which elements must be designed as modules. For legacy systems, the initial steps focus on gathering information associated with the system's existing design and performing the modular partitioning and interface mapping to known functions and capabilities. Once the system design is established, the system, subsystems, and components should be prototyped to demonstrate the integration of the system utilizing the proposed

> *"Holistic Modularity. This is a factory-to-fighting position concept that relies on common platforms, parts, and scalable mission modules throughout the logistics chain."*
> **—Installations and Logistics Road Map 2013**

modular decomposition. There are several advantages to producing a prototype: it allows the design team to see the product assembled (an important aspect of a modular design); early design issues can be identified; it allows for the test of structure and function; and it can be used to generate interest in and discussion of the modularized system.

A HMA will provide the acquisition community with the tools and flexibility needed to maintain the capacity to field capabilities to meet the intent of EF 21 in this era of fiscal constraint. While an HMA concept with standard interfaces is closely related to the concept of designing for technology insert, the decoupled interfaces lead to independent and parallel development of modules. With an HMA, individual module independence supports an environment of open innovation, which facilitates incremental improvement. A new or upgraded module can be added to a system without affecting the system architecture. Frequently, capability and flexibility in system design are either traded away because of competing requirements (cost) or lost because the government's inability to cope with schedule slips associated with design challenges. In the current acquisition approach, capability that does not make it into the initial design may wait until a mid-life upgrade (which sometimes occurs ten years after the original system is delivered to the fleet). A modular design allows the program to move forward while the challenging modules are worked in parallel and delivered when ready without a major setback to the system's delivery schedule.

Modernizing through a modular approach can potentially provide significant benefits. However, a sizable effort will be required up front, beginning with identification or development of standardized interfaces (power, structural, data…), similar to the standardized interfaces, for example, that are found in most computers, such as USB, FireWire, or simple headphone jacks. After standardized interfaces are developed, systems undergoing modernization will require physical modification, such as adding a data bus or a power distribution bus. But once the modular design is adapted to the system, new modules can be procured or developed to ensure that the system maintains its technological advantage or that it adequately addresses the emergent threat.

The challenge will be to partition the modules correctly. Applying the appropriate interfaces as well as holistically partitioning the system will allow the Marine Corps to realize the maximum benefits from a modular design. A Holistic Modularity Approach that is focused on desired operational mission capabilities has the best potential of achieving these results.

> "As the Nation meets current and future challenges, it will rely heavily on the Marine Corps to be ready, relevant, and capable. While there will be consistency in our missions, we must be willing to experiment, take risk, and implement change to overcome those challenges."
> **—U.S. Marine Corps 36th Commandant's Planning Guidance 2015**

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Section 4

FUTURES

"Focus the Future Faster" via the Concept to Capability Process

The PEO LS S&T Director remains focused on the transition of affordable, reliable, and relevant capabilities into PEO LS POR and ultimately into the hands of the warfighter. The PEO uses technology investment Focus Areas as a lens through which to concentrate resources on the critical needs of warfighters. By identifying these Focus Areas in the ATIP, PEO LS has been able to align available resources within the Naval Research Enterprise, address the warfighter's needs expeditiously, and ultimately transition technologies into POR in a timely manner.

These Focus Areas serve as the primary means for identifying critical technology enablers and resolving critical capability challenges. They also incorporate natural supporting technologies that align to PEO LS programs such as fuel efficiency, intelligent power and thermal management, autonomy, corrosion resistance, crew visibility, fuel containment/fire suppression, safety, and weight reduction.

The PEO LS S&T Directorate monitors Marine Corps, Navy, and Joint efforts in the areas of futures assessment and combat development in order to articulate the potential impacts and influences across the PEO LS portfolio. This process supports the identification and prioritization of the PEO LS Top Technical Issues and associated technology needs in order to inform, influence, and align S&T investments in support of transitioning critical capabilities to the Warfighter.

PEO LS's Concept to Capability approach, 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 evolving Marine Corps Force Development System. Future risks are minimized by selecting well researched areas of 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 and to better prepare for the future.

The Concept to Capability process outlined in this plan is initiated by the Combat Developer,

> *"Expeditionary Force 21 provides an aspirational vision of how we will operate in order to guide experimentation, force development activities, and inform programming decisions. Some goals within Expeditionary Force 21 will be achieved quickly while others will require continued work and coordination to develop. However, the overarching goal is to improve how we support the requirements of Geographic Combatant Commanders (GCCs) by providing the right force in the right place at the right time."*
> **—Expeditionary Force 21**

specifically by DC CD&I's Futures Directorate (see Figure 4-1). PEO LS engages with the Futures Directorate to understand and contribute to futures assessments, concepts, and other force development actions to include experimentation and wargaming. This engagement and communication helps inform the future required capabilities. Those concepts, as well as the processes that follow, to produce the capabilities needed are driven by wide-ranging assessments of the future include everything from adversary capabilities to fiscal constraints.

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. In order to get a tailored perspective of the future, the S&T Director uses the Assessment of Plausible Future Security Environments (see Figure 4-2) which examines the possible future with all potentials that include the preferable, probable, and an alternative future. The assessment of the plausible future helps to augment existing concepts as part of the initial steps of the Concept to Capability process.

This methodology of examining current and future capability gaps to inform the ATIP provides relevant context to understanding the most likely future security environment and the capabilities required to address it. The process references and responds to DoD, 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) as espoused by experts from industry, academia, and the international community.

These probable futures are derived from baseline forecasts that extrapolate existing trends into the out years. Trends and forecasts used to support our examination of the most likely future security environments are outlined in a number of 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* (JOAC 2012)
- *Mission Command White Paper* (CJCS 2012)
- *Naval Operations Concept 2010* (NOC 2010)
- *Marine Corps Operating Concepts 2010* (MOC)
- *The Marine Corps Service Campaign Plan 2014-2022* (2014)
- *Quadrennial Defense Review 2014*
- *Expeditionary Force 21* (2014)
- *Commandant's Planning Guidance 2015*
- *Cooperative Strategy For 21st Century Seapower, March 2015*

The trends and forecasts outlined in these seminal documents, relevant to PEO LS, include:

- An era of fiscal austerity and government debt
- Cyber threat 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

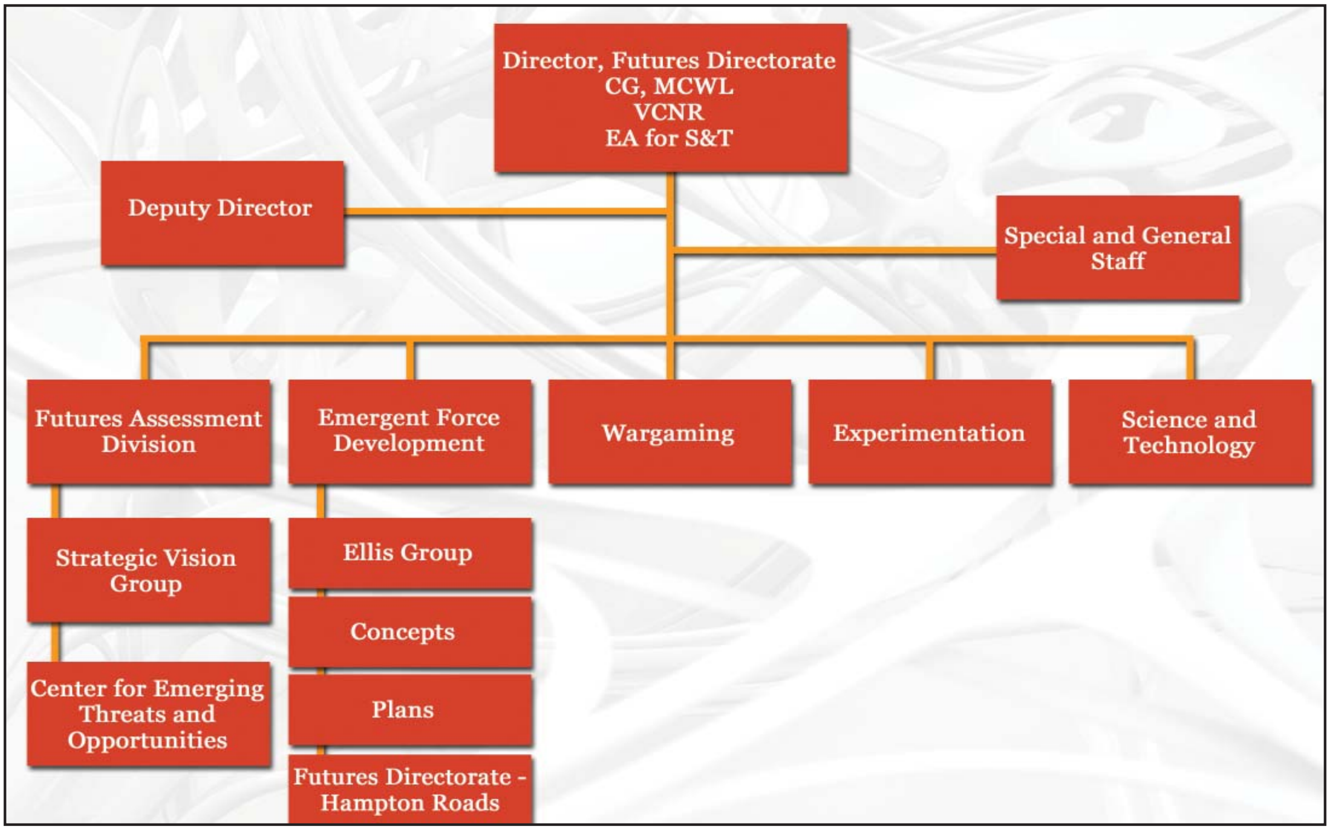

Figure 4-1. Futures Directorate Organizational Chart

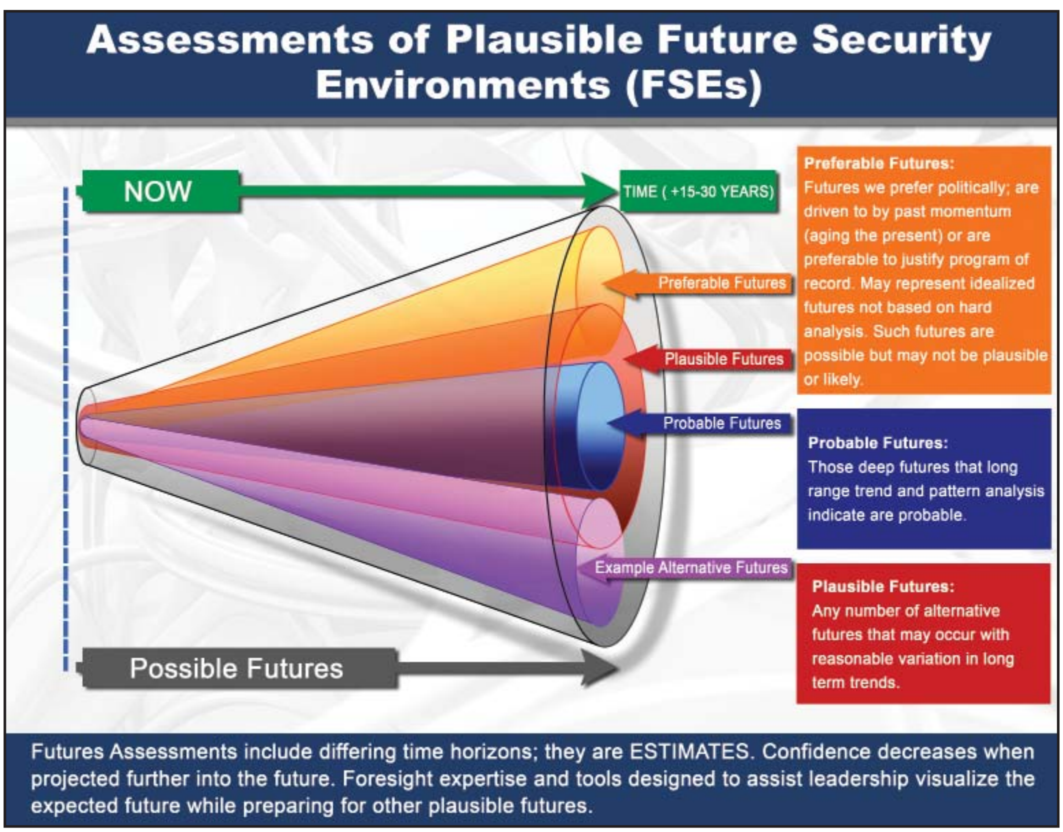

Figure 4-2. Futures Directorate Organizational Chart

- 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

Commandant's Planning Guidance 2015 and Expeditionary Force 21

The Marine Corps' acquisition community is addressing the need to equip that force with the right equipment. Having the right equipment at the right time is a major challenge that every military organization must address. There is a growing need for greater equipment flexibility and adaptability at the company level, where the vehicle operator can reconfigure the vehicle from a weapons platform capability to a protected troop carrier at the discretion of the company commander. **Modernization through Modularity** is a key future enabler and the theme of this year's ATIP. The premise is that a module will be less expensive to procure than a new platform and will allow legacy equipment to be modernized and better keep pace with expected threats in a fiscally restrained environment. A **Modernization through Modularity** approach allows for current platforms to receive periodic technology refresh while the development of new vehicles is underway.

> *"We must win today's battles while evolving, innovating, and adapting to win tomorrow's fight."*
> **—U.S. Marine Corps 36th Commandant's Planning Guidance 2015**

Potential Advantages of Holistic Modularity

- Total structure is more comprehensible.
- Modules can be easily replaced.
- Work division is possible without all participants having an overview of the complete system.
- Effects of changes to one part of a system on other parts are minimized.
- Many different configurations of the system are possible.
- Vendor lock-in is prevented due to standardization.
- Open innovation – enabling external entity innovation input.

Balancing the Tensions Across the Life Cycle

To adequately modernize the force using a HMA, the Marine Corps must balance all the tensions of current and new platforms across the life cycle of the vehicle. From a programmatic perspective, the most important of these tensions is cost. Life cycle cost includes all lifecycle management costs: development, acquisition, operations, support, and disposal. A key factor in the consideration of any system development (or recapitalization) is the impact of the cost to keep the system relevant throughout its life cycle.

By using a modular approach and decomposing the features or characteristics into less complex and more comprehensible pieces, stakeholders can identify the benefits of a system's features or characteristics by life cycle phase, which can aid in balancing competing priorities across the entire life cycle. As depicted in Figure 4-3, balancing the tensions across the system's life cycle will require understanding the benefits of each decomposed feature and characteristic (module). ONR is investigating a Holistic Modular Approach that will provide the knowledge needed to

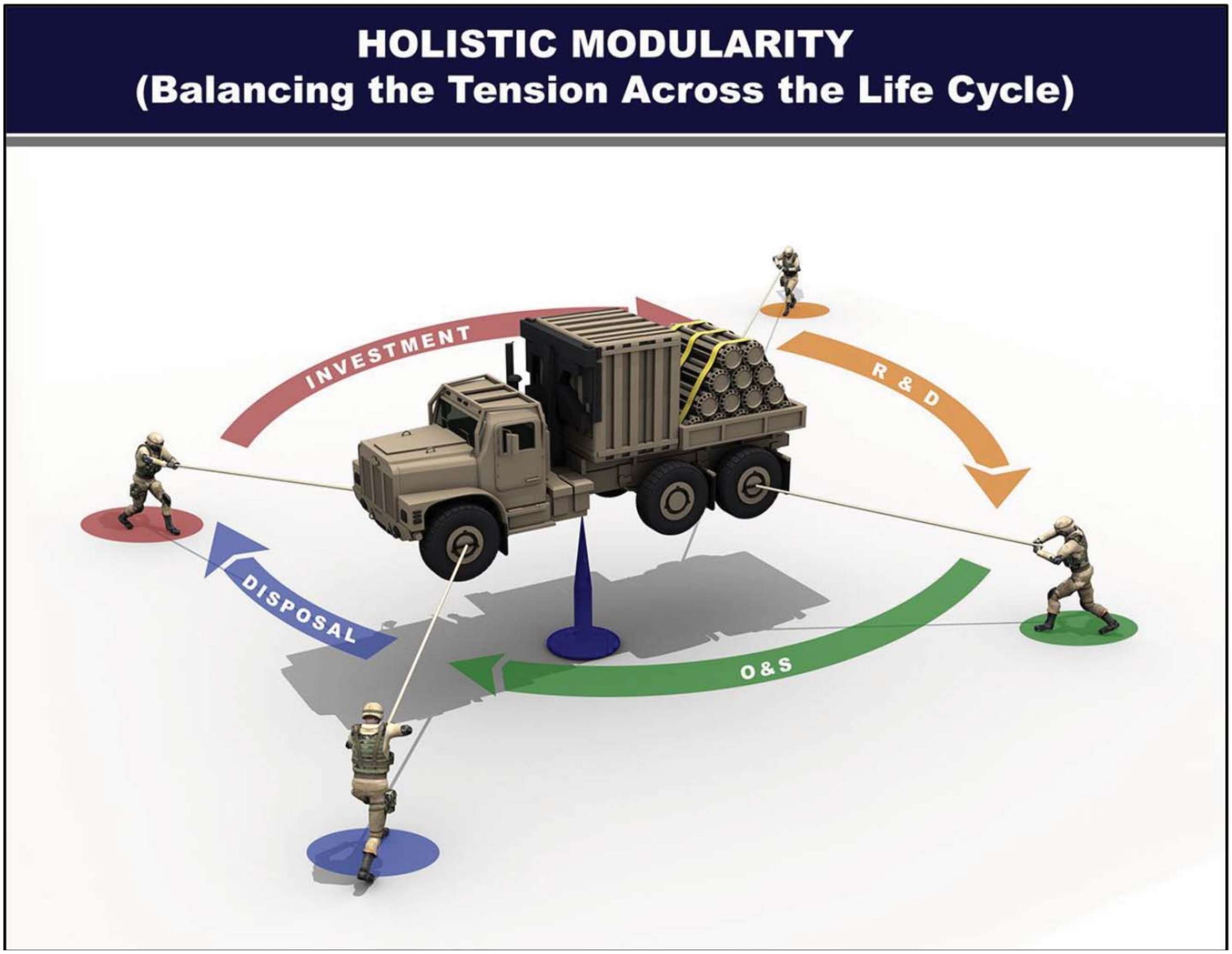

Figure 4-3. Holistic Modularity - Balancing the Tension

make informed decisions regarding necessary trade-offs and ensure the maximum benefit to the end user.

As defined in the previous chapter, modularity can be described as the development of interchangeable system components for a larger complex system that are linked together through a set of common or standard interfaces to perform specific missions or tasks. Modularity enables plug-and-play capabilities that will allow the expeditionary warfighter of the future the flexibility to adapt to the dynamic battlefield by enabling the rapid reconfiguring of forces, ensuring they are optimally configured for any mission.

The current and projected security environment that the Marine Corps will face will require a reshaping of the force. The force must evolve from focusing on capabilities that are designed for major combat operations to focusing on meeting the growing demand for security cooperation activities and crisis response requirements. In addition, this evolution must occur without forfeiting our ability to fight as a significant force in any large conflict or enduring war. Building on the proven concepts of Operational Maneuver from the Sea, Ship to Objective Maneuver, and Seabasing, Expeditionary Force 21 expands the scope and capabilities of these concepts to meet the operating environment challenges of today and tomorrow. Accordingly, building systems that are modular, scalable, and flexible ensures that the future Marine Corps will be able to rapidly innovative, adapt, and win.

> *"The current and future operating environment requires an expeditionary mindset geared toward increased efficiency and reduced consumption, which will make our forces lighter and faster. We will aggressively pursue innovative solutions to reduce energy demand in our platforms and systems, increase our self-sufficiency in our sustainment, and reduce our expeditionary footprint on the battlefield. Transforming the way we use energy is essential to rebalance our Corps and prepare it for the future."*
>
> **—James F. Amos General, U.S. Marine Corps 35th Commandant of the Marine Corps**

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** - 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:

- 3D Printing/Digital Fabrication
- Virtual Collaboration Tools
- Energy Harvesting
- Nanotechnology/Nanomaterials
- Autonomy/Robotics/Artificial Intelligence

Additive Manufacturing

Additive Manufacturing refers to a process by which digital 3D design data is used to build up a component in layers by depositing material. Additive manufacturing uses three-dimensional printing to transform engineering design files into fully functional and durable objects created from sand, metal, and glass. The idea is to use this process at the lowest tactical level where the end user can produce their own repair parts at the Forward Operation Base and reduce the strain on the logistics supply system, thus reducing convoys and enhancing combat power and readiness. A reliable 3D type printer will require raw materials, a reliable power source, and expeditionary equipment. All of these issues must be addressed, but independence from the supply chain affords the Operational Commanders tremendous flexibility.

Decentralized, Transparent Collaboration

PEO LS is currently collaborating with ONR to enhance data discovery, data management, and develop state-of-the-art visualization tools. Integral to this capability is a tool that will learn the decision maker's search patterns, data preferences, and output format preferences (similar to a NETFLIX ™ movie search) to automate many of the routine functions that are often tedious and time consuming. In addition, an enhanced interactive visualization tool will be developed to support the display and manipulation of the data to strengthen decentralized collaboration and provide greater transparency.

To enhance this capability, predictive analysis tools will be developed that will be capable of identifying critical data/information that potentially will impact PEO LS programs' design requirements. The ultimate goal is to identify potential technology solutions through a transparent collaboration environment that provides decision makers with actionable information/solutions before a problem reaches critical mass.

Energy Harvesting

In the current and future battle space, the warfighter's continuing appetite for energy will drive the need for other sources of energy beyond the current battery/fossil fuel based power sources. Portable power sources that result from these efforts will yield field applications that are lighter in weight with increased capacity. Ideally, the goal is to operate all Marine Corps equipment with a universal or interchangeable self-recharging/regenerating power source.

The Marine Corps seeks innovative, versatile, scalable renewable energy and energy storage capabilities that can be deployed in expeditionary environments.

Nanotechnology/Nanomaterials

Nanotechnology is the engineering of functional systems at the molecular scale and provides a number of technical opportunities for the PEO LS portfolio and the warfighter. The field of nanotechnology offers tremendous potential for the Marine Corps in "lightening the MAGTF" through the use of nanomaterials and in the production of lightweight armor and vehicle components.

Various basic research efforts are under way to explore nanotechnologies to enhance protective coatings, camouflage, lubricants, and lightweight materials for both vehicle infrastructure and armor applications.

> *"To strengthen interoperability in the future we will experiment with new concepts and technologies to achieve integrated effects on tomorrow's battlefield…"*
> **—General Joseph F. Dunford**
> **Commandant of the Marine Corps**

Autonomy/Robotics/Artificial Intelligence

Robotics, once solely the domain of the Sci-fi Genre now permeate our daily lives and in the near future will reach the intelligence singularity - where artificial intelligence outpaces human intellect. Advances in motion and sensing technologies continue to improve the precision of robot motion and will eventually allow robots to perform tasks once exclusively the domain of humans. When combined with advances in nanotechnology and artificial intelligence, robotics promises to not only reduce casualties and collateral damage but dramatically lighten the MAGTF.

Therefore, PEO Land Systems' future S&T investments will focus heavily on this critical exponential technology to ensure the Marine Corps remains relevant and is able to evolve, innovate, adapt, and win tomorrow's fight.

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Section 5

PEO LS TOP TECHNICAL ISSUES

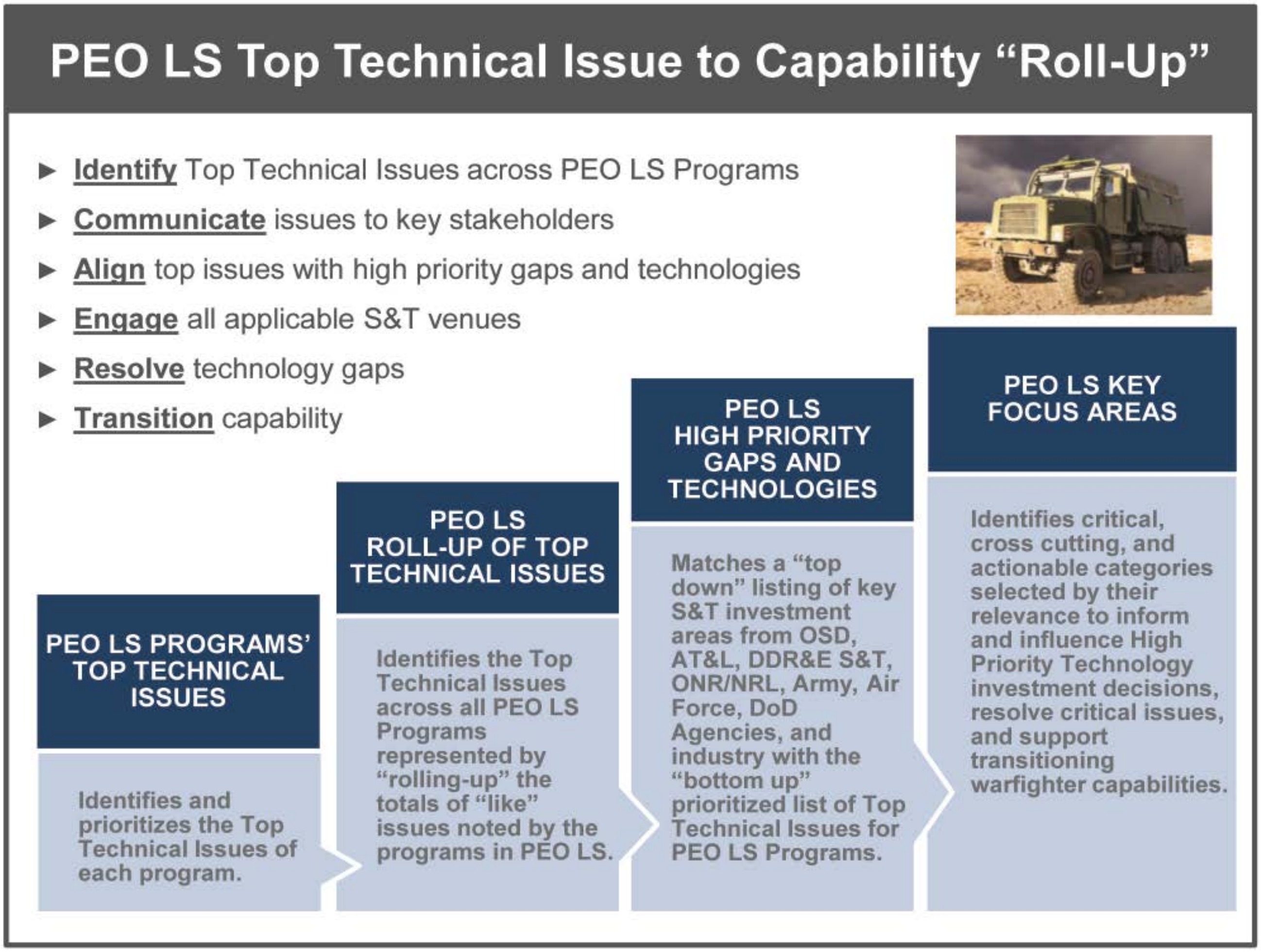


Figure 5-1. PEO LS Technical Issues to Capability "Roll-Up"

The process of determining which Top Technical Issue will result in development of an associated capability begins with identification and prioritization of PEO LS programs' Top Technical Issues. These issues were vetted through each program's S&T Representative, Lead Engineer, Deputy Program Manager, and Program Manager for concurrence and prioritization.

The Top Technical Issues across all PEO LS programs are then "rolled up" into similar categories that establish key Focus Areas and informs the prioritization of funding and research efforts. A "top down" approach of aligning S&T investment areas with the "bottom up" prioritized list of Top Technical Issues ensures a consolidated and focused effort to resolve each program technical issue (see Figure 5-1).

This process assists S&T Representatives from all PEO LS programs to work through the Top Technical Issues of their programs and identify capability gaps where S&T could potentially lead to requirement solutions. This collaborative approach has proven extremely valuable not only in identifying individual program technical 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 5-2 identifies the Top Technical Issues of each PEO LS Program.

PEO LS Programs' Top Technical Issues

Program	Technical Issues
Assault Amphibious Vehicle (AAV)	▪ Survivability ▪ Weight/Buoyancy Management ▪ Sustainment/In-Service Engineering
Amphibious Combat Vehicle Phase 1 Increment 1 (ACV 1.1)	▪ Survivability ▪ Weight ▪ Crew Visibility
Common Aviation Command & Control System (CAC2S)	▪ Voice Network ▪ Direct Air Cooling ▪ Future Data Link Receiver and Processor
Ground Based Air Defense (GBAD)	▪ Stinger Night Sight Replacement ▪ Secure Wireless Communication
Ground/Air Task Oriented Radar (G/ATOR)	▪ Lowering Manufacturing Costs ▪ Transmit/Receive (T/R) Module Efficiency ▪ Lightweight Material
High Mobility Multipurpose Wheeled Vehicle (HMMWV)	▪ Performance ▪ Energy Consumption ▪ Reliability/Durability
Internally Transportable Vehicle (ITV)	▪ Safety (Stability) ▪ Weight Saving Technology ▪ Digital Architecture
Joint Light Tactical Vehicle (JLTV)	▪ Weight/Armor ▪ Corrosion Resistance ▪ JLTV- CCWC Missile Reloading Design
Logistics Vehicle System Replacement (LVSR)	▪ Fuel Economy ▪ Increased Survivability ▪ Safety
Medium Tactical Vehicle Replacement (MTVR)	▪ Fuel Economy ▪ Increased Survivability ▪ Safety
Mine-Resistant Ambush Protected (MRAP) Family of Vehicles: Buffalo, Cougar and M-ATV	▪ Transparent Armor/Ballistic Glass ▪ Performance and Safety Improvements ▪ C4I Interoperability (VICTORY)
Lightweight 155mm Howitzer (LW 155)	▪ Safe and Transportable Battery High Capacity Technology ▪ Secure Wireless: Ruggedized/Low energy ▪ Navigation in a GPS Denied Environment

Figure 5-2. PEO LS Programs' Top Technical Issues Roll-Up

Section 6

PEO LS S&T FOCUS AREAS

Figure 6-1. PEO LS S&T Focus Areas

PEO LS S&T Focus Areas originate from high priority technologies 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 set Focus Areas serve to inform, influence, and align requirements, S&T technology investments, and support the transition of critical capability to the warfighter.

S&T Focus Areas

6.1 Power and Energy. This Focus Area encompasses technologies that expand the overall capability of the MAGTF by increasing the availability/capability of battlefield power while decreasing the logistics footprint.

6.1.1 Fuel Efficiency. This element of the Power and Energy Focus Area encompasses technologies that can enhance vehicle performance while reducing fuel consumption. Gains in this area also have a significant impact on the logistics footprint of the MAGTF.

6.1.2 Intelligent Power and Thermal Management. This element, the intelligent management of power and thermal systems, centers on development of an integrated system that manages power utilization on vehicle platforms, and heat properties in the cab and 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.

6.2 Survivability and Mobility. This Focus Area encompasses technologies that improve mobility and increase the survivability of both the Marine and the vehicle. These technologies include advanced lightweight armor concepts, active protection systems, energy absorbing structures, floating floors, shock mitigating seats, and upgraded drive and suspension systems.

6.2.1.1 Fuel Containment/Fire Suppression. This element of the Survivability and Mobility Focus Area encompasses technologies that safely extinguish internal and external vehicle fires without adversely affecting the crew. Preferred solutions will implement a system-of-systems approach that provides fire suppression and/or containment for the vehicle cab, crew, tires, fuel tank, and engine compartment.

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

6.2.2.1 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.

6.2.2.2 Corrosion. 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. Damage from corrosion can cause significant maintenance requirements, decrease readiness, and potentially degrade operational capabilities. Corrosion resistance technologies will reduce Total Ownership Costs and provide a significant increase in equipment readiness.

6.2.2.3 Autonomy. This element of the Survivability and Mobility Focus Area encompasses technologies that provide full autonomous capabilities and separate the warfighter from potentially hazardous missions while providing increased efficiency and economy of force.

6.2.2.4 Weight Reduction. This element centers on development of modular, scalable, lightweight, and affordable components/packages that are tailored to the mission to provide greater flexibility to the warfighter.

6.3 Modeling and Simulation. This element centers on 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, life cycle costs, survivability, reliability, availability, and maintainability.

6.4 Open Plug and Play Communications Architecture. This element centers on development of an affordable, scalable, and operationally flexible Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance (C4ISR) architecture for use on new and legacy platforms.

Section 6.1 PEO LS S&T Focus Area

POWER AND ENERGY

"As a Corps, we have become more lethal, yet we have also become increasingly dependent on fossil fuel. Our growing demand for liquid logistics comes at a price. By tethering our operations to vulnerable supply lines, it degrades our expeditionary capabilities and ultimately puts Marines at risk. To maintain our lethal edge, we must change the way we use energy.."

—A Cooperative Strategy For 21st Century Seapower, March 2015

The Marine Corps is improving its capabilities as a crisis response force so that it will have extended operational reach, more staying power, and greater independence from sustainment operations. In order to become more energy independent, the Marine Corps will need to achieve the following goals, as stated in the *Marine Corps Service Campaign Plan for 2014-2022:*

- Develop and implement programs and policy to extend the operational reach of the Marine Expeditionary Brigade (MEB) and increase training readiness of our forces.
- Develop and integrate plans to embed expeditionary energy into the USMC ethos. Incorporate energy considerations into doctrine, training, and education.
- Reevaluate MEF/MEB/ Marine Expeditionary Unit (MEU) fuel consumption rates to ensure naval sufficiency to support Marine contingency operations ashore from the sea base.
- Put new processes in place and complete all tasks of the Expeditionary Energy Strategy and Implementation Plan of Action and Milestones.

As these goals are set for the Marine Corps, PEO LS must address increasing energy and fuel efficiency wherever it is practicable. The PEO LS S&T team has created a two-faceted approach to address the needs and requirements of power and energy development: *Fuel Efficiency* projects and *Intelligent Power and Thermal Management* projects. Fuel Efficiency projects focus on increasing the efficiency of mechanistic systems (e.g., the engine, drive train, vehicle aerodynamics) to increase the amount of energy that can be extracted from Marine Corps vehicles per every gallon of fuel used. Intelligent Power and Thermal Management projects concentrate on solutions that increase the utility of electricity and other sources of power once it has been generated. These two Focus Areas are inherently aligned and will continue to maximize the power and energy available for the USMC vehicle fleet.

6.1.1 Fuel Efficiency

The Challenge

The existing tactical vehicle fleet and associated fossil fuel consuming end items will be in the Marine Corps inventory for quite some time. Any improvements to efficiency will have dramatic primary, secondary, and tertiary effects on fuel consumption within the Marine Corps. 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

ONR Efforts

Fuel Efficient Medium Tactical Vehicle Replacement (MTVR) – Future Naval Capability

The objective of the Fuel Efficient MTVR effort is to develop, optimize, integrate, and demonstrate a 15% fuel efficiency improvement over the existing MTVR across a set of driving cycles that are representative of likely operational conditions while maintaining MTVR affordability, current mobility, transportability and survivability capabilities. This $87.5 million ONR FNC effort is currently in Phase II and III of development. After the three 'technology packages' are developed, they will be added to a series of test MTVRs to establish actual fuel savings. The FNC project is expected to transition to the fleet in 2017.

Fuel efficient MTVR components are shown in Figure 6.1-1.

> *In designing our future force, we will.... Improve operational energy capabilities that enhance our reach and energy security. These measures will include the use of Marine Corps initiatives to improve deployed energy consumption, the development of bio-fuels, and other programs that emphasize energy efficiency.*
>
> **—A Cooperative Strategy For 21st Century Seapower, March 2015**

Additional ONR S&T projects that are of interest to PEO LS include:

- Advanced Concepts for Fuel Efficiency
- Fuel Efficiency Improvements

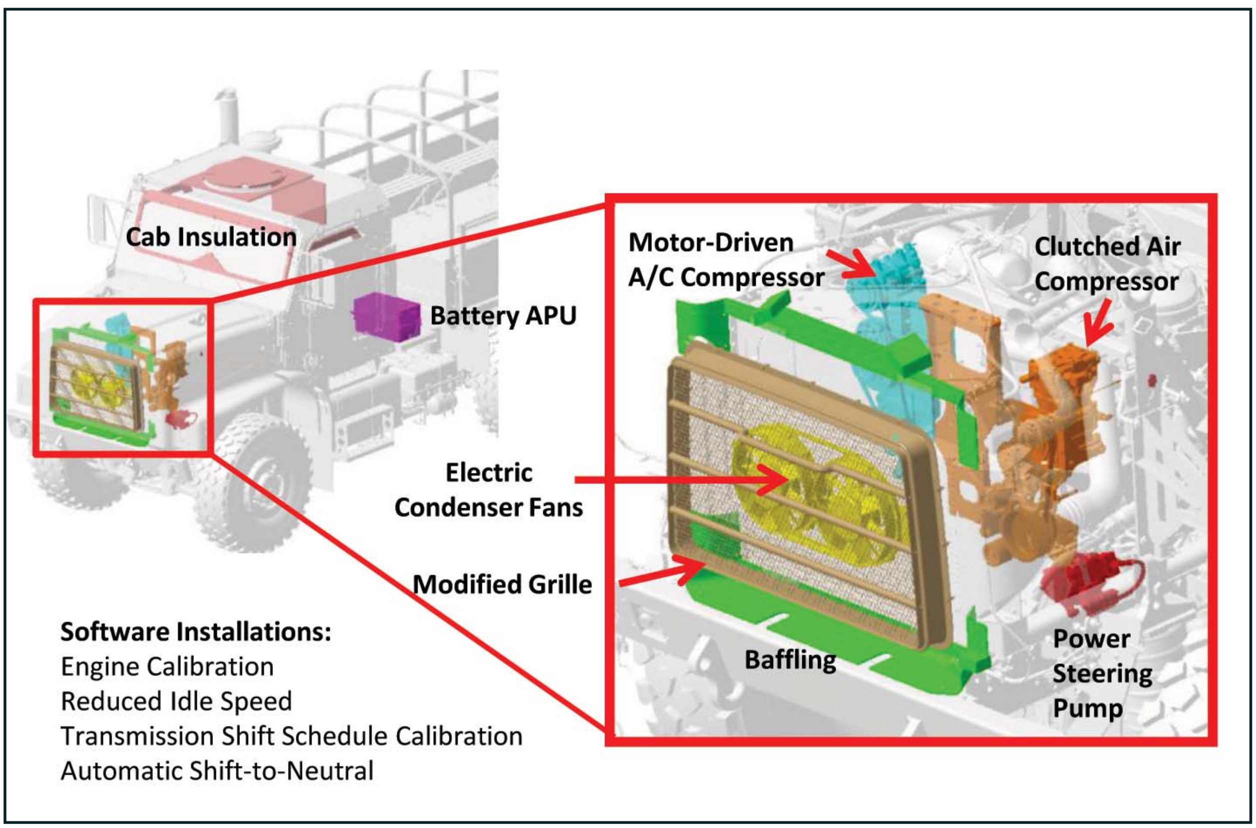


Figure 6.1-1. Fuel Efficient MTVR Components

TARDEC Efforts

Alternative Fuels Qualification (AFQ)
Problem Statement: On-going revisions to jet fuel specifications will allow non-petroleum based (NPB) content posing risk due to the Army's use of jet fuel in ground (diesel) engines. Allow Defense Logistics Agency (DLA)-Energy procurement and delivery of JP-8/F-24 fuel containing NPB to DoD/Army installations. TARDEC qualification delivers spec requirements needed for Army approval of jet fuel containing NPB as a military ground fuel. Current JP-8 spec only contains requirements for Synthesized Paraffinic Kerosene (SPK) (Fischer-Tropsch, Hydroprocessed Esters and Fatty Acids). Tri-Service harmonized qualification plan targets qualification of Alcohol to Jet [Fuel] (ATJ), Direct Sugar to Hydrocarbon (DSHC), Hydroprocessed Depolymerized Cellulosic (HDC), and Catalytic Hydrothermolysis (CH) as drop-in replacements for JP-8 (same performance as current JP-8).

Purpose: Determine JP-8 fuel spec requirements needed for approval of alternative jet fuels (ATJ, DSHC, HDC, & CH) as military ground fuel that enables DLA-Energy to source these fuels when they are commercially available at cost-competitive prices.

Advanced Thermal Management System (ATMS)
Develop efficient and intelligent cooling technology components and sub-systems and integrate with a powerpack to reduce the thermal burden and enhance operational movement and tactical mobility. The products support PM Combat Vehicle Program (CVP) and other armored ground vehicles.

- Advanced Fan System - Provide optimized fan geometry and intelligent fan drive for improved static efficiency and reduction of fan power consumption
- Advanced Heat Exchangers - Increase heat transfer within same space claim; reduce weight/volume buying back performance and internal volume.

Energy Efficient Hydraulic Fluids (EEHF)
Reduce energy (fuel) consumption in Construction Equipment/Material Handling Equipment (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 Efficient Gear Oils (FEGO)
This project will develop the necessary tools and methods to identify fuel efficient gear oils that can be competitively purchased by the DLA.

Fuel Cell In-House
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.

Advanced Combat Engine (ACE)
Development of a 1500hp, high power dense engine (>150 hp/liter) with 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.

Advanced Combat Transmission (ACT)
Development of a high efficient cross-drive transmission for a track vehicle mated to a 1500hp 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.

> *"Transforming the way we use energy is essential to rebalance our Corps and prepare it for the future."*
> **—Gen James F. Amos, 35th Commandant of the Marine Corps**

Additional TARDEC S&T projects that are of interest to PEO LS include:

- Manufacturing of Fuel Cell Hybrid Systems for Extended Missions
- Capability Demonstration 2: Battlefield Fuel Reduction & Water Generation Analysis

Small Business Innovation Research (SBIR) Efforts

Adaptive Diesel Engine Control via Variable Valve (Smart Lifter Technology) (Phase II)

Issue Addressed: Current use profile shows engine operates at two different and distinct load levels 400 brake horse power (BHP) to climb slopes, accelerate under full payload, or traverse soft soils 10 – 20 BHP to support idle vehicle operation generating electricity and heating, venation, and cooling (HVAC) functions. Current state of the art only allows engine optimization at a single operational point. Demonstrate multi-operation point optimization thru use of prototype Smart Lifters operating on a Caterpillar C-12 engine by the end of Phase II.

Objective: Demonstrate the benefit of cylinder deactivation and variable valve timing on Diesel/JP-8 engine fuel economy and power output. Estimates from Phase I suggest up to 31% fuel economy improvement during idle/surveillance mode and up to 15% fuel economy improvement during driving.

Parasitic Load Reduction to Improve Engine Efficiency (Phase II)

This SBIR program focuses on a combined software/hardware solution to reduce the volume of fuel consumed by the MTVR engine during mission operations while increasing the power output of the engine. These goals will be reached thru modification of the Caterpillar C-12 enabling full and independent control of diesel engine components allowing the engine to operate at maximum efficiency across the full spectrum of engine loads.

Variable Speed Accessory Drives (Phase II)

The objective of this Phase II research is to develop a variable ratio cooling fan drive for the MTVR. The MTVR currently utilizes 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.

6.1.2 Intelligent Power and Thermal Management

The Challenge

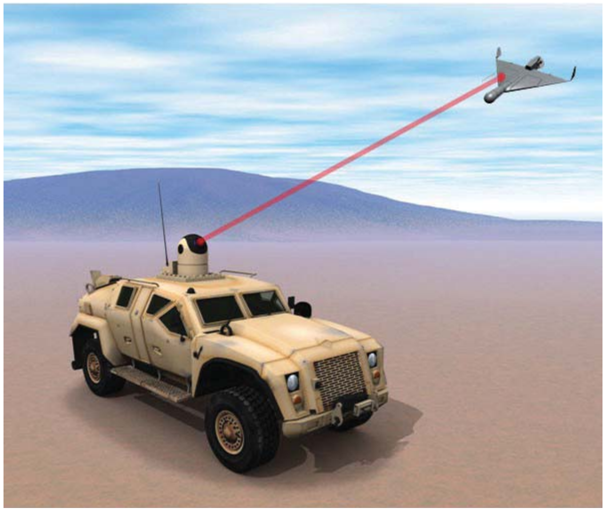
Protecting electrical systems from temperature extremes is imperative to maintaining functionality, efficiency, and operational readiness. Thermal analysis is important to the design of heat shields, anti-icing systems, propulsion system integration, and maintenance of controlled environments in cabins. Using power generated in an optimized manner and managing the different thermal loads can extend vehicle operations. 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

PEO LS Efforts

MTVR Auxiliary Power Unit (APU) Phase II Study

Issue Addressed: Reduce fuel use by MTVR during



GBAD OTM Concept

extended static operations. Use information gathered to inform requirements:

- Fuel savings versus baseline static MTVR
- Fuel savings versus standard 10kW generator
- Operations and maintenance costs
- Cost to upgrade each MTVR
- Changes to MTVR weights and capacities
- Operator and maintainer training impacts
- Provide qualitative user assessment
- Demonstrated capability using only of COTS equipment

Objective: Demonstrate capability of an MTVR with a 10kW Auxiliary Power Unit integrated behind vehicle cab. Support development of operational capability documentation and formal CD&I requirement. Phase II objective is to stand-up 5 MTVRs for User Evaluation and Testing.

ONR Efforts

Ground Based Air Defense On the Move (GBAD OTM) – Future Naval Capability

This Enabling Capability (EC) demonstrates close-in, low altitude surface-to-air laser fire in defense of MAGTF assets defending forward combat areas, maneuvering forces, vital assets installations, and/or units engaged in special/independent operations. This EC will demonstrate the capability of a rugged expeditionary high energy laser demonstrator cued by a radar that is capable of detecting low radar cross section threats and performing soft and hard kills of unmanned aerial systems (UAS) to prevent reconnaissance, surveillance, targeting, and acquisition of expeditionary forces.

SBIR Efforts

Atomic Layer Deposition Technology for Gallium Nitride Microwave (Phase II)

This project targets the development of a commercially viable silicon-nitride (SiN) Atomic Layer Deposition (ALD) process for gallium nitride (GaN) Monolithic Microwave Integrated Circuits (MMIC) applications. In particular, this project will provide a higher quality substitution for commonly used Plasma-Enhanced Chemical Vapor Deposition (PEVCD) SiN passivation layers.

An additional SBIR project that is of interest to PEO LS includes:

- Compact Auxiliary Power System for Amphibious Vehicles

"One of the most mature "game changing" technology areas is Directed Energy, and specifically, High Energy Lasers."

—Statement Testimony of Mr. Alan R. Shaffer, Principal Deputy, Assistant Secretary of Defense for Defense Research and Engineering Before the United States House of Representatives, Committee on Armed Services Subcommittee on Intelligence, Emerging Threats, and Capabilities March 26, 2014

TARDEC Efforts

Integrated Starter Generator (ISG)

The purpose of this is to develop, test and integrate a 160kW ISG system & controls to be implemented as part of the advanced powertrain demonstrator demonstrated at Transition Readiness Levels (TRL) 6.

Advanced Li-Ion Modular Batteries (AMB)

Problem Statement: Current military battery technologies have insufficient energy density to meet silent watch requirements and support the introduction of enhanced capabilities such as an ISG, APU and start/stop functionality on our military vehicle platforms. In addition, current batteries have restrictions with respect to recharge rate and operating temperature limitations. Commercial industry is not addressing this gap by developing batteries capable of meeting military requirements in military specific form factors.

Purpose: Apply recent commercial advances in Lithium-ion based anode, cathode, electrolyte and separator battery materials to electrode, cell, and military specific pack designs to:

- Double the energy density from current lithium-ion batteries from 80Whr/kg to >160Whr/kg while increasing power density by >50%.
- Increased the operating temperature range for the Li-ion batteries from (-20^{o}C to +50^{o}C) to (-46^{o}C to +71^{o}C).

Advanced Auxiliary Power Unit

Supporting CVP. Provide electrical power for ground vehicle main engine off operations. Develop a compact, scalable APU to provide power while meeting size and weight requirement.

Advanced Running Gear (ARG)

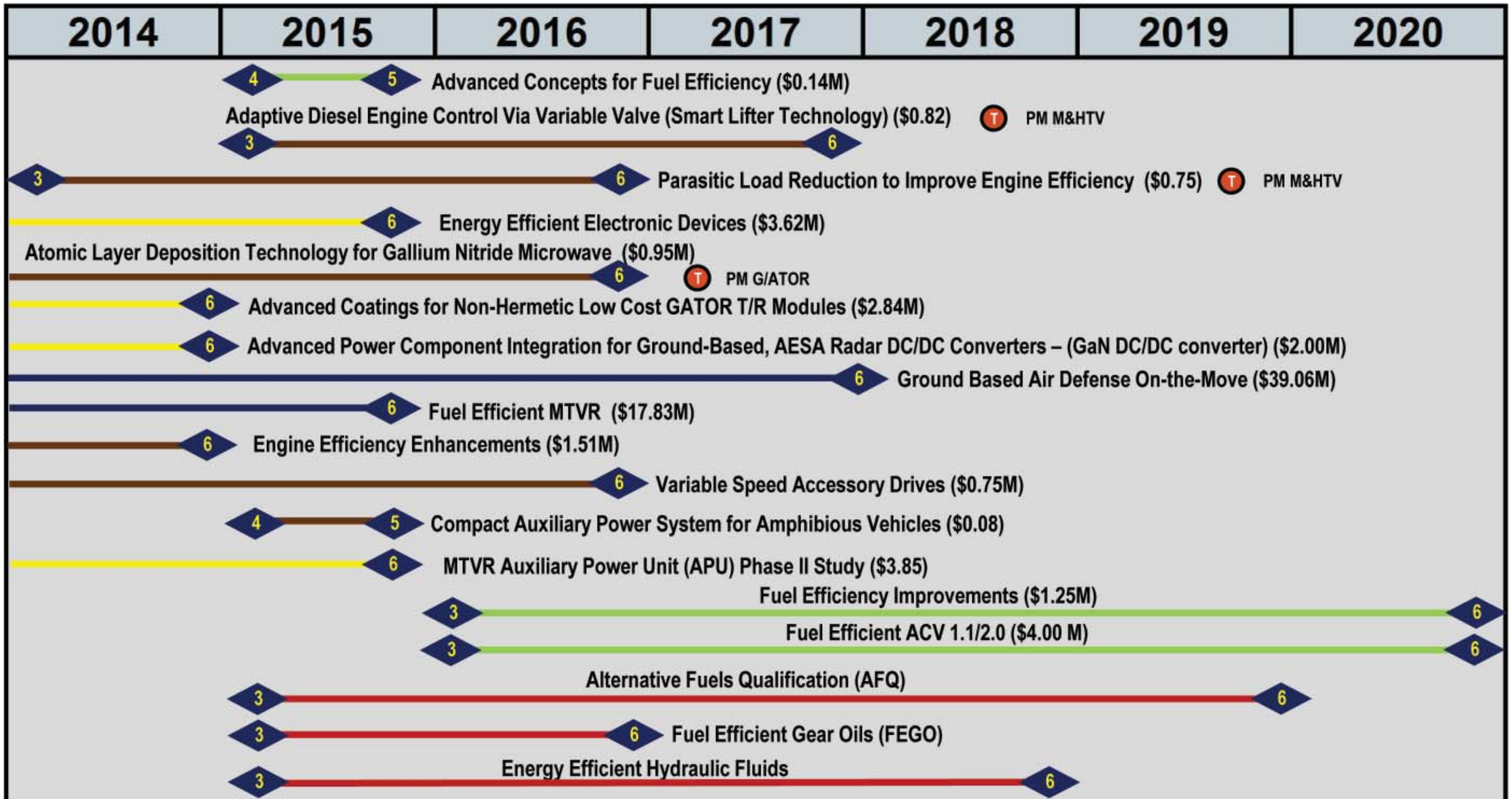
Develop external suspension and high capacity lightweight track system that will improve the vehicle mobility and survivability. The products will support PM CVP with potential to support other heavy tracked vehicle customers.

Additional TARDEC S&T projects that are of interest to PEO LS include:

- Advanced Vehicle Power Technology Alliance (AVPTA)

The Power & Energy Focus Area charts on the following pages highlight critical efforts monitored and supported by the PEO LS S&T Director.

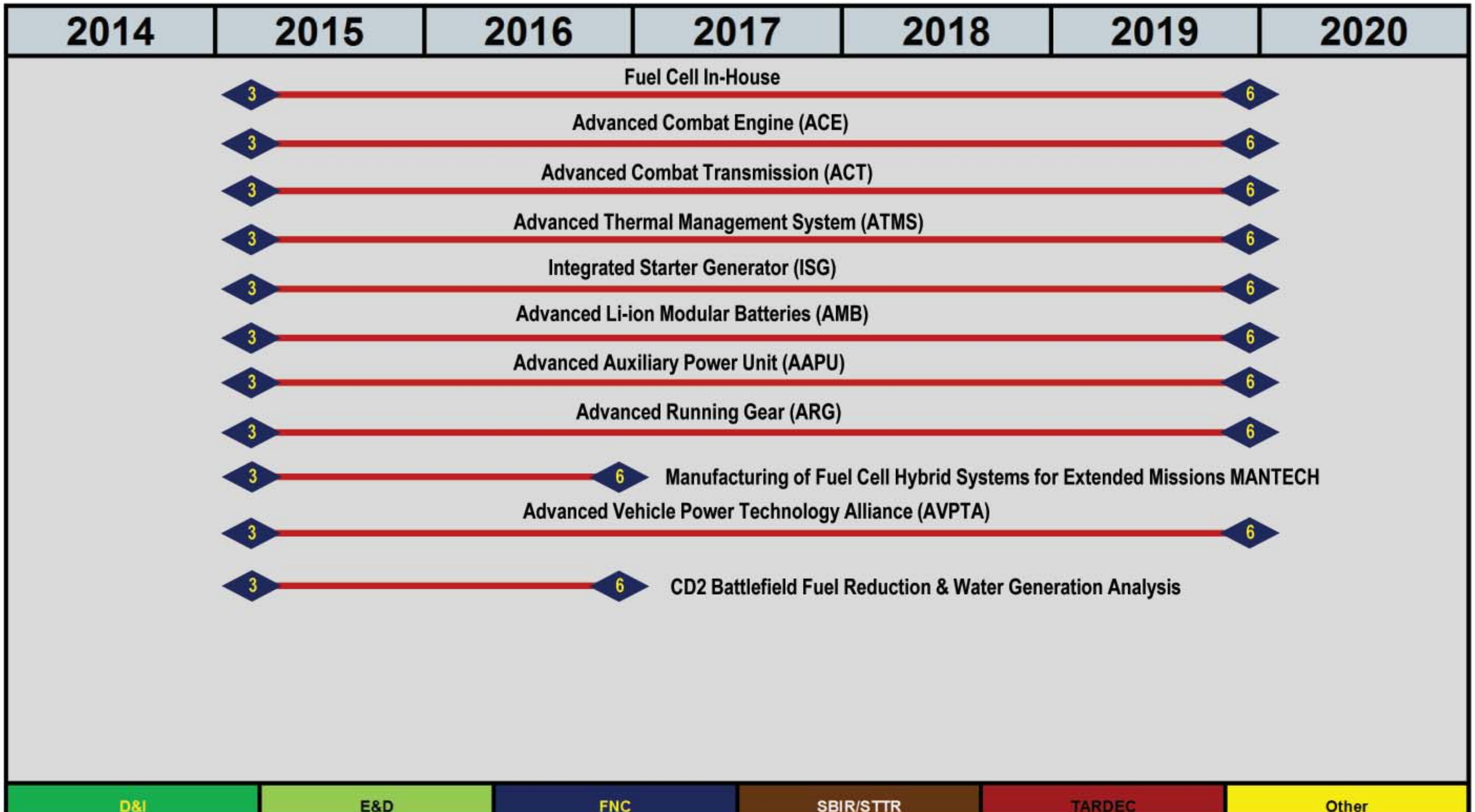
Power & Energy



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	17.31	17.72	11.90	9.81	6.20	4.19	4.25

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

Power & Energy



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)		53.97	62.57	68.48	63.28	62.79	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

Section 6.2 PEO LS S&T Focus Area

SURVIVABILITY AND MOBILITY

"Once ashore, Marines require the ability to transit complex littoral terrain."
—Expeditionary Force 21

The Survivability and Mobility Focus Area involves technologies that enhance mobility and increase the survivability of both the Marine and the vehicle. Survivability and mobility are addressed as a conjoined S&T Focus Area because what affects one often affects the other.

Survivability

The U.S. Marine Corps is focused on maintaining its role as an expeditionary force in readiness that relies on mobility, speed, and agility. Although occupant survivability increases with armor, mobility can also enhance survivability by enabling the force to move fast on unpredictable routes. A practical, affordable system of modular and scalable armor is required that meets the challenges during shipboard operations and ashore.

Mobility

The operational requirements for speed, agility, and transportability are established with the full knowledge that Marines will be taking the vehicles into harm's way. Because tactical mobility is critical to future Marine Corps operations, technologies are needed to increase the maneuver capabilities of current and future USMC vehicles.

The Challenge

Technologies are needed that provide an affordable, scalable, systems of systems solutions for current and future USMC vehicles.

Within the Survivability and Mobility Focus Area, specified sub-topic areas include:

6.2.1 Survivability:

- 6.2.1.1 Fuel Containment/Fire Suppression
- 6.2.1.2 Safety

6.2.2 Mobility:

- 6.2.2.1 Crew Visibility
- 6.2.2.2 Corrosion
- 6.2.2.3 Autonomy
- 6.2.2.4 Weight Reduction

6.2.1 Survivability

With the objective of enhancing warfighter and vehicle survivability, PEO Land Systems is collaborating with MCSC, MCWL, Deputy Commandant Combat Development & Integration (DC, CD&I), ONR, Research, Development, and Engineering Command (RDECOM), TARDEC, and other agencies. The objective is to develop affordable, state-of-the-art survivability technologies such as lightweight armor, blast absorbing seating, and Rocket Propelled Grenade (RPG) countermeasures.

The Challenge

The design, development, production, and modification of existing Marine Corps vehicles that ensure survivability and adequately protect our warfighters require a highly complex "system of systems" engineering approach. Additionally, these vehicles must provide the required mobility in order for the Marine Corps to successfully conduct expeditionary maneuver warfare.

Potential Solutions

ONR Efforts

Advanced Camouflage

This project couples technologies together to provide advanced camouflage for a ground platform that will measurably reduce the probability of detection.

Carbon Nanotube in high strain rate applications

Investigate Carbon Nanotube (CNTs) in high strain rates applications (such as ballistic penetration events) and assess the potential for application in hard-armor systems.

CNT Applications/Integration

Investigate applications of CNTs in high strain rate environments using lessons-learned for application in hard-armor systems.

Crew Hull/Floor Protection

Investigate material and structural solutions for application for floor/hull of USMC amphibious platforms to mitigate blast and ballistic penetration.

Crew Seat Protection

Investigate the next generation of energy absorbing seats for USMC ground systems.

Detection Avoidance Material and Modeling and Simulation (M&S) Development

Investigate innovative materials and develop improved M&S for advanced camouflage application. Funding and timeline information can be found in the M&S section.

Directed Energy Weapons (DEW) Mitigation

Investigate DEW threats and develop countermeasure technologies among three mechanisms; obscuration, reduce probability of electromagnetic (EM) coupling, and EM reflective surfaces.

Disruption of Conductive Particles by Pulsed Currents

Using pulsed currents and Lorentz Forces, disrupt a particulate conductive wire. Pulsing the current on the entire wire surface should provide a destabilization mechanism at lower power requirements.

Energy Absorbing Structures for Blast Mitigation

Develop and demonstrate the use of Energy Absorbing structures mounted between the blast hull and the crew compartment of a general class of tactical vehicles (5 – 15 ton) that substantially mitigates crew injuries from underbody blast (UBB). Funding and timeline information can be found in the M&S section.

Flawless Glass

Develop a methodology to produce flawless glass as part of a transparent armor (TA) system. Reducing surface flaws can increase performance of the TA systems by more than 10% thereby allowing for a reduced weight armor system.

Expeditionary Light Armor Seeding Development

Designed as a two-pronged approach, this project consists of:

1. M&S of unconventional ceramic tile seam design to eliminate weak spots enabling a lighter design

2. Design and fabricate a light armor solution for application to ACV 2.0 by scaling material solutions characterized in previous ONR 30 Maneuver Survivability programs.

Functionally Gradient Armor Materials (Additive Manufacturing)

Using additive manufacturing, fabricate light armor ceramic composite systems with novel geometries and seams.

An MRAP undergoes testing at Aberdeen Test Center, Maryland.

Golem Protection System
This a collaborative program with the Army Research Laboratory (ARL) and the Communications-Electronics Research Development and Engineering Center (CERDEC) to develop and demonstrate an RPG/Anti-Tank Guided Missiles (ATGM) defeat system. ONR funding supports sensor development, fire control system research and software programming, and some experimentation for the Golem Protection System to support USMC vehicle needs.

Momentum Transfer Armor
Examine and utilize a novel material known as sodium polyacrylate (NaPa). NaPa has exhibited compressibility under high compression rates such that if the material can be ejected opposite to the direction of acceleration, it may reduce that acceleration.

Tandem Threat Defeat and select ATGM
The project goal is to continue with technology development to defeat Tandem Chemical Energy (CE) threats and ATGM.

Underbelly Blast Mitigation
The purpose is to investigate the ability to write electric discharges onto surface to open "tubes" to allow preferential gas to flow through them. This ability to quickly and preferentially channel blast gases has potential for both offensive and defensive applications. One example is the potential to reduce the impulse from underbody blast due to high-pressure gases by up to ~50%.

Figure 6.2-1. Multi-Degree Of Freedom Rollover-Impact-Blast Effects Simulator

Multi-Degree Of Freedom (MDOF) Rollover-Impact-Blast Effects Simulator

The goal of this ONR/ARL project is to design and build a MDOF motion simulator to test local and global vertical acceleration and rotation by simulating off-center of gravity underbody blasts and rollover effects in a laboratory setting without the use of explosives (see Figure 6.2-1). This simulator will enable ONR and ARL to develop and validate crew protection concepts under representative loading conditions.

Additional ONR S&T projects that are of interest to PEO LS include:

- Government Blast Model of the MTVR
- Next Generation Accelerometer for Shock Loading

RDECOM & TARDEC Efforts

System Integration Laboratory (SIL)

The Integrated Survivability System Integration Laboratory (ISSIL) developed at TARDEC is a tool that enables and enhances the integration of soldier survivability technology suites. TARDEC utilizes the ISSIL to bridge the gap between concept and capability of survivability initiatives. The ISSIL is a critical tool for enabling the integration of mechanical, electrical, data, and networking components as well as for validating the system integration through soldier/Marine usability trials.

Advanced Armor

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

Advanced Countermine (ACM) / Improvised Explosive Device (IED) Payloads Competency

The ACM/IED Payloads Competency have the objective of:

- Provide forward standoff payloads to mitigate pressure and command actuated under hull explosive hazards that includes manned and unmanned systems

- Enhance existing roller and wire neutralization systems with new technologies to meet identified gaps; effectiveness, mobility, cross platform functionality, etc.

- Provide the ability for the roller to adjust its posture to deliver consistent effectiveness across wheeled platforms and terrain profiles

- Design a dismounted payload to function in worldwide terrain environments

- Develop counter IED technologies for adaptation to a track vehicle.

- Augment other survivability technologies to provide greater overall protection for soldier and platforms.

Advanced Passive / Active Blast Mitigation (BM)
This project explores mature blast mitigation technologies through product development, integration and validation. The goal is to meet the 4X+ underbody blast requirements by integrating interior and exterior blast mitigation technologies on a combat vehicle representative blast buck, and to fully understand blast load paths through vehicle platforms by decomposing the load paths through each subsystem and subsystem interface.

Warfighter Injury Assessment Manikin (WIAMan)
The goal of WIAMan is to develop an improved blast test manikin incorporating medical research that provides an increased capability to measure and predict skeletal injuries of ground vehicle occupants during underbody blast events. Funding and timeline information can be found in the M&S section.

Mitigation of Blast Injuries
The goal is to develop a high fidelity model of the MTVR and Anthropometric Test Dummy (ATD), utilize physics-based code to model mine blast load on vehicle/ATD, and correlate the ATD damage with crew injury. Funding and timeline information can be found in the M&S section.

Additional RDECOM and TARDEC S&T projects that are of interest to PEO LS include:

- Fire Protection Competency

- Interior Impact Protective Solutions

6.2.1.1 Fuel Containment/Fire Suppression

Tactical Ground Vehicle fires pose a significant threat to Marines, their vehicle platforms, and critical cargo. PEO LS is incorporating a systems approach to address fuel containment and fire suppression.

The Challenge

Given the need to provide suitable fuel containment, fire detection, and fire extinguishing capabilities, space and weight limitations present a serious challenge for Program Managers. Potential solutions for providing these capabilities include the use of a “Clean Agent” that safely and effectively suppresses fire, prevents explosion, and provides for rapid crew evacuation. PEO LS is exploring an aqueous-based Automatic Fire Extinguishing System (AFES), which will include research into identifying the crew casualty injury criteria required for design and development of an aqueous-based AFES. Development and testing of a prototype aqueous-based system is planned after crew casualty injury criteria are identified.

Potential Solutions

ONR Efforts

Modular Lightweight External Fuel Tank System
The objective of this ONR SBIR is to design and develop a lightweight modular fuel tank that can withstand hydrodynamic ramming forces and provide protection against a ballistic impact from

Before and after results of pool fire testing at Aberdeen Test Center.
Left photo: Prepared Test Vessel; Right photo: Fuel tank with full volume of fuel post fire

a 14.5mm armor-piercing projectile using a multi-layer laminate design that achieves a significant reduction in weight compared to existing systems. A lightweight modular fuel tank would reduce the power and fuel requirements for an amphibious vehicle while mitigating fire issues.

RDECOM & TARDEC Efforts

Common Automatic Fire Extinguishing System (CAFES)

The goal of this project is to develop a reliable, maintainable, and safe common tactical vehicle AFES that will reduce the probability of crew incapacitation and vehicle kills from fire threats and reduce logistics and maintenance costs.

Fire Protection SIL

This laboratory will provide in-house integration and evaluation of fire protection system technologies, including an M&S capability that will allow prediction of fire extinguishing system performance and comparison of multiple configurations. Other lab capabilities include:

- Analysis of agent distribution within test vehicles.
- Test fire performance of different vehicle configurations in a reconfigurable box.
- Simulations of ballistic threats with variable fuel spray test setup.
- Analysis of occupant safety for noise, impact force, and toxicity levels.
- Conduct of fire performance simulations.
- Reduction in integration and test costs.
- Enhanced ability to transfer fire protection technologies to vehicle PMs.

SBIR Efforts

Aqueous Based AFES

The purpose of this ONR SBIR is to develop an aqueous solution that provides vehicle crew protection against crew cab fires, fire re-flash, and 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.

6.2.1.2 Safety

Safety considerations include vehicle stability; safety equipment, including restraint harnesses; fire suppression; clear fields of view; training; policy; procedures; and lines of communication with the warfighters.

The Challenge

The challenge is to accomplish the Corps' operational objectives while ensuring the safety of personnel. Safety preserves personnel and equipment but safety considerations cannot contradict the mission of the Corps' operational objectives.

Potential Solutions

ONR Efforts

Continuous Estimation of Center of Gravity, Inertia, and Loading

Poseidon Systems, in collaboration with Rochester Institute of Technology proposes to 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 requires minimal set of low cost sensors that can be easily integrated into existing vehicle platforms. Funding and timeline information can be found in the Mobility section.

Modular ATD

The Modular ATD is specifically designed for use in blast and ballistic testing. The ATD offers improved biofidelity compared to existing ATDs, with a frangible skeletal system and soft-tissue covering that simulates the human form. Sensors are provided to document loads experienced during impact events.

Post-IED Hull Inspection Tool (ONR SBIR)

Following a vehicle IED event, it is critical to make informed, accurate decisions for damage assessment and repair. Marines are dependent on qualitative visual inspection of hulls to evaluate damage following IED events. The Post-IED Hull Inspection Tool will provide an integrated suite of tools to quantitatively characterize damage, generate reports, and provide disposition and repair guidance based on an analysis of the data.

The objective is to provide forward-deployed Marines with 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 tool will include:

- 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-developmental item (NDI) technologies

Funding and timeline information can be found in the M&S section.

"We will continue to support the fielding of systems that enhance our proficiency and safety in operating weapons and equipment."
—Commandants Planning Guidance 2015

Variable Vehicle Cone Index (VCI)

The Variable VCI project objective is to develop a system that will enable on the move monitoring of road conditions and automatically adjust to optimal tire pressure. Better traction, safer handling and fuel economy are the payoff. Funding and timeline information can be found in the Mobility section.

SBIR Efforts

Active Laser Protection System

The use of commercial off-the-shelf laser systems as weapons is increasingly becoming real. Battery operated visible and infrared lasers can be purchased with powers near 1-watt, sufficient to cause permanent eye damage. Future threats may include frequency agile lasers. It is critical that countermeasure systems provide laser eye protection (LEP) across the visible and infrared waveband.

Human Body Model

Current ATD used to predict human injury risk in Live Fire Blast testing have several limitations, which are mainly due to a lack of biofidelity and limited injury assessment capability. The ATD is comprised of metals, rubbers, and plastics, and the majority of injury metrics used with the ATD were developed under automotive crash loading scenarios.

The human body model effort leverages 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: 1) allow vehicle designers and evaluators to predict risk of injuries across the severity spectrum experienced in the real world; 2) supplement ATD results with prediction of injuries beyond fracture; 3) expand injury risk assessments beyond the 50th% male; 4) support theater event reconstruction; and 4) deliver injury causation determination. Funding and timeline information can be found in the M&S section.

6.2.2 Mobility

The Challenge

As the nation's premier expeditionary fighting force, mobility is critical to 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

Active Sensing and Predictive Mobility

The goal of this effort is to optimize vehicle performance by adapting on-board systems and components (in real time).

Flex Fuel Combustion will enhance modeling/simulation baselines to predict engine performance/degradation for all DoD platforms using a wide variety of logistic/alternative fuels in a military environment. This will be used to increase operational availability, extension of range via efficiency improvement, and reduce maintenance and increase vehicle availability for platforms by optimally controlling combustion regardless of substantial fuel property variation.

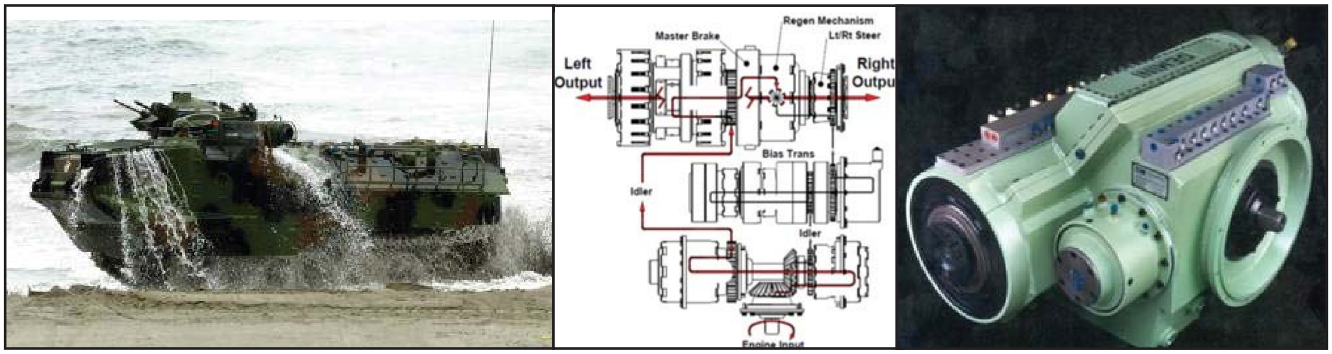
Tech Insertion for Recapitalization

The goal is the development data-based decision methods for evaluation of potential sustainment and upgrade investments from a Total Life Cycle Management perspective.

"Marines will maneuver from the seabase in a family of high-speed connectors that includes amphibious vehicles, tilt-rotor and rotary bladed aircraft, and high-speed surface craft. Once ashore, Marines will have freedom of maneuver either dismounted or utilizing a family of highly mobile and survivable combat vehicles."

—2012 U.S. Marine Corps Strategic Plan

MTVR boarding an amphibious vessel.



The Advanced Transmission Technology is intended to bring new life into the AAV.

Advanced Transmission Technology
This project will develop and demonstrate a 32-speed binary logic transmission with increased transmission efficiency (greater than 90%) and reduced power loss (35% down to 10%) for 20- to 40-ton tracked military vehicles.

Vehicle Agnostic Modularity (VAM)
VAM will provide a well-structured application of Modularity principles to ground platforms that will extend tactical range, extend operational reach and increase endurance in the field, reduce excess capacity and reduce logistic footprint/burden, enhance small unit effectiveness, lighten the MAGTF load, enhance commonality, and reduce Total Ownership Cost (TOC). Funding and timeline information can be found in the Open Plug and Play Comms Architecture section.

Additional ONR Mobility S&T projects that are of interest to PEO Land Systems are:

- Amphibious Vehicle Extended Water Range
- Low Complexity Suspension System for Amphibious Vehicles

<u>RDECOM & TARDEC Efforts</u>

Joint Tactical Transport System (JTTS) Demonstrator
The objectives of the JTTS:

- Aid future acquisition of medium and heavy tactical fleets, by developing concepts that improve commonality and reduce redundancy in mission roles
- Enable trade-offs between affordability and performance in each addressed capability area
- Provide hands-on engineering and integration experience through all phases of development from decision management to requirements, through system evaluation and test.
- Provides for cross-TARDEC, multiple technologies integration platforms by aligning with current S&T landscape.
- Demonstrates integrated systems engineering framework capability for support of ground vehicle development.
- Inform acquisition requirements for future Medium Tactical Vehicle / Heavy Tactical Vehicle platform.

6.2.2.1 Crew Visibility

Tactical vehicle crew members requires unobstructed visibility for achieving maximum situational awareness.

The Challenge

The challenge is to increase vehicle visibility without

Corrosion Service Team (CST) members perform corrosion maintenance on site.

imposing a heavy penalty on size, weight, power (SWaP), and cost is the goal.

Potential Solutions

ONR Efforts

Transparent Armor

The goal of this ONR SBIR is to reduce transparent armor for relevant threat by over 30%, and then transition technology to relevant vehicle platforms. Additionally, the Transparent Armor project will develop a ballistic model useful for other programs.

Transparent Armor Integration

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

Advanced Directed Energy for Protection for Ground Degraded Visual Environment (DVE)

The goal of this project is to increase situational awareness (SA) in all conditions and environments, to include degraded visual environments, for ground vehicle systems. The system will utilize scalable SA sensing and immersive intelligence to improve occupant and vehicle survivability and provide augmented transparent battlefield vision. Funding and timeline information can be found in the Survivability section.

6.2.2.2 Corrosion

Corrosion is the deterioration of metal as a result of a reaction with the environment. Due to the amphibious nature of the Marine Corps, operations are often conducted in highly corrosive environments that can include combinations of saltwater, high humidity, sand, coral, and mud and road debris.

The Challenge

The challenge is to identify and implement enhanced anti-corrosion technologies to extend vehicle service life, reduce required maintenance, and prolong the operational viability of legacy systems.

Potential Solutions

ONR Efforts

Joint Light Tactical Vehicle (JLTV) Self-Healing Paint

ONR partnered with John Hopkins University Applied Physics Lab (JHU/APL) in this three-year effort to develop a self-healing paint that delays the onset of corrosion and extends the life of a particular system. Self-healing paint instantly repairs scratches below a maximum width and protects the material below the paint from corrosion. The current approach is to paint surfaces with a protective coating. Currently available protective coatings have limited abrasion resistance and can be easily compromised exposing the corrosion-susceptible material below.

> *"A major cost driver to the Department of Defense is the force structure but, technology is maturing to augment the human, possibly keeping the warfighter out of harm's way and reducing the numbers of warfighters needed to conduct operations."*
>
> **—Statement Testimony of Mr. Alan R. Shaffer, Principal Deputy, Assistant Secretary of Defense for Defense Research and Engineering Before the United States House of Representatives, Committee on Armed Services Subcommittee on Intelligence, Emerging Threats, and Capabilities March 26, 2014**

MCSC Efforts

Corrosion Prevention and Control (CPAC)

The goal of this MCSC effort is to establish an effective CPAC program to extend the useful life of all Marine Corps tactical ground and ground support equipment, and 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 Service program. 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 over $20 million annually. With the expansion of the program and the use of advanced technology, savings are anticipated to continue to accrue.

6.2.2.3 Autonomy

Autonomy has the potential of becoming a Marine Corps combat multiplier. 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. Additionally, autonomous vehicles can free up manpower from logistics missions, making them available for more tactical roles.

The Challenge

The challenge is to identify, develop, and implement light-weight, affordable, and autonomous technologies/solutions that seamlessly integrate onto existing platforms and dramatically increase the flexibility/capability of operational commanders.

Because Unmanned Ground Vehicles (UGV) have been playing an increasingly important role in combat, the need for new capabilities has been steadily increasing. Current unmanned ground vehicles require a "man-in-the-loop" 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 the 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.

Cognitive Architectures that Engenders Trust
Investigate components to enable effective interaction between robot and warfighter in support of Wingman concept.

Coherent and Accurate Status Updates (CASU)
Adapt existing robotic cognitive architecture models of damage control and patrol to enable meta-information access.

Collaborative Heterogeneous Autonomous Systems
Develop and demonstrate collaborative robotic behaviors involving multiple autonomous vehicle types including mixed teams of ground and air platforms.

Complex Scene Analysis
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
Develop, implement, and demonstrate multi-vehicle autonomy enabling multiple unmanned ground vehicles to perform collaborative behaviors in support of various expeditionary military missions (force resupply, convoy protection, and route reconnaissance).

Intelligent Autonomy Architectures
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.

Internally Transportable Vehicle (ITV) Autonomy Conversion - Autonomy Integration
Facilitate transition, integration, and maturation of autonomous capabilities for a full system demonstration and Limited Military Utility Assessment (LMUA) of Autonomous Logistic Connector Mission in FY16.

Model Predictive Motion Planner

Extend the state-of-the-art in model-predictive motion planning algorithms to include highly reactive driving maneuvers utilized by professional human operators in order to develop a model-predictive hierarchical motion planner for navigation of diverse mobile robot systems in heterogeneous environments.

Natural Interaction between UGV and Squad

The goal of this project is to develop and demonstrate technologies that will enable Marines to communicate with autonomous machines, and vice versa, using the same familiar methods commonly used 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

Explore artificial means of replicating the cognitive and perceptual performance of biological systems in a context relevant to 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

Enable autonomous night operations by developing and quantitatively demonstrating 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) over 1hr in GPS-denied environments at 20mph.

Operation Force Engagement Test Support (MEC)

Establish critical link with user community to improve the design, development, and assessment of Autonomous Logistic Connector capability for FY16 LMUA.

Perception Under Adverse Conditions

Develop and demonstrate 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

Demonstrate that a path planner that uses high-fidelity terrain, kinodynamic vehicle models, and nonholonomic trajectories will enable navigation to be 20% faster and with 25% less interventions through complex (3.5 RMS, Gxx(n)=9.2x10-1(n)-2.1) In cluttered environments (50% obstacle density with an average gap/vehicle width ratio of 1.3 for autonomous unmanned ground vehicles.

Scene Comprehension and Representation

This project builds on previous efforts to further 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

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%; 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 require the ability 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.

Trafficability and Mobility Analysis from Remote Sensing

Using remote sensing products focused on terrain and soil characteristics to generate the mobility corridors from the modified combined obstacle overlay of the intelligence preparation of the battlefield (IPB) to improve maneuver planning in the littorals.

Terrain and Object Perception

Develop perception algorithms for recognition and representation of operationally relevant objects and features in the environment. The approach will utilize 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 allow improved autonomous navigation, actions, intelligent decision-making, and behavioral learning.

Trust in Adaptive Autonomous Systems

Investigate high-trust human-robot interaction by experimenting with an interface/control architecture that integrates three key functionalities: a human cognitive model, an adaptive agent to assist human cognition, and a high-assurance supervisor.

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 the utilization 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

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.

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. The objective of this project is to 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.

World Modeling and Tactical Path Planning

Investigate the potential to extract higher level knowledge elements from world model data sets using segmentation and clustering techniques to identify distinct regions, paths, and objects for use in advanced navigation and reasoning solutions.

RDECOM & TARDEC Efforts

Autonomous Mobility Applique System Maturation

Improve the effectiveness of unit resupply and sustainment operations, including autonomous convoy and vehicle loading/unloading operations through Automated Material Handling Equipment (AMHE).

Autonomous Ground Resupply

Develop a fully autonomous ground resupply that is capable of operating in a multitude of terrains, on and off road.

Autonomous Robotics for Installation & Base Operations (ARIBO)

ARIBO is a strategic initiative to accelerate the adoption and use of intelligent ground vehicle systems for military and commercial applications utilizing a systems approach to link technology with real-world operational settings for use and experimentation in semi-controlled environments.

Multi-UGV Extended Range Experiment

Multi-UGV Extended Range Experiment (MUER) experiment will influence UGV Initial Capabilities Document, Capability Development Document, and Capabilities Production Document requirements development. It is an S&T demonstration of an autonomous ground vehicle, controlled beyond line of sight which deploys Standardized PackBots equipped with their own autonomy kit and chemical, biological, radiological, and nuclear (CBRN)/ Intelligence, Surveillance, and Reconnaissance (ISR) mission payloads. MUER will develop autonomous algorithms for traversing unexplored routes, with limited map data and user interventions.

Sensor Protection from Lasers

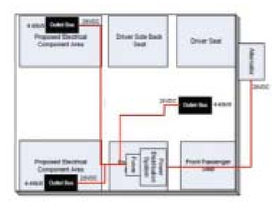
The Sensor Protection from Lasers objective is to prevent failure of fire control & robotic day vision sensors from laser weapons. This project is in coordination with ARL.

6.2.2.4 Weight Reduction

The Commandant of the Marine Corps' directive to "Lighten the MAGTF" led to initiating the Weight Reduction focus area. Lightening the MAGTF will increase the ability to traverse harsh terrain, increase fuel economy (reducing fuel convoys), and enhance maneuver from the sea.

The Challenge

The challenge is to identify, develop, and transition technologies/solutions that successfully reduce platform weight with out survivability or mission capability.



Components for an ITV Autonomy Conversion

Left Photo: The weight of the up-armored HMMWV had resulted in maintenance and logistic issues. Right Photo: Contrasting HMMWV, the ITV is light weight and highly transportable.

Potential Solutions

ONR Efforts

ACV-Scale Light Armor Design
Using knowledge from previous ONR programs, develop, fabricate, and test light armor systems for ACV threats.

Bulk Metallic Glass
Investigate and exploit Bulk Metallic Glass as a key component within a light armor system.

Flawless glass
The objective is to further develop the methodology to produce flawless glass as part of a TA system. Reducing surface flaws can increase performance of the TA systems by more than 10% thereby allowing for a reduced weight armor system.

Lightweight Materials
This ONR project will investigate lightweight materials for armor applications for USMC platforms (ACV, JLTV Objective, etc.).

Lightweight Vehicle Exhaust for Amphibious Vehicles
This ONR SBIR will evaluate the exhaust systems of Amphibious Vehicles and develop a lightweight alternative.

Transparent Armor Polymeric Materials
The function of the Transparent Armor Polymeric Material is to investigate novel Transparent Armor technologies using composite technology that reduce weight and improve multi-hit performance.

RDECOM & TARDEC Efforts

Affordable Lightweight Materials / Structures
Demonstrate best practices in cost-conscious, multi-material design for structures to reduce ground vehicle weight. Utilize and evaluate design tools, advanced materials, manufacturing, and assembly technologies to develop a lightweight structure and enhance core competencies. Support a demonstrator weight savings of ~20-30% over ground combat vehicle's (GCV) baseline. Evaluate the current technical capability of the material supply chain. Funding and timeline information can be found in the M&S section.

SBIR Efforts

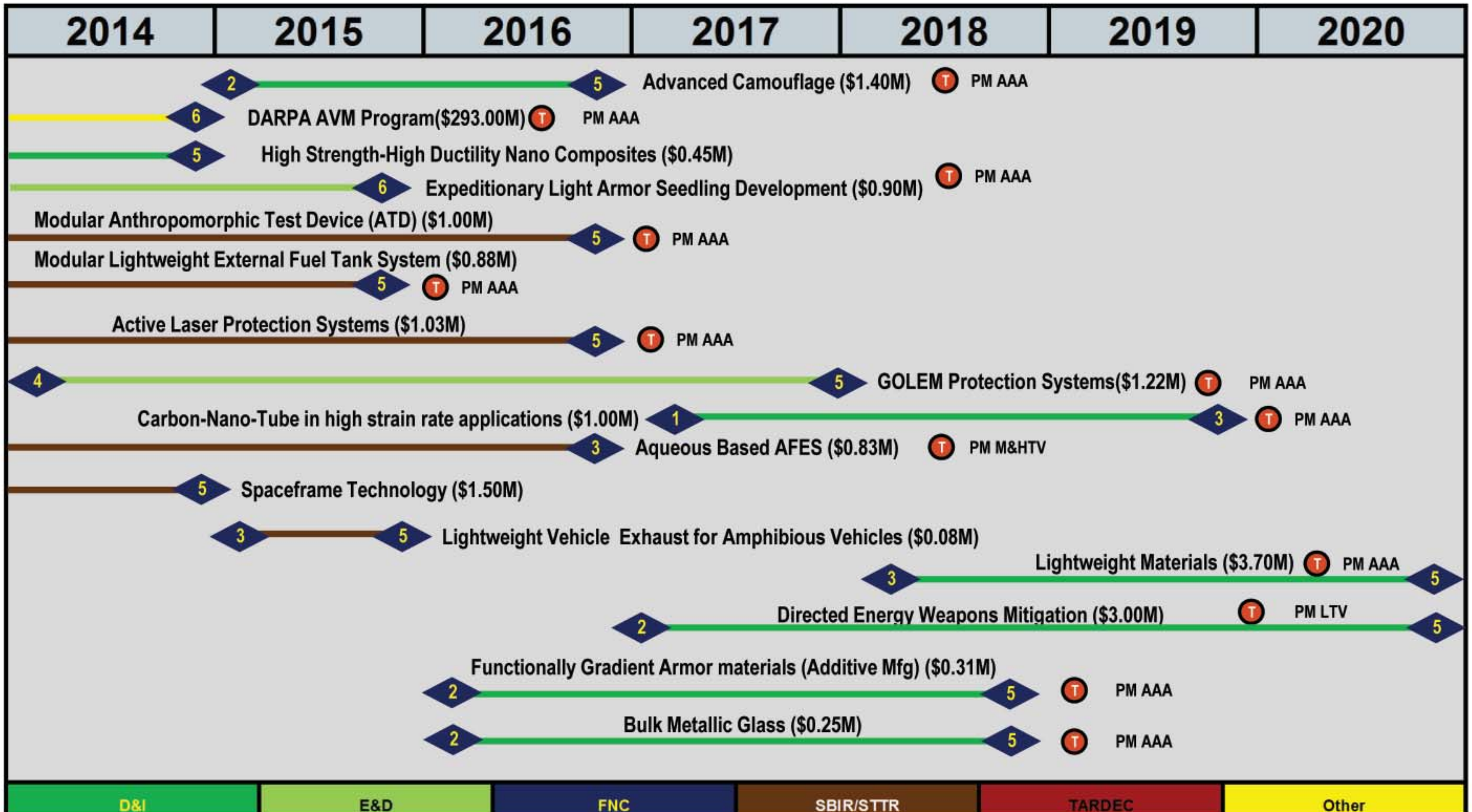
Modular Lightweight External Fuel Tank System
The objective is to design and develop a lightweight, modular fuel tank that can withstand hydrodynamic ramming forces and that can provide protection against a ballistic impact from a 14.5mm armor-piercing projectile using a multi-layer laminate design that achieves a significant reduction in weight compared to existing systems. A lightweight, modular fuel tank would reduce the power and fuel requirements for an amphibious vehicle while mitigating fire issues and increasing freeboard.

MTVR Composite Trailer
The MTVR has substantially increased in gross vehicle weight due to the addition of armor. The goal of the MTVR Composite Trailer Project is to counter the weight of the armor by removing weight from the trailer. Productions costs of a composite trailer are projected to be comparable to the existing trailer with the added benefits of:

- Improved Reliability
- Increased Payload Capability
- Increased Strength
- Reduced Effects of Corrosion

The Survivability & Mobility Focus Area charts on the following pages highlight critical efforts monitored and supported by the PEO LS S&T Director.

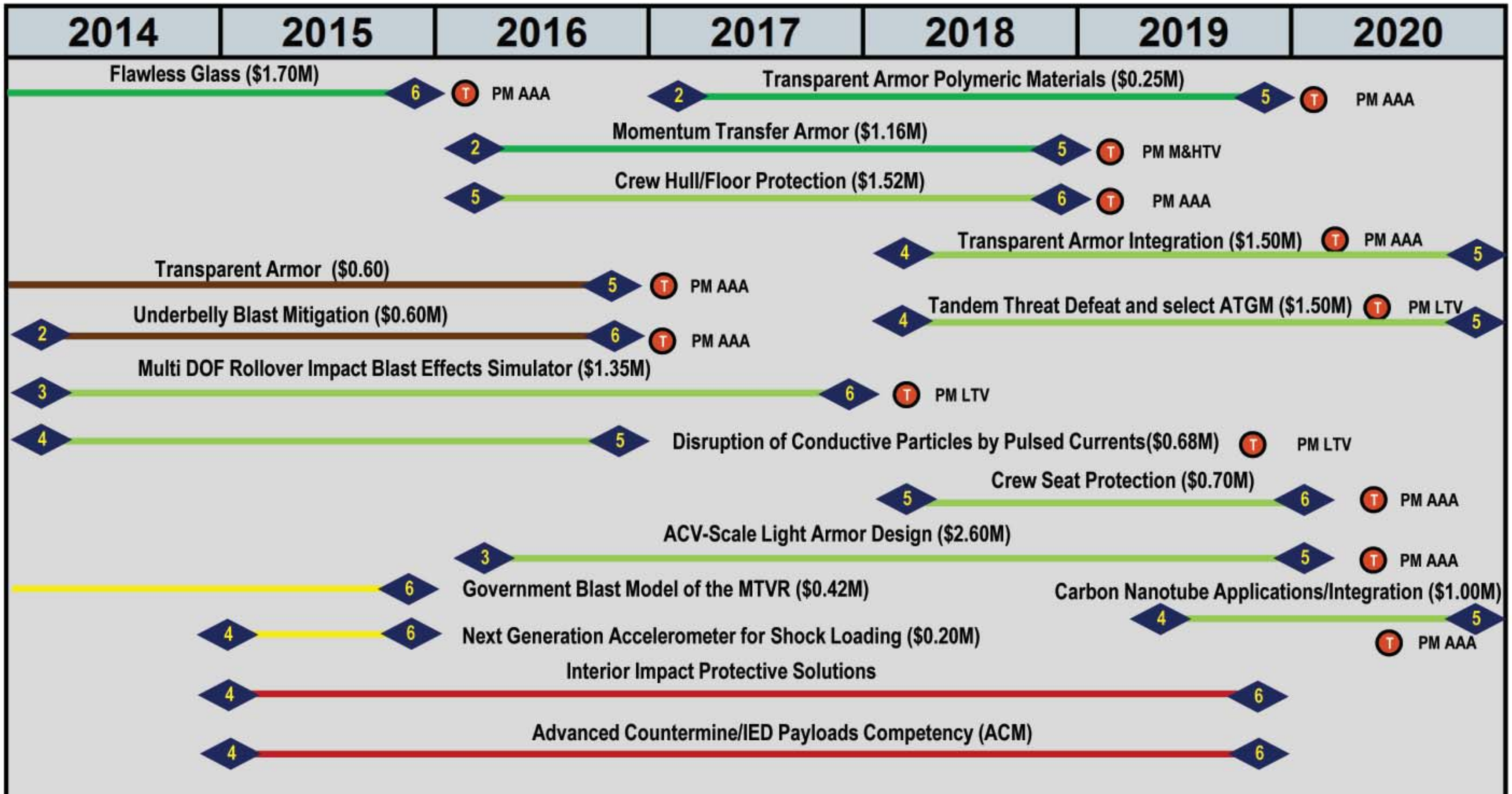
Survivability



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	72.75	2.18	1.95	1.42	1.74	2.75	2.1

6.1 ←→ Science & Technology ←→ 6.3 6.4 ←→ System Development ←→ 6.7

Survivability

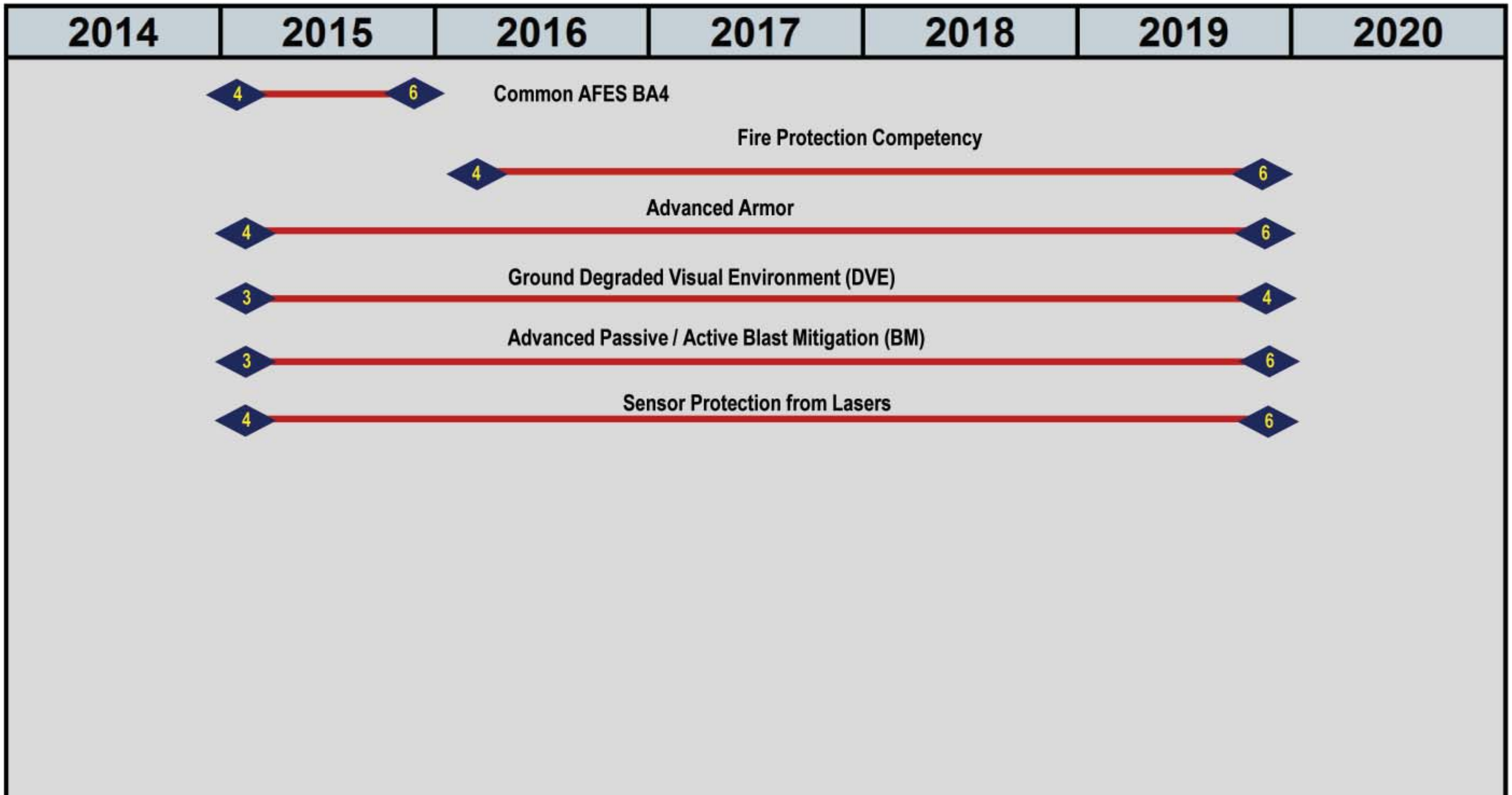


D&I | E&D | FNC | SBIR/STTR | TARDEC | Other

Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	1.94	4.00	3.83	3.52	4.67	4.72	1.75

6.1 ←→ Science & Technology ←→ 6.3 6.4 ←→ System Development ←→ 6.7

Survivability

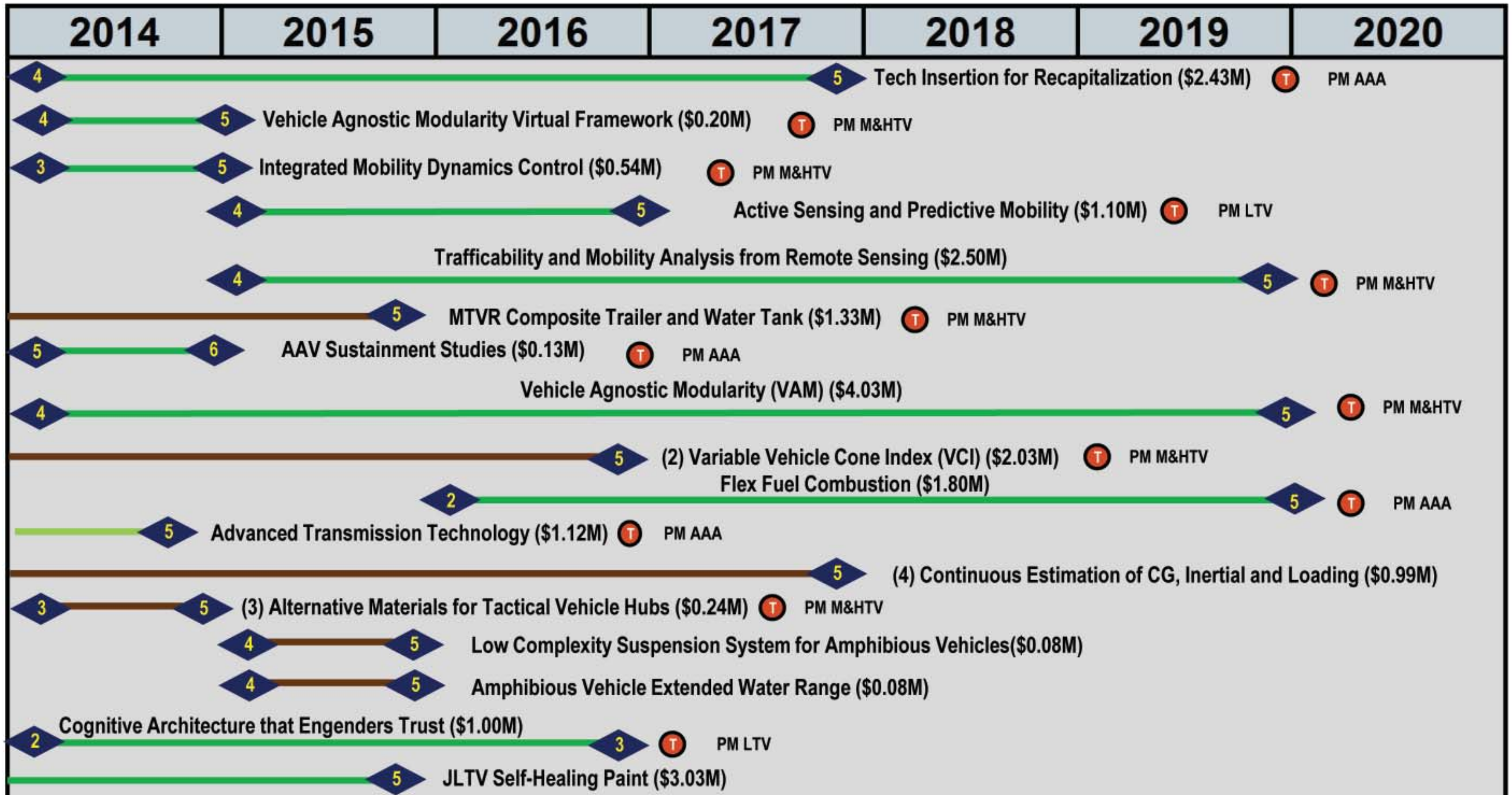


D&I | E&D | FNC | SBIR/STTR | TARDEC | Other

Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)		43.87	49.56	53.43	56.09	47.68	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

Mobility

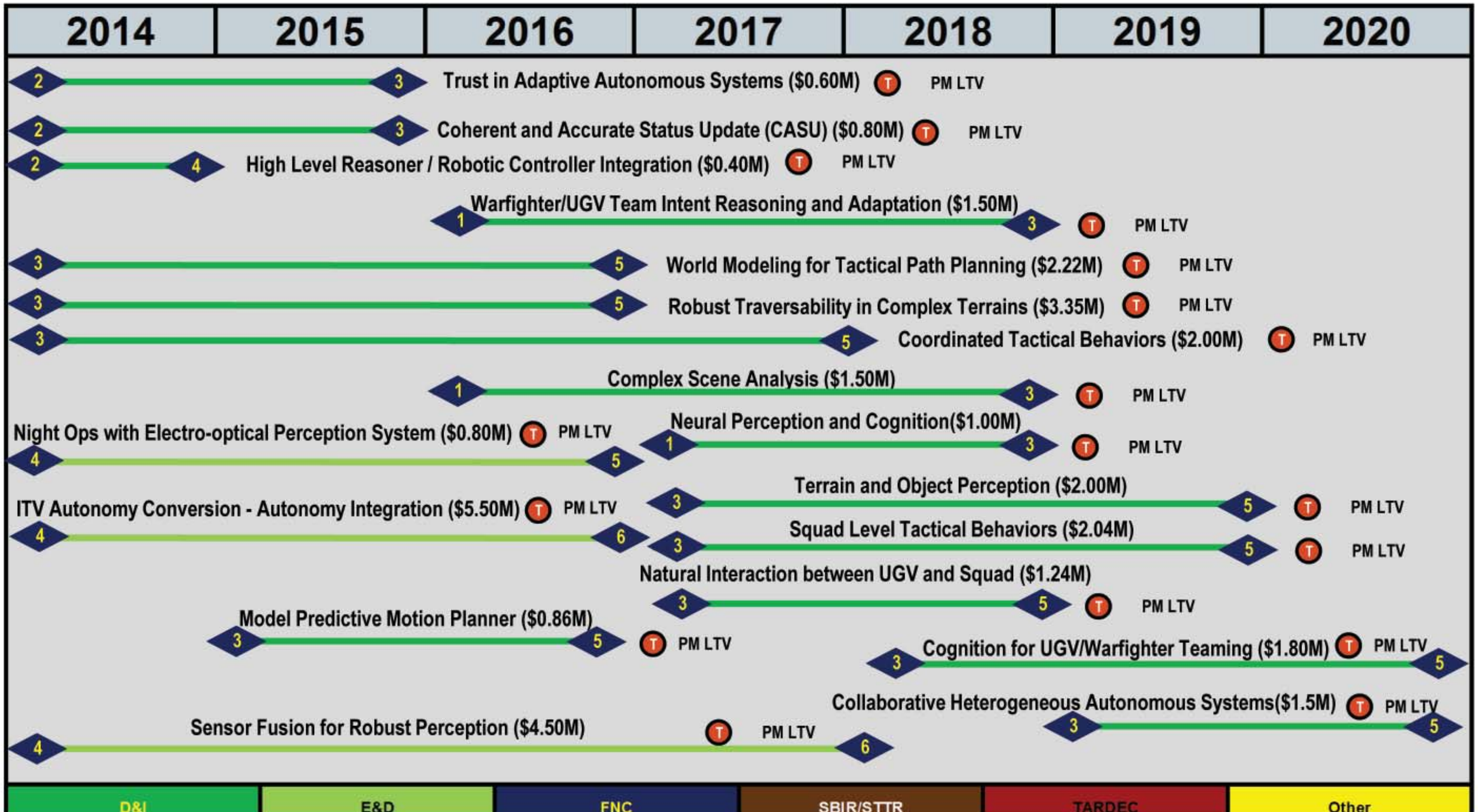


D&I | E&D | FNC | SBIR/STTR | TARDEC | Other

Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	6.30	5.30	4.10	2.80	1.40	1.20	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

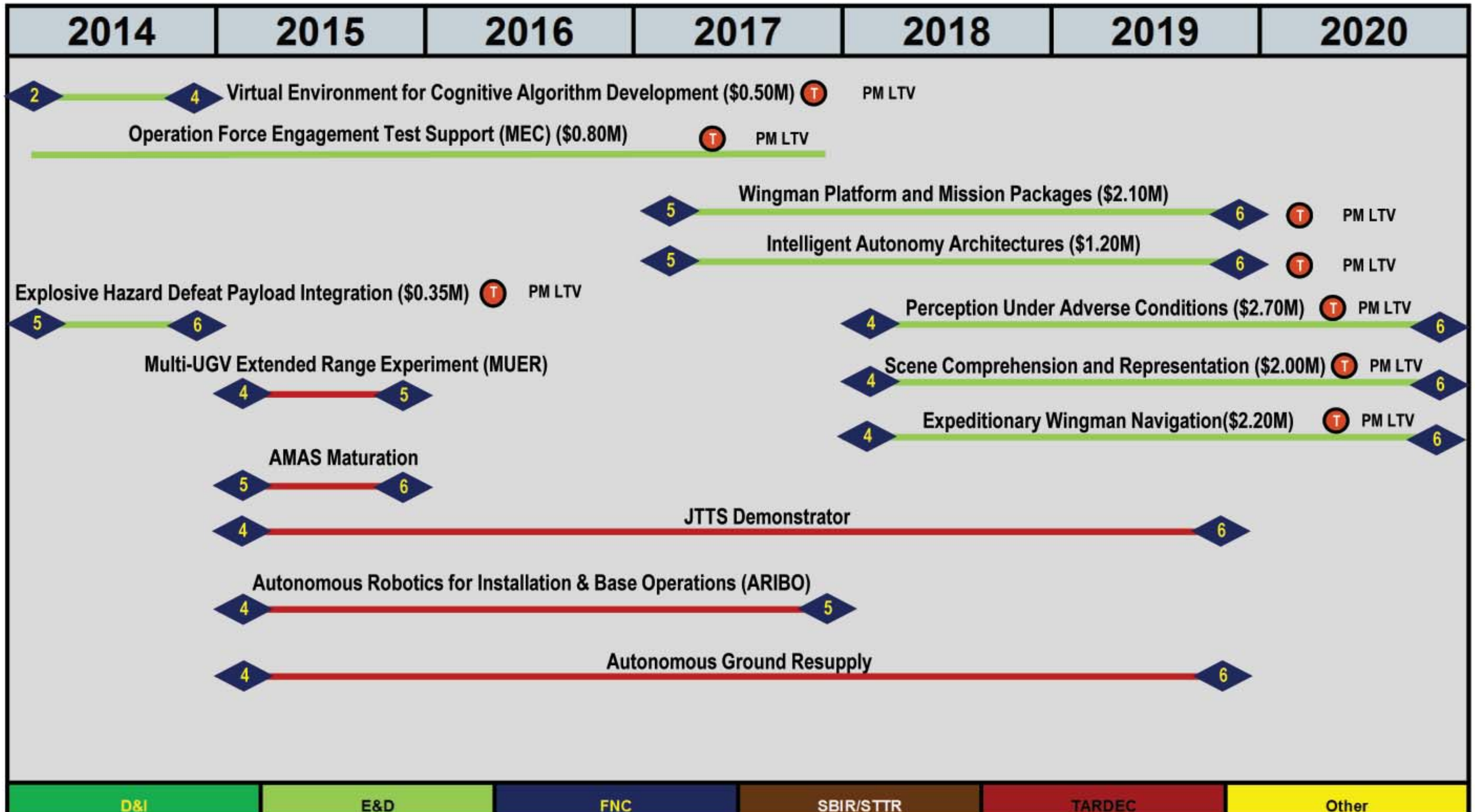
Mobility



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	6.70	6.90	7.10	4.70	3.90	3.00	1.40

6.1 ← → Science & Technology ← → 6.3   6.4 ← → System Development ← → 6.7

Mobility



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	0.97	16.77	19.93	25.01	26.27	24.69	2.47

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

Section 6.3 PEO LS S&T 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 enables 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 (SBA) while bringing optimized, focused capabilities to the Warfighter.

Computer-based simulation of the actual functions of tactical vehicle systems must be expanded in order 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 SBA 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 evaluations 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.

6.3.1 PEO LS Future M&S Vision

The Challenge

PEO LS has a need for a universal M&S aggregation tool that is accurate, verified, and validated. This tool will collect and aggregate component and platform data provided by industry 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 6.3-1).

The development of a universal M&S aggregation tool will provide:

- A streamlined and standardized approach for assessing CSP of future GCVs and proposed upgrades/modifications.
- A single integration tool capable of assessing multiple platforms and multiple configurations.
- Allows plug and play capability for upgrade or alternative component comparison, as well as future modernization programs.
- Utilizes requirement's based scenarios to assess total LCC and performance for each platform/configuration and upgrade.
- Establishes standardized interfaces for

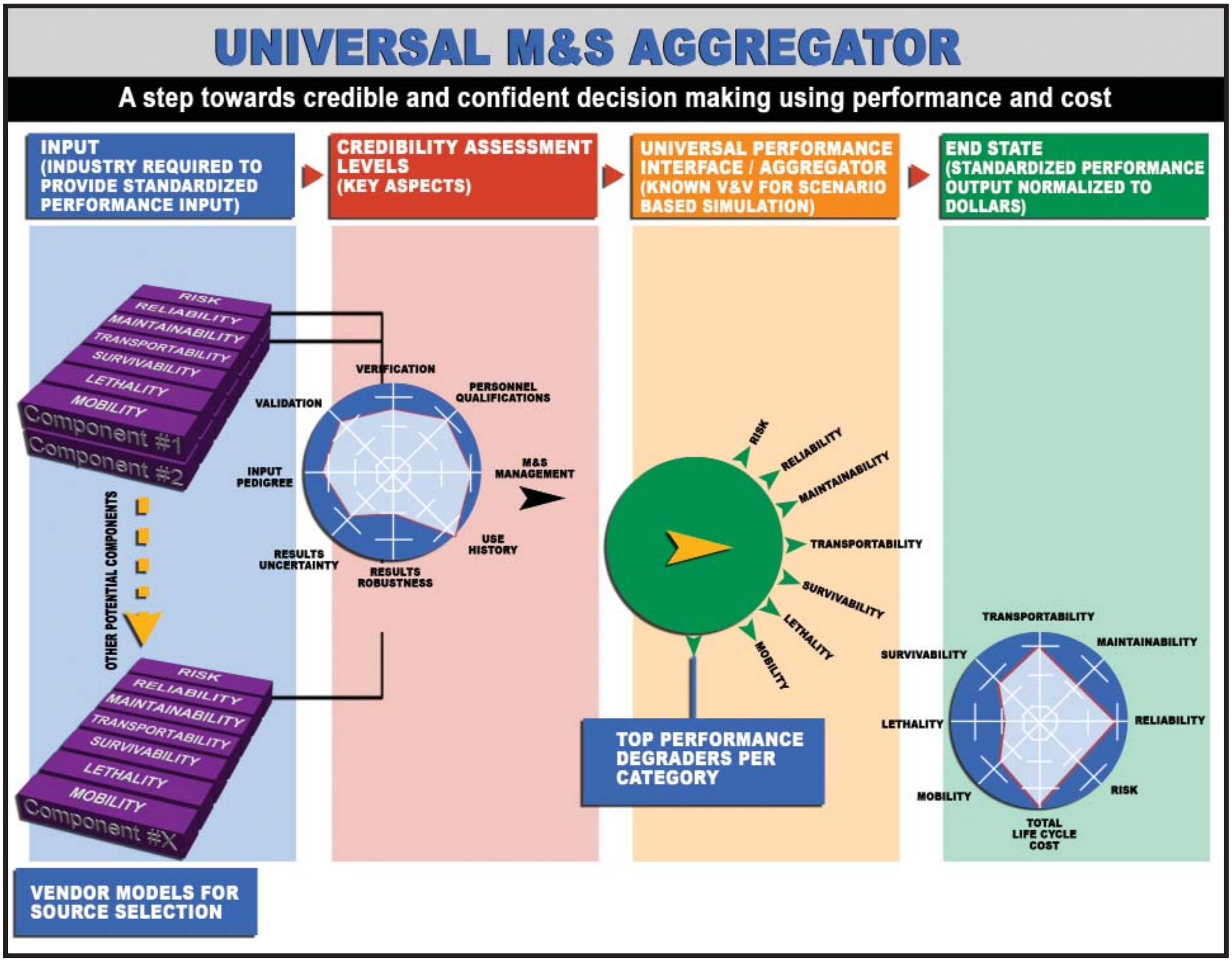


Figure 6.3-1. Universal M&S Aggregator

industry to design component models as well as establishing acceptable credibility assessment levels for key design aspects.

- Provides decision making tools for acquisition leadership with a known confidence level.
- Reduces total ownership costs while maximizing limited S&T resources.

6.3.2 Shaping the Future M&S

Framework Assessing Cost Technology (FACT)

MCSC commissioned the development of FACT (Figure 6.3-2) as a framework to tie together disparate component and platform modeling efforts. FACT is a M&S 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 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.

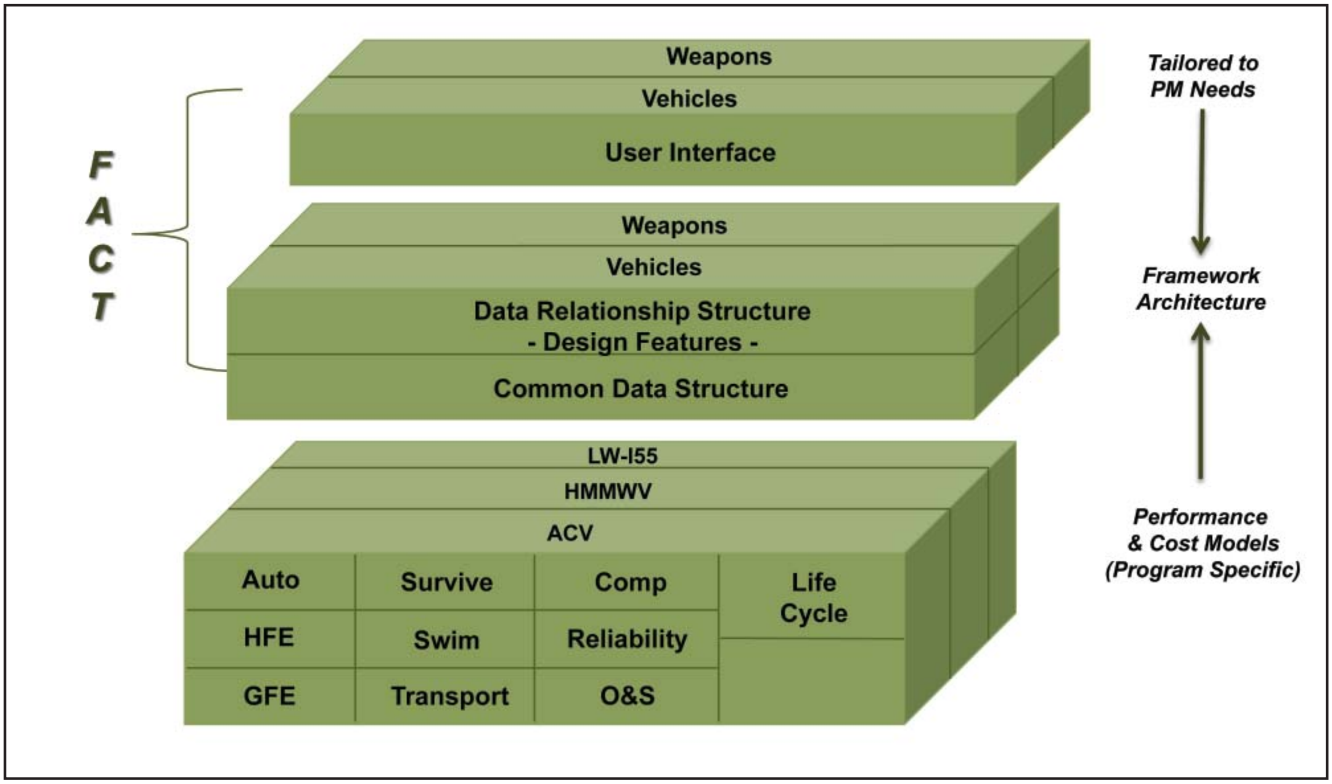


Figure 6.3-2. FACT Architecture

ACV/AAV

PM Advanced Amphibious Assault (AAA) received delivery of the FACT toolkit in February 2012 to conduct analysis on thresholds delineated in the Capability Development Document for the ACV program. The tool provided the Program Manager with an understanding of the possible trade-offs where further investment may result in enhanced capability.

6.3.3 Ongoing M&S Efforts

AAV Survivability Upgrade M&S

Utilizing high fidelity computational physics-based M&S of blast events; the AAV Survivability Upgrade vendor designs are being evaluated against performance requirements, prior to contract award decisions.

Human Body Model

Current ATDs used to predict human injury risk in live fire blast testing have several limitations, mainly due to a lack of biofidelity and limited injury assessment capability. The ATD is comprised 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 allow 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% male and support theater event reconstruction and deliver injury causation determination. Beyond the scope of the PEO LS effort focused on injury prediction in IED events, this model could be utilized in the areas of ballistic protection, blast overpressure, burn injuries, and non-lethal munitions.

Post IED Damage SBIR

Following a vehicle IED event, it is critical to make informed, accurate decisions for damage assessment and repair. Unnecessary repairs lead to vehicle downtime and wasted maintenance manpower. Conversely, the reintroduction into service of a vehicle with significant internal damage, unseen through visual inspection alone, can put warfighters at higher risk for injury or death.

Two companies are currently in Phase II of SBIR contracts to develop the capability to systematically gather and store data from the vehicle and scene post event and then process this data into a format that allows the vehicle Program Management Office (PMO) to assess risk of repair vs redeployment.

SURVICE 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.

Tool to include:

- 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 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 closes match and calculates the risk of redeploying vs repairing the vehicle structure. The tool will also allow for event-reconstruction, identifying the most likely threat scenario that led to the damage. 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.

High Fidelity Computational Physics Blast Modeling Improvements

Utilizing FY2103 Rapid Innovation Funds, further development of high fidelity computational physics -based methods, tools, and models is on-going. The capability to model explosively formed penetrator (EFP), fragmenting IED, and littoral mine threats will be developed under this effort. Additionally, research will be conducted to allow for improvements to the already well-established underbody mine and IED vs armored vehicle simulation capability. Improvements will be seen in material models of soils and a progressive damage model for structural composite materials will be developed. These capabilities will allow improved M&S support to survivability improvement initiatives and aid in the design and evaluation processes required to meet occupant centric protection objectives.

JLTV Blast M&S

The objective of this effort is to develop and execute a physics-based model able to account for both soil/structure interaction and gross vehicle response. CORVID TECHNOLOGIES has prepared high fidelity models for the JLTV Program. The UBB M&S efforts will:

- Provide the 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, and

- Provide supplemental information to support key performance parameter (KPP) analyses. The JPO also plans to use M&S for future evaluations of vehicle design modifications and Engineering Change Proposals (ECPs).

Additional M&S projects supporting PEO LS include:

- Tactical Wheeled Vehicle (TWV) Modernization Study is the development of a plan that synchronizes the strategies and actions involved in lifecycle management of USMC TWV requirements, procurement, integration, sustainment, and management.

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

- Light Tactical Vehicle Technology Advancement Rapid Innovation Fund. Improved design methods and simulation tools will enable optimum performance, reduce expensive "trial and error" tests, and result in lighter, more survivable and cost effective vehicles.

Potential Solutions

ONR Efforts

ONR has a broad mix of projects, many focused on ground vehicle programs, which add to the development of a comprehensive suite of M&S tools for the Marine Corps:

Energy Absorbing Structures for Blast Mitigation Light Tactical Vehicles

The objective of this effort is to develop lightweight energy absorbing structures for incorporation into Marine Corps ground systems to enhance occupant survivability. The project includes a review of potential energy absorbing structures for incident angles, computational evaluation of design parameters for selected mechanisms, LS-DYNA simulations of standoff, hull shape, energy absorber characteristics, manufacture, and test selected energy absorbing mechanisms into a prototype and then blast tests to validate the modeling and utility of the selected design. Focus has been on designing a surrogate V-hull to be compatible with use of EA for the light tactical vehicle design. The intent is to develop and demonstrate the use of Energy Absorbing structures mounted between the blast hull and the crew compartment of a general class of tactical vehicles (5 – 15 ton) that substantially mitigates crew injuries.

Detection Avoidance Material and M&S Development

This effort will investigate materials and develop improved M&S for advanced camouflage application.

Mitigation of Blast Injuries through M&S (Reaction Engineering and Protection Engineering)

The objective of this SBIR effort is to investigate the effect of non-centerline buried IED/mine explosives used against military vehicles and to develop a physics-based model that will assist in the design of safety components. The proposed effort builds upon previous work performed under US Army funded program and will develop next-generation simulation capabilities to better predict the effects of buried explosives on ground vehicles and occupants. Blast and soil modeling will be performed using advanced simulation tools developed as part of the Department of Energy, Accelerated Strategic Computing Initiative at the University of Utah and the vehicles will be modeled with the LS-DYNA FE code. Occupant modeling will be performed using LS-DYNA. The final product of the Phase II will be a micro-coupled MPMICE-LS-DYNA model, which leverages the best capabilities of each simulation tool. Comparisons will be made between simulations of the MTVR exposed to a buried threat and live-fire test data for the same configuration.

TARDEC Efforts

Virtual Experiments Capability (VEC)

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

Far Term Advanced Capability Development (FAVCAD)

The majority of Army S&T technologists are focused on CVP (near to mid-term). Some are engaged with U.S. Army's Training & Doctrine Command (TRADOC) 2025 but at the individual technology level and not the platform level (mid term). TRADOC is now starting to look into far term operational needs. TARDEC with its Next Gen study is delivering representative Far Term platform concepts integrating RDECOM S&T (technologies and platforms).

Warrior Injury Assessment Manikin (WIAMan)

This project will conduct cadaveric research to establish a scientific and statistical basis for evaluating skeletal injuries to occupants during Under Body Blast events. WIAMan will also develop an improved blast test manikin that incorporates the medical research which provides an increased capability to measure and predict skeletal occupant injury during UBB events.

Modular Active Protection System (MAPS)

MAPS will allow commonality across the vehicle fleet, tailoring of systems to meet PM needs, and platform constraints, provide growth capability to address emerging threats and facilitate transition.

Affordable Lightweight Materials/Structures

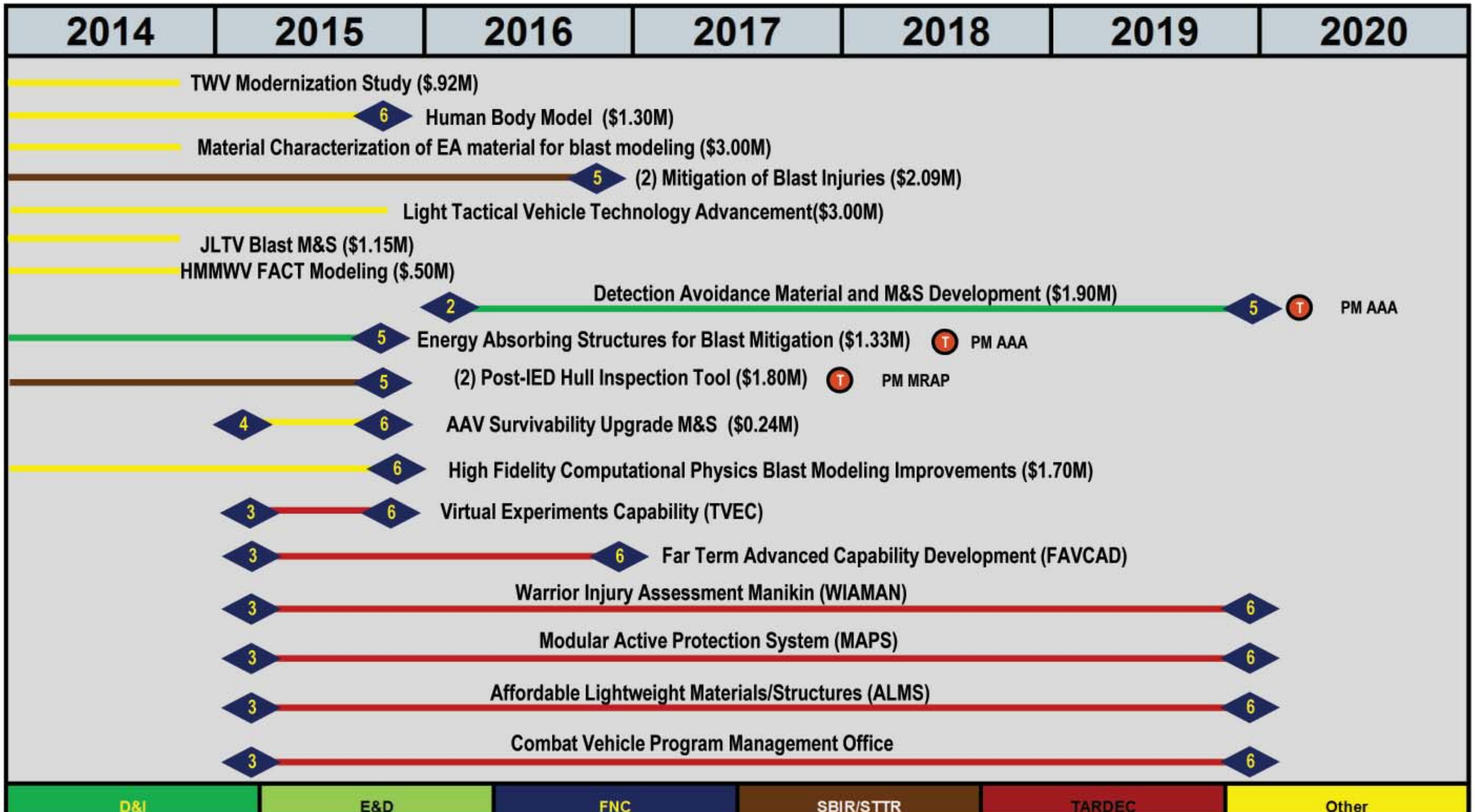
This effort will demonstrate best practices in cost-conscious, multi-material design for structures to reduce ground vehicle weight. This effort utilizes and evaluates design tools, advanced materials, manufacturing, and assembly technologies to develop a lightweight structure and enhance core competencies. Support a demonstrator weight savings of ~20-30% over GCV's baseline. Evaluate the current technical capability of the material supply chain.

Combat Vehicle Program PMO

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.

The M&S Focus Area Charts on the following pages highlight critical efforts monitored and supported by the PEO LS S&T Director.

Modeling and Simulation



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	7.60	54.50	52.31	59.82	59.29	41.62	

6.1 ←→ Science & Technology ←→ 6.3 6.4 ←→ System Development ←→ 6.7

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Section 6.4 PEO LS S&T Focus Area

OPEN PLUG AND PLAY COMMUNICATIONS ARCHITECTURE

"Innovation and fiscal responsibility will also continue to be hallmarks of the Marine Corps. We will continue to invest limited resources to restore combat capability and enhance our Marines' readiness at home and in overseas operating areas."

—U.S. Marine Corp Concepts and Programs 2014

M-ATV

By facilitating interoperability and using an open plug-and-play architecture within tactical vehicles, the Marine Corps will improve it's tactical, operational, and strategic advantages. Towards this end, the Marine Corps continues to develop a standardized approach to Command, Control, Communications, Computers, and Intelligence (C4I) and Electronic Warfare (EW) integration. PEO Land Systems continues to work to integrate these systems through a coordinated development and acquisition process.

The Challenge

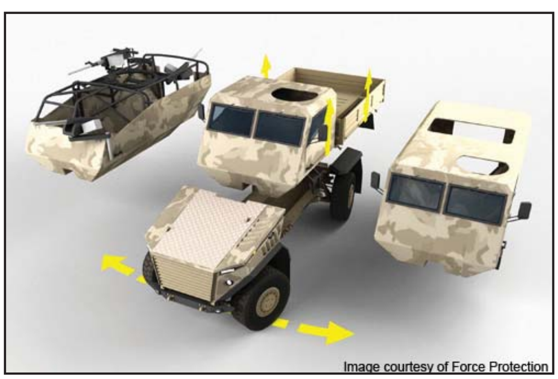
Most current C4I/EW systems, which are primarily driven by urgent operational needs, are standalone solutions that are integrated onto tactical vehicles in a "bolt-on" fashion. Current tactical vehicles were not designed to support the multiple new technologies that have been added to enhance combat operations. The development of modular, scalable, open system architectures that enable a plug-and-play mission capability across all tactical vehicles will enable rapid vehicle modernization, shared resource allocation, and eliminate duplicate equipment for both legacy and future vehicle programs.

Potential Solutions

ONR Code 30 Efforts

Vehicle Agnostic Modularity (VAM)

This ONR 30 effort is focused on developing a scalable, reusable, and subdivided vehicle system that will employ a series of self-contained functional modules (trauma, C2, remote weapons station, power, etc.). While the program is exploring potential solutions to a variety of technical challenges, it will require an open plug-and-play architecture to support the various modules and platform elements. This C4ISR backbone will permit system-wide power and thermal management and provide common interfaces for the different modules, thus enabling vehicle mission optimization. This S&T effort will result in reconfigurable multi-mission modules integrated into vehicle cargo areas that are applicable across a range of tactical vehicles.



Potential VAM Construct

The intent of the VAM program is that the structured application of Modularity principles to ground platforms will extend tactical range and operational reach, increase endurance in the field, reduce excess capacity and logistic footprint/burden, enhance small unit effectiveness, lighten the MAGTF load, enhance commonality, and reduce TOC.

TARDEC Efforts

Vehicular Integration for C4ISR/EW Interoperability (VICTORY)

The VICTORY open plug-and-play architecture is being developed as a solution to the "bolt-on" approach to integrating C4ISR systems into 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 these 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 U.S. Army ground vehicles. The framework is comprised 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 instantiated to create designs against various types of requirements and environments.

The architecture is documented in VICTORY Architecture - Version A2, which identifies the systems, components, and interfaces but does not provide technical details. The technical details are

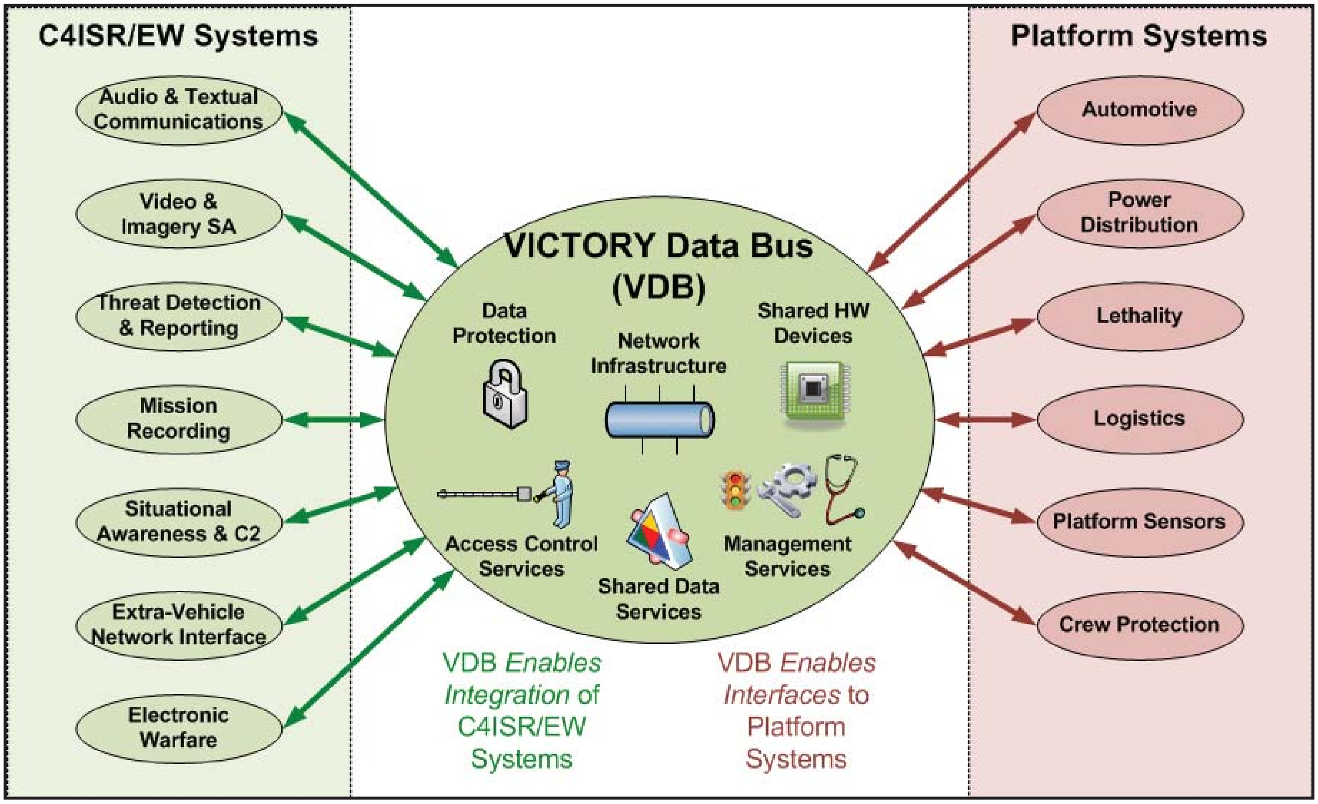


Figure 6.4-1. Core Concept: VICTORY Data Bus (VDB)

specified in the VICTORY standard specifications and are intended to be used by the system acquisition and S&T communities as a citable reference in new procurements, modernization activities, and engineering change proposals.

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.

Marine Corps Systems Command and PEO Land Systems have approved the VICTORY Standard for future Marine Corps Vehicles. The current version of the standard is 1.6.1. This standard will be critical for future development of modular C4ISR systems.

Common SIL

The development of a Common SIL will create a system-of-systems integration laboratory capability to support vehicle modernization efforts, demonstrate advanced technologies, and build the expertise of the workforce. Comprised of two separate SILs, a Vehicle Electronics and Architecture (VEA) Research SIL housed at TARDEC, and a C4ISR SIL located at the U.S. Army's Communications-Electronics Research, Development and Engineering Center, the Common SIL will link together through the Defense Research and Engineering Network to create an end-to-end simulation and evaluation capability.

Electrical Power Standards

The development of electrical power architecture will allow seamless electrical integration of any load that converts or consumes electrical power. Similar to the VICTORY architecture, but intended for electrical power, electrical power architecture will create commonality of loads and power conversion devices for any ground vehicle that adopts the standards. Creating and adopting common voltage standards and electrical power architectures for new start and modernization programs will lead to common components and plug-and-play ability between platforms; common implementations and control schemes that reduce training; and a common approach to achieving safety for high voltage systems.

VEA Mobile Demonstrator

The VEA technical area was formed in January 2009 to improve TARDEC's responsiveness to its enterprise partners' emerging needs and to better address requirements. VEA, part of TARDEC's Research Technology and Integration (RTI) Group, aims to develop technologies, processes, and capabilities while maintaining the overarching architecture of hardware and software systems that support Army ground vehicles. TARDEC's VEA consists of three main groups: Electrical Power, Vehicle Architectures, and Systems Integration Laboratories & Customer Support, with teams supporting multiple subgroups. VEA is currently involved in a four year effort developing a mobile demonstrator.

Vehicle Architectures Group

The Vehicle Architectures group is comprised of several subgroups: electromagnetic environmental effects; intra-vehicle data networks; computers; component thermal; and the VICTORY architecture team. The Vehicle Architectures Group works to develop hardware and software that enables communication and data sharing among various electronic devices and computing elements within a vehicle.

SILs and Customer Support Group

The SILs and Customer Support group is primarily composed of the engineers and facilities that support the program management offices. Current support activities include matrixed engineers for the PM-Heavy Brigade Combat Team; the PM Stryker Brigade Combat Team (SBCT); the PM MRAP; PEO Combat Support &Combat Systems Support; and the Integrated Logistics Support Center. This group also maintains SIL facilities to support PM SBCT and PM MRAP, and is working to develop the VEA Research SIL component for the Research Development Engineering Command Common SIL initiative.

Vehicle Electronics & Architecture Research (VRS)

The Warfighter faces considerable challenges when integrating electronics on ground vehicles, compounded by the need to reduce cost and redundancy across multiple platforms. The VRS project will create a complete reference architecture that addresses the power, vehicle electronics, 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.

Additional TARDEC projects that are of interest to PEO LS include:

Radio Frequency (RF) Convergence

This effort will 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.

High Efficiency Truck Users Forum (HTUF)

This will include commercial/military medium and heavy duty trucking communication protocols/needs with National Highway Traffic Safety Administration's car and light duty trucks communication protocols for safety. It will also facilitate VEA's military truck cyber security protections to aid commercial adoption to protect commercial trucks communication systems and capability with entire trucking industry. This project will also continue working Ground Vehicle Robotics (GVR) autonomous safety standards and connectivity.

Other Government Agencies (OGA) Engagements

This effort will include commercial/military medium and heavy duty trucking communication protocols/needs with the Federal Highway Administration's (FHWA) car and light duty trucks communication protocols for Vehicle to Infrastructure (V2I) isues/safety. This will facilitate VEA's and Software Engineering Center's (SEC) military truck cyber security protections to aid commercial adoption to protect commercial trucks communication systems and capability with entire trucking industry. Also, it will continue working GVR/SEC/VEA autonomous safety standards, protocols, cyber and connectivity with FHWA and V2I.

VICTORY Standards Maturation (VSM)

This effort will maintain, develop, and adopt future capabilities to continue to enhance the VICTORY Specifications. It will enhance existing SIL capabilities to perform Validation and Verification for the updated Standards and will 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.

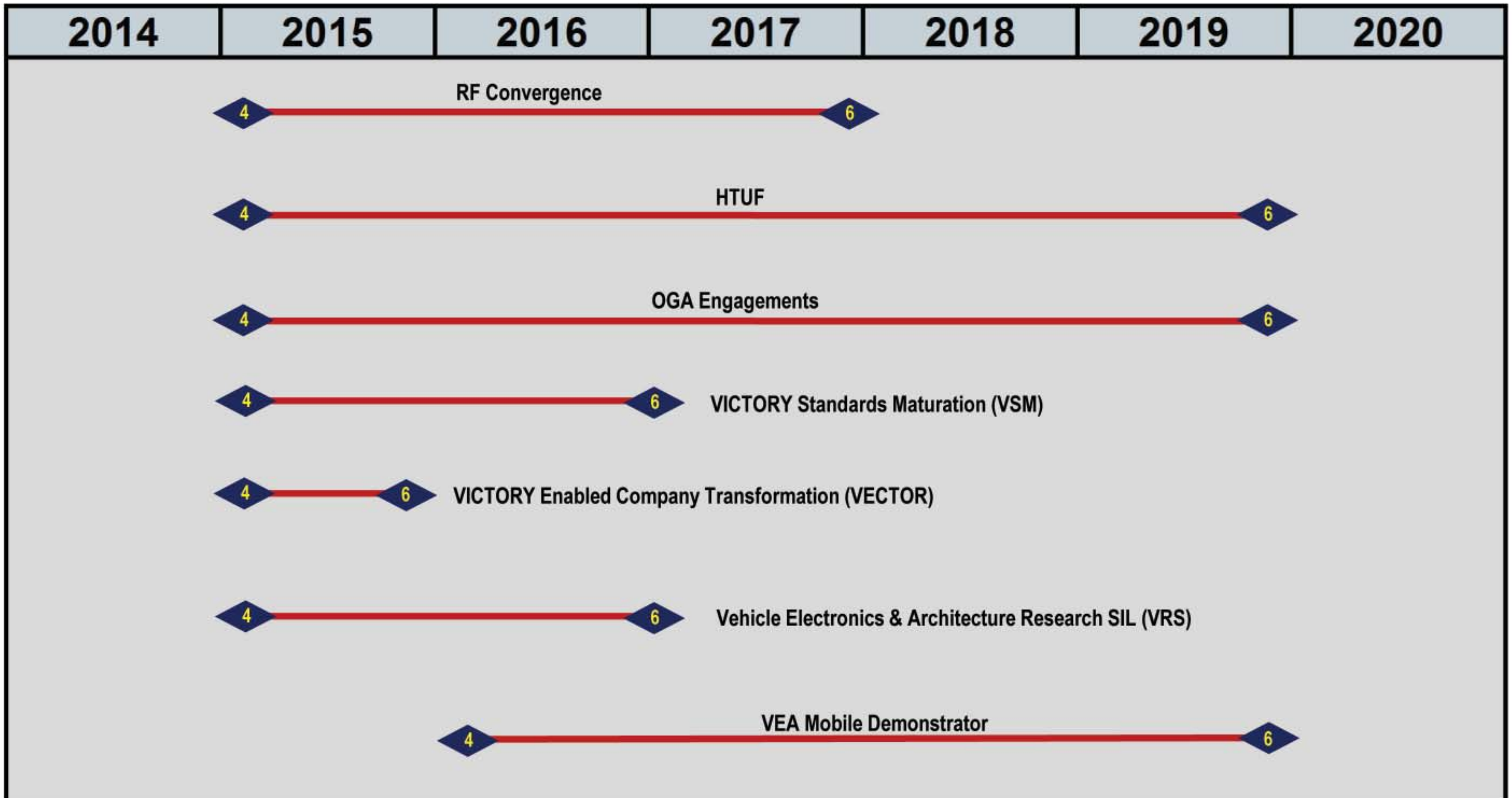
VICTORY Enabled Company Transformation (VECTOR)

This project will transition and demonstrate TARDEC's VICTORY investment from its current TRL 4 Lab Components to TRL 6 vehicle systems applicable to all platforms. This will reduce the risks for PMs of transitioning VICTORY components and systems onto their vehicle platforms by providing an accredited Information Assurance (IA) solution, aiding in the integration of legacy components, and providing a common vehicle integration package for VICTORY.

The Open Plug and Play Communications Architecture Focus Area charts on the following pages highlight critical efforts monitored and supported by the PEO LS S&T Director.

MRAP Loaded with C4I/EW Equipment

Open Plug and Play Comms Architecture



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	25.63	14.41	13.24	11.06	10.63	75.56	

6.1 ←→ Science & Technology ←→ 6.3 6.4 ←→ System Development ←→ 6.7

Section 7

PEO LS PROGRAMS

Advanced Technology Investment Plan


Section 7.1 PEO LS Program

ASSAULT AMPHIBIOUS VEHICLE

Assault Amphibious Vehicle

Program Background

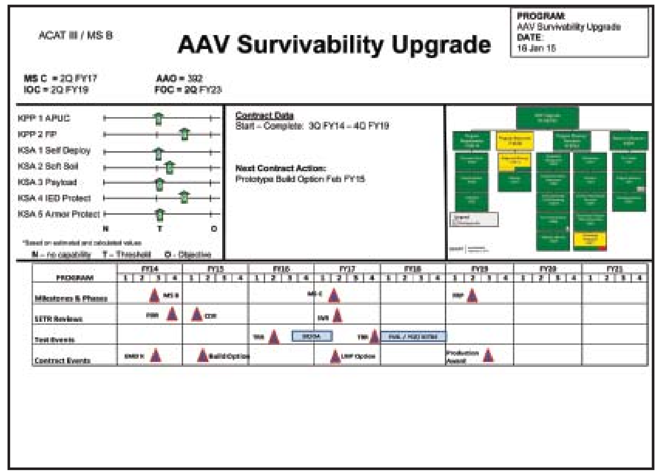
The Assault Amphibious Vehicle (AAV) was initially fielded in 1972 as the Landing Vehicle Tracked 7 (LVT7). It was subsequently renamed the AAV7 and upgraded to the AAV7A1 configuration in the late 1980s and it was upgraded to the AAV7A1 RAM/RS (Reliability Availability Maintainability/Return to Standard) 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 I Increment I.

Program Status

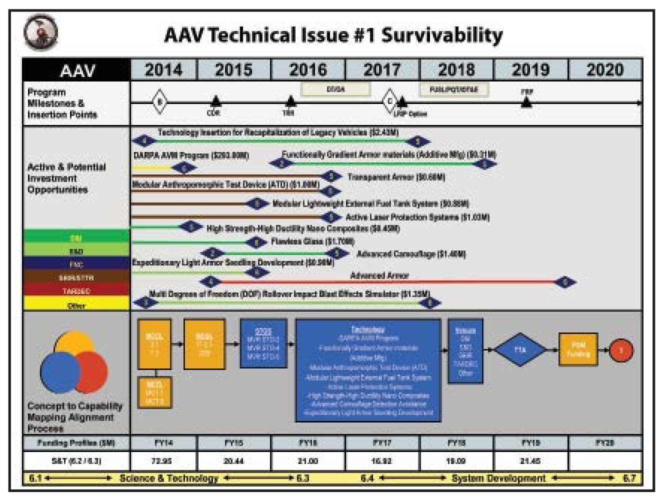
The AAV Survivability Upgrade Program entered the acquisition cycle at Milestone B during FY14 and began the engineering, manufacturing, and development phase. The program will improve force protection and platform survivability by integrating mature technologies into the AAV. These upgrades include belly and sponson armor, blast-mitigating seats, spall liners, and expected automotive and suspension upgrades. Currently slated for approximately 392 AAV personnel variants, the upgrades will provide Marine Corps operational

98 PEO LS Advanced Technology Investment Plan 2015

Part One



Part Two



Part Three

PEO LS consists of seven program offices overseeing 20 programs. The following sections discuss the Advanced Technology Investment Plans 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 describes the program's background, status, and Top Technical Issues.

Part Two 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 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:

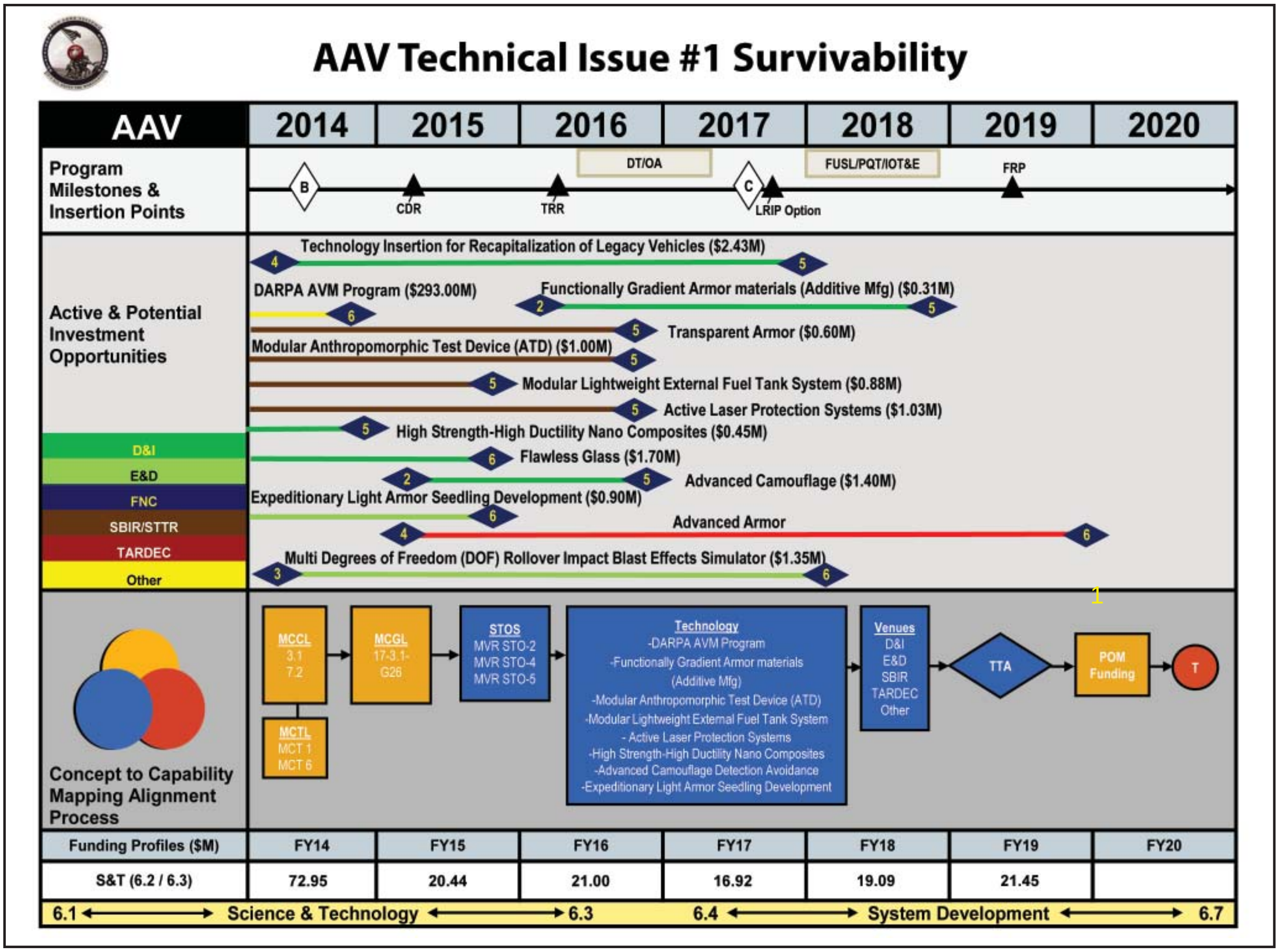


Figure 7-1. AAV Technical Issue #1 Chart

Row one identifies the program's major milestones.

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

The red circle with a T in the center is used at the end of a project to identify initiatives being targeted for transition.

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.

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 six 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 comprised 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 the Appendix 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 STO that are identified in the Marine Corps S&T Strategic Plan, and other S&T venues that address the technical issue to illustrate the transition of technology to the Program of Record.

The mapping alignment process traces the technology issue/S&T initiative from the required capability to the transitioned technology. Using AAV Technical Issue #1, 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) Science and Technology Objective (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 in order to map from the concept to the capability identifying that solving this technical problem and how it can transition into a program of record.

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

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

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Section 7.1 PEO LS Program

ASSAULT AMPHIBIOUS VEHICLE

Assault Amphibious Vehicle

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 will improve 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 approximately 392 AAV personnel 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 planned for FY16-17. 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. Sustainment/In-Service Engineering

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.


Assault Amphibious Vehicle

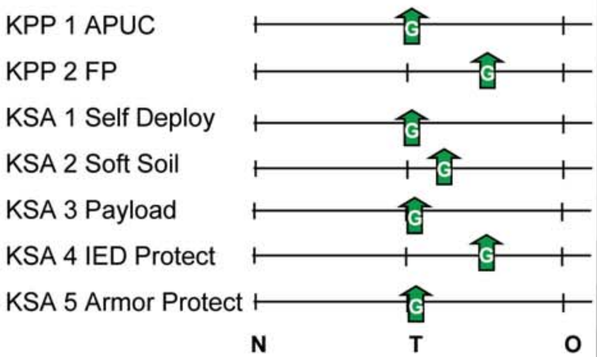
ACAT III / MS B

AAV Survivability Upgrade

PROGRAM:
AAV Survivability Upgrade
DATE:
16 Jan 15

MS C = 2Q FY17
IOC = 2Q FY19

AAO = 392
FOC = 2Q FY23

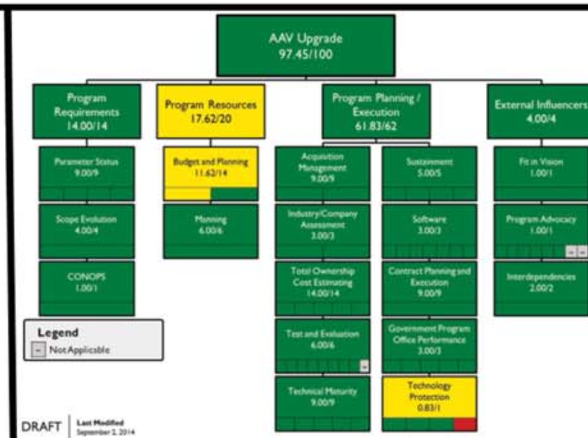


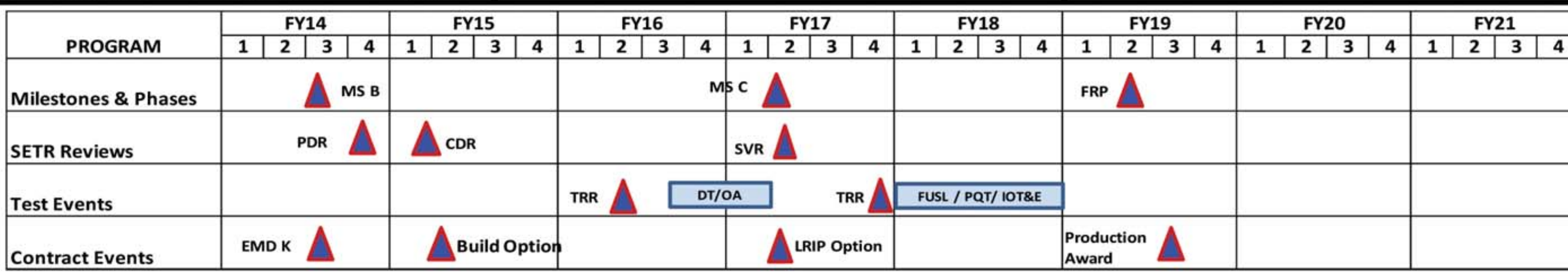
*Based on estimated and calculated values

N – no capability **T** – Threshold **O** - Objective

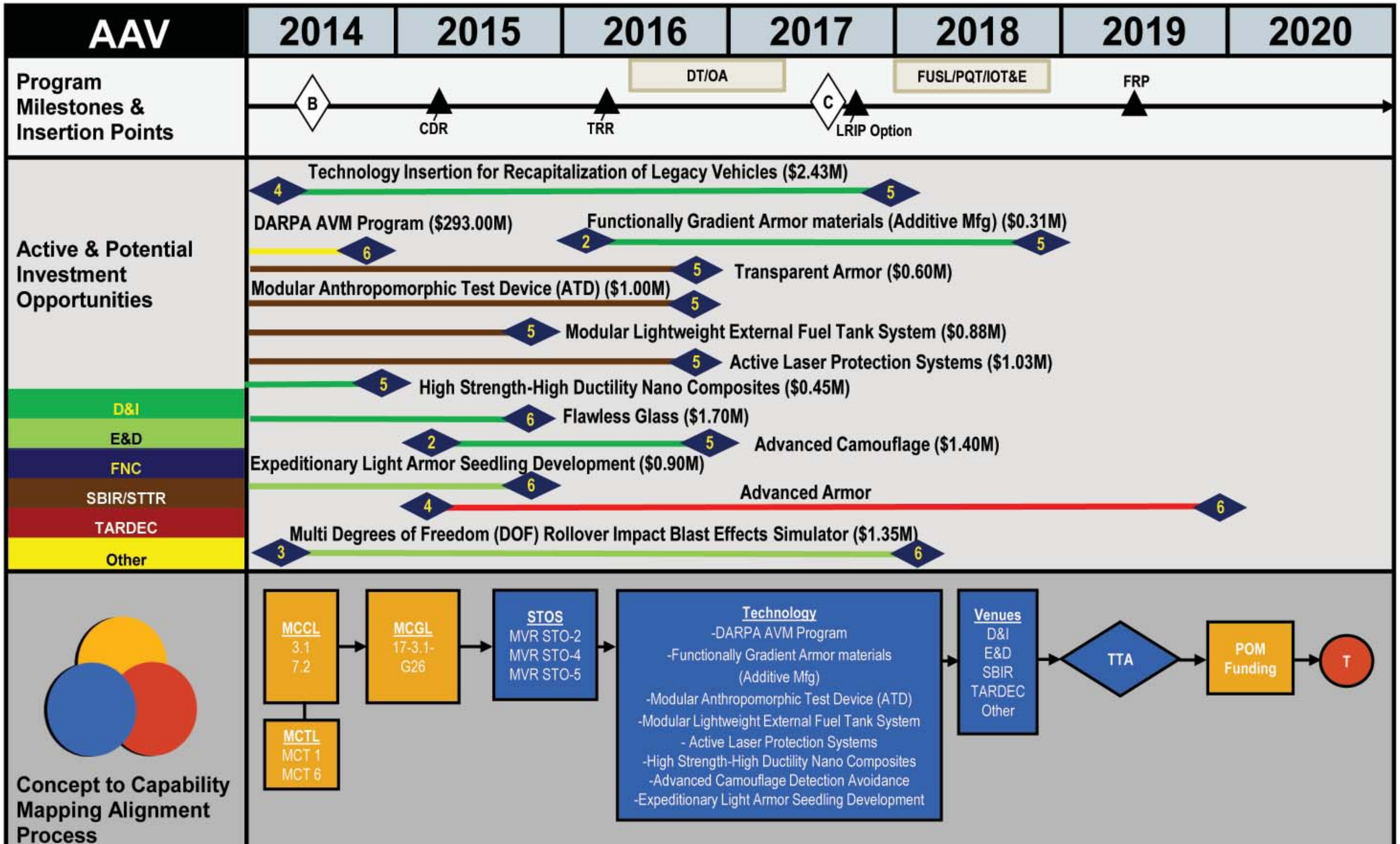
Contract Data
Start – Complete: 3Q FY14 – 4Q FY19

Next Contract Action:
Prototype Build Option Feb FY15





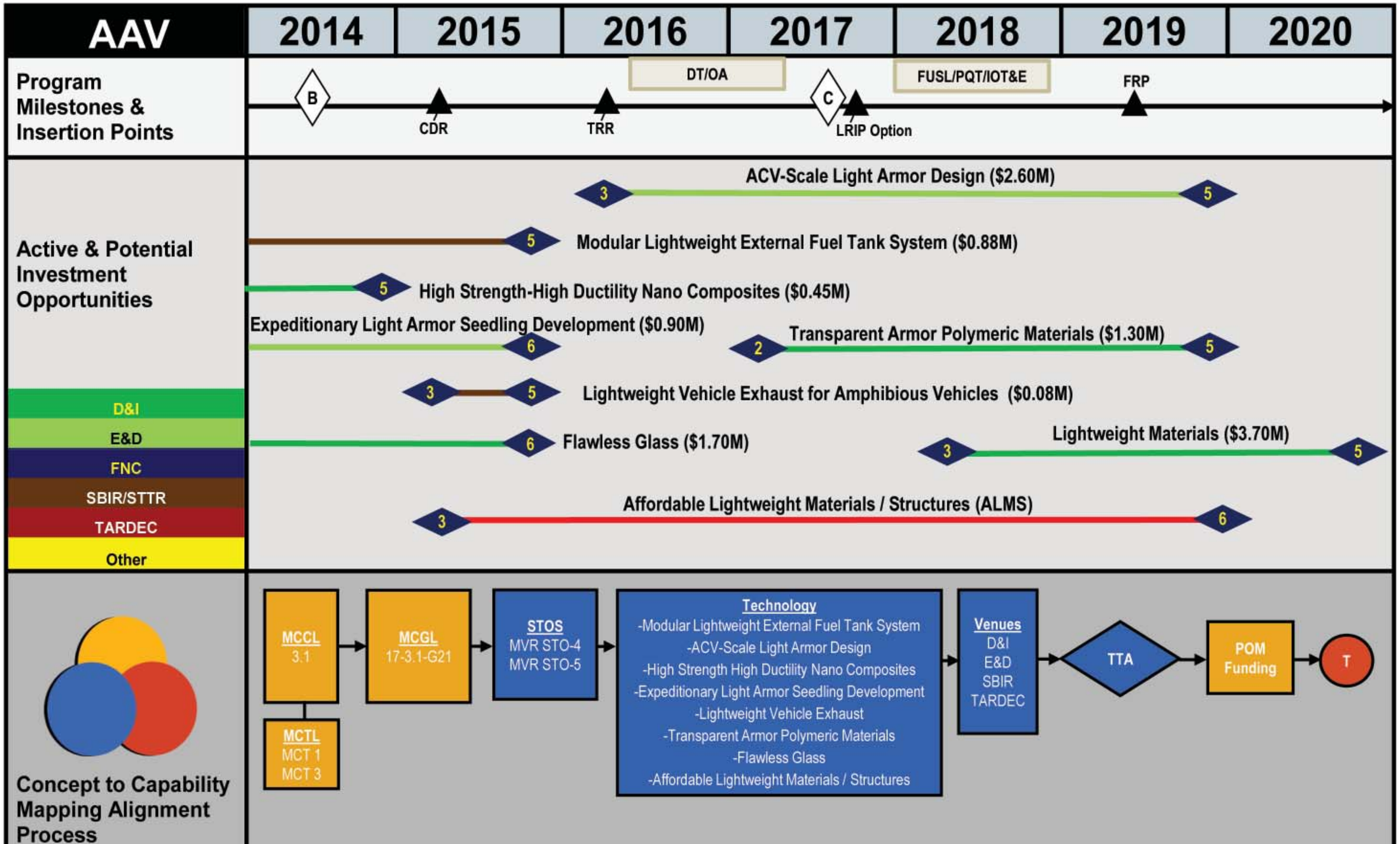
AAV Technical Issue #1 Survivability



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	72.95	20.44	21.00	16.92	19.09	21.45	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

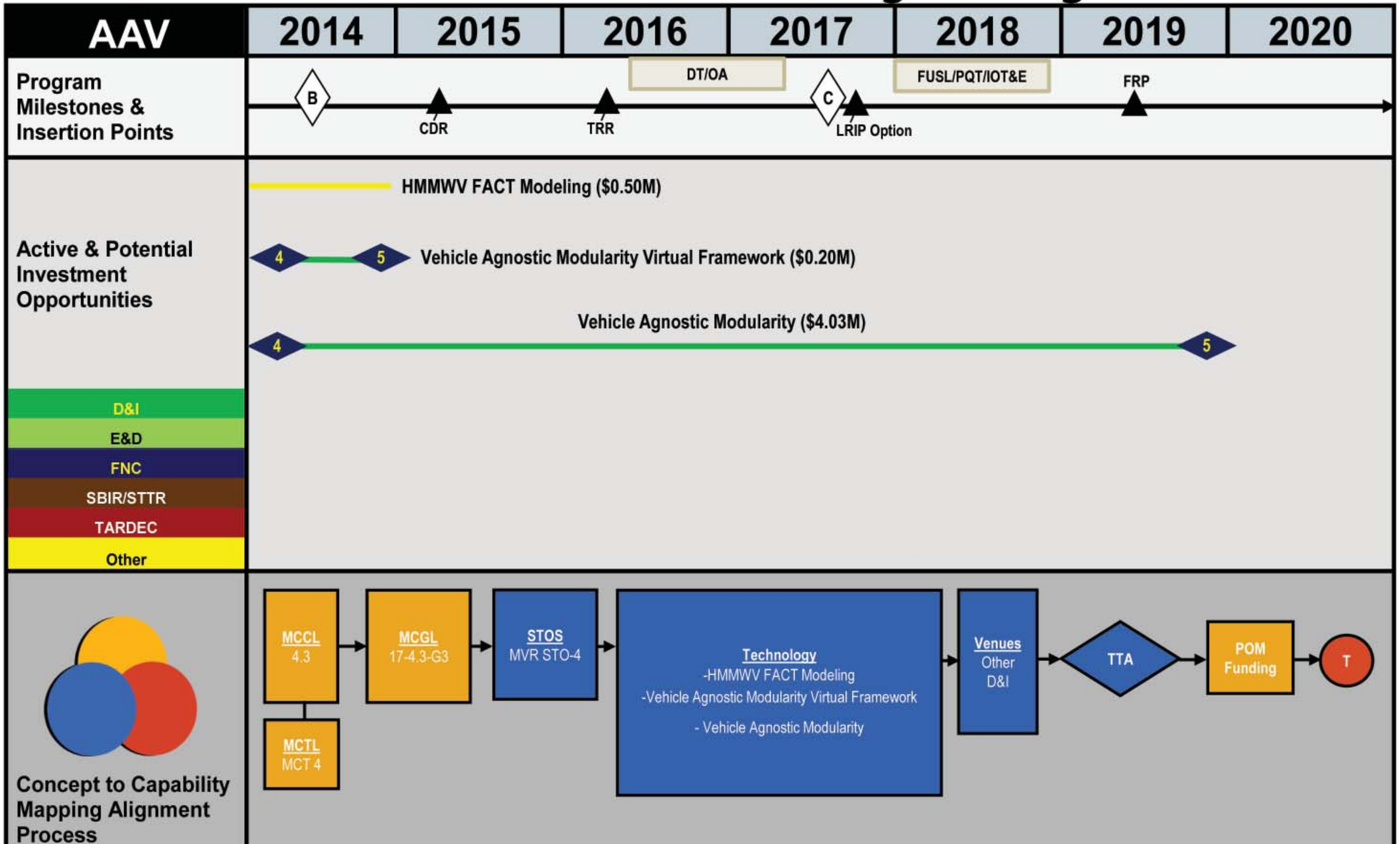
AAV Technical Issue #2 Weight/Buoyancy



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	2.00	10.36	6.91	11.75	12.65	6.15	1.60

6.1 ← → Science & Technology ← → 6.3 | 6.4 ← → System Development ← → 6.7

AAV Technical Issue #3
Sustainment/In-Service Engineering



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	1.40	1.03	0.58	0.49	0.49	0.49	0.00

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

Section 7.2 PEO LS Program

AMPHIBIOUS COMBAT VEHICLE PHASE 1 INCREMENT 1

Program Background

The Amphibious Combat Vehicle Phase 1 Increment 1 (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. Arriving as follow-on support assets, the ACVs will provide a very robust combat capability, with features ranging from MRAP level survivability to the amphibious ability to negotiate two-foot significant wave height and four-foot plunging surf.

Program Status

The Marine Corps published a draft RFP in November 2014, a second draft RFP is planned to be issued in December 2014, and a final RFP is planned for February 2015. Two vendors will be selected to compete for the program and the Marine Corps expects to down select to a single vendor in FY 2018. ACV 1.1 is expected to achieve Initial Operational Capability (IOC) in FY 2020.


ACV 1.1

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.

2. Weight

Technologies that provide lightweight solutions for vehicle materials and components are needed in order for the ACV to achieve future survivability, lethality, and troop/equipment capacity upgrades.

3. Crew Visibility

The ACV crew must maintain direct sensory knowledge of their surroundings in order to safely and effectively employ the system. This requirement pertains to, 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.

Pre-MDAP/ TMRR Phase

C (Y) S (Y) P (G)

ACV 1.1

PROGRAM: ACV 1.1
DATE: 16 Jan 15

MS B = 1Q FY16
IOC = 4Q FY20

AAO = 204
FOC = 3Q FY23

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

Key Performance Parameter (KPP)	Definition
1. Net Ready	Per CJCS 3170
2. Sustainment Materiel Availability	75%
3. Sustainment Operational Availability	81%
4. Energy	1.28 miles per gallon/1.9 gallons per hour
5. Sea Connectors	Transportable via connectors
6. Force Protection	Under-vehicle mine/IED protection
7. System Survivability	Egress kill zone, 5 miles, protected fuel
8. Water Mobility	Shore-to-Shore, 3 NM, 2ft SWH
9. Payload	3 Crew, 10 Infantry PAX plus additional DoS
10. Training	Course lengths no longer than equivalent AAV courses

Key System Attributes (KSA)	Definition
1. Soft Soil Mobility (Mud)	Traverse soil with Rating Cone Index of 30
2. Soft Soil Mobility (Sand)	Climb dry sand slope w/ 40% grade
3. Weapon System	Single mount, stabilized RWS
4. Direct Fire Protection (Force Protection)	Equivalent to AAV & LAV with applique
5. Roadside IED Protection	MRAP equivalent
6. System Reliability	0.77 probability of completing any single one of the scenarios described in the OMS/MP
7. O&S Costs	Equal to or less than $3.068B (T) $2.761B (O) in FY14$B
8. Afloat Ready	Interoperability, MPSRON, L-Class

Contract Data

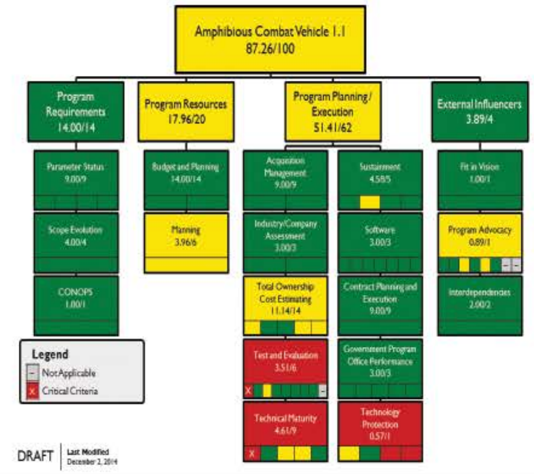
RFP Draft #1 Released - 5 Nov 14

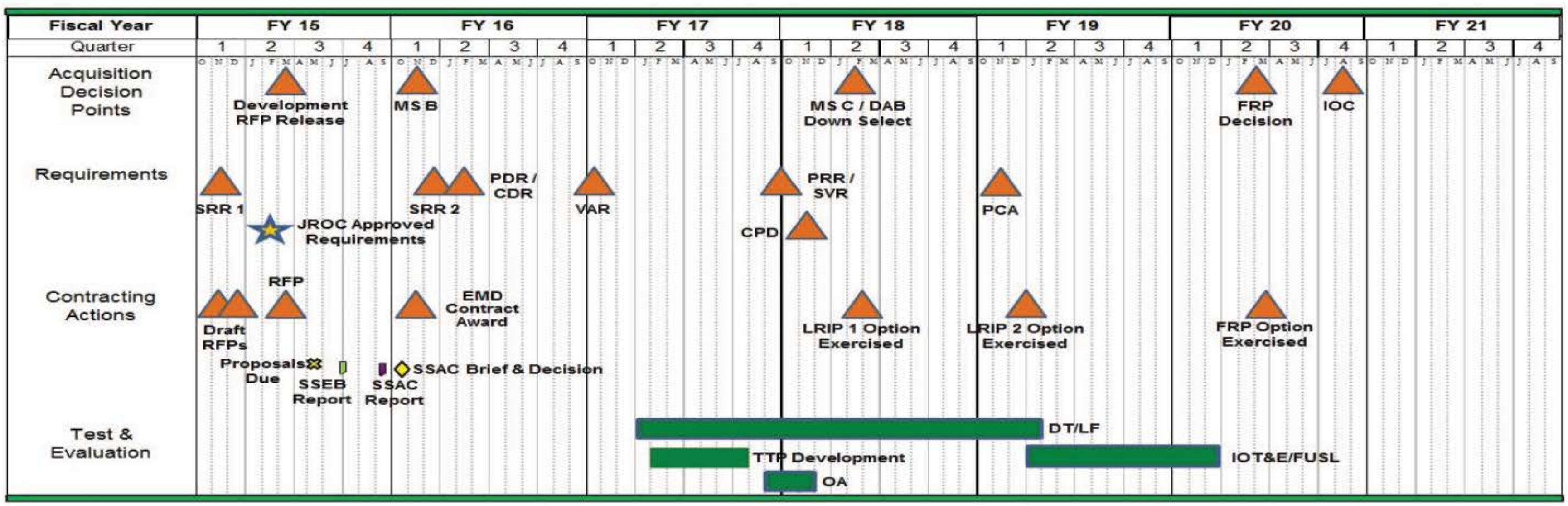
Source Selection Plan to be completed - 30 Jan 15

RFP Draft #2 Released- 8 Jan 15

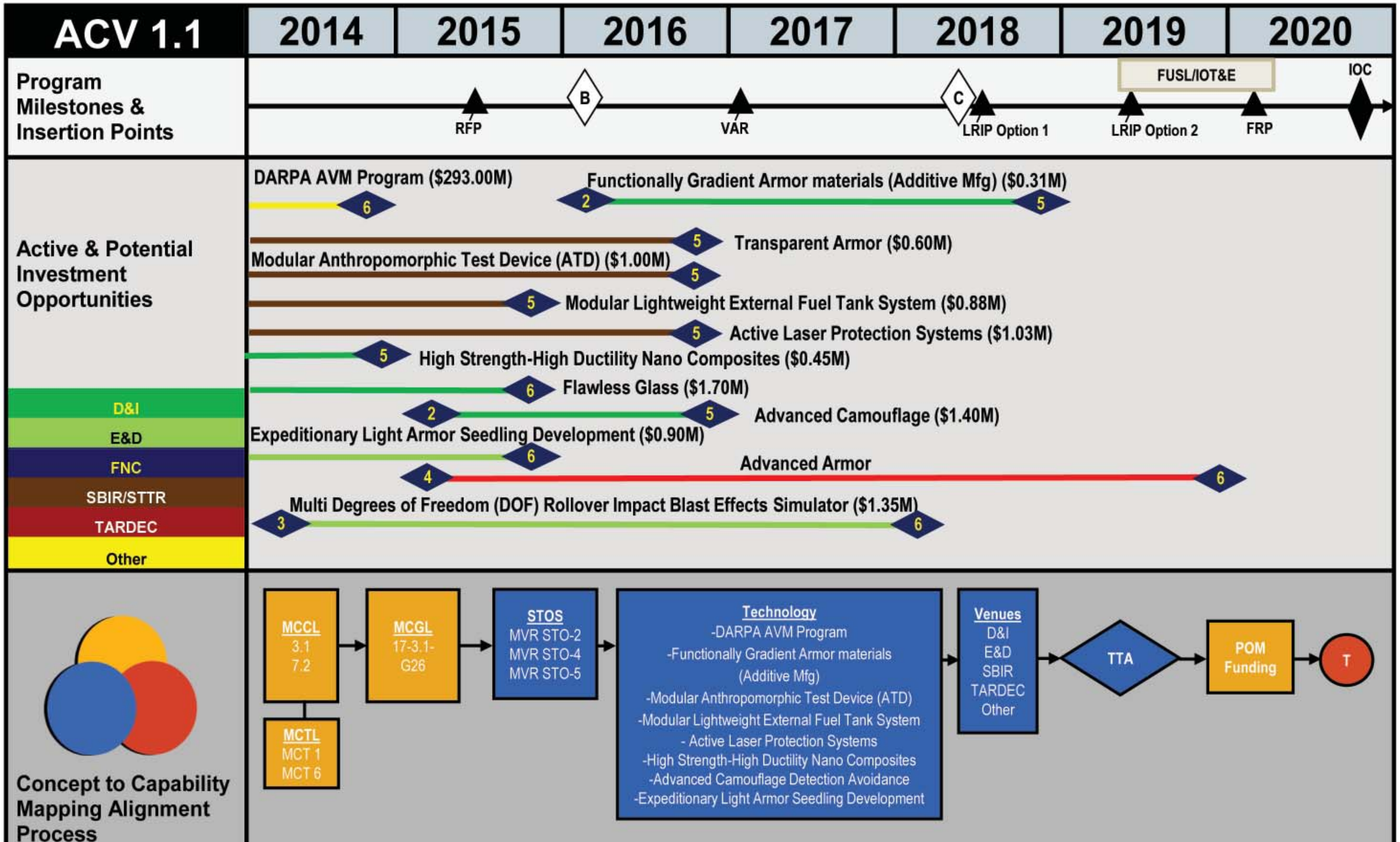
RFP Final/DAB Meeting scheduled for – 18 Mar 15

RFP Release scheduled for – 25 Mar 15





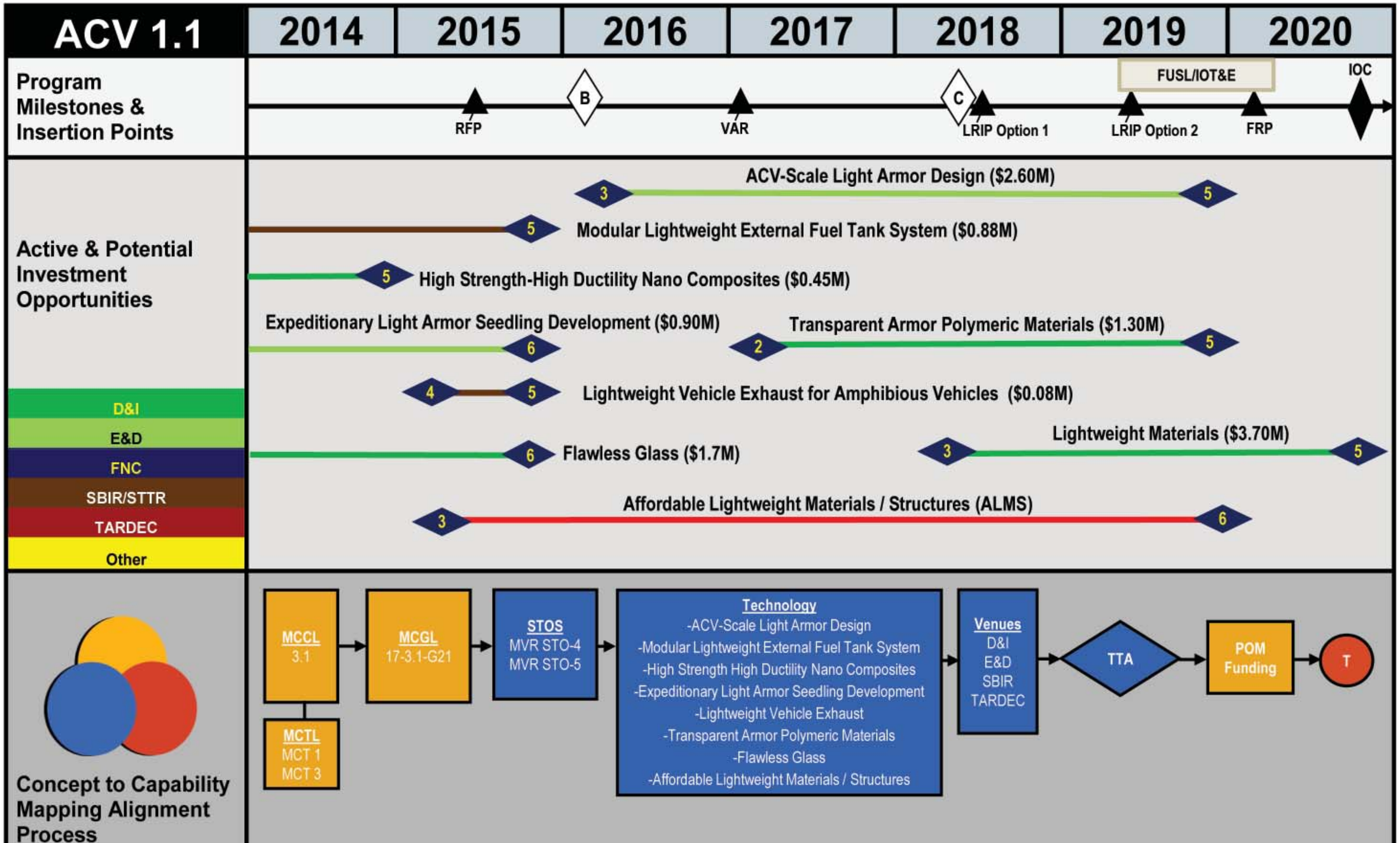
ACV 1.1 Technical Issue #1 Survivability



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	72.75	20.24	19.97	15.92	19.09	21.45	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

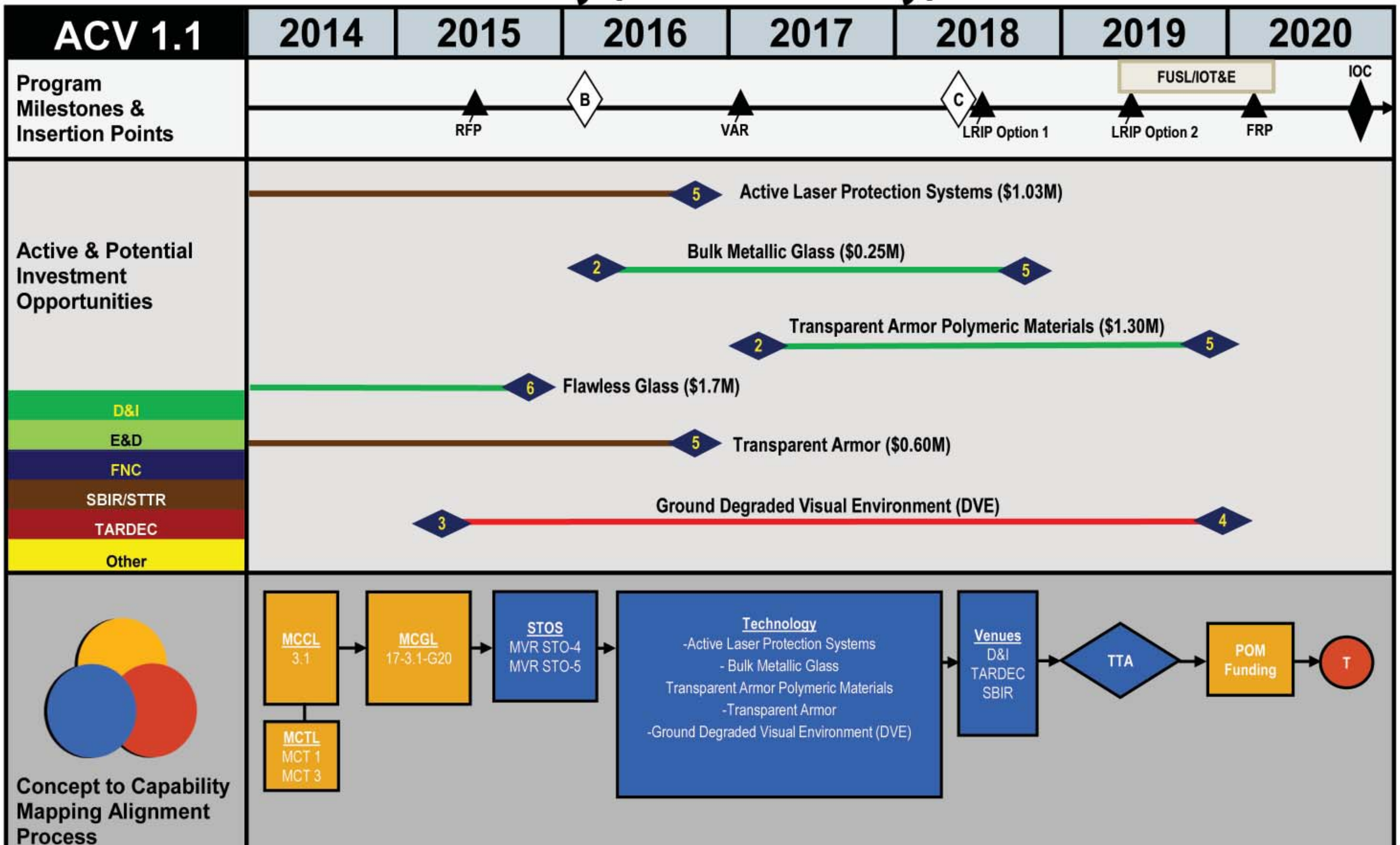
ACV 1.1 Technical Issue #2 Weight



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	2.00	10.36	6.91	11.75	12.65	6.15	1.60

6.1 ←→ Science & Technology ←→ 6.3 6.4 ←→ System Development ←→ 6.7

ACV 1.1 Technical Issue #3
Safety (Crew Visibility)



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	1.10	4.33	7.55	7.64	6.16	5.11	

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

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COMMON AVIATION COMMAND AND CONTROL SYSTEM

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) and to 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 utilizing 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 FY16.

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 awarded the Phase 2 Engineering, Manufacturing, and Development prime contract to General Dynamics C4 Systems, which is located in Scottsdale, AZ. The program completed its Critical Design Review in October 2013, conducted a series of three progressive, iterative developmental test periods in 2014, and completed an Operational Assessment in October 2014. Four Engineering Development Models were delivered by the prime contractor to the Government for the Developmental Tests and the Operational Assessment. A Milestone C decision is scheduled for 2QFY15 and seeks authorization from the Milestone Decision Authority to procure four Limited Deployment Units (LRIP) as production articles for Initial Operational Test & Evaluation in 2QFY16.

The success of the new CAC2S technology was publicly highlighted on June 15, 2012, when former Under Secretary of the Navy Robert O. Work and Assistant Secretary of the Navy for Research, Development and Acquisition Sean Stackley recognized the CAC2S program as one of the Department of the Navy's Major Acquisition Activity Awards for their "creative and effective practices that lead to lower costs and better technical performance."

CAC2S' Top Technical Issues

1. Voice Network

Technologies that provide modern hardware and software solutions are needed to replace the aging voice network system to minimize increasing obsolescence issues and increase to system capabilities. The CAC2S currently utilizes Digital Service Access Node (DSAN) software and a gateway (Digital Switching Unit) to access and control military radios from voice workstations. Obsolescence issues require a CAC2S Voice Network upgrade. In addition, these systems must integrate into the current CAC2S Phase 1 network architecture, which would serve to minimize change and decrease the development effort.

2. Direct Air Cooling

The CAC2S Program responds to "Lightening the MAGTF" initiatives by seeking ways to reduce its system size, weight, and power footprint. To this end, the program is seeking alternative technologies and methods to cool electronic equipment without the use of large, heavy Environmental Control Units (ECU). The current Phase 2 contractor is using a direct air cooling system to cool the CAC2S Phase 2 PDS using high velocity, high capacity fans to accelerate air across the equipment. Cooling of electronic equipment without ECUs continues to be a technical challenge for the program. The program seeks efficient methods of cooling and heating electronic systems without ECUs to further reduce the footprint and power consumption of the CAC2S.

3. Future Data Link Receiver and Processor

The advent of future data links for 5th generation fighter aircraft introduces tremendous opportunities for the MACCS to participate in the exchange of high quality, high fidelity battlefield information collected by an array of airborne sensors. Examples of emerging data link technology include the F-35's Multi-Function Advance Data Links (MADL). To take advantage of the technology and phenomenology aboard these 5th generation airborne assets, the PMO seeks technologies that will allow CAC2S to participate in this currently fighter-to-fighter domain.

4. C2 Command Tools

Collaboration between staff members and other commanders is one of the major contributors to a Commander's situational awareness (SA). To improve SA decision making for the Commander, the CAC2S Program is seeking technologies that address information load and the cognitive demands of future network-centric forces. The program seeks new human-machine systems that translate high-rate inflow of battlespace data into a high-agility battle commands. The PMO seeks integration and awareness tools that continuously and autonomously fuse data into a high-quality shared information portrait. Moreover, the program seeks execution tools that support human-controlled automation of intelligence information, maneuver and air control measures, fires, and battle damage assessment.

5. Multi-Level Security Solutions

As CAC2S integrates with fifth generation aircraft and potentially with coalition forces, the system requires the ability to provide multi-level security processing and dissemination. The PMO seeks tools and systems that will allow the automatic exchange of information with systems in discrete classification domains. The PMO will need NSA-approved, small factor, and lightweight solutions that will permit the system to function in a multi-level security environment.

6. 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.

7. Video Compression

The proliferation of unmanned aerial vehicles in the battlespace has presented a new challenge for the C2 systems and command posts. The large volume of video downloaded from these systems presents a technical challenge for storing and sharing the video products in a low-bandwidth environment. The PMO seeks technologies to effectively compress videos while retaining attributes that make them effective for situational awareness and decision making.

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

C (Y) S (G) P (G)

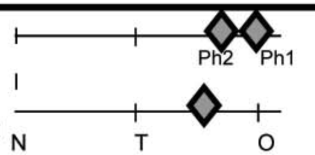
CAC2S Increment I

Phase 2 MS C = Sep 14(O)/Mar 15(T) **AAO =** 50
LDC = Feb 12 **FDD =** Oct 11 **FD =** Mar 22 Threshold

Description: 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 with the PDS and will provide an Air Command and Control Subsystem (AC2S). Fielding of Phase 2 will complete CAC2S Increment I.

KPP Net Ready

KPP Data Fusion (Phase 2 Only)



N – No capability **T** – Threshold **O** - Objective

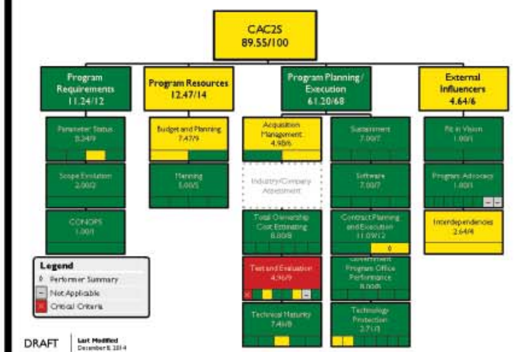
* Assessment is based on an independent evaluation performed by NSWC Corona using results from DT and OA. 4 of the 5 Data Fusion KPP attributes were consistently above threshold. The 5th Data Fusion KPP deals with ATO Association and requires additional testing with more complex ATOs before the requirement can be fully evaluated. Additional testing will be conducted through DT prior to IOT&E to validate test results on production system.

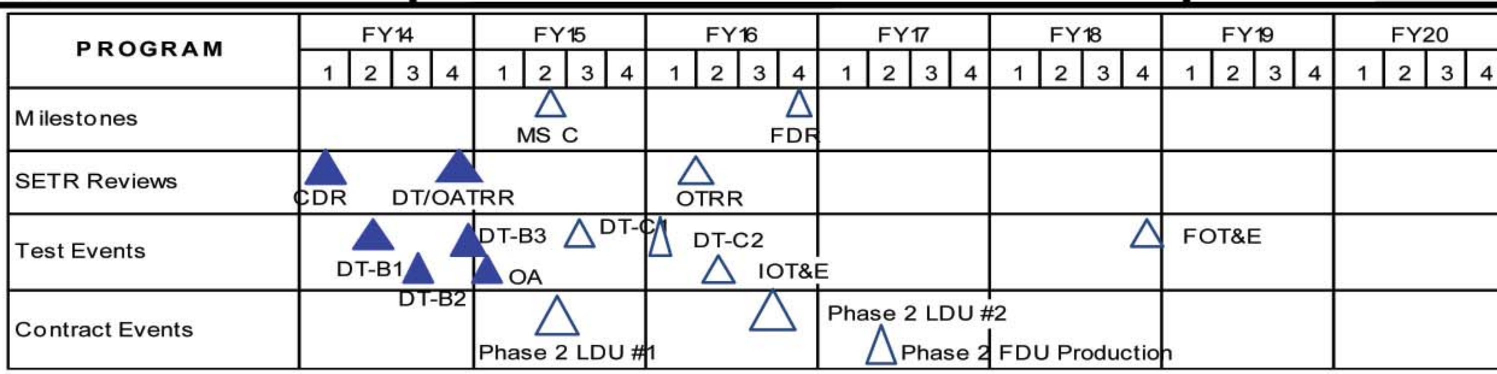
Contract Data: FPIF (EMD RDT&E), 2 FPIF LDU Option CLINS (PMC), 2 FFP S/W Maintenance Option CLINS (OMMC) and 1 FFP Refurb/Initial Spares Option CLIN (PMC)
Contractor GDC4S
Start – Complete 7 Nov 2012 – 3QFY16 (EMD RDT&E)
Next Contract: FRP = 2QFY17

DCMA Schedule Health Assessment = 6/13

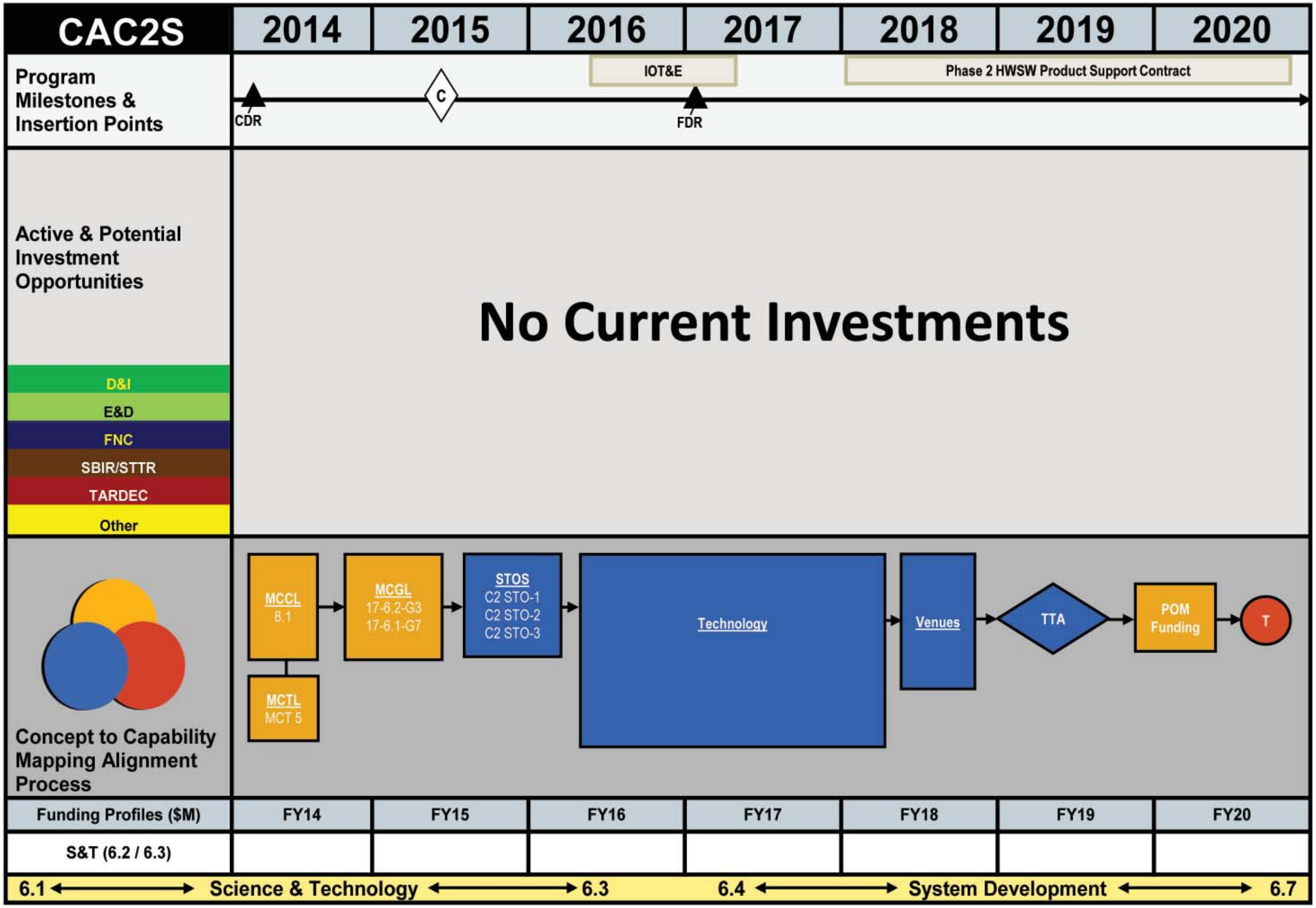
ISSUES: Expenditures lag OSD benchmark because of Performance Payment schedule

19 Dec 2014

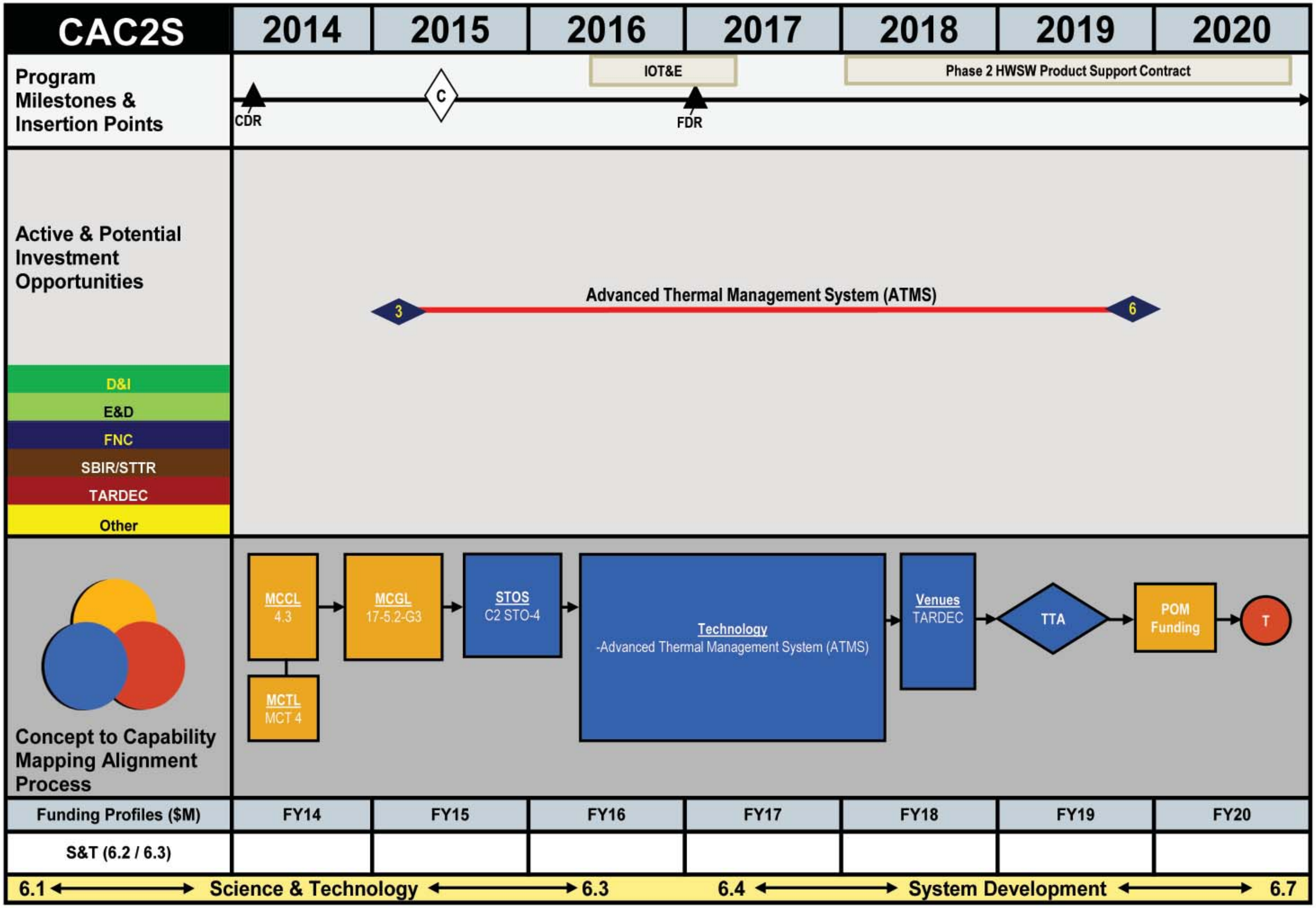




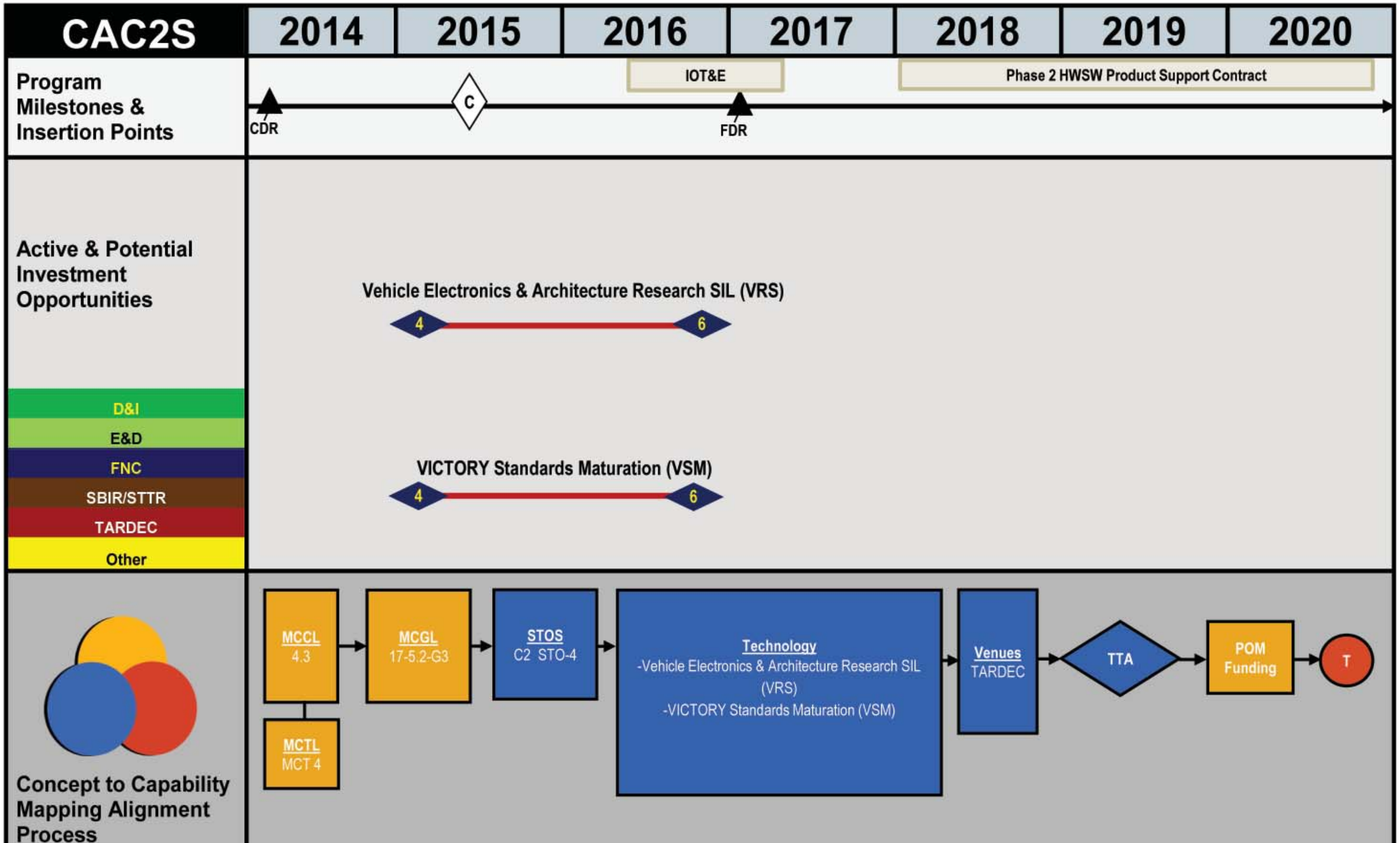
CAC2S Technical Issue #1 Voice Network



CAC2S Technical Issue #2 Direct Air Cooling



CAC2S Technical Issue #3
Future Data Link Receiver and Processor



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)		11.19	4.13				

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

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Section 7.4 PEO LS Program

GROUND BASED AIR DEFENSE

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 units currently use the Stinger missile, originally fielded in 1981 and upgraded since to Block I configuration, as its primary weapon for air defense. It is expected that the Stinger missile will be the primary GBAD asset for the near future, and the missile is undergoing a Service Life Extension Program (SLEP) to maintain its operational effectiveness. Future GBAD systems are being investigated to take advantage of the new G/ATOR system capabilities and may possibly employ advanced technology, to include a pulsed energy system.

Programs and projects included in the GBAD portfolio are:

- Stinger Missile SLEP
- Advanced Man-Portable Air Defense (A-MANPADS) System Increments 0 & 1
- LAAD Sustainment
- Stinger Night Sight Replacement
- Identification Friend or Foe (IFF) Mode IV Replacement
- GBAD Future Weapon System

Program Status

Stinger Missile SLEP

A Stinger Missile SLEP was started in FY14 and will complete delivery in FY17. The SLEP is required to meet the War Reserve Munitions Requirement and to provide sufficient training rounds after 2019.

A-MANPADS Increments 0 & 1

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 Approved Acquisition Objective for Increment 1 conversion is 38 Section Leader Vehicles (SLV) and 143 Fire Unit Vehicles (FUV), with an Actual Acquisition Quantity (AACQ) of 13 SLVs and 50 FUVs. A Joint Range Extension Sustainment Contract was awarded in September 2013 for five years. All A-MANPADS FUVs will be upgraded to a M1114 Prime Mover platform to rectify obsolescence of the current chassis.

LAAD Sustainment

LAAD sustainment consists of Target Support for Stinger Missile Live Firing Exercises, repair of Stinger Ground Support Equipment, and the Improved Moving Target Simulator (IMTS) upgrade currently taking place at the two LAAD Battalions. The IMTS upgrade contract was awarded in August 2013.

Stinger Night Sight Replacement

The AN/PAS-18 Stinger Night Sight is being investigated for replacement with a COTS/NDI system.

IFF Mode IV Replacement

GBAD plans to procure a replacement IFF in FY18-20 from the U.S. Army to meet a Joint Requirements Oversight Council requirement to be Mode V capable by 2020.

ONR Directed Energy Effort

GBAD Future Weapon System replacement is being investigated, including the GBAD OTM Future Naval Capability program being funded by the Office of Naval Research and developed by Naval Surface Warfare Center, Dahlgren, VA.

GBAD's Top Technical Issues

1. Stinger Night Sight Replacement

The following characteristics are needed to produce a mountable day/night sight for the Stinger missile to meet the operational requirements:

1) Ability to detect traditional air-breathing as well as emerging small/light Unmanned Aerial Systems and cruise missiles.

2) Capability to:

(a) Distinguish targets up to the current seeker head lock-on range of the Stinger Missile.

(b) Provide the operator with a distinguishable outline of the target.

(c) Provide a field of view of at least 20 degrees in azimuth and 12 degrees in elevation.

(d) Utilize Naval Sea System Command (NAVSEA) compliant batteries with an operating time of 6 hours.

3) Be of cooled or uncooled technology and with a max time from off or standby to operate of 10 seconds.

4) Have a size, weight, and power SWaP comparable to the AN/PAS-18 or smaller.

3) Be of cooled or uncooled technology and with a max time from off or standby to operate of 10 seconds.

4) Have a SWaP comparable to the AN/PAS-18 or smaller

2. Secure Wireless Communication

The A-MANPADS Increment 1 FUV currently has a requirement to allow the gunner to dismount the vehicle and maintain connectivity to the Adaptive Networking Wideband Waveform (ANW2) data network remotely for situational awareness of the current air threat, with the capability for Voice over Internet Protocol transmissions, and with a remote distance of up to 50m. Proposed solutions are being investigated; however, these radio systems are not supported by a Program Manager within MCSC. These radios must be in the smallest form factor that allows for secure (NSA accredited Type I encryption) data/voice transmission over the ANW2 network.

AAP IN 2005

GBAD
5 DEC 14

GBAD PORTFOLIO

MS C = Jul 15 2007
IOC = Dec 2012

AAO = SLV 38/**FUV** 143
FOC = AACQ = SLV13/**FUV** 50

*All information provided is for A-MANPDS Increment I
*AACQ = Actual Acquisition Quantities

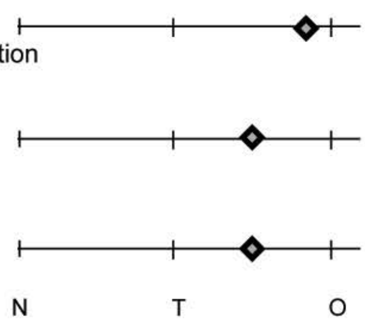
FOC for AACQ Dec 2014

Description: GBAD is a Portfolio of acquisition activities comprised of 2 programs: Advanced MANPADS Increment 1 and Stinger SLEP, and 4 projects: Sustainment, GBAD Aerial Targets, D-UNS, and GBAD OTM. The GBAD program has the mission to counter low altitude aerial threats to the MAGTF. Managed by PM GBAD – G/ATOR, PEO LS.

KPP
Survivability/Protection

KPP
Transportability

KPP
Net Ready



*Based on estimated and calculated values of A-MANPADS Inc I

N – no capability **T** – Threshold **O** - Objective

Contract Data - FFP
Contractor Engility Corporation

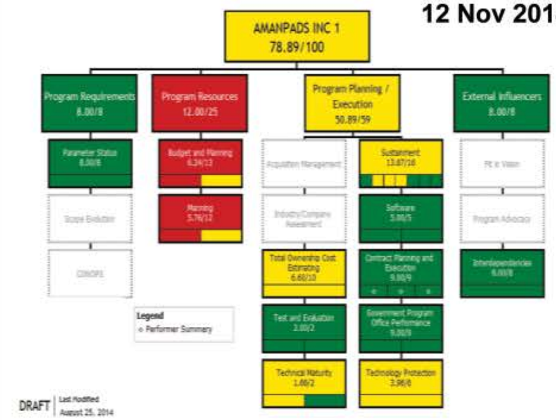
Start – Complete 30 Aug 13 – 29 Aug 18

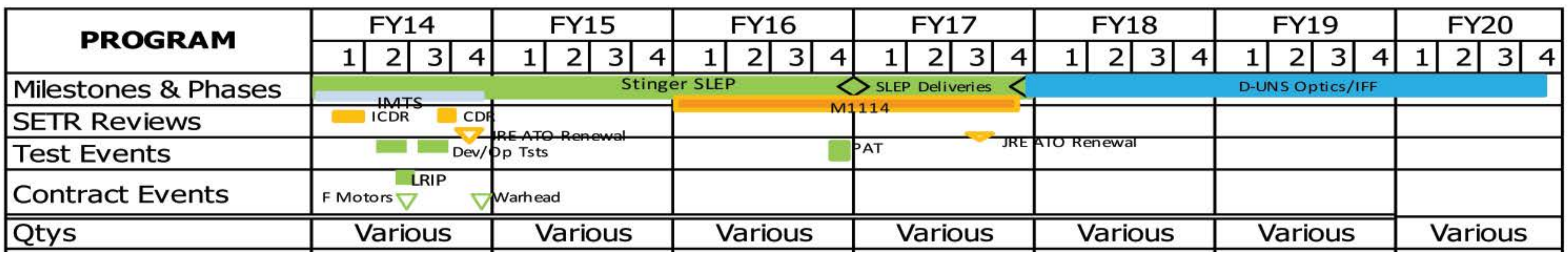
Next Contract: N/A

DCMA = N/A
CPI = N/A
EAC = N/A

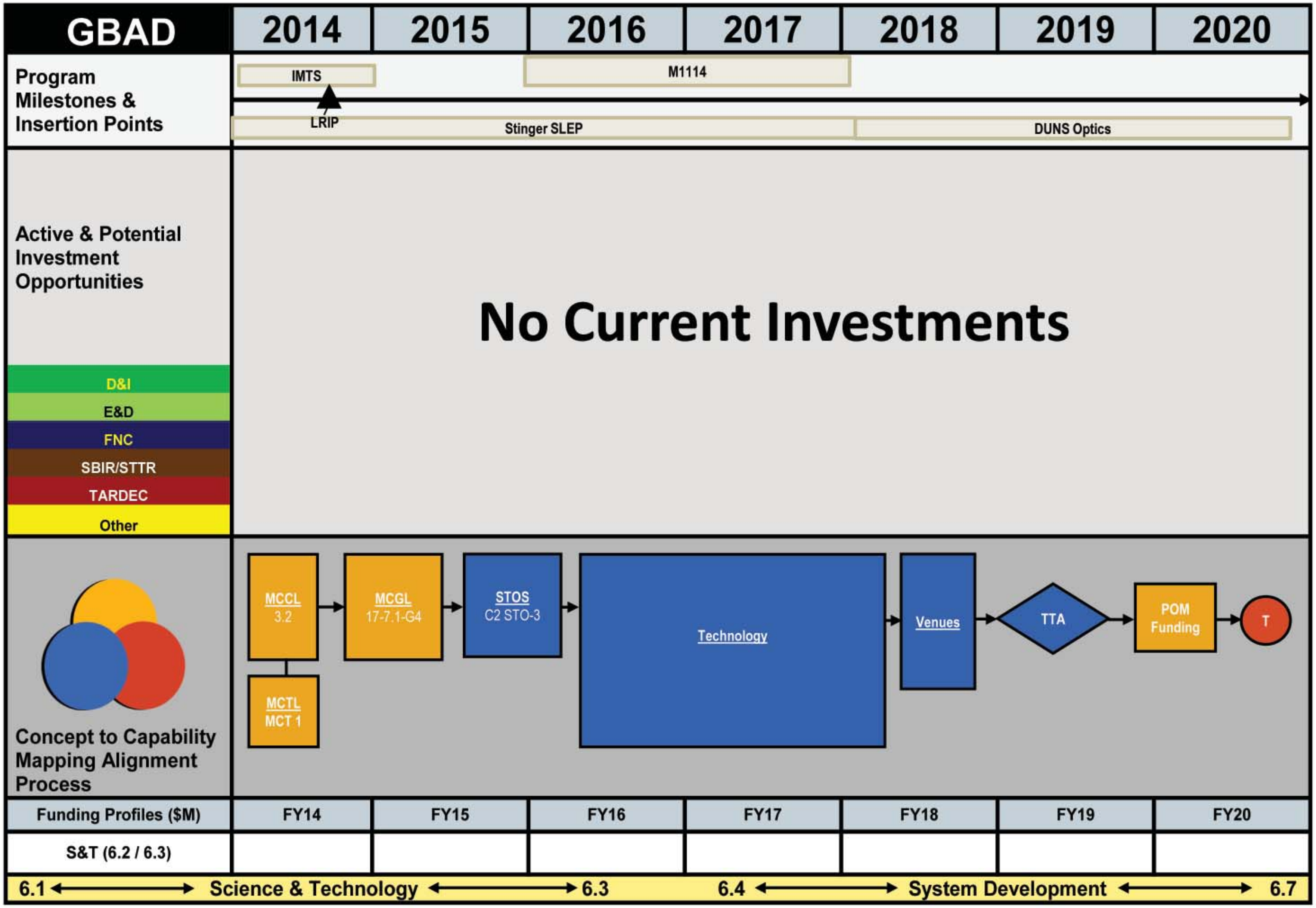
Issues:
PMC funding to complete AAO / M1114
Maintenance Manpower Structure
Secure Tactical Wireless Replacement
Fire Unit Laptops (FUL) EOL/64 Bit Win7

12 Nov 2014

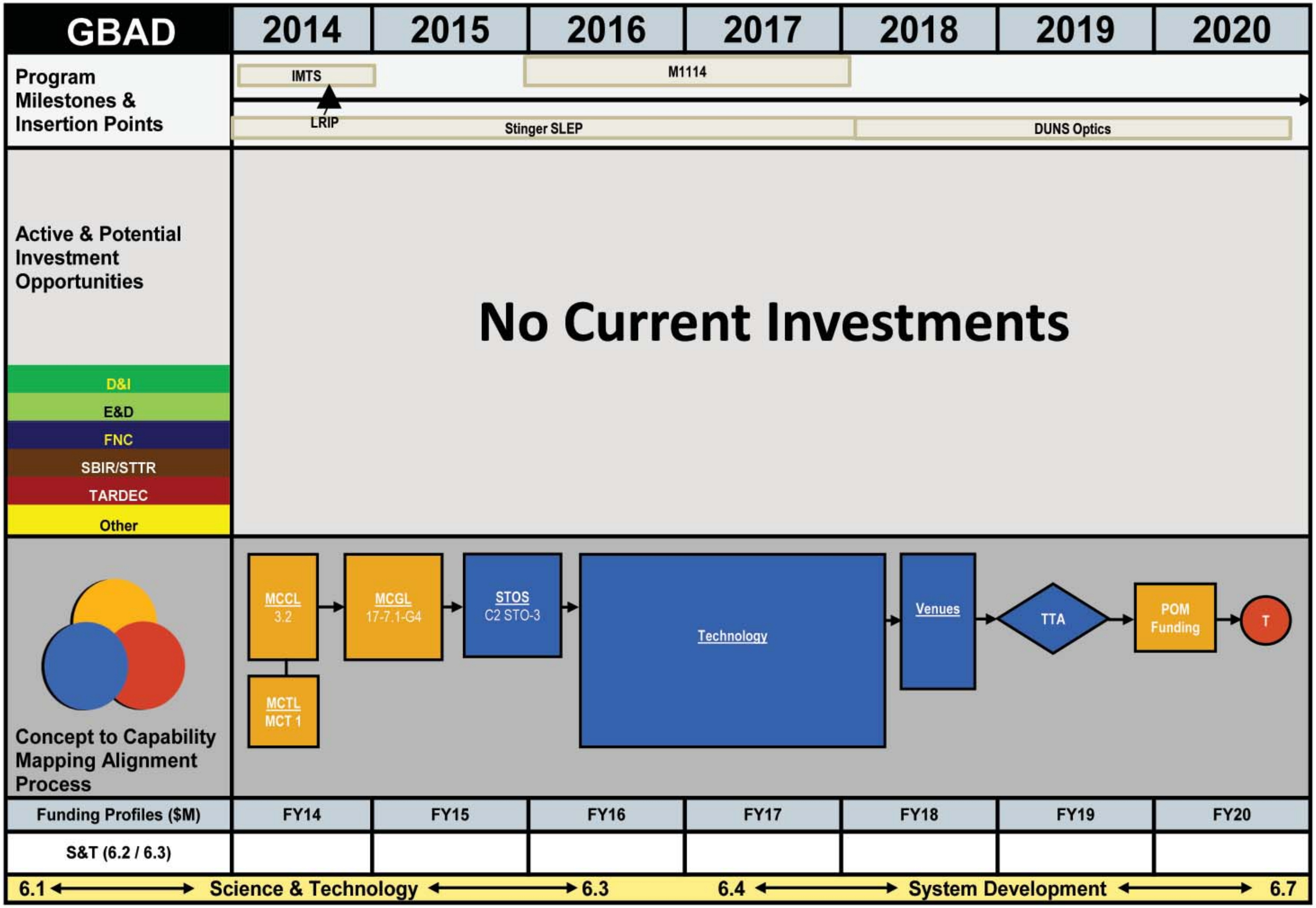




GBAD Technical Issue #1 Stinger Night Sight Replacement



GBAD Technical Issue #2 Secure Wireless Communication



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GROUND/AIR TASK ORIENTED RADAR

G/ATOR

Program Background

Ground/Air Task Oriented Radar (G/ATOR) is a three-dimensional short-to-medium-range tactical radar that is designed to detect, identify, and track low level cruise missiles, manned aircraft, and unmanned aerial vehicles (UAVs) as well as rockets, mortars, and artillery fire. G/ATOR capabilities include the ability to track hostile UAVs, assist in air traffic control, serve as a fire control system, support ground-based air defense, and detect rockets, artillery, and mortars in order to direct the counter fire.

Developed by prime contractor Northrop Grumman Electronic Systems in Baltimore, Md., G/ATOR will replace legacy radar systems to perform air surveillance, cue air defense weapons, determine hostile indirect firing locations, and provide data to air traffic controllers.

Program Status

In July 2012 Northrop Grumman delivered the AN/TPS-80 G/ATOR system to Surface Combat Systems Center Wallops Island for Developmental Testing (DT). The successful DT and the Operational Assessment for G/ATOR were completed in Yuma, Arizona, in 2013.

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 contract in October 2014 for four systems.

G/ATOR's Top Technical Issues:

1. Lowering Manufacturing Costs

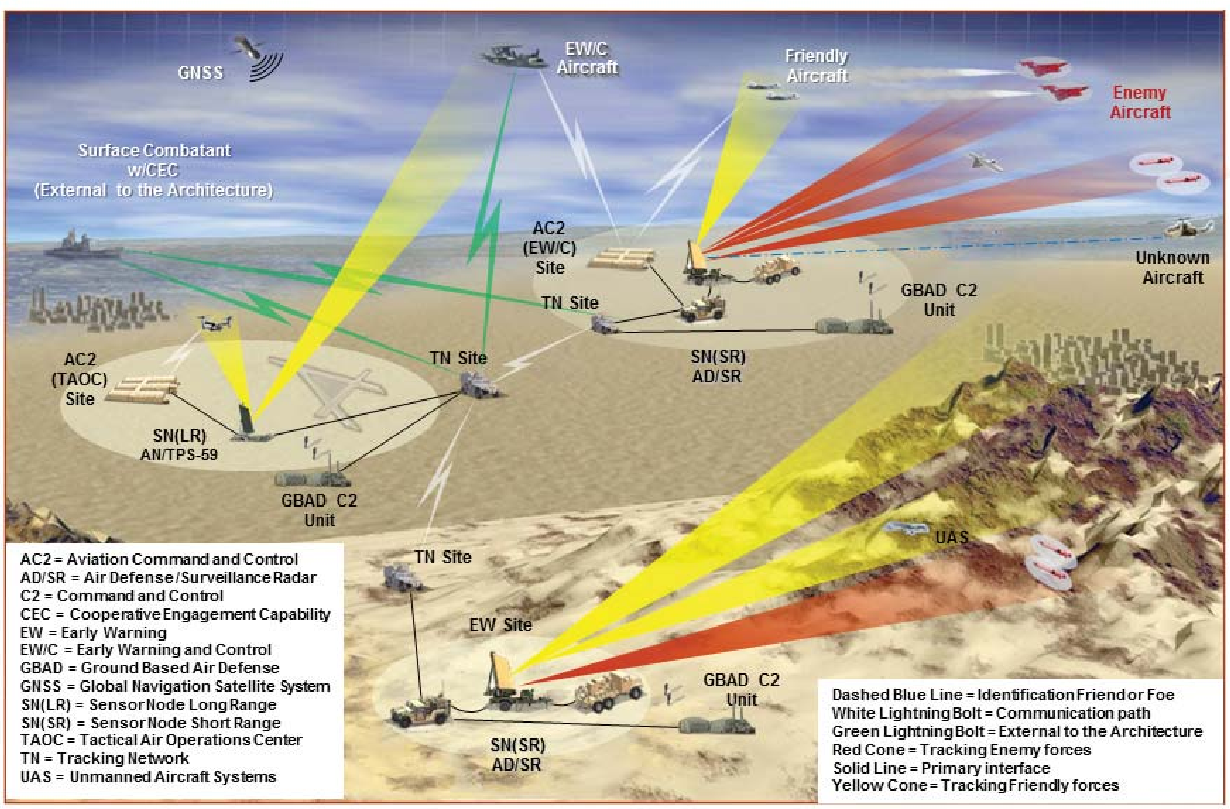
Technologies are needed that reduce manufacturing cost across multiple areas of production, including: 1) air ducts that provide precise mounting and cooling of the T/R modules and array elements (the air duct is very time consuming to produce and assemble and thus is very expensive); 2) T/R module packaging, which requires expensive materials and hermetic sealing that reduces yield; and 3) Circulator Isolator Radiator Filter boards, which are required for the T/R modules and which require a multi-step, medium yield manufacturing process.

2. T/R Module Efficiency

The G/ATOR system currently operates at the limit of its primary power source. As the largest aggregate consumer of power, the T/R modules require technologies that increase power efficiency, such as: 1) higher efficiency power amplification; 2) a higher efficiency DC/DC power supply; and 3) greater integration of components.

3. Lightweight Material

PM G/ATOR has started a CEG Shelter Working Group that will finalize the CEG Shelter requirements for the shelter integration. In order to reduce the weight, a technology firm is needed to look at designing lighter weight materials for either the vehicle up-armor, the shelter shell and equipment racks, or all of these.



G/ATOR Operational View (From U.S. Marine Corps Concepts & Programs)

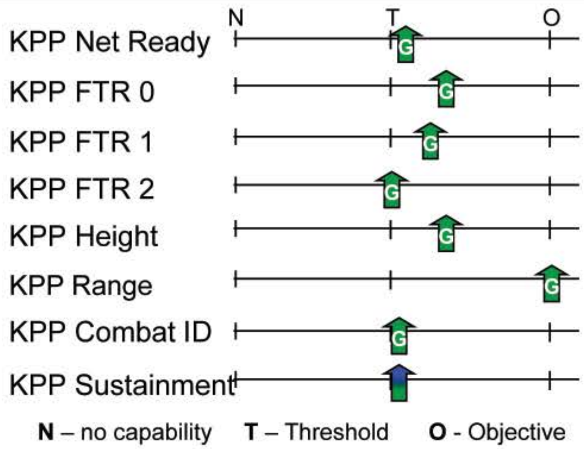
C G S G P G

GATOR

ACAT 1C/Production & Deployment

MS C = 10 Mar 14 **Qty =** 45
GB1 IOC = Feb 17 (O)/Feb 18 (T)
GB2 IOC = Feb 18 (O)/Feb 19 (T) **GB1/2 FOC =** 2024

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.



Contract Data - FPIF
Contractor NGSC

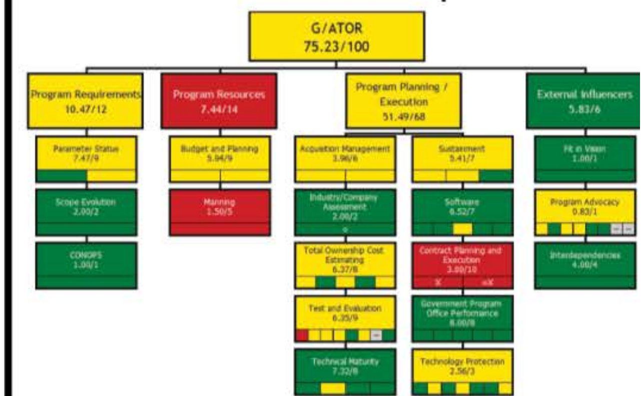
LRIP Start – Complete 10/23/2014—10/31/2017
Next Contract: GB2 Proposal received 11/26/2014, LRIP Option Lot 2 2Q 15

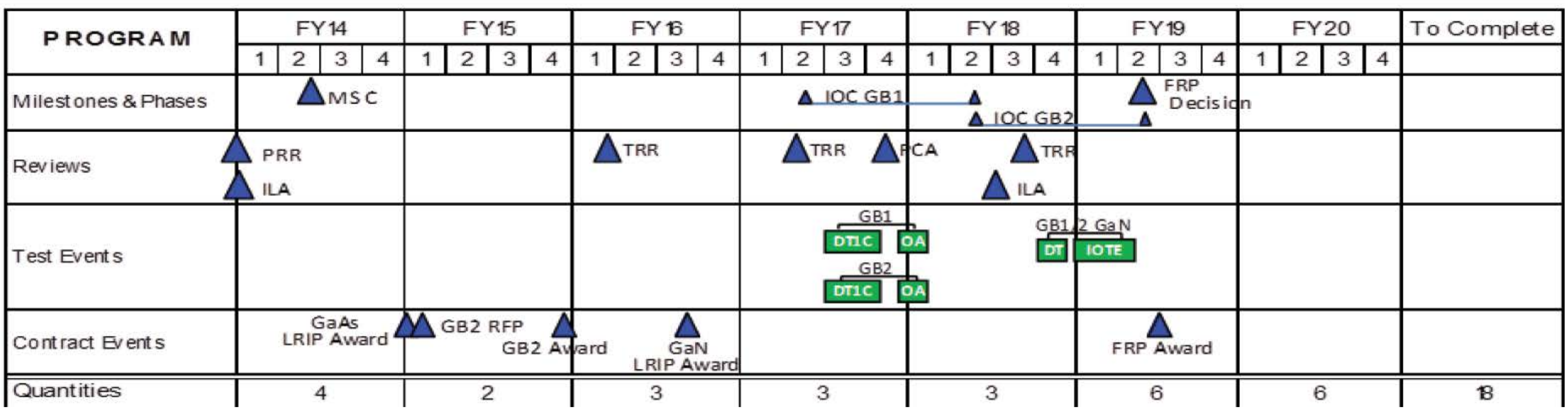
DCMA : TBD (TBD)

CPI* = TBD SPI* = TBD

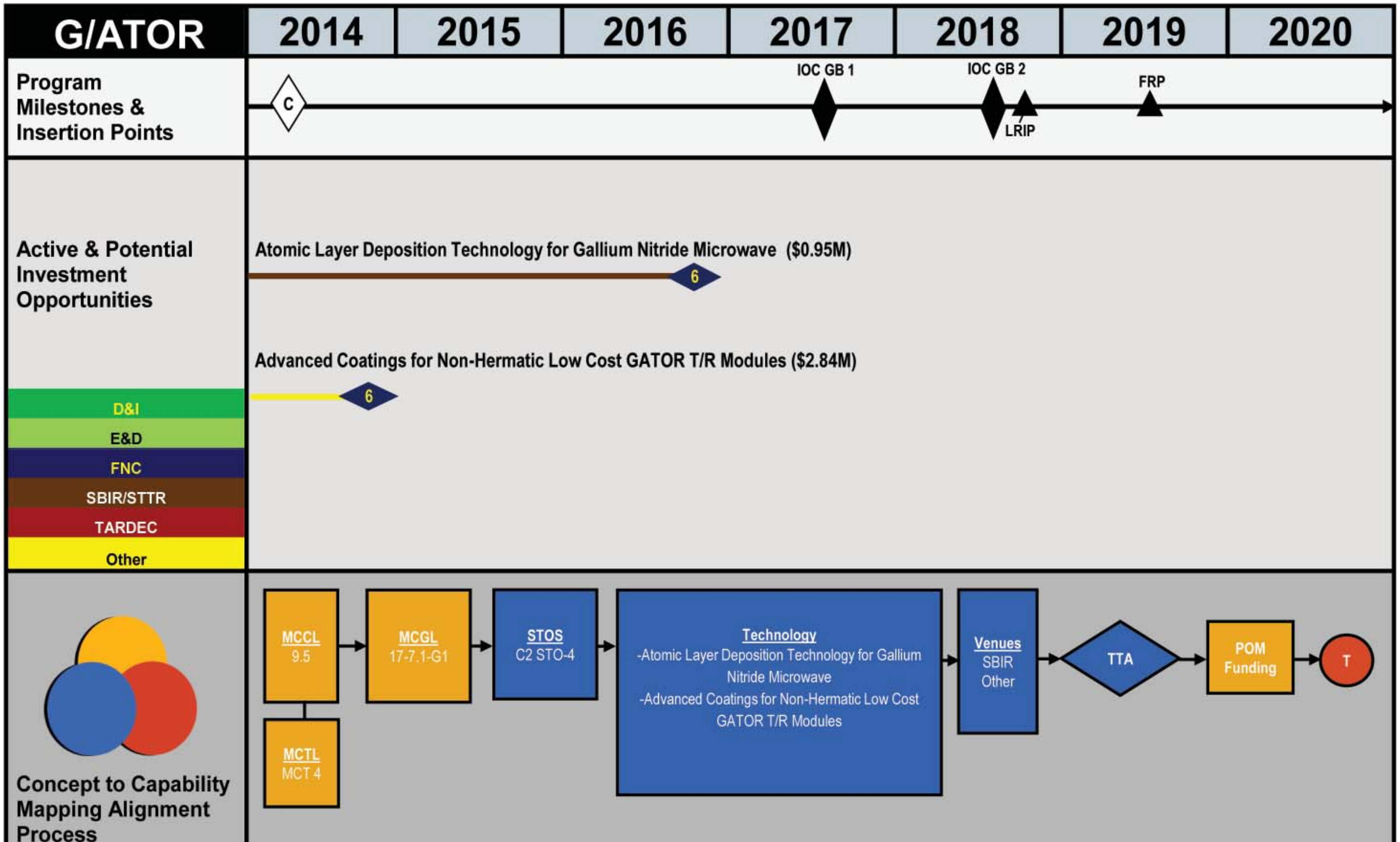
Issues: None
*Initial CPR due mid-late Jan 2015

24 September 2014





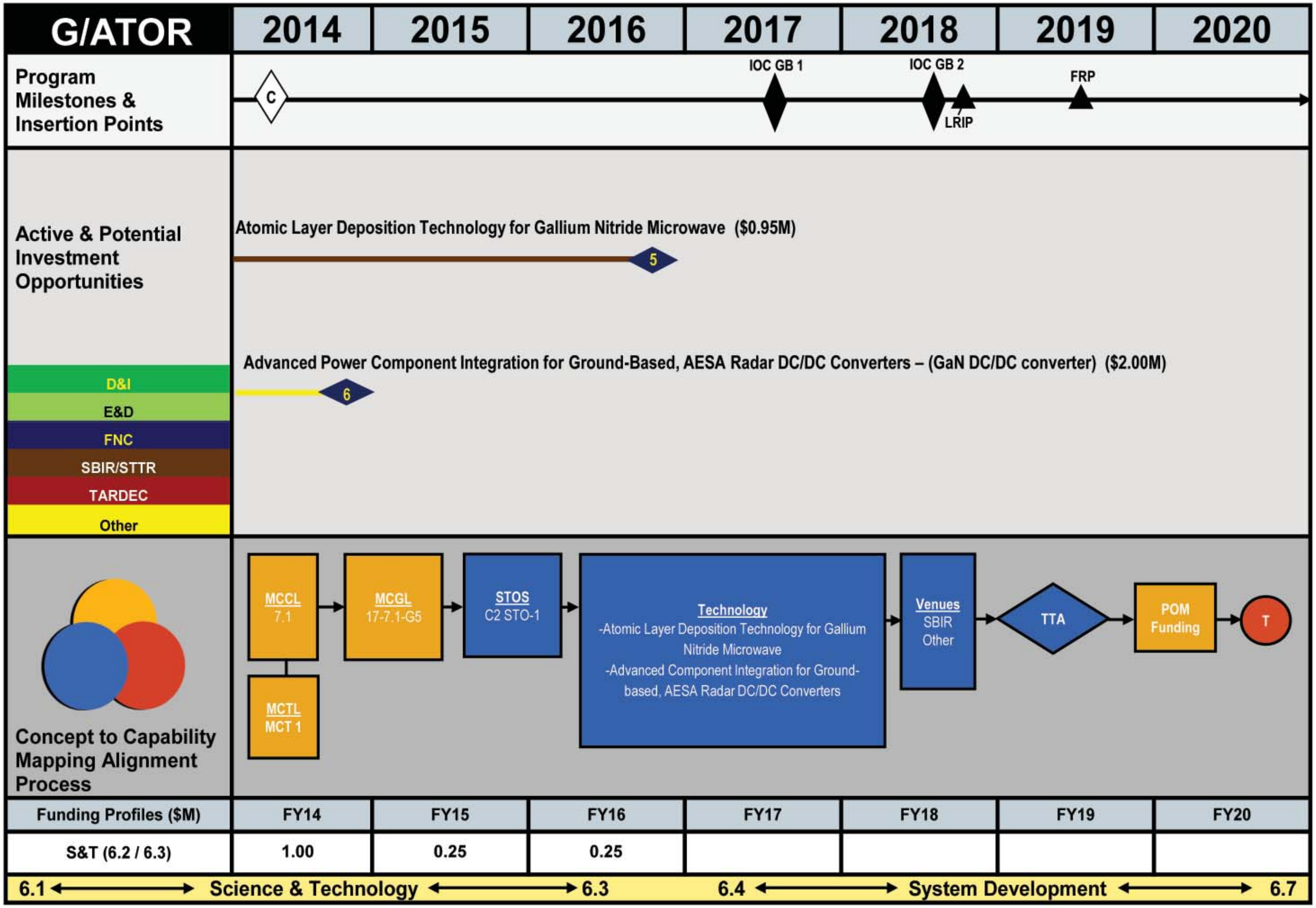
G/ATOR Technical Issue #1
Lowering Manufacturing Costs



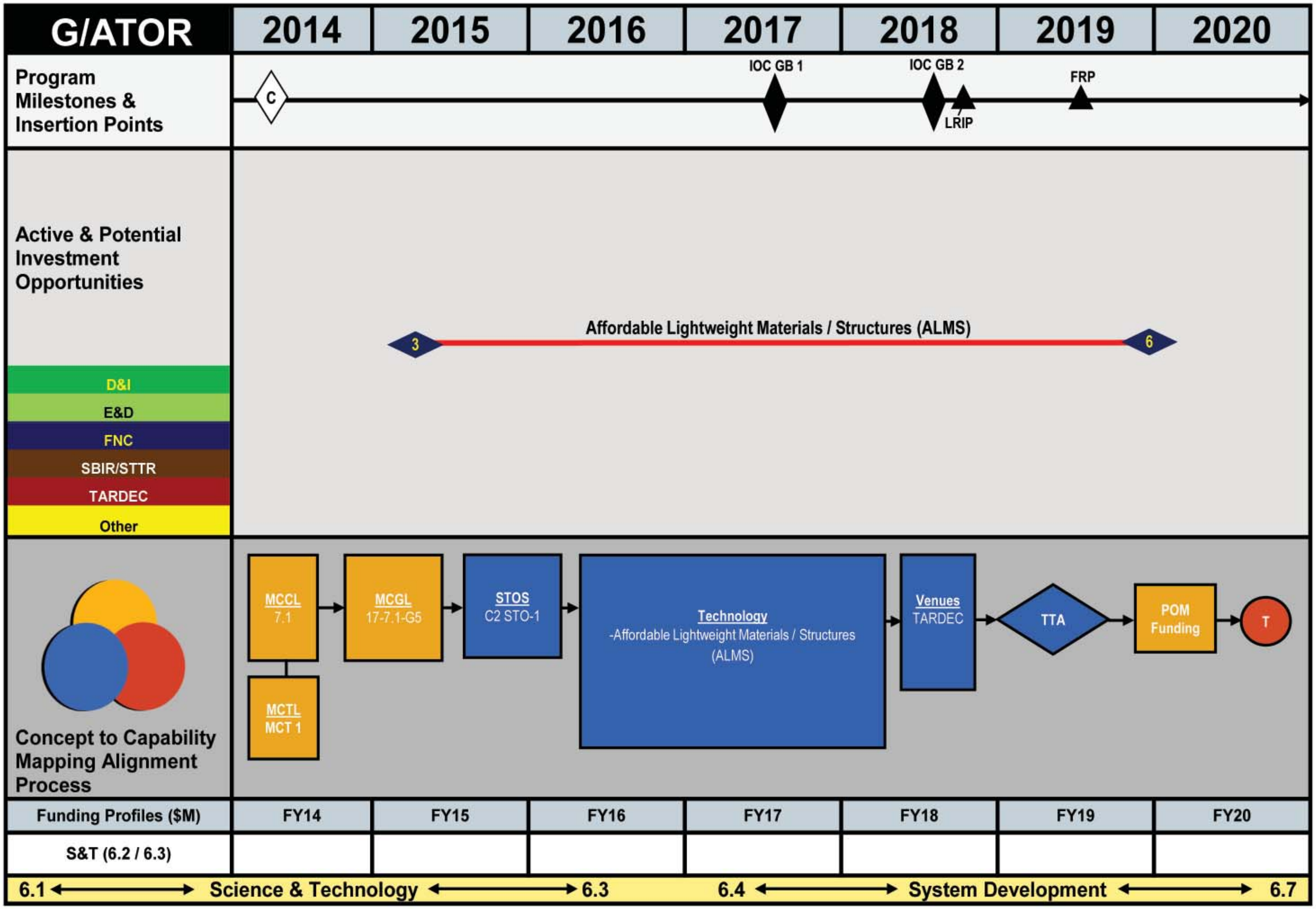
Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	0.45	0.25	0.25				

6.1 ←→ Science & Technology ←→ 6.3 6.4 ←→ System Development ←→ 6.7

G/ATOR Technical Issue #2 Transmit/Receive (T/R) Module Efficiency



G/ATOR Technical Issue #3 Lightweight Material



Section 7.6 PEO LS Program

HIGH MOBILITY MULTI-PURPOSE WHEELED VEHICLE

Program Background

The High Mobility Multi-Purpose Wheeled Vehicle (HMMWV), commonly known as the Humvee, is a four-wheel drive military automobile produced by AM General. The Marine Corps' most recent variant of the HMMWV is the Expanded Capacity Vehicle (ECV), which is the 4th generation design of the HMMWV. The Marine Corps plans to reduce the HMMWV fleet from 24,000 vehicles to approximately 18,500, with 5,500 of those vehicles subsequently replaced by the Joint Light Tactical Vehicle. The remaining Marine Corps HMMWV fleet of approximately 13,000 vehicles will require sustainment through 2030. The HMMWV Sustainment Modification Initiative proposes to leverage mature and production ready designs/technologies that will help restore the existing expanded capacity variant of the HMMWV to pre-armoring levels in terms of safety, performance, and reliability.

Program Status

The current armoring necessary to secure occupant survivability for operations in Operation Enduring

Freedom has resulted in the HMMWV ECV being burdened with thousands of pounds of weight above its gross vehicle weight, which has reduced driver control, stability, mobility, and reliability.

The PM Light Tactical Vehicles (LTV) conducted technology/concept evaluations at the Nevada Automotive Test Center in FY13 to explore technological possibilities in regard to HMMWV fleet sustainment and upgrades. The results of these evaluations were then utilized to inform and update the HMMWV Operational Requirements Document (ORD). After completion of an ORD Clarification letter, PM LTV was directed by MCCDC to not conduct any HMMWV modernization. The HMMWV program is currently in sustainment.

HMMWV'S Top Technical Issues:

1. Performance

As a result of the armoring levels required to meet the demands of Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF), HMMWV fleet performance has been significantly degraded. Technologies are needed that increase safety, mobility, and payload and that restore full performance.

2. Energy Consumption

As a result of the armoring levels required to meet the demands of OIF and OEF, the HMMWV energy efficiency (fuel efficiency) has experienced a severe negative impact. Technologies are needed to restore HMMWV energy efficiency.

3. Reliability/Durability

Technologies are needed that increase the reliability and durability of the HMMWV across the spectrum of its mission profiles.

2 DEC 2014

ACAT IC

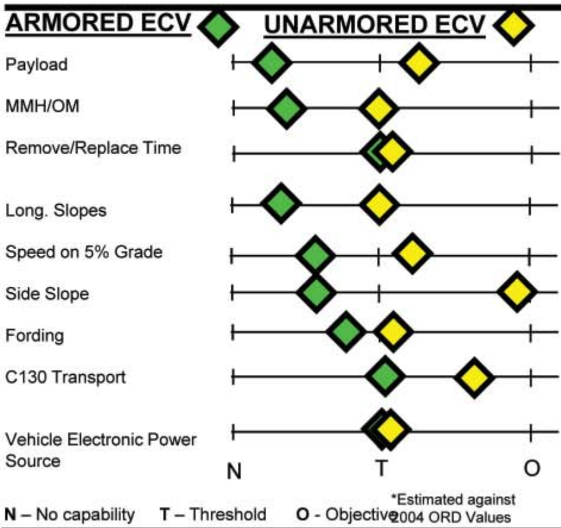
FY15 AAO = 18,500

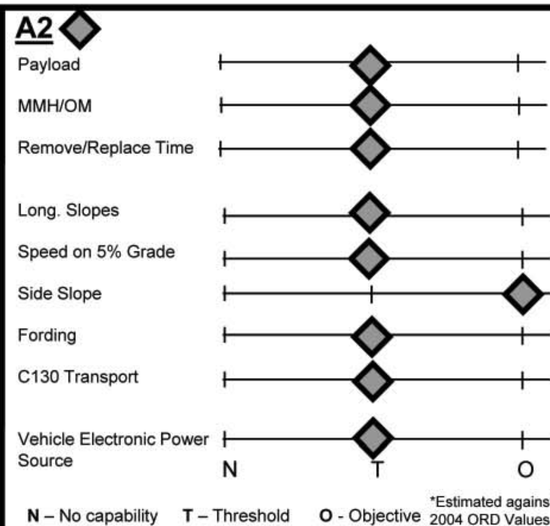
IOC = Oct 1986 **FOC =** Dec 2010

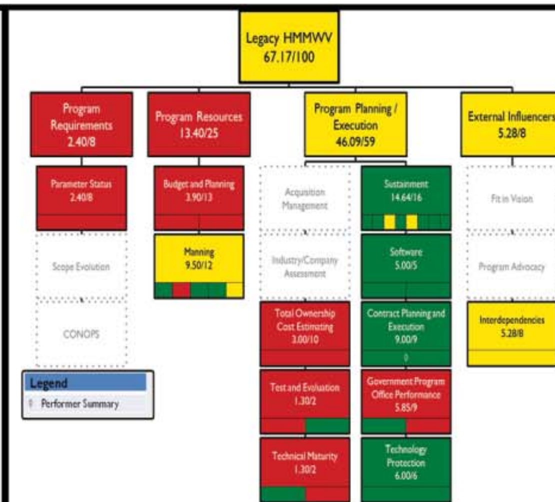
C (G) S (G) P (G)

HMMWV

Description: The High Mobility Multipurpose Wheeled Vehicle (HMMWV) serves as the primary light tactical vehicle for command and control, troop transport, ambulatory support, light cargo transport, armament carrier, TOW missile system carrier, towed weapons mover, and specialized shelter carrier throughout all areas of the battlefield or mission area.

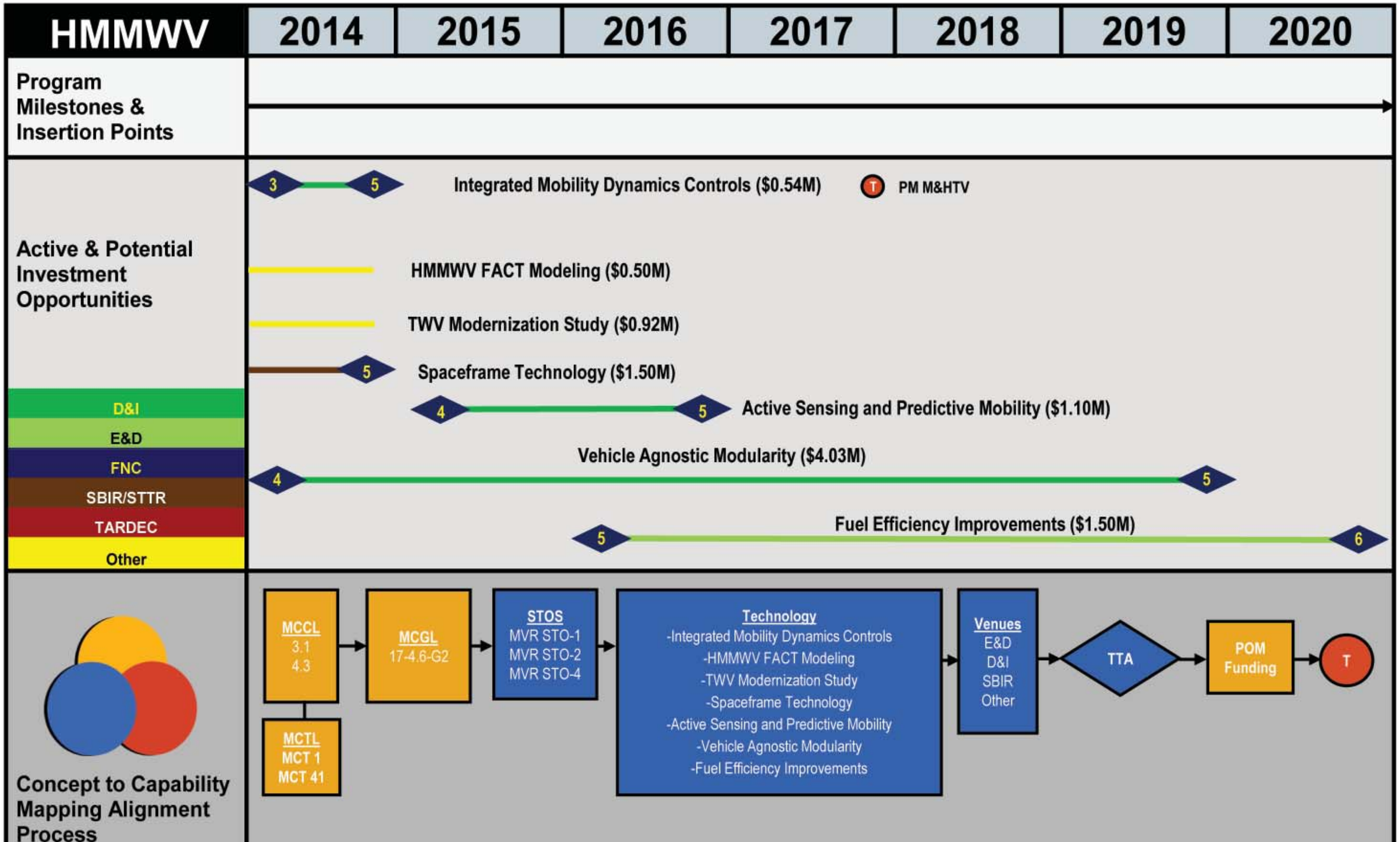






Test Events								
Contract Events								
Qtys								

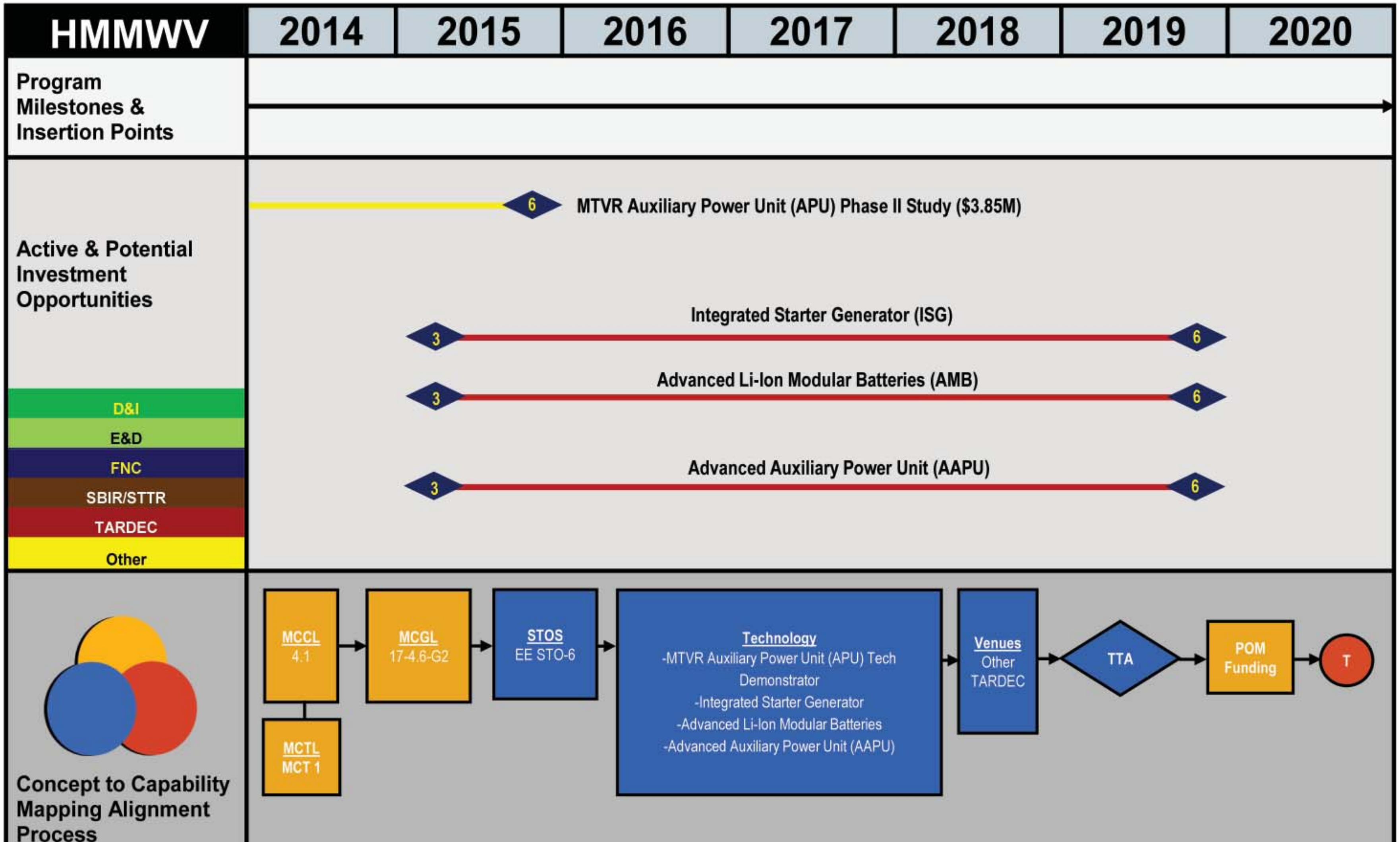
HMMWV Technical Issue #1 Performance



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	2.54	1.57	1.43	0.84	0.89	0.74	0.25

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

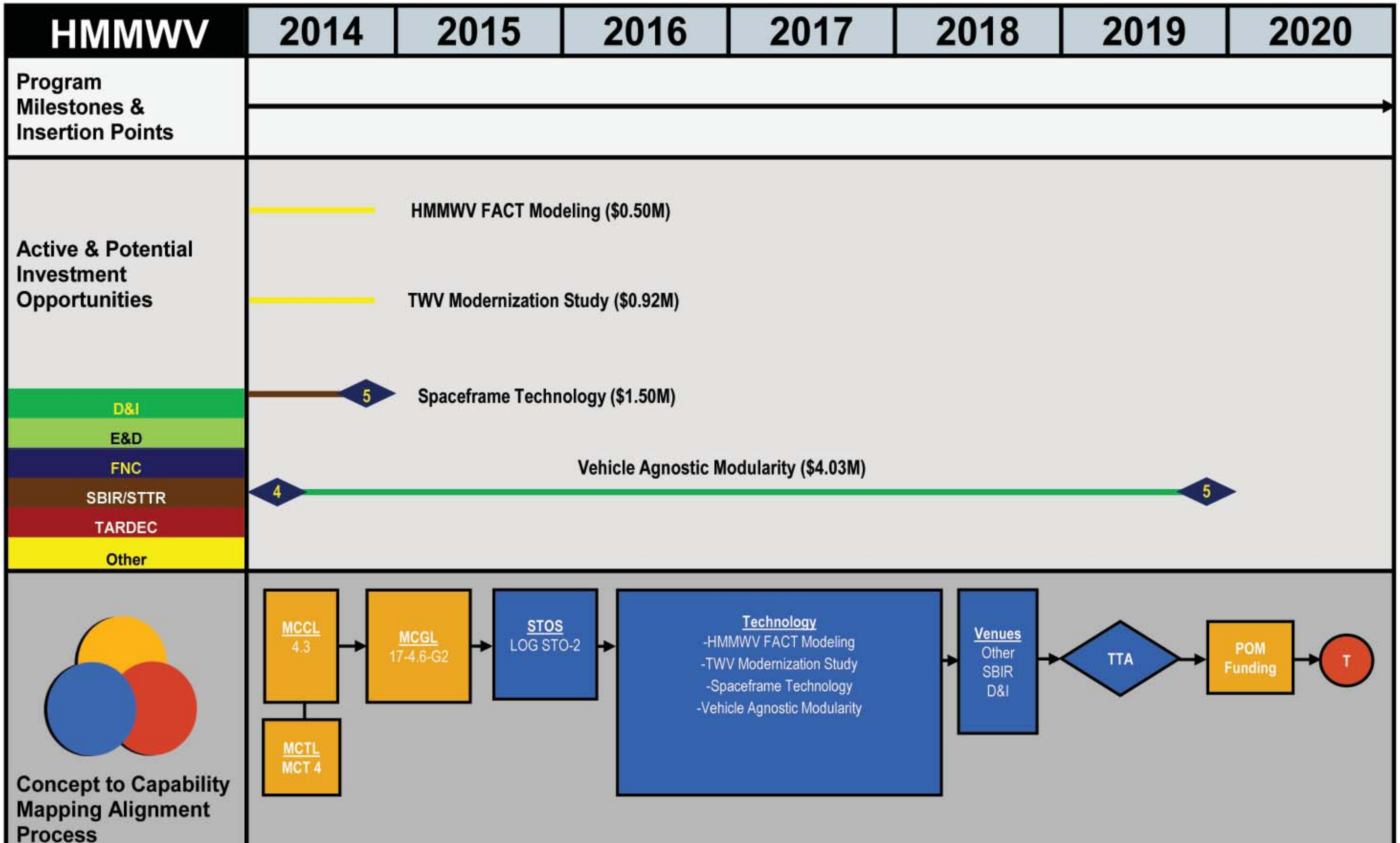
HMMWV Technical Issue #2 Energy Consumption



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	1.50	8.44	13.23	10.90	8.53	9.96	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

HMMWV Technical Issue #3 Reliability/Durability



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	2.00	1.03	0.58	0.49	0.49	0.49	

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

Section 7.7 PEO LS Program

INTERNALLY TRANSPORTABLE VEHICLE

Program Background

The Internally Transportable Vehicle (ITV) Family of Vehicles (FoV) is comprised of lightweight wheeled vehicle systems that are internally transportable in the V-22, CH-53D, and CH-53E. There are two variants, the Prime Mover (PM) and Light Strike Vehicle (LSV). The PM variant tows the M327 120mm Rifled Towed Mortar and M1164 ammo trailer of the Expeditionary Fire Support System. The LSV variant serves as a 4-man light attack vehicle with crew-served weapons (MK-19 or M-2 capability). The LSV also provides Special Operations Forces with a platform to support their primary and secondary missions.

The vehicle has four-wheel drive, an adjustable suspension system, and adjustable tire pressure to adapt to different ground conditions. Its ability to mount weapons, its all-terrain maneuverability, and its ability to carry supplies and equipment over long distances make the ITV a valuable addition to expeditionary operations. The vehicle's speed and maneuverability and the use of cover and concealment provide the crew its primary means of survival.

Program Status

The ITV Program is currently in sustainment. Support will transition from contractor logistics

support to organic support in FY18. Follow-on performance and reliability testing has identified numerous ITV safety/reliability issues that are currently being investigated, and PM LTV plans to identify upgrades to address these issues.

An ITV being offloaded from an AAV

ITV'S Top Technical Issues:

1. Safety (Stability)

Technologies are needed that increase vehicle safety in terms of stability to decrease the probability of vehicle rollovers and to mitigate the severity of rollovers if they do occur. While minimal weight can be added, these technologies must allow the ITV to maintain current off-road/on-road mission profile requirements. In addition, the ITV must maintain the current curb-to-curb turning radius requirement, which is currently achieved through the use of a rear steer system.

2. Weight Saving Technology

The current curb weight of the ITV allows for minimal payload capability due to transport mode weight restrictions. Material technologies are needed that decrease the weight of low-technology assemblies and components (e.g., hood, chassis, roll cage, skid plate, etc...) at a minimal cost.

ITVs aligned and conducting a fire mission with the Expeditionary Fire Support System

3. Digital Architecture

Material technologies are needed in order to enable and facilitate the exchange and update of vehicle diagnostics data through the use of a vehicle sensor data bus that is compliant with the SAE J1939 standard. The current engine, an MWM 2.78L turbo diesel, has no compatible electronic components to interface with diagnostic equipment. The current transmission is a GM 4L70-E. The vehicle does not have anti-lock brakes or electronic stability control. The material technologies must at a minimum have a zero net weight gain to the vehicle curb weight.

02 Dec 2014

ACAT III

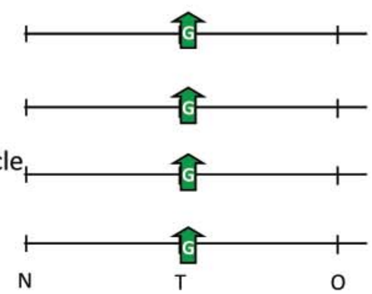
MS C = June 2005 **AAO** = 411

IOC = June 2009

C (Y) S (Y) P (R)

ITV

Description: The ITV Family of Vehicles (FoV) is lightweight and internally transportable in the V-22, CH-53D & CH-53E helos. There are two variants; the Prime Mover (PM) and the Light Strike Variant (LSV). The PM variant tows the M327 120 mm Rifled Towed Mortar (RTM) and M1164 ammo trailer of the Expeditionary Fire Support System (EFSS). The LSV serves as a 4-man light attack vehicle with crew-served weapons (MK-19 or M-2 capability). The LSV also provides Special Operations Forces (SOF) with a platform to support their primary and secondary missions.



N – no capability **T** – Threshold **O** - Objective

Contract Data

CLS Contractor TecMasters, Inc.

Contract Type FFP

Start – Complete 06/28/14- 06/27/2015

(working with contracts to extend contract 90 days)

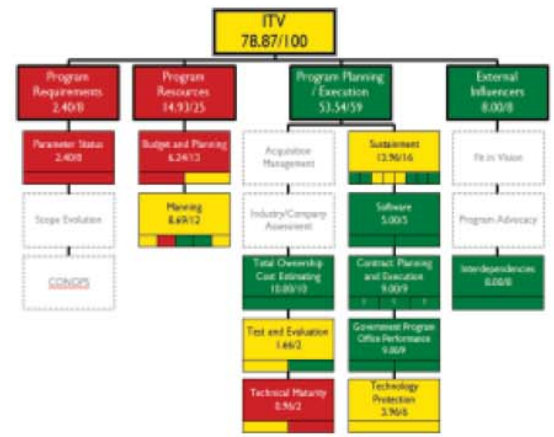
Next Contract: New Interim CLS contract (06/2015)

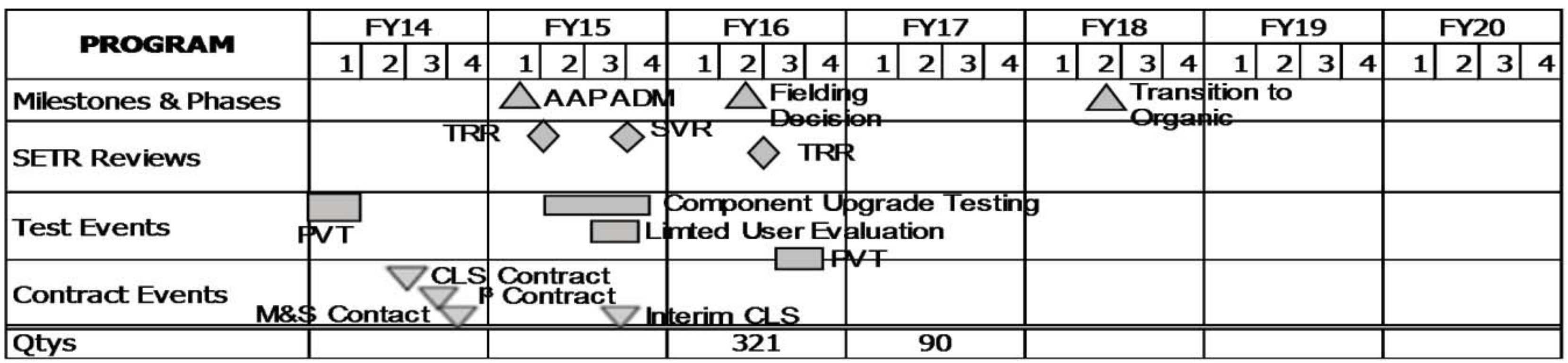
DCMA = N/A

CPI = N/A

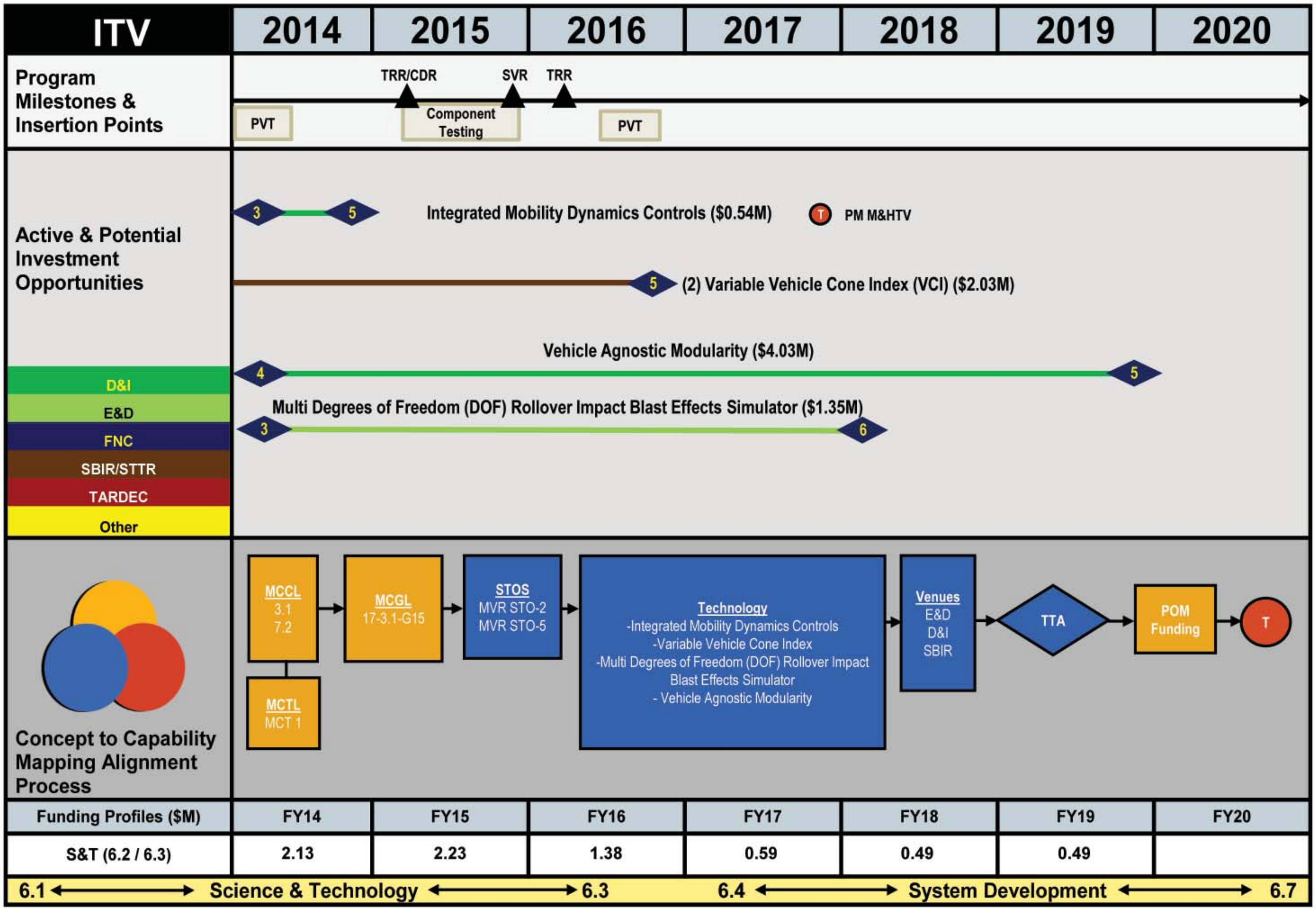
EAC = N/A

Issues: The program lacks OMMC funding for follow-on Interim CLS contract

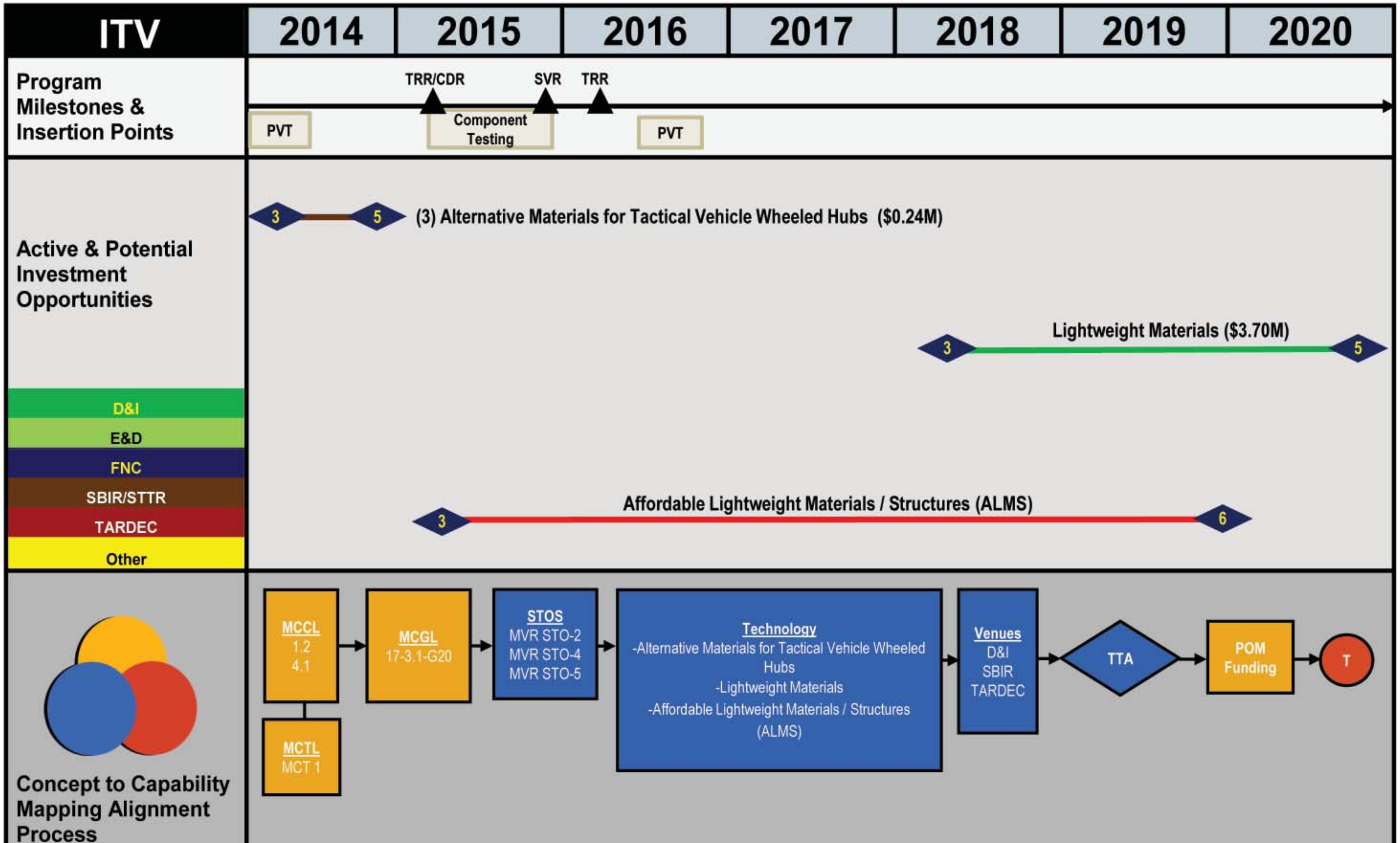




ITV Technical Issue #1 Safety (Stability)



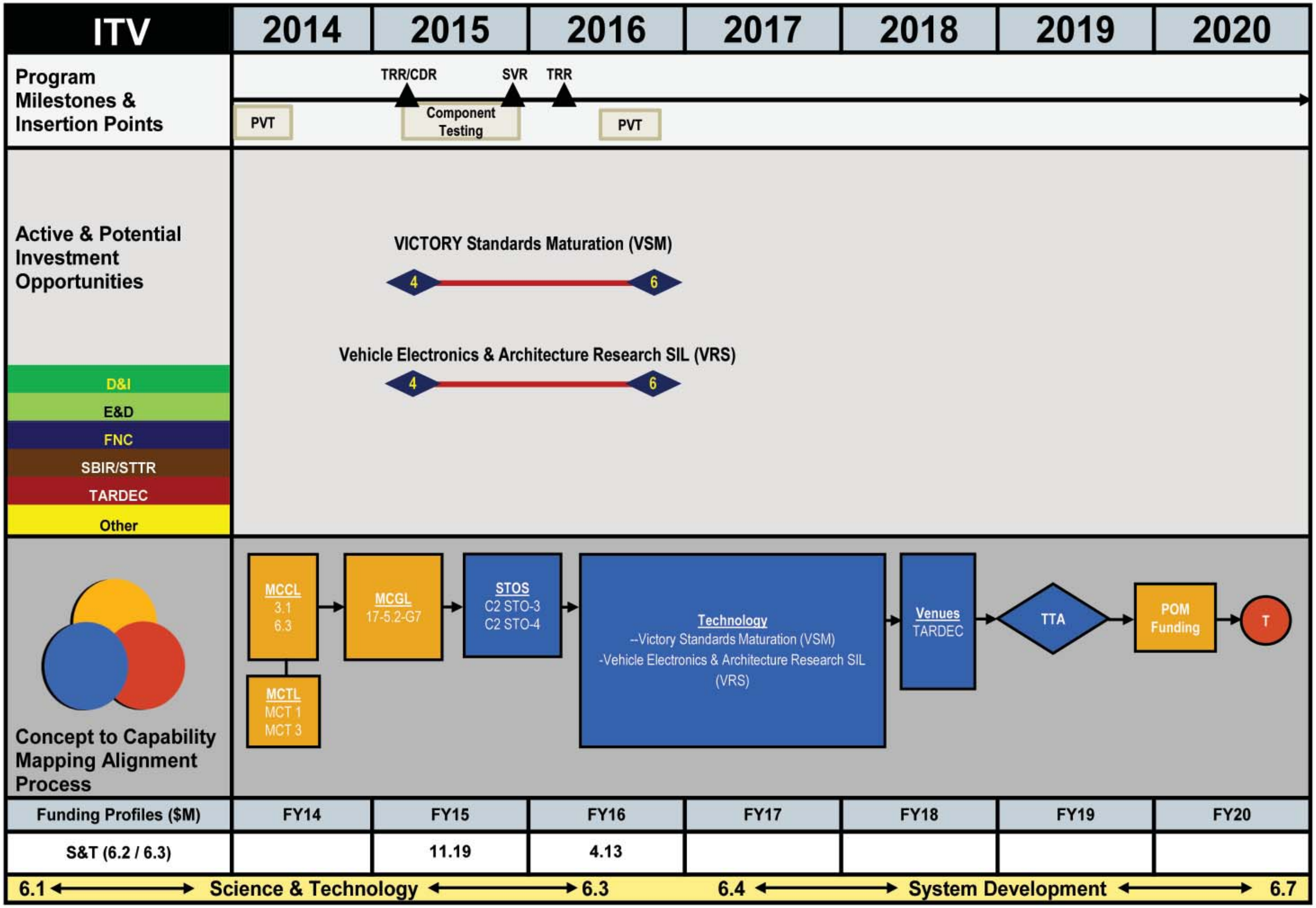
ITV Technical Issue #2 Weight Saving Technology



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	0.24	8.93	6.31	10.85	11.55	4.85	1.60

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

ITV Technical Issue #3 Digital Architecture



JOINT LIGHT TACTICAL VEHICLE

The three JLTV contenders selected for the Engineering and Manufacturing Development (EMD) phase of the JLTV Competition (from left to right, AM General, Oshkosh Defense, Lockheed Martin).

Program Background

The Joint Light Tactical Vehicle (JLTV) is a major Army-Marine Corps defense acquisition program that addresses a new generation tactical wheeled vehicle to replace a portion of the Services' HMMWV fleet. The program's aim is to develop a new multi-mission light tactical vehicle family with superior crew protection and performance compared to current HMMWVs. The JLTV family will balance critical weight and transportability constraints against performance, protection, and payload requirements while ensuring an affordable solution for the Army and USMC.

The development of the JLTV reinforces the Services' approach to interoperable platforms that provide expeditionary and protected maneuver capabilities to forces that are currently supported by HMMWVs. The JLTV will also 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. Expected JLTV fleet reliability and fuel efficiency targets will be significantly greater than the current HMMWV fleet, providing millions of dollars in savings over the JLTV life cycle.

The Marine Corps intends to acquire 5,500 JLTVs with Full Operational Capability by the end of FY22.

Program Status

The JLTV program is currently in the Engineering and Manufacturing Development (EMD) phase. On August 22, 2012, PM JLTV awarded three EMD awards to AM General LLC, Lockheed Martin Corporation, and Oshkosh Corporation. Each of these EMD vendors delivered 22 full-up prototypes on or ahead of time and they are currently engaged in a comprehensive 14-month Government test program, including blast, automotive, and reliability testing, which will be followed by a limited user test. The program is on schedule for a Milestone C, and an eight-year Low-Rate Initial Production/Full Rate Production contract is planned to be awarded in late FY15.

JLTV's Top Technical Issues:

1. Weight/Armor

The JLTV design must meet competing requirements for a balanced solution of protection, payload, and performance. Although the JLTV armor system can meet the functional requirements, it will continue to require improvement in weight to accommodate future integration programs. Therefore, add-on armor solutions that can reduce vehicle weight but still meet the force protection requirements are critical to the success of the JLTV program. Lower weight, affordable, and transparent armor and EFP kit solutions are also needed. Because of stringent affordability constraints on the program, the armor solution must be in the price range of current JLTV armor solutions.

2. Corrosion Resistance

The JLTV will be stored and maintained for long durations in pre-positioned stocks ashore and at sea, in outdoor motor pools, and in other areas where it will be exposed to salt air, rain, snow, heat, cold, and other corrosive environments that must be mitigated. Corrosion-resistant technologies will reduce total ownership costs and provide a significant increase in equipment readiness.

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

The JLTV-CCWC is the mission package configuration for employment of the TOW/SABER. During the course of the JLTV EMD phase, the warfighter operational requirements for the TOW/SABER system are evolving and, as a result of the current EMD phase designs for JLTV TOW integration, the requirement for the TOW/SABER system integration may become obsolete. A design effort to integrate TOW/ITAS components and capabilities on a CCWC is needed (independent of the vendors competing for the low-rate initial production (LRIP) contract) as a risk reduction initiative in the event that the design proposed by the vendor selected for LRIP does not satisfy the revised operational requirements. The required 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 and the TOW system Initial Capabilities Document for JLTV.

2 Dec 14

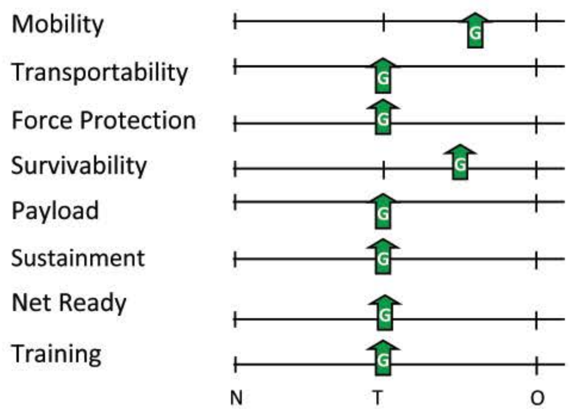
C (Y) S (G) P (G)

JLTV

ACAT I D / EMD

MS C = May 15 (O)/ Nov 15 (T) **AAO** = 5500
IOC = May 18 (O)/Nov 18 (T)

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.



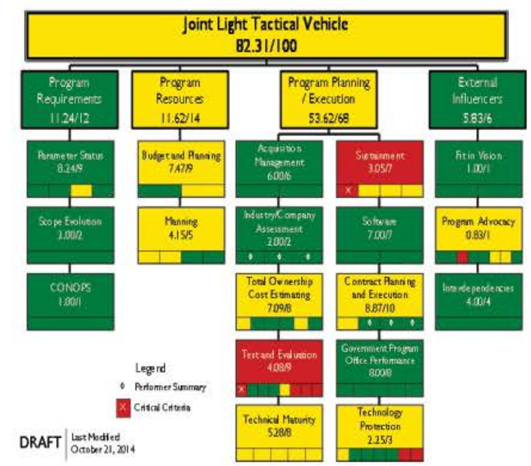
*Based on estimated and calculated values
N – no capability **T** – Threshold **O** - Objective

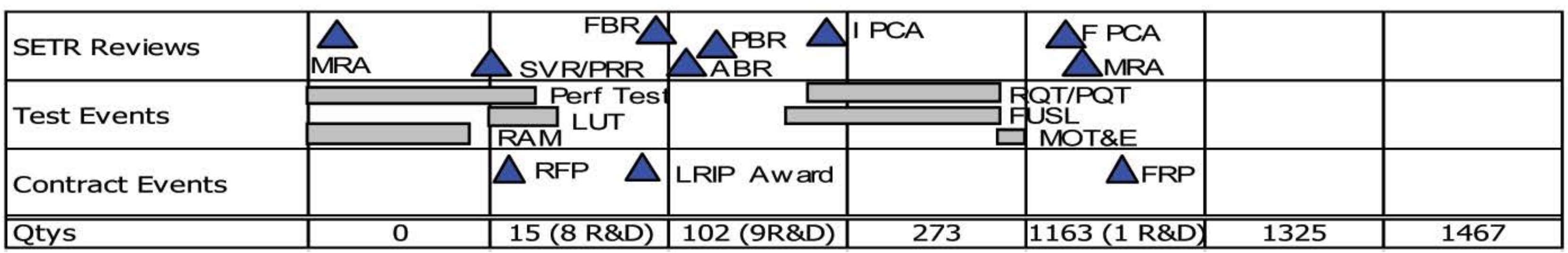
Contracts Data
Fixed Price
Contractors AMG, OSH, LM
Start – Complete Aug 12 – Nov 14

Next Contract: LRIP = Jul 15
DCMA = (G)

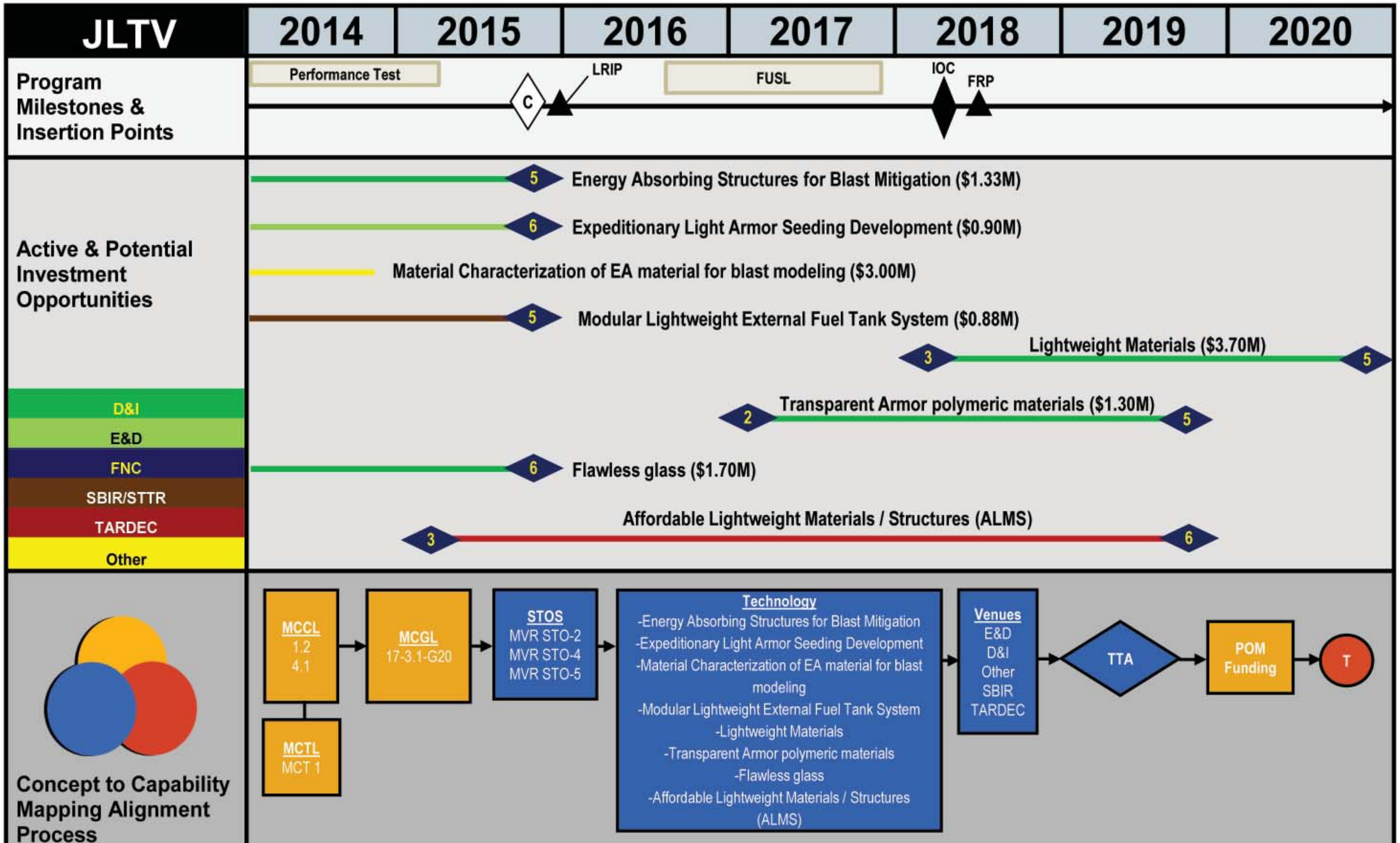
CPI = NA SPI = NA
EAC = NA

Issues:





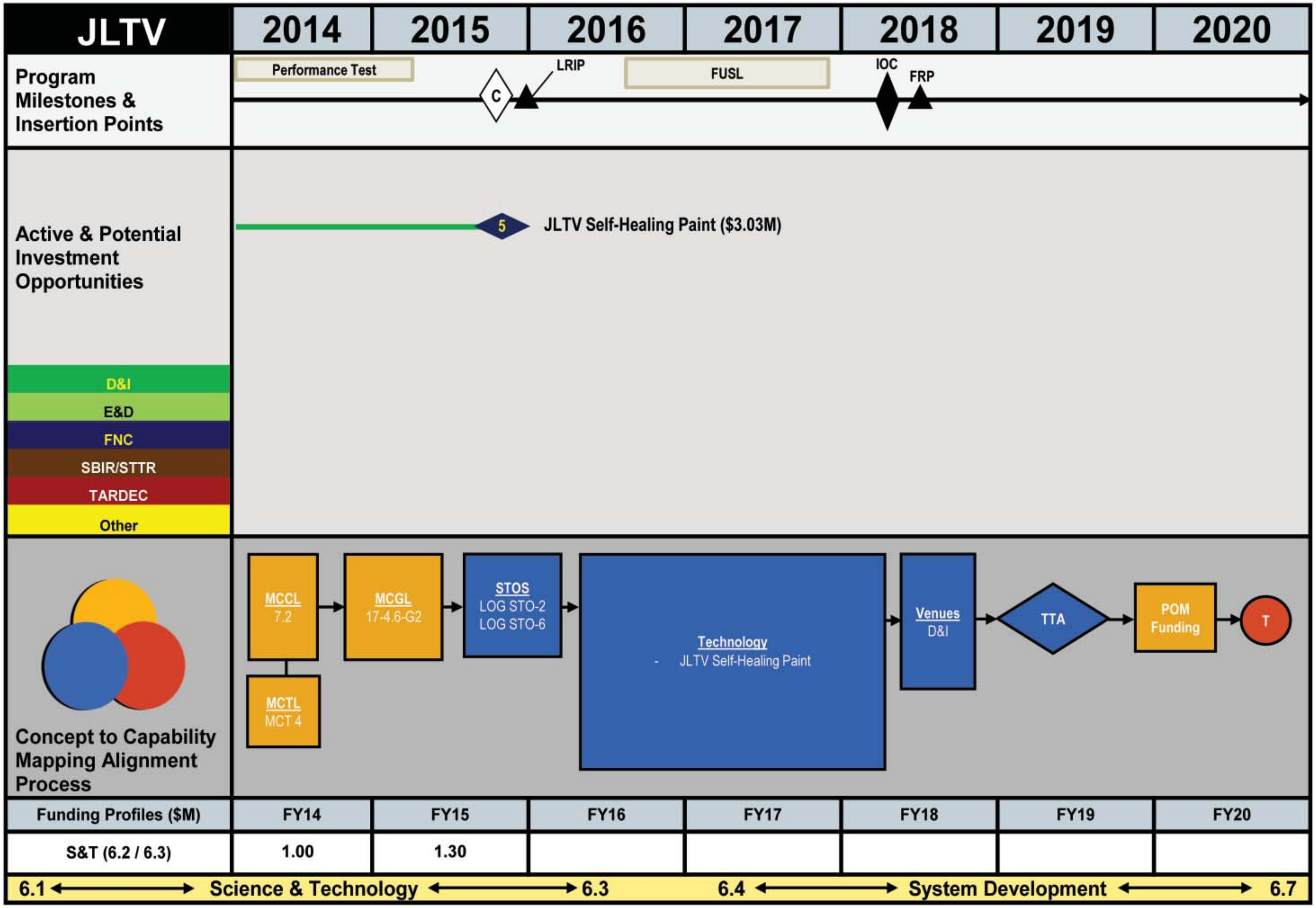
JLTV Technical Issue #1 Weight/Armor



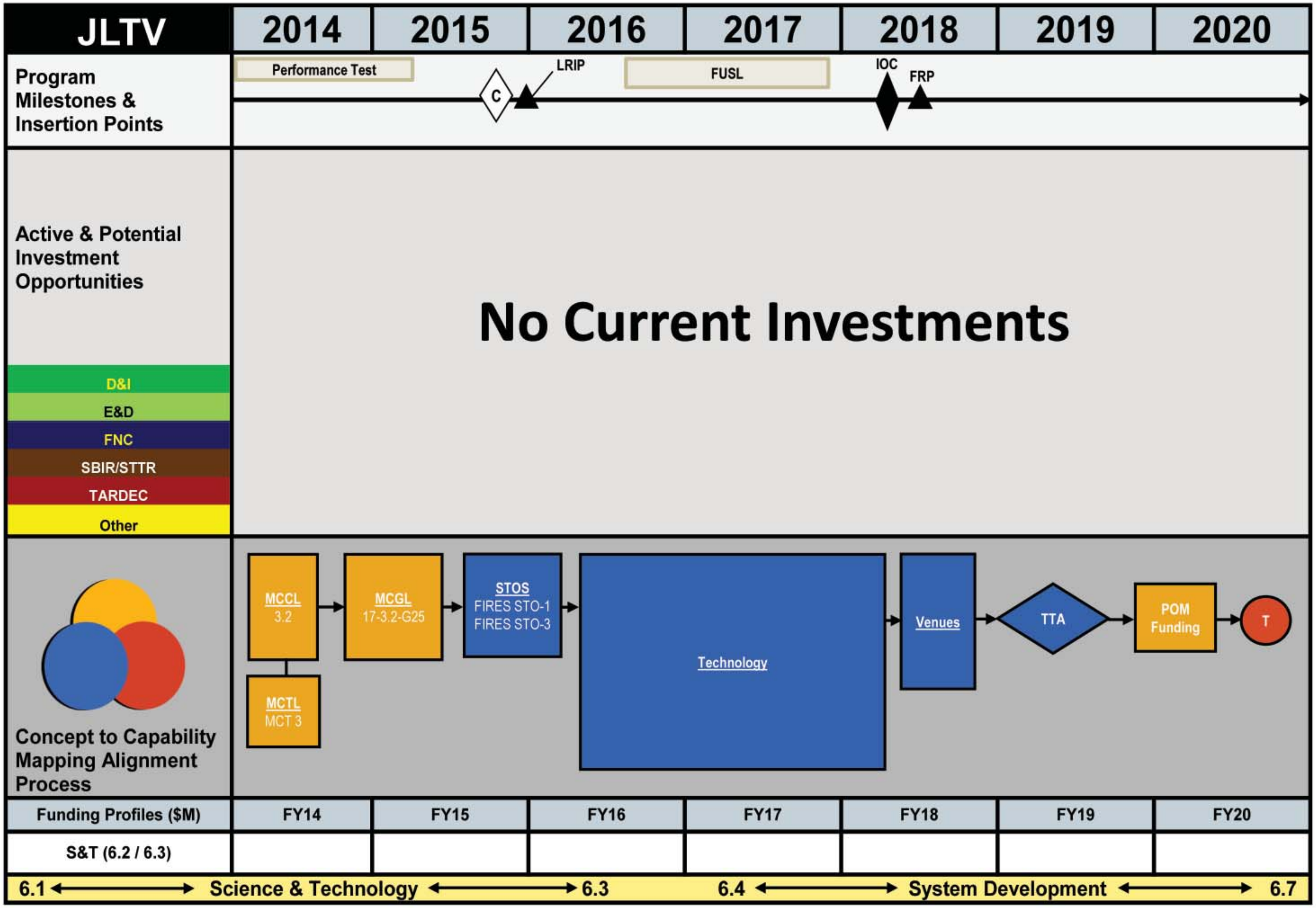
Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	3.78	10.88	6.31	11.15	12.05	5.35	1.60

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

JLTV Technical Issue #2 Corrosion Resistance



JLTV Technical Issue #3 JLTV-CCWC Missile Reloading Design



Section 7.9 PEO LS Program

LOGISTICS VEHICLE SYSTEMS REPLACEMENT

Program Background

The Logistics Vehicle Systems Replacement (LVSR) system serves as the Marine Corps' heavy logistics vehicle. The LVSR replaces the Marine Corps' aging Logistics Vehicle System (LVS) and incorporates the MK 48/MK 48A1 front power unit with associated Rear Body Units to transport large quantities of supplies across the battlefield. The LVSR is deployed in the Marine Logistics Group, in Marine Divisions, and in Marine Aircraft Wings.

The LVSR includes three variants: MKR 18 Cargo, MKR 16 Tractor, and MKR 15 Wrecker. The vehicle has a 22.5-ton (20,412 kilograms) on-road/16.5-ton (14,969 kilograms) off-road payload; 600-horsepower diesel engine; Command Zone™ integrated control and diagnostics; and factory-installed armor that is integrated into the initial vehicle design.

The LVSR can travel up to 65 miles per hour on paved surfaces and ford five feet of water, and it has a cruising range of 300 miles. Built by Oshkosh Corporation, the new tactical-distribution heavy hauler is capable of carrying fuel, water, ammunition, standardized containers, palletized cargo, and heavy equipment. The earlier-vintage LVS, also built by Oshkosh, consisted of a two-piece truck-trailer with a four-wheel-drive front power unit and five categories of trailer rear-body units.

In contrast, 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. There is an acquisition objective of 2246 vehicles, with Full Operational Capability scheduled for 3QFY14 for all variants.

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 Economy

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 millions of dollars. Technologies are required to increase the fuel efficiency of the LVSR. Potential technologies include engine-mounted fuel efficiency technologies and regenerative braking.

2. Increased Survivability

Technologies are needed 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.

3. Safety

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

ACAT II/P&D

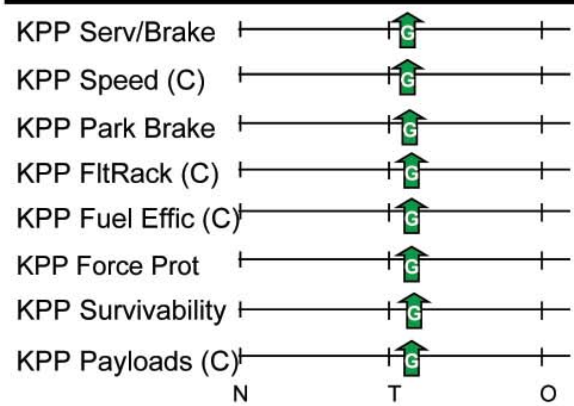
C (G) S (Y) P (G)

LVSR

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.

MS C= (C)Jun 06 (O)/Aug 06 (T)
(T/W)Jun 08 (O)/Dec 08 (T)
IOC = Aug 16(O)/Feb 17 (T) **FOC =** Mar14 (O)/Sep14 (T) **AAO = 2000**

JAN 2015

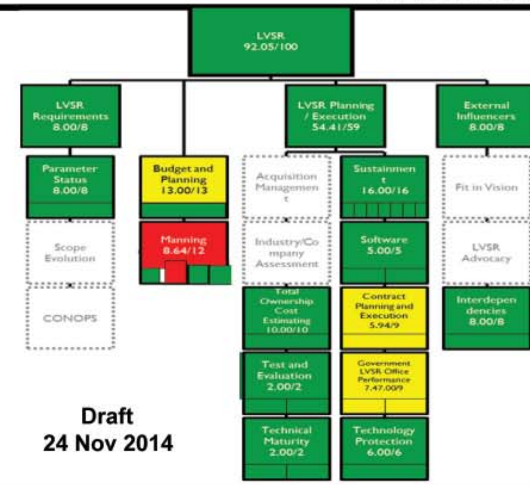


N – no capability **T** – Threshold **O** - Objective

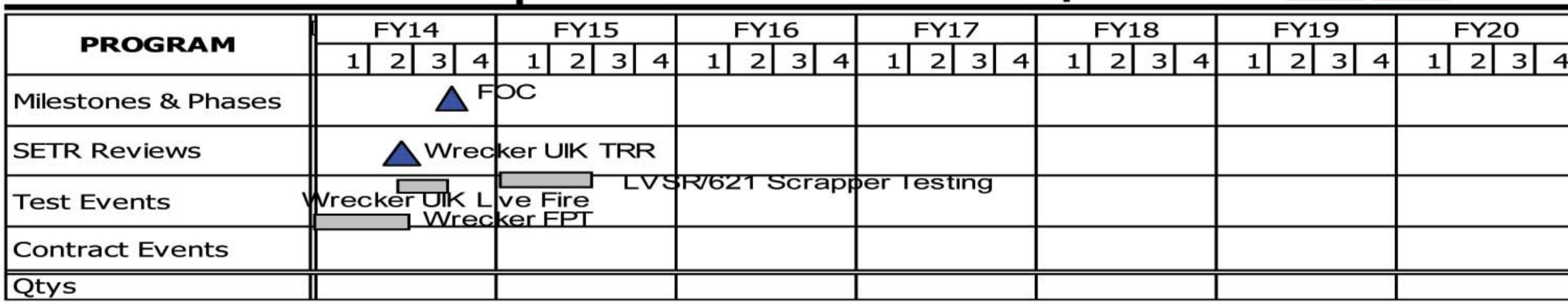
Previous Contract Data - FFP/IDIQ
Contractor Oshkosh Defense
Start – Complete 03/07/09 - 09/12

Current Contract: Follow on Production = Aug
Contractor Oshkosh Defense
Start – Complete 08/15/13 – 08/15/16

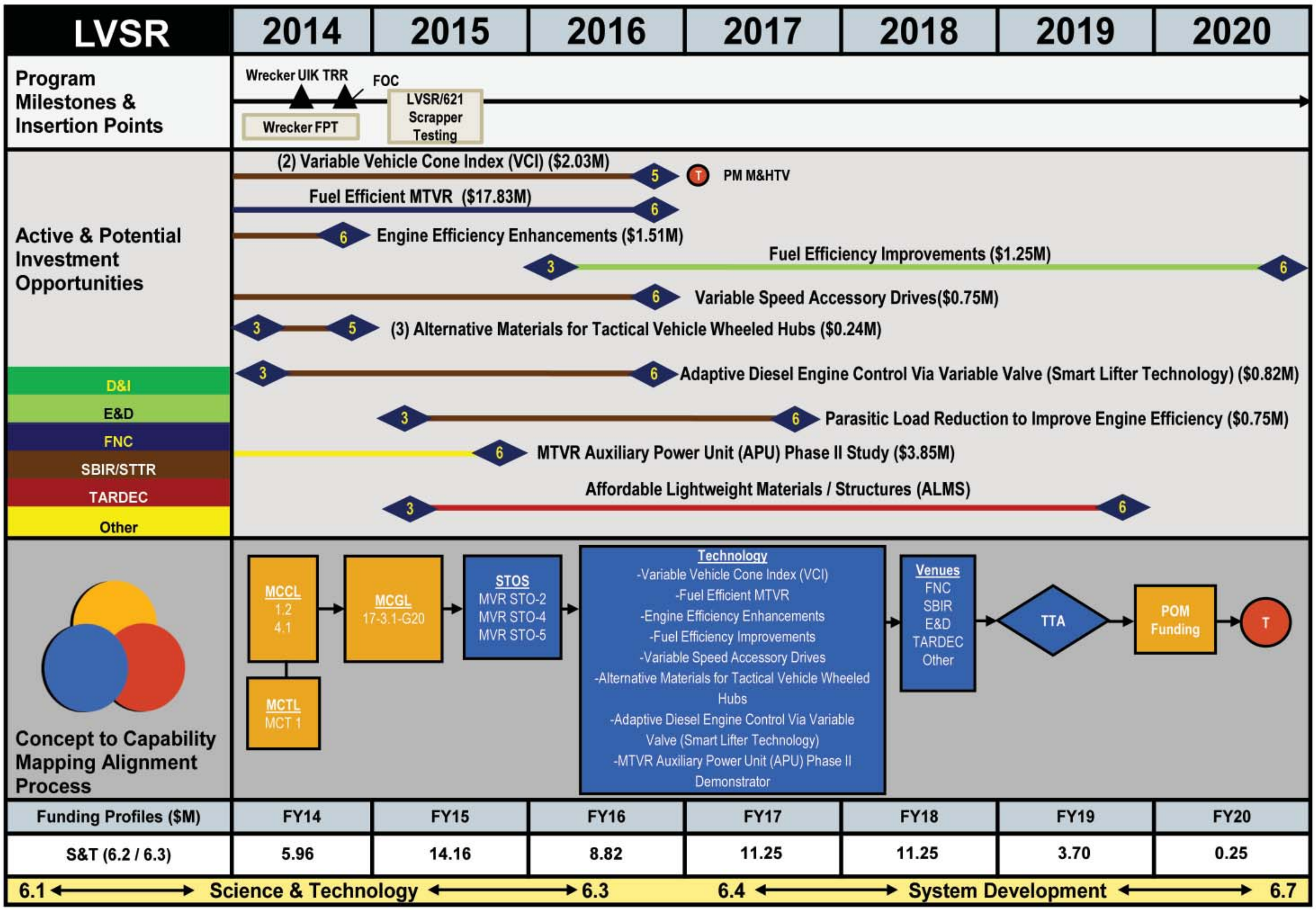
Issues: Follow on CLINs being negotiated as PRs are submitted are delaying obligations



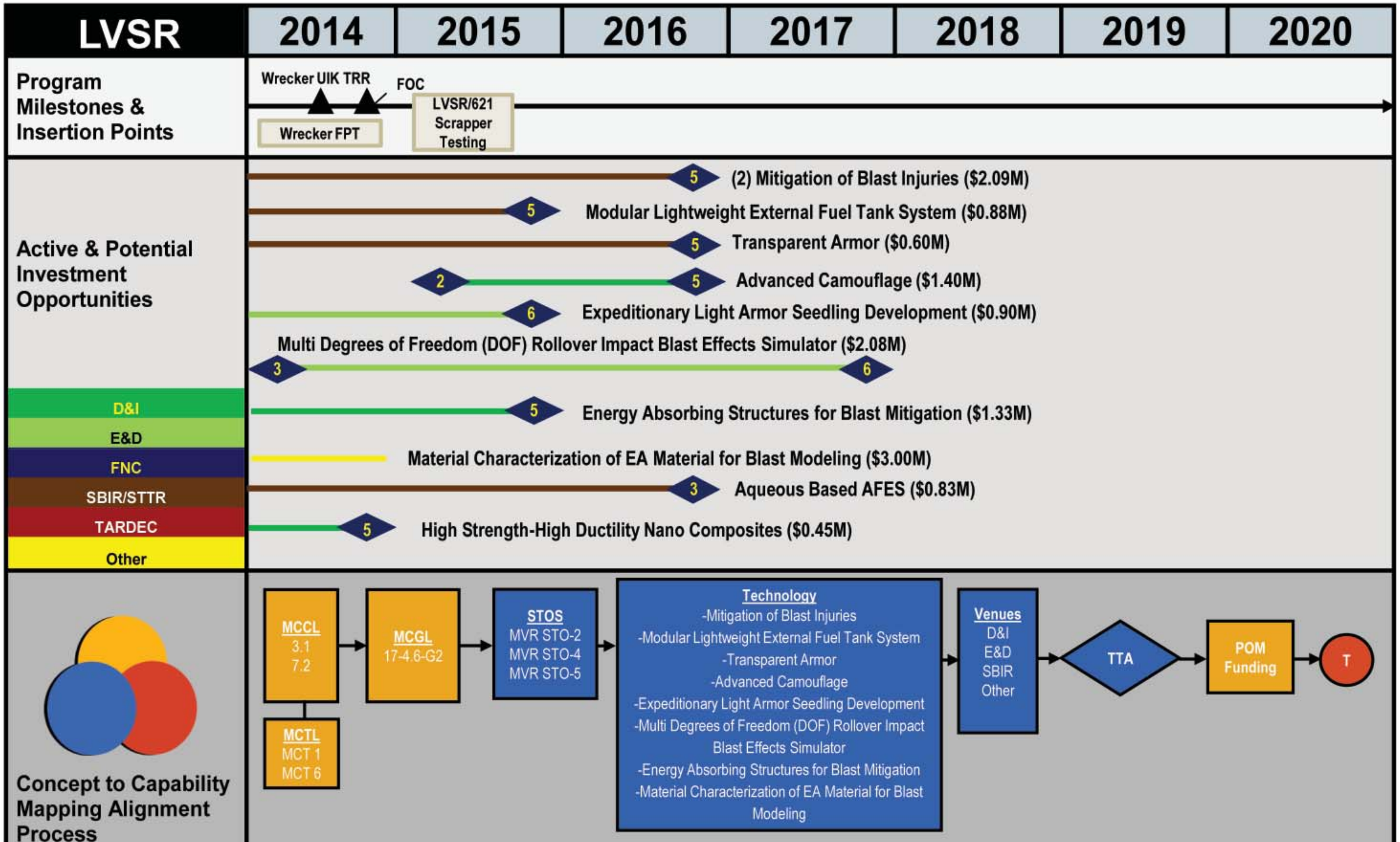
Draft
24 Nov 2014



LVSR Technical Issue #1 Fuel Economy



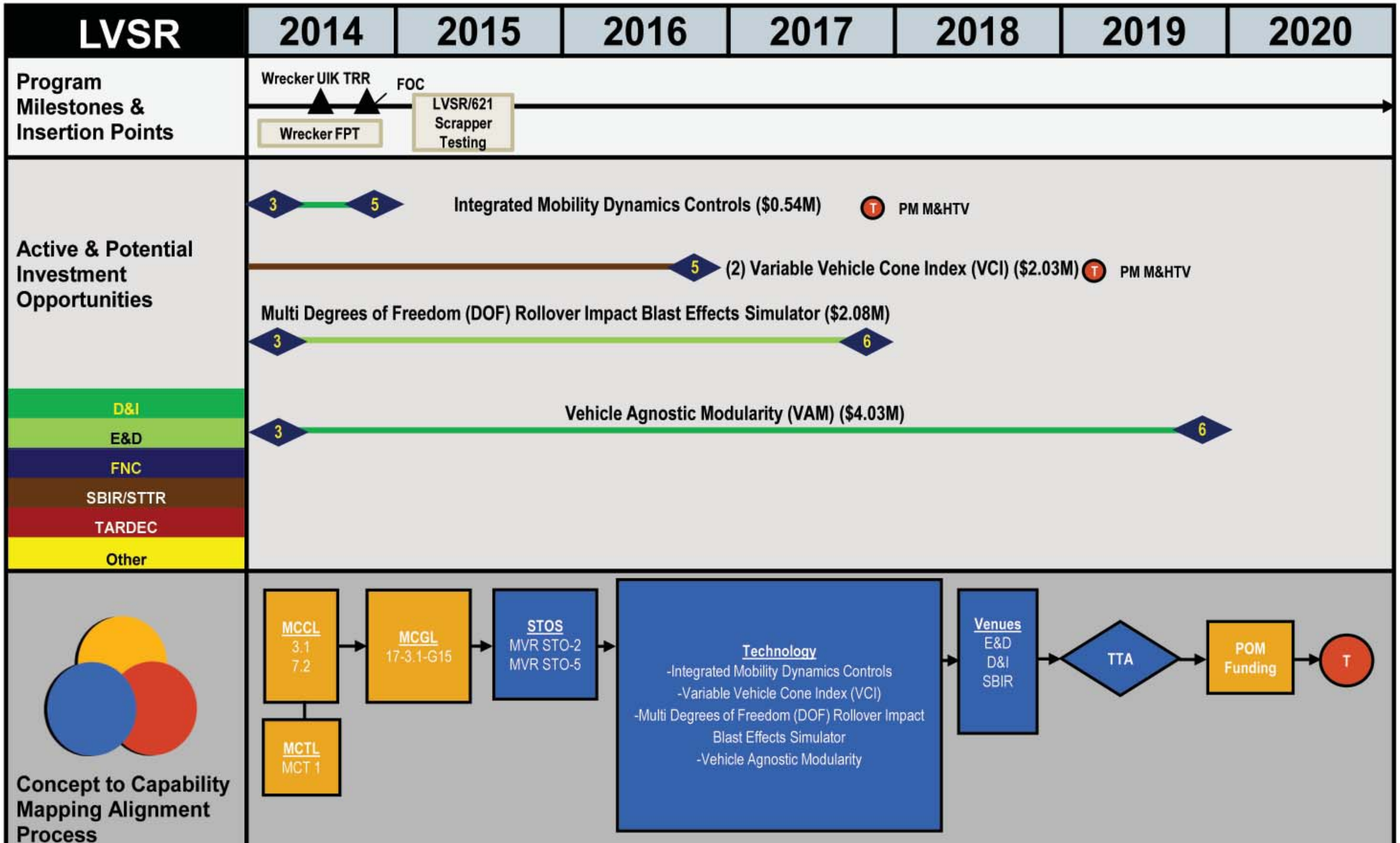
LVSR Technical Issue #2 Increased Survivability



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	4.35	3.28	1.60	0.10			

6.1 ↔ Science & Technology ↔ 6.3 | 6.4 ↔ System Development ↔ 6.7

LVSR Technical Issue #3 Safety



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	2.13	2.23	1.38	0.59	0.49	0.49	

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

Section 7.10 PEO LS Program

MEDIUM TACTICAL VEHICLE REPLACEMENT

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 as replacements for the obsolete M809 series and M939 series vehicles. The platforms have an on-road cruising range of 300 miles (483 kilometers) and the ability to ford five feet (1.5 meters) of water, and they can 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 Command Zone™ 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 Marine Corps' Ground Combat Tactical Vehicle Strategy reduced the MTVR

Authorized Acquisition Objective to 8,750 vehicles. The Navy Expeditionary Combat Command also possesses over 1,800 MTVRs that are used in riverine and combat engineering missions. More than 800 USMC MTVRs have been in service in Afghanistan.

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 Economy

Given the MTVR's 3.8 miles per gallon fuel consumption rate and the fully burdened cost of fuel, even moderate increases in the fuel efficiency of the MTVR can potentially save millions of dollars. Therefore, technologies that improve MTVR fuel efficiency will have a dramatic effect across the MAGTF. Such technologies include idle reduction/ Auxiliary Power Unit; accessory electrification; engine-mounted fuel efficiency technologies; high efficiency transmissions; regenerative braking; hybrids; and electric drives.

2. Increased Survivability

Technologies are needed that maintain or increase the survivability of the vehicle and the occupants, which include 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.

3. Safety

Technologies are needed that increase vehicle stability and that can mitigate the effects of vehicle rollovers while maintaining the ability of the MTVR to achieve its 70% off-road/30% on-road mission profile.

ACAT 1C/SUST

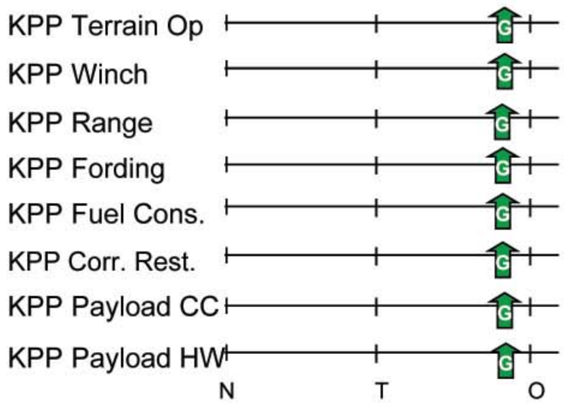
C G S G P G

MTVR

Description: MTVR is a 7.1-ton off-road, 15-ton on-road medium lift tactical vehicle available in six variants: cargo, extended wheelbase cargo, dump, tractor, wrecker and HIMARS Resupply Vehicle. Variants can be armored or not, with some cab armor able to be removed (reduced) for greater shipboard transport flexibility.

MS C = Feb 2006 **AAO** = 8,750
FOC = Sep 2010

JAN 2015



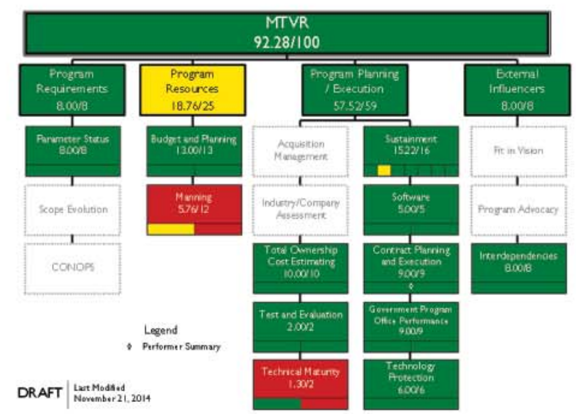
CC = Cross Country HW = Highway
N – no capability **T** – Threshold **O** - Objective

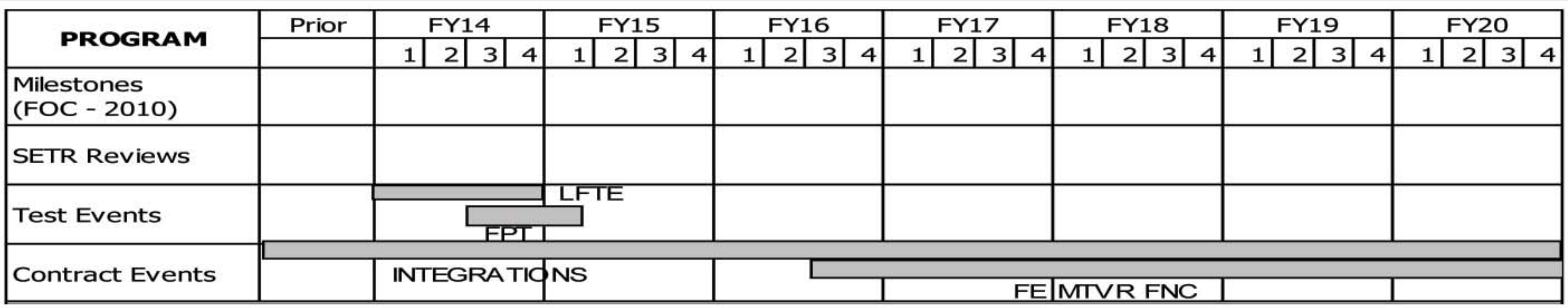
Contract Data - FFP/IDIQ
Contractor Oshkosh
Start – Complete 5/12 - 05/16

Next Contract: Procurement of additional MTVRs (Tentatively 34-35)

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

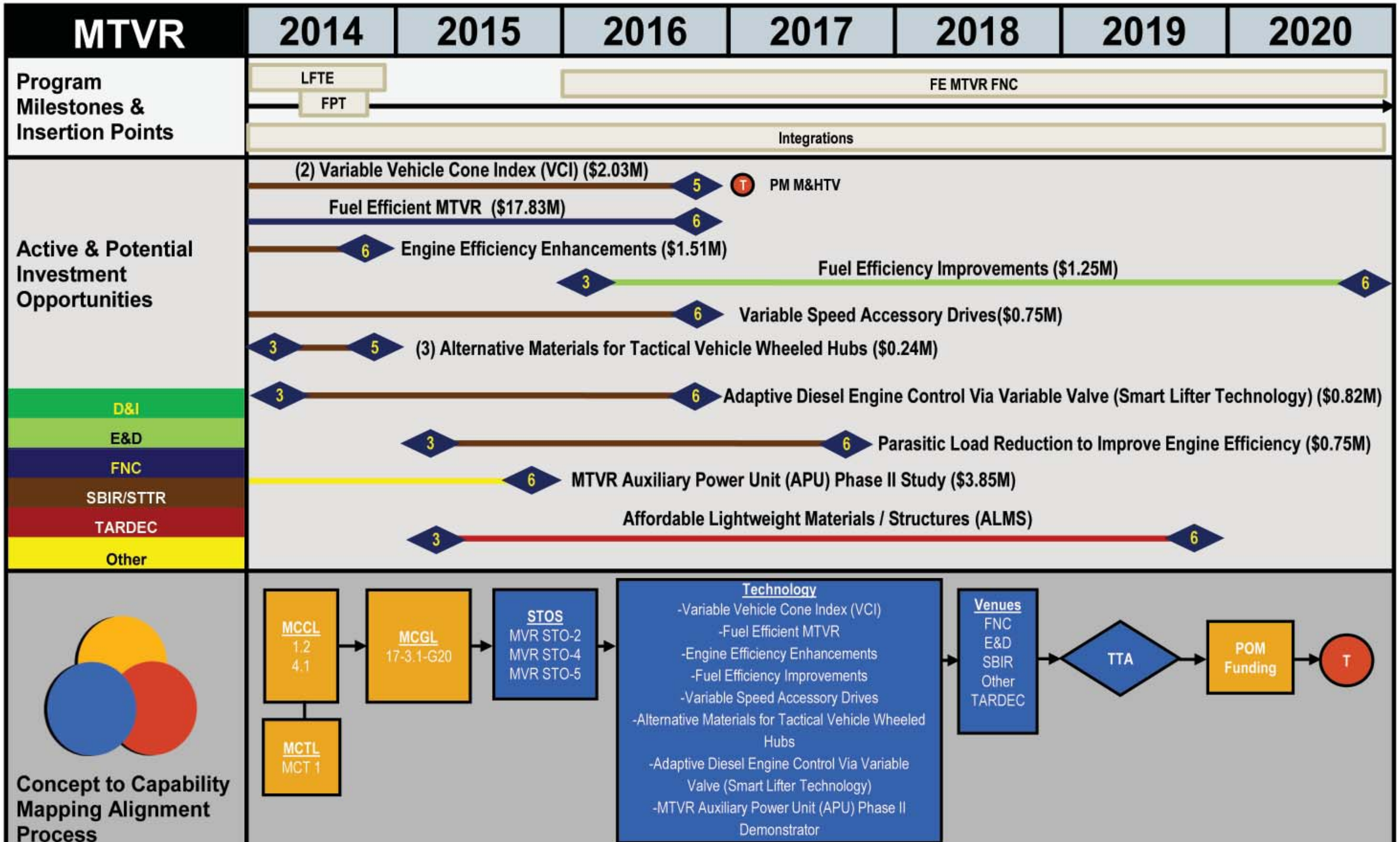
Issues: N/A





Requirement Source: LCCE dtd 24Nov11

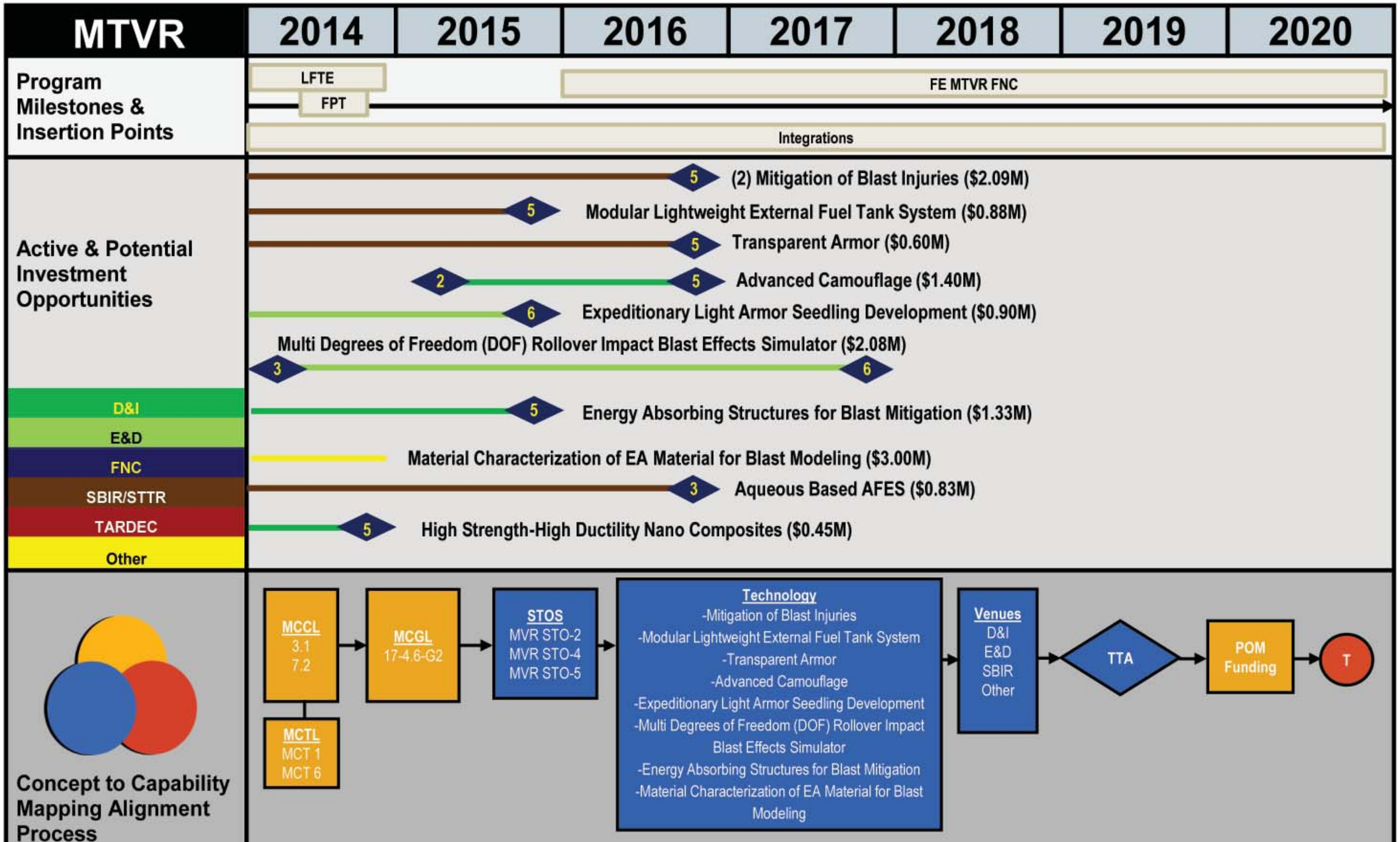
MTVR Technical Issue #1 Fuel Economy



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	5.96	14.16	8.82	11.25	11.25	3.70	0.25

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

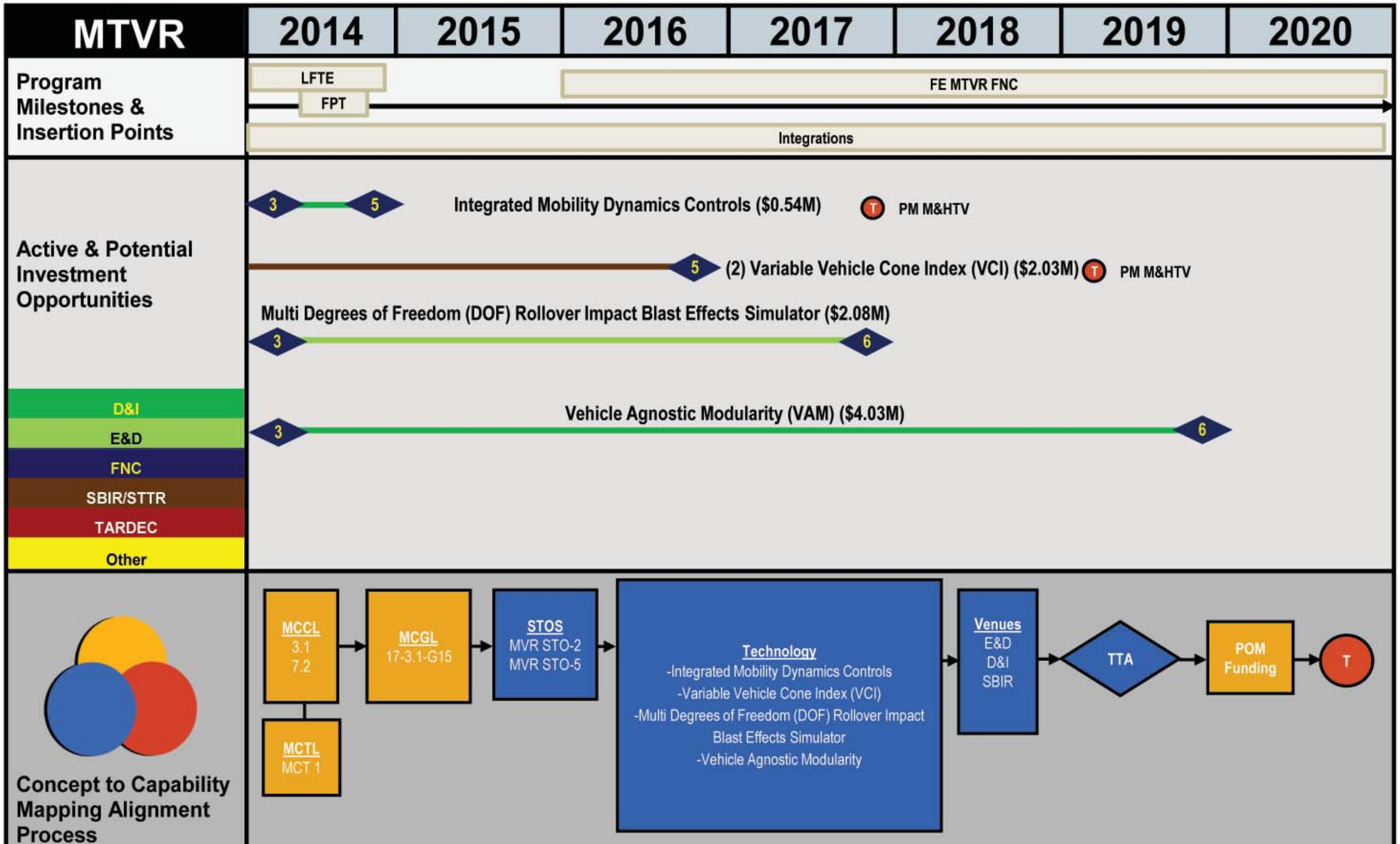
MTVR Technical Issue #2 Increased Survivability



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	4.35	3.28	1.60	0.10			

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

MTVR Technical Issue #3 Safety



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	2.13	2.23	1.38	0.59	0.49	0.49	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

MINE-RESISTANT AMBUSH PROTECTED FAMILY OF VEHICLES

Program Background

The USMC Mine-Resistant Ambush Protected (MRAP) FoV consists of multiple variants that are designed to reduce casualties and increase the survivability of personnel subjected to mine explosions, IED detonations, and small arms fire. The USMC MRAP FoV consists of the MRAP All-Terrain Vehicle (M-ATV), the Category I and II Cougar variants, and the Category III Buffalo. The MRAP vehicle was designed to meet requirements identified during Operation Iraqi Freedom and Operation Enduring Freedom, with a focus on continual improvement of vehicle and warfighter survivability. The USMC will retain 2,510 MRAP vehicles, comprised of M-ATVs, Cougars, and Buffalos, to satisfy the enduring requirement established by the Marine Corps Requirements Oversight Council (MROC).

The M-ATV provides better overall mobility characteristics than other MRAP variants while still providing MRAP-level survivability. It supports mounted patrols, reconnaissance, security, convoy protection, casualty evacuation, data interchange, and command and control functions. The addition of the Underbody Improvement Kit-2 (UIK2) 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.

Both Cougar variants support small unit combat operations in complex and highly restricted rural, mountainous, and urban terrains. They consist of Category I (4X4 variant), which is capable of transporting five crew members and one gunner; and Category II (6X6), which is capable of transporting nine crew members and one gunner. A third, low-density Cougar variant is an ambulance that provides the ability to transport and conduct emergency care for multiple acute battlefield casualties in an armored ambulance while in close proximity to enemy troops. The Cougar ambulance is based on the CAT II and can transport up to four wounded patients and two patients carried on litters as well as the 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 and anti-personnel and anti-tank mines. The Buffalo has a 30-ft. articulating arm, with an attached claw and air digger, to remotely investigate suspected IED sites. The claw, combined with the air digger and boom-mounted video camera, is utilized to find and uncover concealed IEDs and enables the crew to confirm or deny and classify the explosive hazard with precision and operator standoff protection.

Program Status

The MRAP FoV is currently fielded to all three Marine Expeditionary Forces. A total of 2,017 of the 2,510 enduring requirement vehicles are scheduled to receive a maintenance reset at USMC and Army depots and a commercial repair facility through calendar year 2017. Once the USMC laydown is validated, reset vehicles will be reissued to meet mission requirements.

MRAP FoV's Top Technical Issues:

1. Transparent Armor/Ballistic Glass

Advancements are needed in the area of transparent armor. The current MRAP FoV transparent armor meets the requirements for ballistic performance; however, significant logistics and financial burdens are realized as a result of glass delamination. Delamination reduces visibility and makes it more difficult for the crew members to operate safely and view the surroundings effectively. The PMO has experienced a 100% replacement rate within three years. Finding a solution that retains the armor's ballistic performance and maintains visibility would provide the USMC significant cost savings, reduce logistics burdens, and continue to promote safety benefits.

2. Performance and Safety Improvements

Continued investments in technologies to improve the performance and safety of USMC MRAP vehicles are required. Such investments could include stopping performance (enhanced braking) and survivability improvements via post-production vehicle improvements and add-on kits to protect against explosively-formed penetrators. Improved safety features such as Electronic Stability Control can reduce the number of rollovers and significantly increase the safety of operation by eliminating or reducing rollovers.

3. C4I Interoperability (VICTORY)

VICTORY stands for "Vehicular Integration of C4ISR/EW Interoperability." VICTORY is a set of standards which will enable several of the vehicle components to be interoperable. The U.S. Army and the USMC are both pursuing VICTORY capability for the M-ATV MRAP variant. Each service is customizing their VICTORY system to be oriented toward the GFE contained within the vehicle. VICTORY can assist with diagnostics, enable relocation of electronic components to outside the crew area, and reduce SWAP-C (size, weight and power, cost) requirements by enabling common standards that will allow interoperability and multi-functionality of components.

ACAT III / SUSTAINMENT

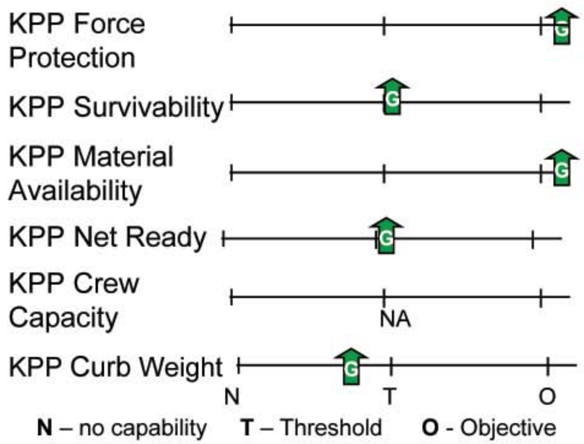
Buffalo

Description: The Buffalo CAT III MRAP vehicle is a heavy-category vehicle that provides route clearance capability and personnel protection against Anti-Personnel (AP) and Anti-Tank (AT) mines.

15 Dec 2014

AAO = 38 (ER)
IOC = October 2007

FOC = December 2009



Contract Data: M67854-07-D-5006
Contractor: General Dynamics Land Systems (previously Force Protection (FPII))

Production/Fielding Complete: 2010

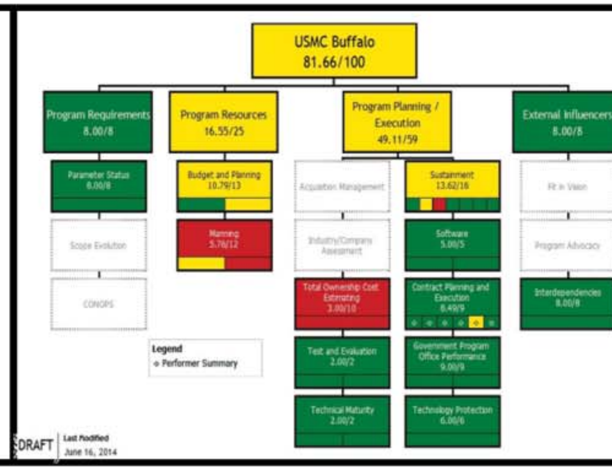
Next Contract: N/A

DCMA

CPI SPI

EAC

Issues: None



PROGRAM	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19
	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	1 2 3 4
Milestones & Phases								
SETR Reviews								
Test Events	ECP 51 testing 2Q FY12 Ride Quality Testing 1-3Q FY12	Rear Door Assist Testing 1Q FY13 4X Testing Conducted 4Q FY13	Transparent Armor / 3rd Plane of Egress environmental testing 1Q FY14					
Contract Events	PM AMS ManTech CLSS EOR Awarded 2Q FY12 Base Awarded 3Q FY12	XMCO, Inc. Block II ETM Awarded 4Q FY13	PM AMS ManTech CLSS Option Year 1 Awarded 1Q FY14	PM AMS ManTech CLSS Option Year 2 Awarded 1Q FY15				

ACAT IV (M) / PROCUREMENT

C (G) S (G) P (G)

Cougar Block I Mod

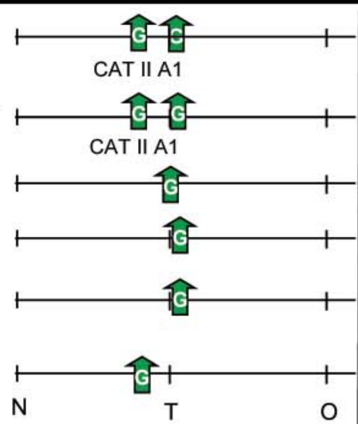
Seat Survivability Upgrade & Egress

Description: **Seat Survivability Upgrade (SSU):** Will increase force protection of the CAT II A1 occupants and will meet the requirement of the Capability Production Document (CPD) dated 7 July 2009 once the SSU kit(s) and associated reset reconfigurations are completed. **Egress:** Will satisfy two UUNS requirements to mitigate hazards associated with egress from overturned MRAP vehicles.

15 Dec 2014

MS C = 9 February 2007 **AAO =** SSU: 303 / Egress:1,383
IOC = **FOC =**

KPP Force Protection
KPP Survivability
KPP Material Availability
KPP Net Ready
KPP Crew Capacity
KPP Curb Weight



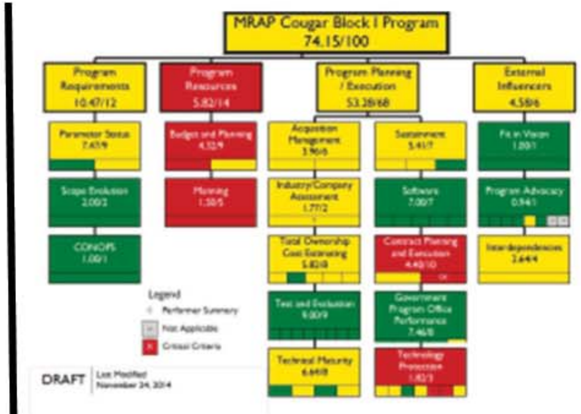
N – no capability **T** – Threshold **O** - Objective

Contract Data - M67854-14-C-5500/5501
Contractor General Dynamics Land Systems (Force Protection formerly FPII)
Production/Fielding Completed 20 April 2017

Next Contract:
DCMA

CPI SPI
EAC

Issues: None



PROGRAM (More In-depth Schedule Follows)	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19
	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	1 2 3 4
Milestones & Phases	**SSU and Egress Full Rate Production and Production Decision**							
SETR Reviews			SSU PDR - 26 Mar SSU CDR - 27 May Egress CDR	Follow-on Egress CDR				
Test Events			SSU A1, A2, A3 SSU B1, B2, SSU User Eval Saber TOW Slug fire	Egress User Eval Egress A1 Egress B1 Egress B2				
Contract Events			SSU Award - 30 Jan Egress Award - 28 Mar Additional Egress – 29 Sept	SSU FRPD Egress FRPD				

C (G) S (G) P (G)

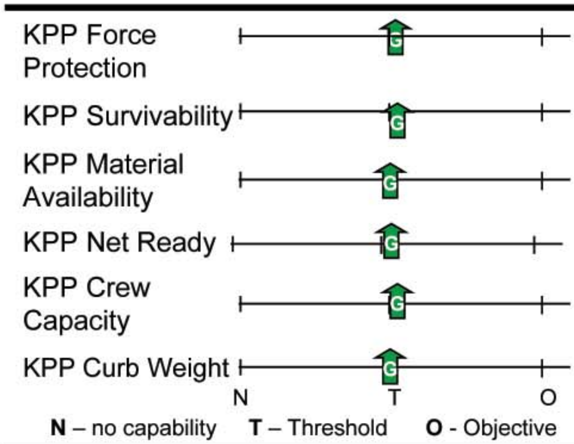
ACAT 1D / SUSTAINMENT

M-ATV

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), EFPs, and Small Arms Fire (SAF).

15 Dec 2014

AAO = 704 (ER)
IOC = December 2009 **FOC =** April 2012



Contract Data -

W56HZV09D0111 (MATV TACOM Contract majority of funding belongs to USA)

W56HZV13C0180 (MATV TACOM Contract majority of funding belongs to USA)

Production/Fielding Completed:
NOV2011/FEB2012

Next Contract: NA

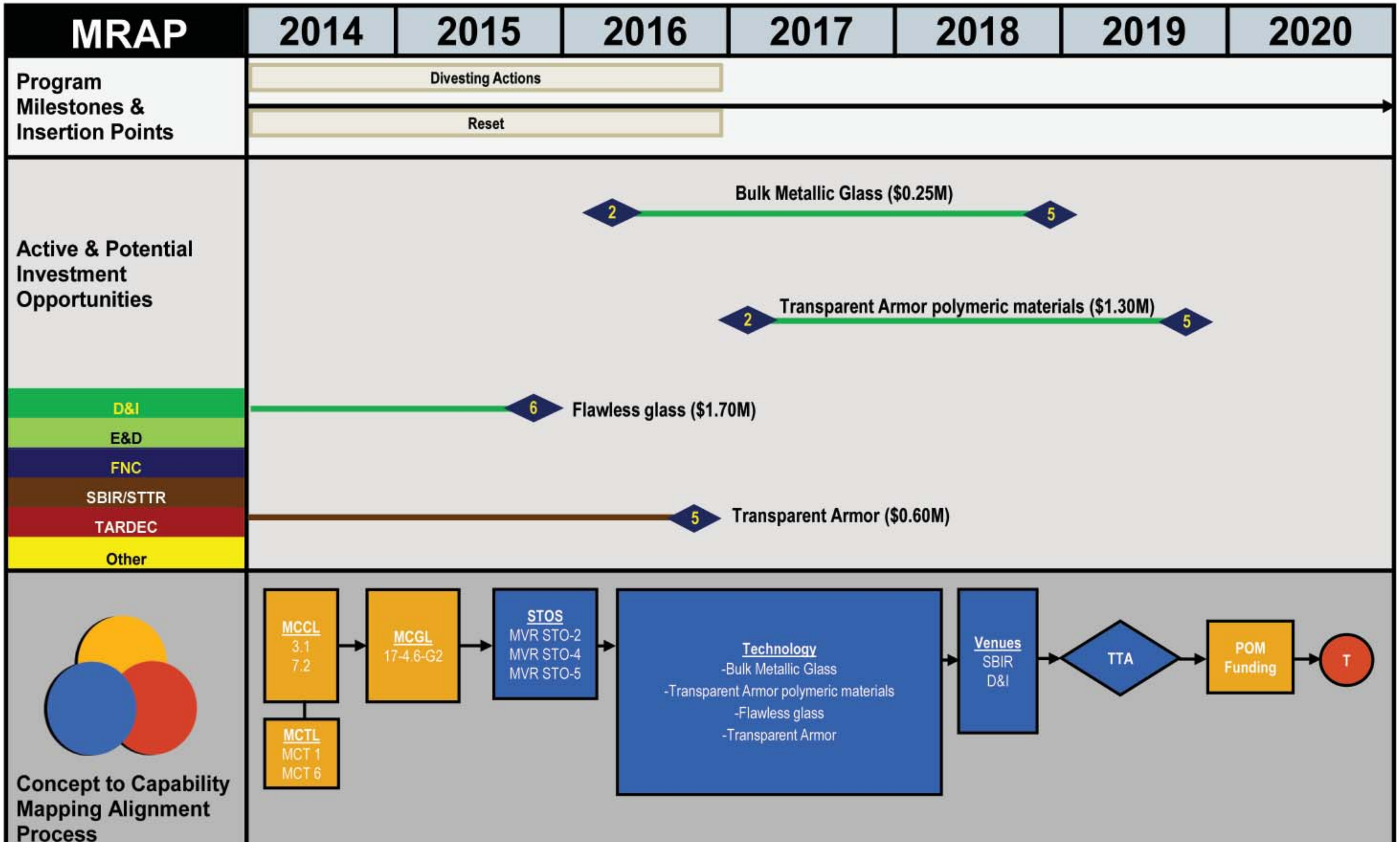
Issues: None

Top Issues

- Material Management for IROAN/Reset
- Fielding to the new MROC requirement
- Orientation of new personnel to Program

PROGRAM	FY12	FY13	FY14	FY15	FY16	FY17	FY18	FY19
	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	1 2 3 4
Milestones & Phases								
SETR Reviews								
Test Events	OWM Shaker Table 3Q UIK Endurance	Pintle/MACAW 2-4Q 4X Conducted 2Q		OWM FAI 2Q				
Production/Shipping Events				OWM Full Rate Production 3Q OWM Shipments to MAP 4Q Adj.Pintle Production 2Q				
Contract Events			OWM funding accepted 4Q		FSR Recompete Contract Award Q1			

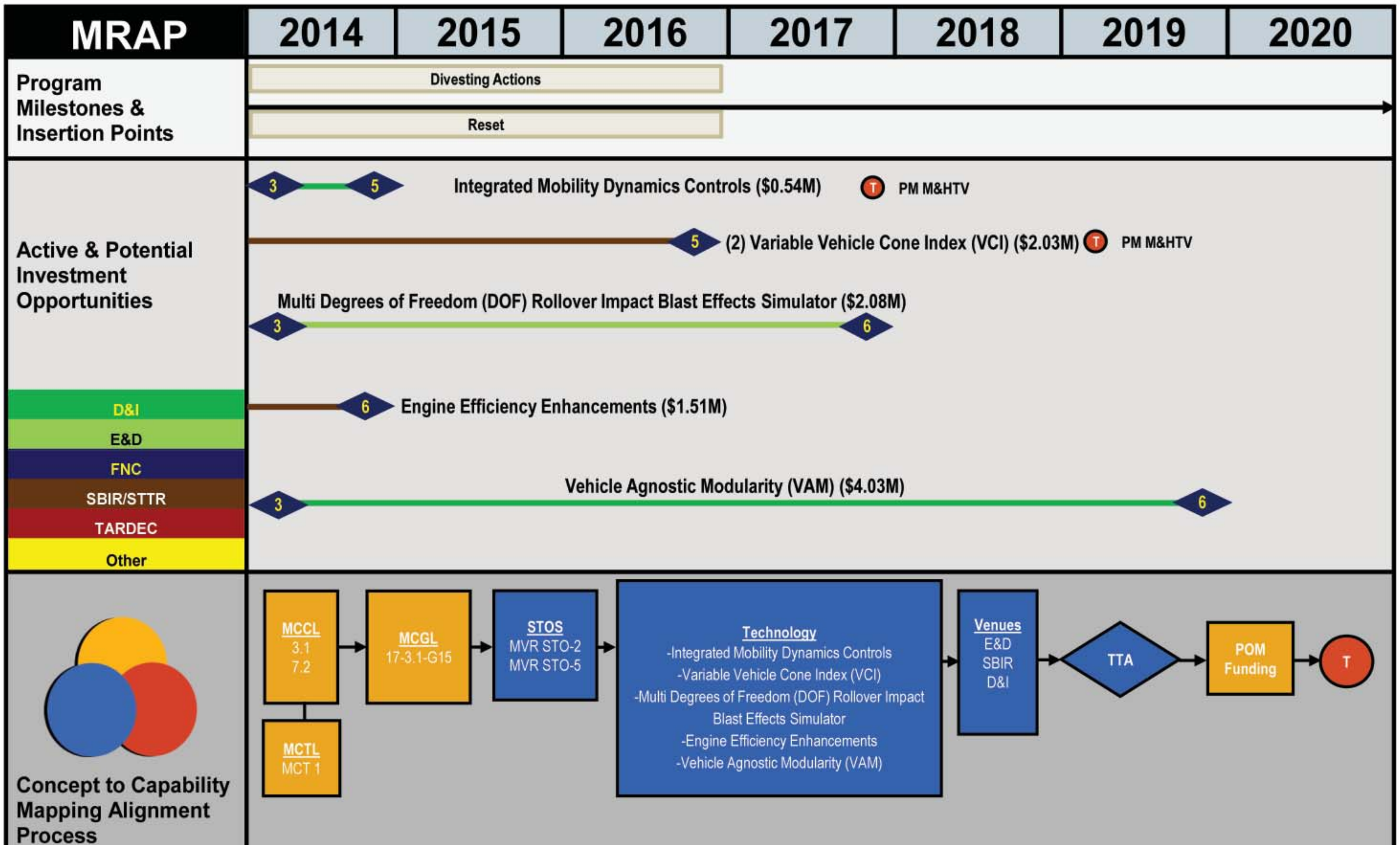
MRAP Technical Issue #1 Transparent Armor/Ballistic Glass



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	1.10	0.95	0.30	0.40	0.60	0.50	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

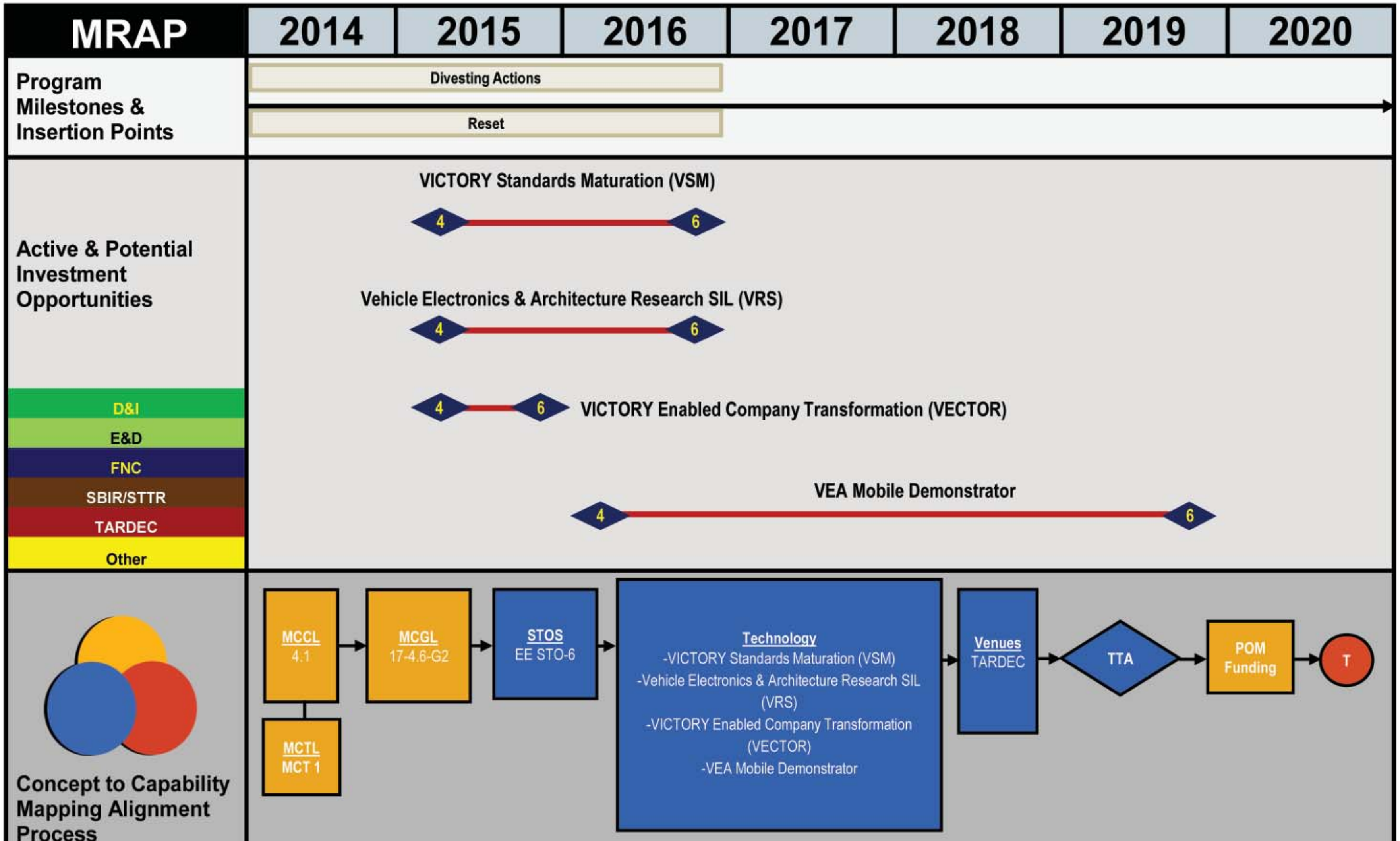
MRAP Technical Issue #2 Performance and Safety Improvements



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	8.24	7.53	7.01	6.19	5.78	0.49	

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

MRAP Technical Issue #3 C4I Interoperability (VICTORY)



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)		18.98	8.53	7.96	8.10	7.75	

6.1 ←→ Science & Technology ←→ 6.3 6.4 ←→ System Development ←→ 6.7

Section 7.12 PEO LS Program

LIGHTWEIGHT 155MM HOWITZER

Program Background

A cornerstone of the PM Towed Artillery Systems (PM TAS) portfolio is the "Triple Seven," or the M777A2 Lightweight 155mm Howitzer. Produced by BAE Systems in the United Kingdom, the Lightweight 155 is a Marine Corps led joint program with the Army. The M777A2 replaces the Marine Corps' outdated M198 155mm weapons.

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 1,071 M777 howitzers:: 481 for the Marine Corps and 518 for the Army, with the balance for foreign military sales customers Canada and Australia. To date, over 1000 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 refresh initiatives entering production in 2015 are a new Mission System Computer, Chief of Section Display, and power supply.

LW 155's Top Technical Issues:

1. Safe and Transportable Battery High Capacity Technology

The M777A2 howitzer, as well as other towed artillery platforms, power their 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. In order 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.

2. Secure Wireless: Ruggedized/Low Energy

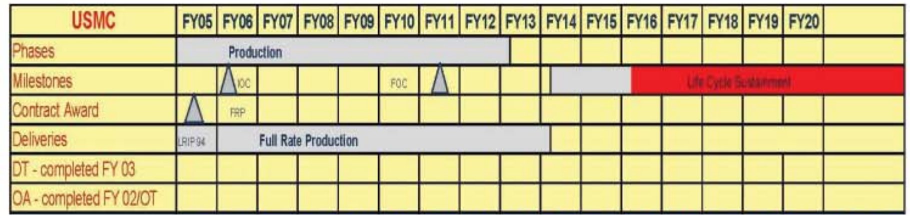
Communications between interfacing components of the M777A2 digital fire control systems is accomplished over physical wires. The required cabling constrains the solution space and introduces points of failure, particularly for cables that need to flex or be moved as part of normal operations. A short-haul, 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.

3. 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.

LW155 (M777A2) Howitzer

LW155
Sustainment
1QFY15
DEC 2014



Mission:

Provide direct, reinforcing, and general support fires to maneuver forces. Direct support artillery for the Stryker Brigade Combat Teams. Replaced the M198 howitzer as the general support artillery for light forces in the Army. Replaced all howitzers in all missions in the USMC.

Capability / Improvements:

Improved lethality & strategic deployment
Increased tactical mobility & reliability
Improved Survivability (decreased emplace/displace time -- shoot and scoot tactics with digital fire control)
Digitizes Army and USMC towed artillery
First artillery platform with Excalibur capability fully embedded

Requirements:

Weight	**10,000 pounds or less**
Emplace, Displace	**<3 min, 2-3 min**
Maximum Range	30 km (assisted)
Rate-of-Fire	4/min max, 2/min sustained
Prime Mover	Current 5T truck, FMTV, MTVR
Air Mobility	MV22, CH53D/E, CH47D
Fire Control	Digital & Optical
Precision Fire	Excalibur Capable & PGK Capable

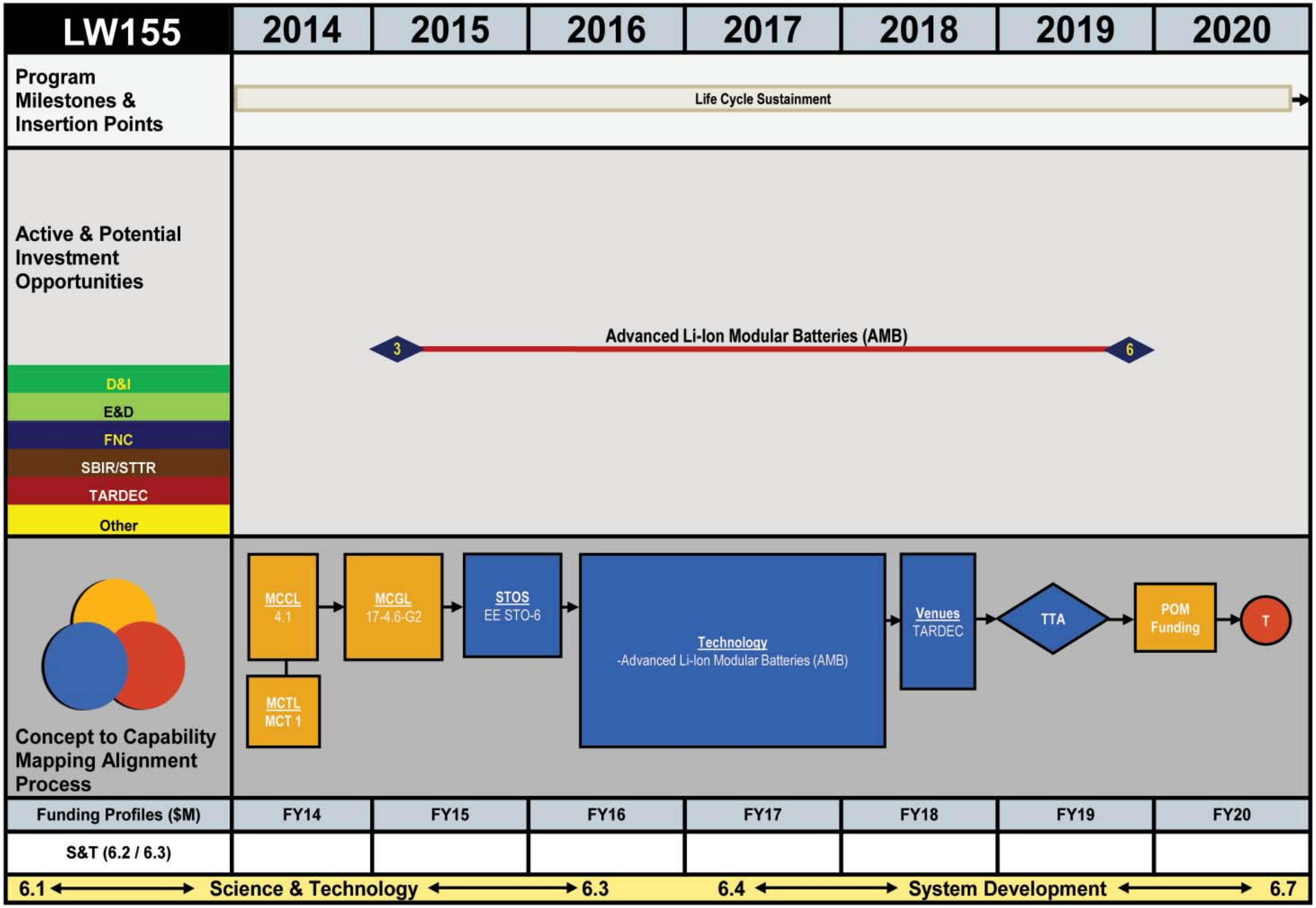
Status:

- Nov 04 JORD – All KPP's Met
- Joint Program
- Full Rate Production Complete (1090 weapons purchased)
- Last weapon delivered in Jan 2014 (USMC Apr 2013)
- USMC and FMS fieldings complete. Army still fielding.
- All Weapons Excalibur Capable
- FMS Cases with Canada & Australia
- PBLCS: Currently in Year 2 of potential 10 yr contract.

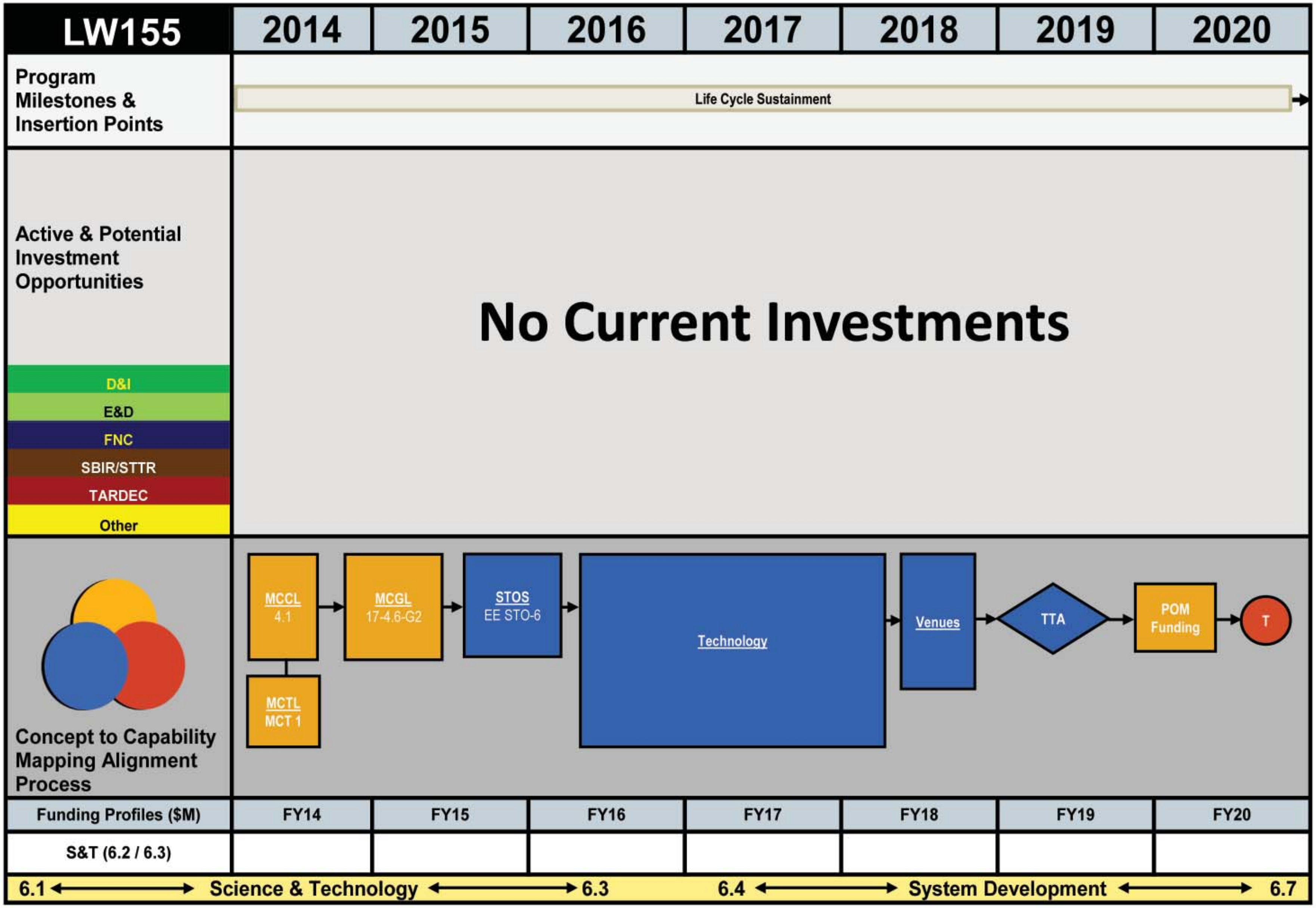
	IOC	FOC	AAO	AAO Funded	AAO Unfunded
USMC	Dec 05	Jun 11	481	511*	0
Army	Oct 06	Jun 14	542	488	54

* 30 weapons transferred to Army in exchange for HIMARS

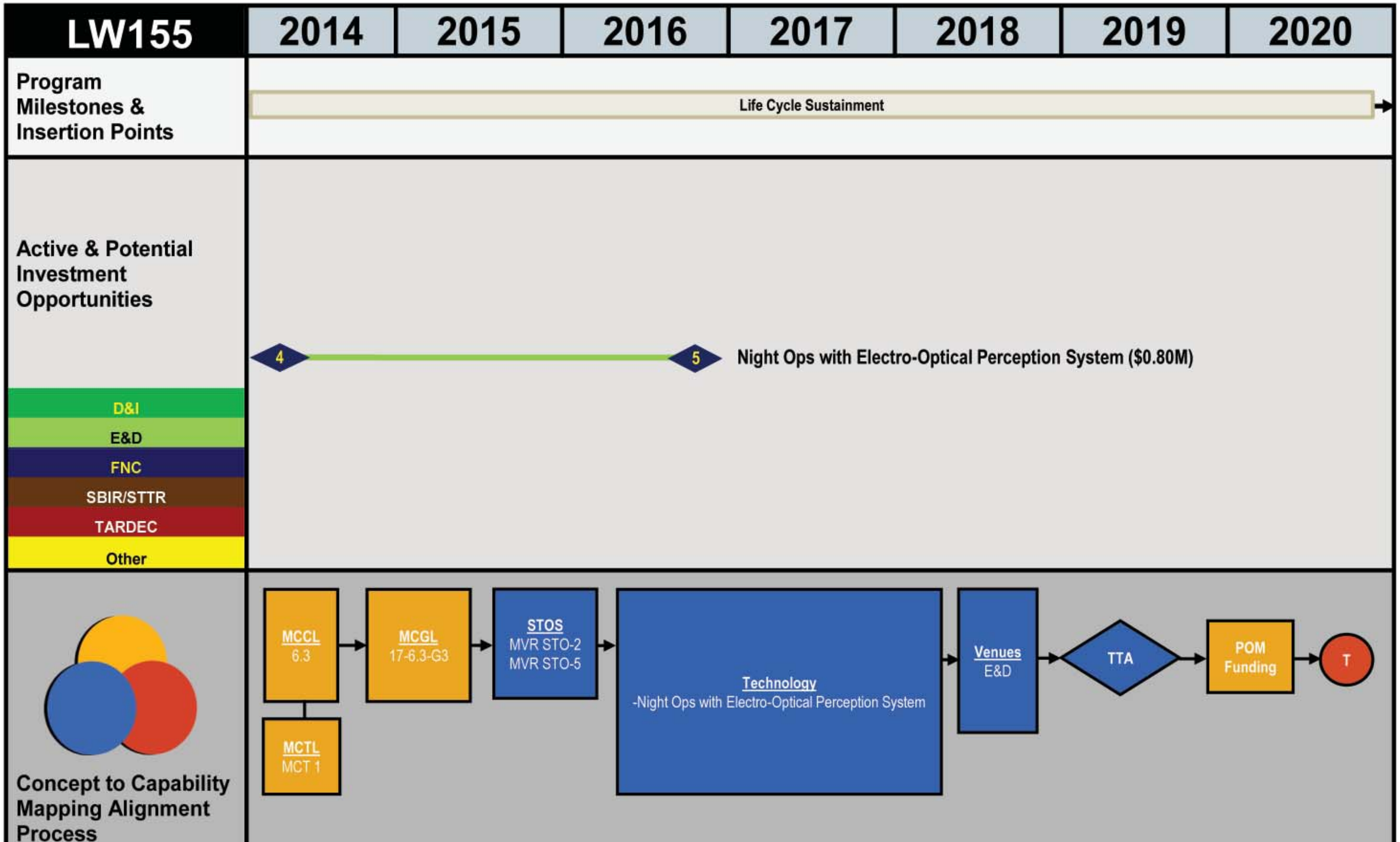
LW155 Technical Issue #1
Safe and Transportable Battery High Capacity Technology



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



LW155 Technical Issue #3
Navigation in a GPS Denied Environment



Funding Profiles ($M)	FY14	FY15	FY16	FY17	FY18	FY19	FY20
S&T (6.2 / 6.3)	0.35	0.25	0.20				

6.1 ← → Science & Technology ← → 6.3 6.4 ← → System Development ← → 6.7

Advanced Technology Investment Plan

2015 - Volume VI

ATIP

PEO LAND SYSTEMS
ACQUISITION EXCELLENCE
IT'S ALL ABOUT THE WARFIGHTER

IT'S ALL ABOUT THE WARFIGHTER

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