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Acquiring Capabilities Within a Prototype Warfare Mindset

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ABSTRACT

Prototype Warfare represents a paradigm shift in how the US Department of Defense (DoD) executes acquisition of defense systems in a manner that is significantly faster than traditional acquisition. The idea was initially presented in a whitepaper entitled "Mission Engineering and Prototype Warfare: Operationalizing Technology Faster to Stay Ahead of the Threat" that was introduced in at GVSETS 2018. This paper organizes prototype warfare into three classes of systems, each with their own acquisition path toward putting Prototype Warfare on the battlefield. These approaches do not come without risks, issues, and downfalls, but a renaissance in traditional acquisition processes do not come risk free either. By rethinking how we determine operational needs, engineer new systems, and place systems in service, there are opportunities to provide radically new capabilities to the hands of the warfighter on timescales measured in weeks or months, not years.

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1. INTRODUCTION

For purposes of the discussion within this paper, the term "prototype" means a system that has not completed its final iteration of design. It means, as it would traditionally, a system that may not be fully finalized, but an iteration of the concept to demonstrate capability, test performance, and understand production processes. Prototype Warfare is an idea that advocates the use of prototype-like systems in warfare in order to close the time gap between identification of need and fielding of systems to fill that need. Prototype is not to imply that the system is necessarily low TRL nor untested or unsafe. These characteristics are still necessary in both traditional and prototype systems, however the time it takes to ensure a prototype system is safe is considerably less than a traditional system because the prototype's requirement set is significantly scoped down to a specific use case(s).

According to Like Shabro, deputy director for the US Army Mad Scientist Initiative at TRADOC G-2, "Warfare changes so much with pace and technological advancements that we can no longer rely on what we previously had [in order to be successful]." (Rovery, 2019) Prototype Warfare represents a shift in the paradigm of how the US Department of Defense (DoD) develops and acquires defense systems from traditional acquisition models in order to meet that challenge. At its core, Prototype Warfare argues for a shift in focus from large fleets of one-size-fits-all exquisite systems to small quantities of rapidly-fielded, highly tailored systems tuned to provide specific capabilities in a specific operational environment. By limiting the system's capabilities to only what is required for a short duration mission, Prototype Warfare significantly increases the speed at which urgently needed capabilities are brought to the field. With a Prototype Warfare approach, Service components can reduce the amount requirements that are levied on a system, in turn reducing development timelines, testing needs, and unit costs ultimately placing new technologies in the hands of the Warfighter faster than with traditional methods.

The concepts and fundamental arguments for Prototype Warfare were outlined in a previous paper from the Army's Combat Capabilities Development Command (CCDC) Ground Vehicle Systems Center (GVSC). That document, titled "Mission Engineering and Prototype Warfare: Operationalizing Technology Faster to Stay Ahead of the Threat", and serves as a foundation to the concepts and arguments presented within this paper.

While Prototype Warfare promises to bring revolutionary change in how the DoD procures new capabilities, it is also important to note that it is not the only solution to all DoD acquisition. In fact, the political, economic, and diplomatic realities of the world still require exquisite systems that are able to be placed in a variety of environments and situations. Strategic deterrence, for example, is still a useful tool of national willpower. Defense systems that are able to provide world-wide applicability to support the US's strategic national interests are still valid. Instead, Prototype Warfare aims to revolutionize not the entire DoD Acquisition process, but only a part that fit specific criteria suitable to a Prototype Warfare approach. Stated differently, a Prototype Warfare approach is presented here as an option for future Program Management Offices to consider as part of their Acquisition Strategy, not as the only solution to streamline acquisition.

After publication of the foundational Prototype Warfare Paper in 2018, one of the most common questions received back was "How do you operationalize the ideas of Prototype Warfare in a real program?" While conceptually the idea of taking prototype systems and literally bringing them into war as the name suggests seems appealing, challenges within legal and regulatory acquisition framework prevent simply fielding prototype systems direct from the contractor to the warfighter. However, even in the current environment, there are still ways to adopt Prototype Warfare-minded approaches, if bringing literally prototype systems into combat is unpalatable. This paper lays out our ideas about how to bring a Prototype Warfare mentality forward, in cases where it makes sense to do so, while not ignoring the realities of the acquisition environment today.

2. Classifying Prototype Systems

The term "prototype system" is too broad to explain the different paths available to bring a prototype system to fielding. Therefore, we organize prototype systems into three distinct classes. This distinction is important because the risk associated with bringing these types of systems into war is significantly different between classes. Therefore, an approach that is realistically achievable within today's acquisition environment is different between all three.

Class I Prototype System – Hardware focused. Prototype systems in Class I are hardware-centric. The immature technology and the reason the system is considered prototype is primarily due to something that is physical, electrical, or mechanical in nature. The system may have software on it, but it is not the focus of the technology. Electrical components, if they exists are primarily analog or

	Class I	Class II	Class III
Tech Focus	Hardware	Software	System Integration
Characteristics	Physical, electrical, mechanical	Logical, Software, Firmware	Multiple technologies
Primary Source of Risk	New physical components	New software functionality	Integration of new components or integration of mature components in new and novel ways
Examples	Combat clothing items, individual weapons, vehicle mine rollers	Software defined radios, Artificial Intelligence	Robotic ground vehicles, unmanned aerial systems, microsatellites

Table 1 - Three Classes of Prototype Systems

are mature technologies. Examples within this class of systems are: combat clothing, individual weapon systems, and mine rollers for vehicles.

Class II Prototype System – Software focused. Prototype systems in Class II are software-centric. The immature technology and the reason the system is considered prototype is primarily due to something that is logic oriented like software and firmware. The system may have physical components to it, but they are not the focus of the technology and are technologically mature as physical components. In this class of prototype systems, the risk within the prototype system is the maturity of the software itself or the integration and operation of the software within the physical system. Examples within this class of systems are: software defined radios, artificial intelligence algorithms to reduce operator burden, software applications on tactical mobile devices.

Class III Prototype System – System focused. Prototype systems in Class III are system-centric. Class III systems may have a mix of prototype hardware and/or software components in varying levels of maturity. What makes Class III particularly unique is that the risk is not only within the maturity of the technology by itself, but more importantly the risk of the technology when integrated into other systems as a system-of-systems. Because of the integration aspects in this category, Class III Prototype Systems are often major end items and may contain both of the other Classes of prototype systems within them. Examples within this class of systems are: ground combat vehicles, unmanned aerial systems, and microsatellites.

3. Acquiring Prototypes Within Each Class

Each of these classes of prototype systems have their own challenges and associated risks. Therefore, the realistic acquisition approach to fielding these systems must, in turn, be different. Generically, the risk associated with fielding a prototype system increase from Class I to Class III. However, these classes are not defined with hard boundaries that have prescribed actions for systems with them. Instead, they acknowledge the range of maturity and risk within a system when talking about Prototype Warfare. Acquisition approaches for one class of systems might not be suitable for a different class.

3.1. Class I Prototype Systems

Class I Prototype Systems are not new to acquisition, although they may have been described by different names. Historically, these systems are referred to as “kits” that exist outside the baseline

Technical Data Package (TDP) of the system, but offer some enhanced capabilities that were needed immediately. For the purpose of Prototype Warfare, regardless of their name these types of systems, ones that exist beyond the baseline configuration, are still prototype systems. However, once a prototype system becomes part of a system baseline at some future point in time, for purposes of Prototype Warfare, the system will cease being a prototype.

Acquisition processes already exist to bring Class I prototype systems to the field and were extensively used during Operation Iraqi Freedom (OIF) and Operation Enduring Freedom (OEF). Both of these conflicts brought unique operational requirements that were unable to be met by the current inventory of equipment and in the interest of time, prototype systems were used to fill critical needs. The Rapid Fielding Initiative (RFI) executed by the U.S. Army's Program Executive Office (PEO) Soldier brought an entire overhaul to the infantryman's kit above baseline, including improved body armor, new load carrying equipment, and close quarters optical sights. A second well known example was the development of Mine Resistant Ambush Protected (MRAP) vehicles, which were fielded against an urgent need above baseline Modified Table of Equipment (MTOE) authorizations. (MRAP is considered a Class I Prototype because the vehicle itself as a system was mature, the technological immaturity was in the configuration of the protection systems). Indeed, Prototype Warfare has already been fought, if only for low risk, commercially available systems.

In future war, there will continue to be a need for Class I Prototype Systems. Fortunately, much of the trailblazing of how to acquire and operationalize these prototype systems has already been done. However, that shouldn't take away the importance of continuing to look for opportunities to fill a need with a Class I prototype system. Because the risk is generally lower for these types and the path to success has been mapped out, this may be the fastest way to operationalize a prototype to fill an urgent need.

3.2. Class II Prototype Systems

Class II prototype systems are not new within the industry either, but operationalizing these systems within a Prototype Warfare framework has not been as extensive as Class I. However, Class II systems hold the most near-term potential for realization of Prototype Warfare because the software industry and software development processes, such as Agile Development and DevOps, are already well-established. These development approaches are compatible with Prototype Warfare goals to produce immediate capabilities, allow iterative adjustments over time, and the permit requirements change as the user needs become better understood. Such flexibility in the development and delivery process is required to truly achieve the goals of Prototype Warfare.

Using software to provide flexibility over time minimizes the time between iterations, enabling capabilities to be brought to the field, and adapted as the environment changes, faster than previously possible. This is especially true for legacy hardware-centric technologies that can now be replicated using software, such as a radio being converted to a software-defined radio (SDR). At its core, a SDR is essentially a simple computer and a Radio Frequency (RF) antenna, both mature technologies from a hardware perspective. However, instead of hard wiring the waveforms requirements into the radio through specific electronic components, the SDR uses software to reproduce the same electronic result. The resultant benefit of the SDR over the traditional radio is that if the characteristics of the waveform need to change, the SDR can meet the need with a software update where a traditional hardware radio would require the entire radio to be physically replaced. When coupling a SDR with a method to wirelessly push updates to the radio, the benefits of SDRs within a Prototype Warfare mindset become overtly evident. Capabilities can be added to systems with no need for a maintainer to touch the vehicle, decreasing the time to deploy a new capability while increasing operational availability (A_o) since systems do not need to be taken in for retrofit.

Suppose the following example to see the power of software-defined systems over legacy hardware systems. Consider two similar vehicles in a combat environment. Both have counter- improvised explosive device (IED) radio frequency (RF) jammers on them similar to the CREW system. But on one vehicle, the system is a traditional electronics RF jammer and the other vehicle uses a SDR RF jammer. Initially, both vehicles are just as successful at defeating IEDs but eventually the enemy gets wise to jammer and changes tactics by altering the frequency of their IED detonator. Perhaps the move away from using a Global System for Mobile (GSM) mobile phone to an 800 MHz Radio. Since the traditional jammer is a robust system, let's assume it is already designed to defeat 800MHz as well, but it needs a maintainer to enable that mode on the system. For the SDR jammer, engineers tweak the code and push a wireless update to the vehicle overnight. The next day, both vehicles again have the same performance and can counter the new tactic, however expanding the example to not just one but a fleet of vehicles, the traditional jammer has used orders of magnitude higher maintenance man-hours across the theater switching each individual vehicle to the new mode. For the SDR system, maintenance hours were confined to a small software development team to alter the software and push it over the air to each vehicle.

Let us take the scenario one step further. The 800MHz change works well for a short while, but the enemy adapts new tactics again, now using small commercial UAS systems to drop conventional munitions upon passing convoys. Suppose the UAS systems have a vulnerability in their Wi-Fi protocol that connects the drone to the controller. To exploit this vulnerability, the SDR radio, gets a new software update that allows it to communicate over Wi-Fi, enabling it to exploit the drone. This is possible because a SDR does not require the developers to understand all the use cases or requirements up front and is adaptable to new requirements not included during the initial development phase. In this case, the radio was initially developed to be an IED jammer but now is being used as an offensive UAS cyber-emitter. The traditional jammer however, is incapable of exploiting Wi-Fi since that was not within the original requirements set. A new system needs to be developed, tested, and installed on the vehicle in order to counter this change in enemy tactic. When considering the amount of time and man-hours required to implement a change against a traditional system, including the time to install it in the vehicle, the appeal of using software-defined systems for Prototype Warfare becomes apparent.

The takeaway from the SDR example above is that a Prototype Warfare mindset is enabled by looking for opportunities to take traditional hardware-centric capabilities and realize them using software. If system capabilities are enabled by the software and not hard-coded into the hardware, the ability to operationalize prototype capabilities in cycles much faster than traditional acquisition can be achieved. Programs pursuing a Class II Prototype System approach should attempt to make the physical hardware as broad as possible and let the software control the specific unique needs of the requirements. In the case of the SDR jammer above, having a computer with enough processing power to handle multiple waveforms while integrating an antenna with the broadest bandwidth possible within size and weight constraints would provide the most options available for future software uses.

3.3. Class III Prototype Systems

Class III Prototype systems are perhaps the most interesting of the set because the complexity of the system requires a novel approach to acquisition. A prototype system within Class III will likely have multiple capabilities within it that are prototype in their own right. In addition, the Class III prototype may intrinsically be a system that is new to the warfighter, requiring significant DOTML-PF changes including updated doctrine and TTPs. It is these characteristics – ones that suggest the system is a revolutionary, not evolutionary, change – that are prime for a prototype warfare mindset approach to acquisition.

For Class III systems it is unlikely that the system will be fielded like Class I or II systems, sent in partially complete condition, or for a specific use case and then disposed of. These systems will likely be too revolutionary, too new to the warfighter, and too expensive (both financially and technologically) to dispose of when the mission is over. They will require a more robust and complete requirement set to ensure they are cost effective, safe, and don't fall into the wrong hands for exploitation. Instead, these systems require an entirely different approach to acquisition, which still follows the idea of Prototype Warfare.

For example, the Army's Robotic Combat Vehicle (RCV) could fit the Class III Prototype System model. The Army is developing a set of RCVs to partner with manned-combat vehicles utilizing manned-unmanned teaming (MUM-T) concepts. These vehicles not only have a significant amount of new technology on them but also break the mold with respect to how the Army fights war. There is no analogous system tactics to compare the RCV's capabilities to and if fielded, the RCV will require Soldiers to update their force structure, doctrine, and tactics. With these characteristics, the RCV is an ideal system to fit into a Prototype Warfare acquisition model.

For Class III prototype systems, which generally represent major end items like the RCV, a new engineering and acquisition model would be more appropriate. Instead of producing and fielding RCVs as a single iteration across the entire Army, developing incremental increases over time which are continually fielded across the Service, a smaller fielding with more iterations, perhaps 1 BCT per iteration, will mature these type of systems faster while providing better capabilities to the soldiers at the point of need.

Operationally, again using RCV as an example, it could work like this: A core development activity develops the baseline characteristics of the RCV. Then Brigade 1 receives notification of deployment in support of combat operations in a Theater A. The RCV development team completes the RCV, Iteration 1 design and fields the system to Brigade 1 prior to deployment. Brigade 1 provides feedback into the RCV program which impact both the core development as well as the Theater A specific development. Brigade 2 receives notification they will relieve Brigade 1 in theater and the RCV team starts development toward that iteration. The team completes and fields RCV Iteration 2 to Brigade 2. Brigade 2 deploys with its variant and provides feedback back to the RCV team for future iterations.

Brigade 3 then received notification of deployment to theater and the cycle restarts. The process continues with fielding, deployment and feedback returning to the RCV team to influence future iterations, eventually resulting into Iteration *n* where the system is finally matured beyond prototype phase.. In reality, these loops would occur not only in series, but in parallel as multiple brigades are activated at once or with offset timelines.

Each of these iterations build upon themselves as the tactics, requirements, and logistics are developed on the fly from the initial baseline in the operational environment. This method allows the soldiers to be directly involved in the development process, leveraging their creativity to employ the systems in ways the system developers cannot foresee. Additionally, since their feedback is critical input to the next development cycle, the operators' input has direct input and influence more than it ever has before.

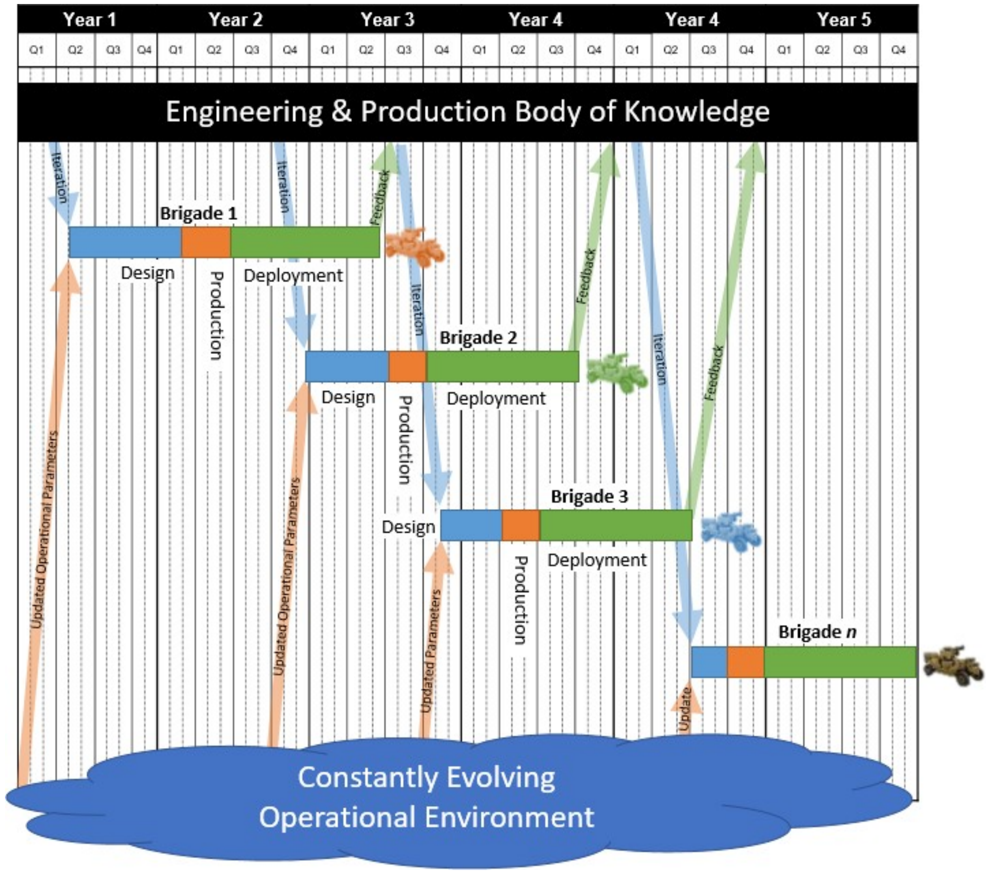

Figure 1 - Notional Class III Prototype System Development Plan

4. CONCLUSION

Acquisition of systems capable of Prototype Warfare will require a change to the traditional acquisition models of system development, but the changes are not completely untried or untested. By employing acquisition planning creativity and developing systems with a deliberate expedited and deliberate approach, bringing new capabilities to the field in a prototype capability is possible. However, the goal of the acquisition team must be prioritized on bringing a very specific and narrow capability to the field to realize the time saving benefits of Prototype Warfare.

In order to keep ahead of the pace of technology and maintain overmatch, we must continue to look for creative ways to place the latest technology in the hands of the warfighter to enable them to complete their mission. By thinking differently in our acquisition approach and focusing on specific use cases instead of worldwide applicability, we can minimize the time it takes to meet a need and doing so enables us to acquire new capabilities within a Prototype Warfare mindset.

5. REFERENCES

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