



Transitioning science and technology into acquisition programs: assessing one government laboratory's processes

Title	Transitioning science and technology into acquisition programs: assessing one government laboratory's processes
Item Type	Thesis
Authors	Bonano, Norman;Magidson, Laura
URI	https://hdl.handle.net/10945/47907
Publisher	Monterey, CA; Naval Postgraduate School
Date Issued	2015-12
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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

JOINT APPLIED PROJECT

TRANSITIONING SCIENCE AND TECHNOLOGY INTO ACQUISITION PROGRAMS: ASSESSING ONE GOVERNMENT LABORATORY'S PROCESSES

December 2015

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REPORT DOCUMENTATION PAGE			Form Approved OMB No. 0704-0188	
Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instruction, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188) Washington, DC 20503.				
1. AGENCY USE ONLY (Leave blank)		2. REPORT DATE December 2015		3. REPORT TYPE AND DATES COVERED Joint Applied Project
4. TITLE AND SUBTITLE TRANSITIONING SCIENCE AND TECHNOLOGY INTO ACQUISITION PROGRAMS: ASSESSING ONE GOVERNMENT LABORATORY'S PROCESSES			5. FUNDING NUMBERS	
6. AUTHOR(S) Norman Bonano and Laura Magidson				
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Naval Postgraduate School Monterey, CA 93943-5000			8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING /MONITORING AGENCY NAME(S) AND ADDRESS(ES) N/A			10. SPONSORING / MONITORING AGENCY REPORT NUMBER	
11. SUPPLEMENTARY NOTES The views expressed in this thesis are those of the author and do not reflect the official policy or position of the Department of Defense or the U.S. government. IRB Protocol number ___N/A___.				
12a. DISTRIBUTION / AVAILABILITY STATEMENT Approved for public release; distribution is unlimited			12b. DISTRIBUTION CODE	
13. ABSTRACT (maximum 200 words) <p>This paper examined the strengths and weaknesses of the overall technology transition process between Armament Research, Development and Engineering Center (ARDEC) and its partnered program offices in transitioning technology into established Programs of Record. This examination was a direct review and comparison of Department of Defense policies, U.S. Government Accountability Office reports and recommendations, and ARDEC and the program managers established processes.</p> <p>The research indicated that the following recommendations should be implemented by other research and development (R&D) organizations to foster proper technology transition: endorsement from future customers, collaboration early on with the soldier and developing organizations, alignment with soldier needs, lever available capabilities, and introduction of technology transition agreements.</p> <p>Research also indicated that in order for ARDEC to continue to improve its technology transition process, it should focus on the transition and inclusion of industry, address all changes and decisions, and conduct affordability and tradeoff analysis. Additionally, ARDEC should fill all management positions with qualified individuals, assign managers for durations of program, stress importance of operations deployment, and use service acquisition organizations to review the process and R&D adaptability to PM expectations.</p>				
14. SUBJECT TERMS Armament Research, Development and Engineering Center (ARDEC), transitioning technology into programs of record, Technology Readiness Levels (TRLs), DOD, GAO			15. NUMBER OF PAGES 73	
			16. PRICE CODE	
17. SECURITY CLASSIFICATION OF REPORT Unclassified	18. SECURITY CLASSIFICATION OF THIS PAGE Unclassified	19. SECURITY CLASSIFICATION OF ABSTRACT Unclassified	20. LIMITATION OF ABSTRACT UU	

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**TRANSITIONING SCIENCE AND TECHNOLOGY INTO ACQUISITION
PROGRAMS: ASSESSING ONE GOVERNMENT LABORATORY'S
PROCESSES**

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Submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE IN PROGRAM MANAGEMENT

from the

**NAVAL POSTGRADUATE SCHOOL
December 2015**

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LIST OF ACRONYMS AND ABBREVIATIONS

AAA	Army Audit Agency
ADUSD	Assistant Deputy Under Secretary of Defense
ARDEC	Armament, Research, Development and Engineering Center
ASD(R&E)	Assistant Secretary of Defense for Research and Engineering
CoE	Centers of Excellence
CTO	Chief Technology Officer
DOD	Department of Defense
FY	Fiscal Year
GAO	Government Accountability Office
I&TT	Innovation and Technology Transition
IPT	Integrated Product Team
JCIDS	Joint Capabilities Integration Development System
ODOT	Office of the Director of Technology
OTT	Office of Technology Transition
PEO	Program Executive Office
PEO Ammo	Program Executive Office Ammunition
PM	Program Manager
PMO	Program Management Offices
POM	Program Objectives Memorandum
PoR	Program of Record
R&D	Research and Development
RDECOM	Research Development Engineering Command
REF	Rapid Equipment Force
SBIR	Small Business Innovation Research
SME	Subject Matter Experts
SOCOM	Special Operations Command
S&T	Science and Technology
TCL	Transition Commitment Level
TRA	Technology Readiness Assessment
TRADOC	Training and Doctrine Command
TOC	Total Ownership Cost
TRL	Technology Readiness Level
TTA	Technology Transition Agreement

TTC	Technology Transition Council
TTI	Technology Transition Initiative
TTP	Technology Transition Program
WFO	War Fighter Outcomes

EXECUTIVE SUMMARY

Over the past several years, many groups have tried to study the Science and Technology “Valley of Death”: the transition of technology from a research and development organization to a program manager. Some of these organizations include the Defense Acquisition University (DAU), the U.S. Government Accountability Office (GAO), the U.S. Armament, Research, Development and Engineering Center (ARDEC) and the Program Executive Office for Ammunition (PEO Ammo).

The FY 2006 Defense Authorization Act directed the DOD to “assess organizational barriers, acquisition regulations, requirements validation, and the planning, programming, budgeting, and execution processes impacting the ability to transition *the technology* from science and technology (S&T) into acquisition” programs (Harger & Kubricky, 2007, pp. 1–3). As requested by Section 255 of the FY 2006 Act, in 2007 the Department of Defense (DOD) reported to Congress on the Technology Transition challenges and identified several barriers.

As briefly noted above, transitioning technology into established Programs of Record (PoR) has been a longstanding defense challenge. In 1999, the adoption of Technology Readiness Levels (TRLs) may have introduced unintended consequences impeding the transition process. The TRL scale measured the “maturity of an individual technology, with a view toward operational use in a system context. A more comprehensive set of concerns became relevant when this metric is abstracted from an individual technology to a system context, which involved interplay between multiple technologies” (Ramirez-Marques & Sauser, 2009, p. 533). Traditionally, S&T communities advance programs to a TRL 5 level of maturity or even TRL 6 level, and then move on to the next program. Acquisition communities, on the other hand, require a higher level of maturity for consideration as a PoR, specifically, TRL 7 level, to help reduce risk. Harger and Kubricky (2007) determined that there might be “disconnects between the S&T and acquisition communities” (p. 1). Therefore, although meant to create a common understanding of technology readiness terminology, the TRL system created a gap. This technology/maturity gap, although seemingly small, is commonly referred to as the “Valley

of Death.” The S&T community’s efforts could be for naught; many of their researched technologies, although they work and provide a solution, seem rarely to become PoRs.

As a leading U.S. Army Center for Research and Development (R&D) work, the Armament Research, Development and Engineering Center (ARDEC) is continuously trying to improve the overall process of transitioning technology. This research will examine the strengths and weaknesses of that overall *technology transition* process in the following primary areas: inter-organizational barriers between ARDEC and its customers, acquisition regulations, requirements validation, and the planning, programming, budgeting, and execution process. We analyze the overall problems in the various reports, the description of what ARDEC has done to address these issues, and the complementary processes that PEO Ammo has implemented. We can use these examples to help other organizations utilize the best practices that ARDEC and PEO Ammo currently use. We also identify areas where they are still working to improve, which will add further examples for organizations to achieve better technology transition.

Through the exploration of these topics, we make some recommendations that organizations should consider incorporating into their S&T Process to improve the transition of technology to PEO and PM customers.

First, an endorsement from the current and future customers is critical to the identification of interest in technology and where it should be inserted. This endorsement should include the type of technology, the specific transition time frame, and how it will fit within the overall program framework. Many PEOs and PMOs have begun developing roadmaps for their specific commodities to plan technology insertion points, quantify the number of spare parts for the lifetime of a system, and to identify a system’s useful life requirements before it is planned to be replaced with an upgraded or new system/solution.

Second, to assist in the development of requirements up-front and early collaboration with the Soldier community and the respective CoE is essential. Without requirements, completed S&T projects have few avenues for proceeding as PoRs. Aside from participating in demonstrations to gain interest from SOCOM, Rapid Equipment Force (REF) or another organization with the ability to purchase systems independent of

the normal Acquisition Life Cycle Process, there needs to be a requirement in order for S&T efforts to become PoRs. Collaboration will help make the CoE aware of the capabilities of S&T and make the CoE aware of the current technologies that are available or already being developed.

Third, alignment with currently identified Soldier needs and existing/staffed requirements documents is needed. Similar to the previous collaboration, this is a document review and match between existing identified gap areas from the Soldier community, such as War Fighter Outcomes (WFOs) and the prioritized gap areas from each CoE. Analyzing the WFOs and current requirements documents and then aligning S&T Portfolio with these documents can be very helpful in transitioning to a PoR. Having requirement documents already completed is a huge advantage in this matter. However, even without a requirements document, it is important to at least be aligned with existing documentation of gap areas in order to justify the work that you do, while you can work with the CoE in order to develop a requirements document for transition when the effort is complete.

Fourth, up-front and early collaboration and communication between developing organizations is essential. Most projects require inter-operability and different development agencies to work in harmony in order to accomplish the successful, timely, and technical completion of a project. For example, the identified weapons experts must work with the platform experts and the communications experts. Without this collaboration, integration, functionality and logistics support technology transition would be at a very high risk and could easily lead to the transition failing or being delayed. Working together and defining interfaces and controls for those interfaces is paramount to having the systems work together as they need to in today's System-of-Systems reality of the battlefield.

Fifth, having the ability to successfully leverage capabilities available to provide the best possible solution to the War Fighter is imperative. This includes being aware of and collaborating with academia, industry and foreign agencies. There are many ways to perform this collaboration; through attendance at conferences, industry research and development reviews, technical information exchanges, foreign technology information

papers, and even Internet searches. All of these help us to leverage as much technological knowledge as possible when developing the solutions to War Fighter needs that can be transitioned to PoRs and ultimately the Soldiers themselves.

Finally, TTAs need to be in place and have explicit criteria for both the developing agency and the future customers. The two major issues with this currently are that the deliverables of the S&T efforts are not clearly defined and that the future customers make no commitments to use the developed technologies. This is why having a defined requirement is so important. Without a requirements document of some kind, it is difficult for a customer to transition the technology to a PoR. Additionally, regular status reviews between the PM and ARDEC are very important in assuring continued commitment, alignment and execution of the technology for transition.

The below are recommendations that ARDEC should continue to pursue or should incorporate into their S&T Process to improve the transition of technology to PEO and PM customers:

1. Focus on the transition, and identify and track meaningful metrics associated with technology transition. The kind of metrics to be used are situational dependent; however, the metrics should be agreed to up-front by all stakeholders and reviewed regularly.
2. Include industry in a systematic and routine way as part of the process, so that it is beneficial to both the industry and government sectors.
3. Address all “-ilities” in a meaningful way, rather than merely assuring membership on the S&T project IPTs. This means being able to identify design and functionality changes and decisions that were influenced by these design considerations.
4. Conduct affordability and cost tradeoffs by updating the cost data as the technology matures and as relevant manufacturing and support costs become more evident.
5. Fill all key project management positions with qualified people. Individuals with technology transition experience would be the best choice.
6. Assure that program managers and transition managers remain assigned for the duration of the associated project(s).

7. Favor operational development over formal demonstrations.
8. Use service acquisition organizations to periodically evaluate and advise the project team.
9. Adapt the R&D project deliverables or tradeoffs in cost, schedule, performance and risk based upon the expectations of the PM transition partner.

LIST OF REFERENCES

Harger, K.L & Kubricky, J. J. (2007). *Department of Defense report to congress on technology transition*. Washington, DC: The Office of Department of the Undersecretary of Defense. Retrieved from <https://acc.dau.mil/adl/en-US/173369/file/31016/Tech%20Transition%20Report%20to%20Congress%20-%20August%202007.pdf>

Ramirez-Marquez, J.E & Sauser, B.J. (2009, August 3). System development planning via system maturity optimization. *IEEE Transactions on Engineering Management*, 56 (3), 533–548. Retrieved from <http://ieeexplore.ieee.org/stamp/stamp.jsp?arnumber=4806066>

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ACKNOWLEDGMENTS

I would like to thank my wife for pushing me and reminding me every day of my goals. Thank you staying up with me and motivating me to keep moving forward. I also would like to thank my kids for sacrificing time away from “Daddy” and allowing me focus on this project.

I would also like to thank my organization and group members for affording me the time to work on my degree during duty hours.

—Norman Bonano

I would like to thank my family, friends and colleagues for helping me throughout the life of the program. Most especially, I would like to thank my wonderful husband for being so understanding and patient and pushing me to complete the program. I also would like to thank my children for understanding when I needed time to myself to complete my schoolwork and other projects.

—Laura Magidson

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I. INTRODUCTION

A. CHAPTER INTRODUCTION

This chapter presents the historical background of the problems inherent to technology transition in the DOD and will provide scope for the subsequent chapters. It describes the purpose and background of technology transition, listing identified problems and how the rest of this paper addresses these problems through the analysis of the case of the Armament Research Development Engineering Center (ARDEC) and the Program Executive Office for Ammunition (PEO-AMMO).

B. PURPOSE OF THE STUDY

According to Section 255 of the Defense Authorization Act of 2006, transitioning technology into established Programs of Record (PoR) has been a longstanding Department of Defense (DOD) challenge. Technology transition has been a hot major challenge for the government over the last several years. As stated in “Accelerating Technology Transition: Bridging the Valley of Death for Materials and Processes in Defense Systems,” the Department of Defense is changing course and transitioning from a Cold War-era fighting force to a more efficient technology driven group. Historical instances of technology transition have been neither fast nor efficient. The usual interval of time requisite for a technology to transition is at least 10 years. Therefore accelerating technology transition of new ideas into actual defense systems is fundamental in accomplishing this change (Committee on Accelerating Technology Transition, 2004, p. 1).

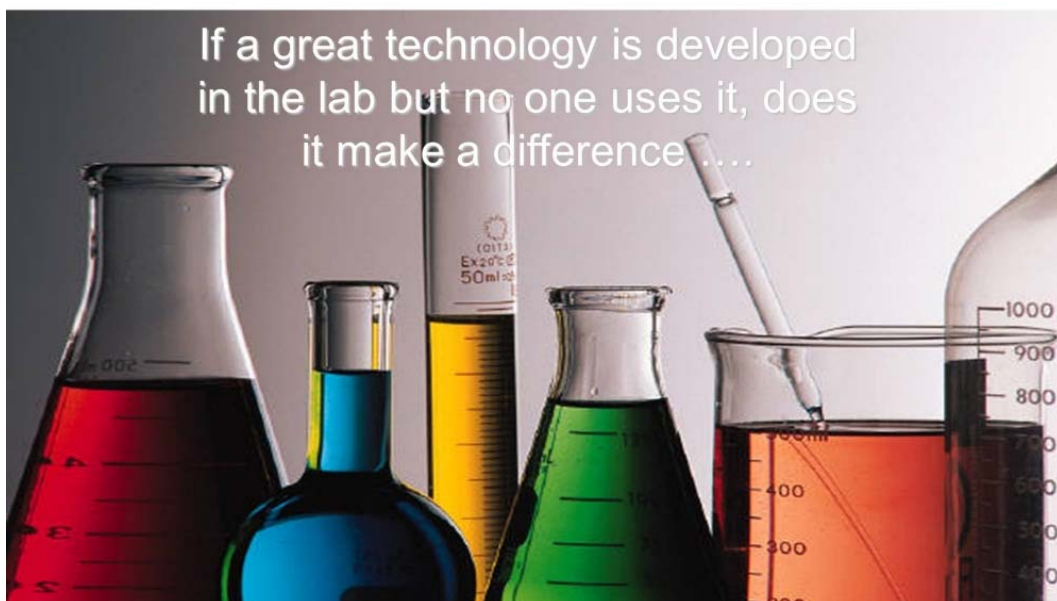
This research explored both the shortcomings and processes implemented to resolve those issues of transitioning Science & Technology (S&T) community’s technology into PoRs. This exploration was accomplished through the examination of communication, organizational structure and processes used between U.S. Armament, Research, Development and Engineering Center (ARDEC) and their largest customer, the Program Executive Office for Ammunition (PEO Ammo). Through highlighting the relationship between ARDEC and the PEO Ammo, we found strengths and weaknesses. By evaluating ARDEC’s strategy for improving the transition of S&T technology, we

found best practices and shortfalls. Through this study, we provided recommendations for what ARDEC should be doing and should not be doing.

C. BACKGROUND

In order to understand the current issues with transition, we needed first to understand some of the history of technology transition within the DOD. This section gives some of the structure of the organizations reviewed in this paper, as well as some of the history of technology transition within the DOD. The following highlight the reliance of the DOD on its research and development organizations. DOD is highly dependent on “its research laboratories, test facilities, industry and academia” to evolve and improve highly advanced new technologies (Government Accountability Office [GAO], 2005, p. 4). The report further states that, historically these facilities have experienced difficulties transitioning these new technologies to the acquisition community, which controls the bulk of the DOD’s R&D funding. As illustrated by Figure 1, this transitioning difficulty is due to the acquisition programs’ reluctance to finance the technology through its final technology readiness stages into integration (Government Accountability Office [GAO], 2005, p. 4).

Figure 1. Avoiding the Valley of Death



Source: R. Lightsey. (n.d.). Transition techniques (avoiding the “Valley of Death”), [PowerPoint slides]. Retrieved from Defense Acquisition University: <https://acc.dau.mil/search?id=1&q=Robert+Lightsey&lang=en-US>

Technology transition is defined as

the use of technology in military systems to create effective weapons and support systems in the quantity and quality needed by the warfighter to carry out assigned missions at the 'best value' as measured by the warfighter. Best value refers to increased performance as well as reduced cost for developing, producing, acquiring, and operating systems throughout their life cycle. (Defense Procurement and Acquisition Policy [DPAP] Office of the Under Secretary of Defense, 2003, p. 1-1)

The senior executives at the Department of Defense recognize many of the challenges associated with transitioning technology from S&T into acquisition programs. One of the intentions of technology transition is to achieve the Soldier's needs at the minimum Total Ownership Cost (TOC). As a result, technology transition's objectives are to utilize resources that are readily available. This is done by leveraging the best commercial and non-commercial technology, expeditiously transitioning novel technology into new or existing systems, incremental improvements to existing technologies to help maintain overmatch and safeguarding any new cutting-edge research and technology to prevent disclosure of any kind (DPAP Office of the Under Secretary of Defense, 2003, p. 1-2).

As with all organizations within the Research Development Engineering Command (RDECOM), as illustrated in Figure 2, ARDEC strives to transition technology at as high a rate as possible. RDECOM tracks this as part of an annual data call referred to as the Technology Characterization Index (TCI). Due to locality, ARDEC began to explore how to improve the transition process with the resident customer at Picatinny: PEO Ammo. The two organizations worked together with mutual interest to develop processes and procedures that benefitted both organizations, and by extension, the warfighter. As a result of this collaborative nature, ARDEC was able to better quantify and qualify how the two organizations' portfolios were aligned. In November 2007, ARDEC "became the first Department of Defense (DOD) organization in history selected to receive the prestigious Malcolm Baldrige National Quality Award," which according to the National Institute of Standards and Technology (NIST) "is the nation's highest presidential honor for quality and organizational performance excellence" (Bush, 2007; Kosko, 2005). Part of its award

recognition was its focus on technology transition. Baldrige performance excellence is defined as follows:

the framework and an assessment tool for understanding organizational strengths and opportunities for improvement. Performance excellence refers to an integrated approach to organization performance management that results in delivery of ever-improving value to customers and stakeholders, contributing to organizational sustainability, improvement of overall organizational effectiveness and capabilities and organizational and personal learning (“What is Performance Excellence?”, 2010).

In the same timeframe, the Army Audit Agency (AAA) also designated ARDEC as the Army’s benchmark for technology transition, further emphasizing that ARDEC recognized the importance of technology transition. This by no means indicated that ARDEC had all of the answers. Instead, it signified the center had certain activities in place to assist in the transition process that have worked and have served as examples for other DOD organizations. We explored some of these processes, organizational structures and communication methods that were used to achieve the improvements in technology transition as well as those areas that still need improvement.

Figure 2. RDECOM Organization Chart



Source: Army Technology. (n.d.). Greater than the sum of its Parts [Chart]. Retrieved October 14, 2015 from http://armytechnology.armylive.dodlive.mil/index.php/2013/02/13/greater-than-the-sum-of-its-parts/nn_020813_1pt_a001-arc-2/.

D. PROBLEM IDENTIFICATION

Although recognized for its technology transition processes, transitioning technology into established Programs of Record (PoR) has been a historical challenge for ARDEC. The ARDEC Portfolio Review Analysis and the RDECOM Technology Characterization Index (TCI) perform reviews and analyses of the successful transition rate for ARDEC S&T projects. Both the ARDEC Portfolio Analysis and the TCI are performed annually to gauge the rate of transition within the organization. This study analyzed how the structure and process of inter-organizational technology transition may be generating impediments, specifically ARDEC's strategy for improving the technology transition rate. It also explores the improvements that both ARDEC and its major customer, Program Executive Officer – Ammunition (PEO Ammo), have made to their processes in order to address this low rate of transition.

E. RESEARCH QUESTION

This project addresses one primary and two subsidiary research questions:

1. Primary Question

- What are the strengths and weaknesses of the overall processes whereby the ARDEC Headquarters transitions S&T into Acquisition Programs of Record?

2. Secondary Questions

- How can the communication structure and process between ARDEC and the S&T community be described (i.e., extent of effectiveness of inter-organizational communications and external stakeholder management).
- What is the relationship structure between ARDEC and relevant Program Managers (PM); and ARDEC and PEO Ammo concerning the transition of S&T technology into ARDEC, and how is that relationship changing?

F. BENEFITS AND LIMITATIONS

Benefits of this study included the following:

- Objectively assessing ARDEC's strengths and pitfalls in technology transition,

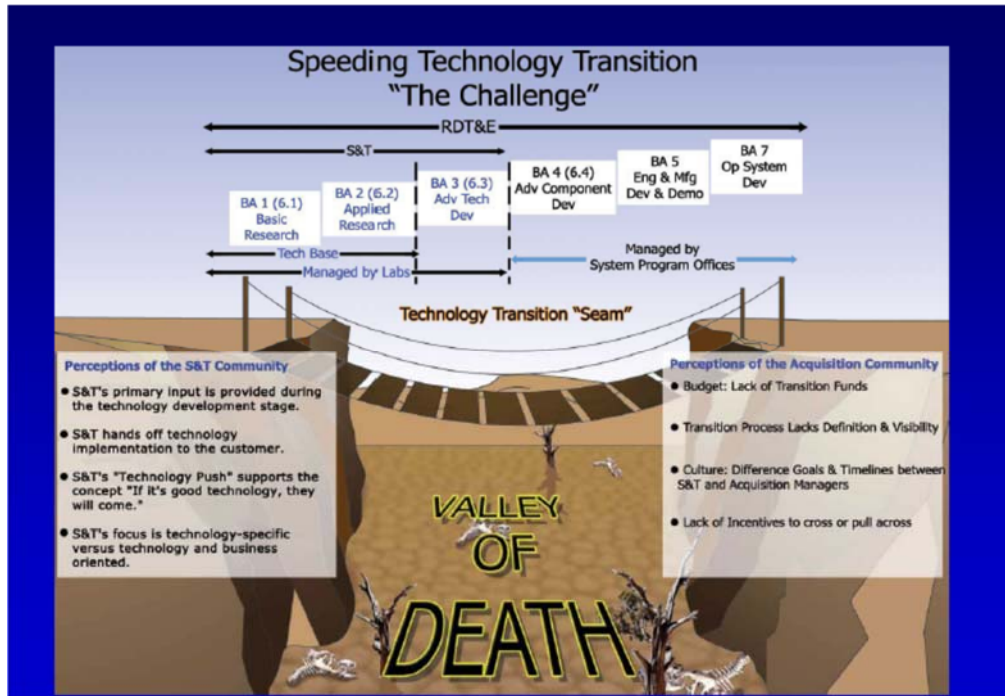
- Identifying improvements, that ARDEC may have implemented and that can be utilized by other organizations.
- Identifying of best practices utilized by ARDEC and PEO Ammo that can be utilized by other organizations to improve their own technology transition processes.
- Drawing conclusions on best practices and in-process work that both ARDEC and PEO Ammo exemplified that can be leveraged by other organizations in their own technology transition.

The limitations to this study were the changing and evolving processes that were being identified, explored and evaluated. Other limitations were access to sensitive information pertaining to certain technologies and/or Programs of Record.

G. SIGNIFICANCE OF STUDY

The technology/maturity gap, also known as the “Valley of Death,” as illustrated in Figure 3, is a problem with which ARDEC is all too familiar. Headquartered at Picatinny Arsenal, NJ, ARDEC is a leading center for Research and Development work. ARDEC is continuously trying to improve the overall process of transitioning technology. This research examines the strengths and weaknesses of that overall technology transition process in the following primary areas: ARDEC organizational barriers, acquisition regulations, requirements validation, and the planning, programming, budgeting, and execution process.

Figure 3. The “Valley of Death”: the Divide between the S&T and Program Management



Source: Hagan, G. (2011). Transition of Technology into the DoD Acquisition Process [PowerPoint slide]. Retrieved from: [http://www.darpa.mil/attachments/\(6T5\)%20Global%20Nav%20-%20Work%20With%200Us%20-%20For%20Small%20Business%20-%20Resource%20\(Approved\).pdf](http://www.darpa.mil/attachments/(6T5)%20Global%20Nav%20-%20Work%20With%200Us%20-%20For%20Small%20Business%20-%20Resource%20(Approved).pdf).

H. METHODOLOGY

This study was dependent on literature reviews that stem from internal documents from ARDEC, Government Accountability Office (GAO) reports, Defense Acquisition University courses and other scholarly articles focused on technology transition. The analysis methodology focused on the information in these documents to provide a better understanding of what the issues truly were, and what ARDEC and PEO Ammo have done to address those issues. We then compared and contrasted these documents to identify both similarities that showed consistency of the issues, as well as the trial-and-error state of the solution sets to this technology transition issue. This study reviewed the structure and processes used by ARDEC to improve technology transition.

I. OVERVIEW

This chapter began with a background of the problems inherent to technology transition in the DOD and provided a framework for the subsequent chapters. This chapter also discussed the purpose and background of technology transition. There is a list of problems that have been identified. The rest of this paper addresses these problems through the analysis of the case of the Armament Research Development Engineering Center (ARDEC) and the Program Executive Office for Ammunition (PEO-AMMO). The chapter concluded with an overview and methodology that was used for the research project. The next chapter of this project will identify the literature reviewed for the analysis and research on technology transition for the DOD, ARDEC and PEO Ammo.

II. LITERATURE REVIEW

A. CHAPTER INTRODUCTION

This chapter identifies the literature reviewed for the analysis and research on technology transition for the DOD, ARDEC and PEO Ammo. It specifically addresses the legislation and policy enacted by Congress with regard to technology transfer, including the Defense Authorization Act of 2006. This chapter discusses DOD's response to the mandates in this Act. We discuss investigations and reports completed by GAO regarding technology transfer. This will help to frame the discussion on technology transfer for our benchmark organizations: ARDEC and PEO Ammo.

B. CONGRESS INITIATIVE

Technology transition is an area of concern for the legislative branch, “since 1980, Congress has enacted a series of laws to promote technology transition and to provide technology transition mechanisms” (Federal Laboratory Consortium for Technology Transfer, 2013, p. x). The Federal Laboratory Consortium for Technology Transfer goes on to state that “although federal technology transition policy is established by legislation and executive orders... each federal department and agency” establishes the definite and comprehensive approach and practices “that guide how technology transfer is to be conducted within its own organization” (p. viii). Two relevant pieces of legislation deserve special attention.

1. National Defense Authorization Act of FY 2003

This act established the Technology Transition Initiative (TTI), a DOD program which helped advance technology from an S&T program into a DOD acquisition program. As was stated in Title 10 Armed Forces 2359a Technology Transition Initiative, “Congress established the TTI, in 2002, to bridge the gap between demonstration and production of S&T funded technology” (“Technology Transition Initiative,” n.d., para. 1). This act recognized that often it “takes 2–3 years to obtain procurement funding to buy a product, and during that time, many technology projects either become obsolete

or are cancelled due to a lack of funding” - the TTI was meant to help to prevent this (para. 1).

2. National Defense Authorization Act of FY 2006

A portion of the Defense Authorization Act of FY 2006, section 255 titled Technology Transition, established a requirement for the DOD to file a report concerning the challenges linked with technology transition. In the purpose section of the report, it stated that the focus of the report was to find any barriers within the DOD, an assessment of the effects of Department regulations, an assessment of the effects of the requirements validation process and any other challenges found by the Secretary. Below is the Department of Defense response (National Defense Authorization Act, 2006, pp. 3180–3181).

C. DEPARTMENT OF DEFENSE RESPONSE

As stated above, the DOD’s formal response is described below. It highlighted the findings of attributes of a successful technology transition program and some courses of action that the DOD planned to take in order to improve technology transition.

1. Department of Defense Report to Congress on Technology Transition

The purpose of the July 2007 DOD report was to “examine the principal barriers that impede technology transition and outline a plan to address the root causes of those barriers” (Harger & Kubricky, 2007, Foreword). As stated in Table 1, the DOD report to Congress found that there were improvements in the way S&T was transitioned; however, it also found that there was a significant opportunity for improvement and addressed challenges that needed to be overcome. Table 1 lists many of the same obstacles found in reports going back 10 years.

Table 1. Excerpt of S&T Affordability Workshop, Transition Panel, June 10–11, 1997

What's Good?	What's Bad?
Frequent communication with warfighter & acquisition customer both before & during S&T	Artificial barriers between government & industry
Early definition of requirements	Inconsistent, undisciplined process of S&T management's prioritization of projects
Formal roadmaps	Ricebowls
Honest peer review of S&T/merit based	"Good Ol' Boy" System
S&T manager must be a marketeer	Requirements/capabilities not well-defined
Establish Transition Team from beginning	Lacking measures/expectations related to affordability (lack of incentives)
Transition focus	Improper alignment with warfighter needs
Multi-disciplinary team	S&T personnel not motivated to achieve transition
Address all -ilities including logistics	Acquisition process changing – confusing
Include industry	Lack of overarching 10-20 year vision for DoD and the Military Departments
Balance design with process capability	Lack of communication with right people at right time
Conduct affordability-cost trade-offs (begin production cost modeling)	Industry has short-term outlook
Establish S&T metrics on transition	Lack of focus on weapon sustainability
Mitigate/define risk	Lack of understanding of S&T objectives by acquisition customer and user
Funding strategy for transition	Lack of communication facilitator to provide linkages.
Establish IPT	

Source: Harger, K.L. & Kubricky, J. J. (2007). *Department of defense report to congress on technology transition*. Washington, DC: The Office of Department of the Undersecretary of Defense. Retrieved from <https://acc.dau.mil/adl/en-US/173369/file/31016/Tech%20Transition%20Report%20to%20Congress%20-%20August%202007.pdf>.

However, according to the DOD report to Congress, there were some improvements made toward successful technology transition such as the military departments' and defense agencies' leadership accepted that early technology transition planning and achievement were necessary to succeed in the future. Leadership rolled out experimental trial programs to exhibit methods for transitioning technology. Additionally, in order to obtain a more agile transition force, the military departments worked on restructuring the Technology Transition Council (TTC), which was comprised of senior leadership from Combatant Commands, military defense agencies, the acquisition and S&T communities. As a result of the aforementioned, the Department's Chief Technology Officer (CTO) assigned an Assistant Deputy Under Secretary of Defense for Innovation and Technology Transition (ADUSD [I&TT]) to focus on successful technology transition (Harger & Kubricky, 2007, pp. 4–5). Table 2 lists some of the initiatives or approaches taken by the

different branches of DOD to try to help breach the technology transition gap from the R&D phase to a PoR.

Table 2. Examples of Technology Transition Programs/Initiatives within DOD

Program	Management	Characteristics that Facilitate Transition
Advanced Concept/ Joint Capabilities Technology Demonstration (AC/JCTD)	<ul style="list-style-type: none"> • Program direction and oversight by OSD • Projects managed and executed by Military Departments, Defense Agencies and SOCOM 	<ul style="list-style-type: none"> • Focuses on Joint Warfighter Functional Capabilities which are often under-resourced and with no one organization tasked to meet these needs • Allows warfighters to evaluate a technology for its potential
Agile Integration and Development	<ul style="list-style-type: none"> • Army 	<ul style="list-style-type: none"> • Funds acceleration for selected high-payoff emerging technologies • Improves technology readiness by accelerating the tech development schedule and/or performing detailed safety & validation tests in field/operational environment
Collaborative Technology Alliances	<ul style="list-style-type: none"> • Army 	<ul style="list-style-type: none"> • Collaboration among Government-Industry-University researchers to achieve affordable transition of innovative technologies
Defense Acquisition Challenge Program (DAC)	<ul style="list-style-type: none"> • OSD oversight • Military Department/ Defense Agency management and execution 	<ul style="list-style-type: none"> • Provides an "on-ramp" for industry and government to propose innovative new technology and equipment solutions for acquisition programs
Foreign Comparative Testing (FCT)	<ul style="list-style-type: none"> • OSD oversight • Military Department/ Defense Agency management and execution 	<ul style="list-style-type: none"> • Helps find developed technologies in allied nations and funds their testing for potential procurement
Future Naval Capabilities (FNC)	<ul style="list-style-type: none"> • Navy 	<ul style="list-style-type: none"> • Involves near-term S&T efforts that deliver maturing technologies for more timely incorporation
Rapid Deployment Capability (RDC)	<ul style="list-style-type: none"> • Navy 	<ul style="list-style-type: none"> • Provides the ability to reach immediately to a newly discovered threat or to respond to significant and urgent safety situations
Rapid Technology Transition Program (RTT)	<ul style="list-style-type: none"> • Navy 	<ul style="list-style-type: none"> • Has a charter to rapidly transition technology from any source, including those not traditionally associated with defense technology, into PORs
SBIR Commercialization Pilot Program (CPP)	<ul style="list-style-type: none"> • Army, Navy, Air Force • OSD Oversight, Direction, and Coordination 	<ul style="list-style-type: none"> • Identifies projects with potential to meet high priority military needs • Provides assistance to affect rapid transition

Program	Management	Characteristics that Facilitate Transition
Technology Insertion for Savings Program (TIPS)	<ul style="list-style-type: none"> Navy 	<ul style="list-style-type: none"> Concentrates on existing and/or COTS technology that can be formed quickly into the solution and has a high return on investment after insertion
Technology Transition Initiative (TTI)	<ul style="list-style-type: none"> Program direction and oversight by OSD Projects managed and executed by Military Departments, Defense Agencies and SOCOM 	<ul style="list-style-type: none"> Accelerate the introduction of new technologies into operational capabilities for the armed forces
Warfighter Rapid Acquisition Process	<ul style="list-style-type: none"> Air Force 	<ul style="list-style-type: none"> Provides transition funding for development & fielding of successful experiments, demonstrations, & innovative approaches Complete, approved acquisition plan.. Budget Activity 7.

Source: Harger, K.L. & Kubricky, J. J. (2007). *Department of defense report to congress on technology transition*. Washington, DC: The Office of Department of the Undersecretary of Defense. Retrieved from <https://acc.dau.mil/adl/en-US/173369/file/31016/Tech%20Transition%20Report%20to%20Congress%20-%20August%202007.pdf>.

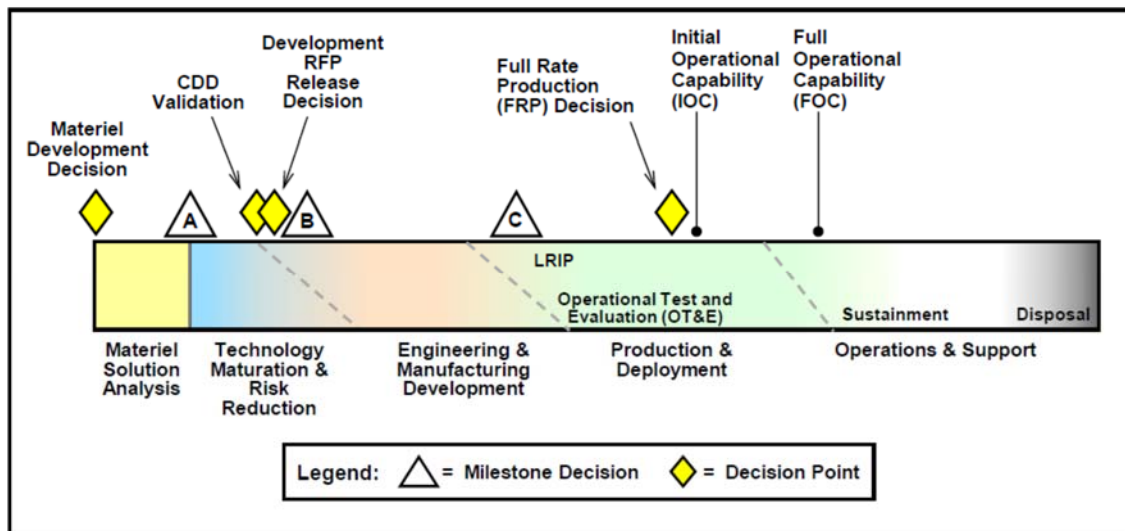
The report concluded that there was a disconnect between the TRL of the S&T community’s goals and the acquisition policy. Acquisition policy required a minimum of a TRL 7 maturity for use in a POR, and the S&T community only matured technology to a TRL 5 in preparation of that transition. This was a significant gap between the needs of both communities (creation and integration of new technologies) (Harger & Kubricky, 2007, pp. 1–16). The report stated the following Technology Transition could be attained through a collaborative effort of the acquisition and S&T community. This up-front, early and frequent communication was key to assuring that the S&T and acquisition communities were aligned. By ascribing a commitment of resources, leadership experiences and administering a strong management relationship, the warfighter would receive its necessary capabilities (pp. 14–15).

2. Acquisition, Technology and Logistics

As Dobbins described in *Planning for Technology Transition*, acquisition programs require more oversight: Good transition planning was essential because technologies that were ready to be transitioned were not usually a component of the program objectives memorandum (POM) for a specific acquisition program. As a result, that lack of oversight or documentation placed these new technologies at risk of missing an opportunity for a successful transition (Dobbins, 2004, p. 14).

The article stated that acquisition programs required more oversight than what was required for initial technology development; therefore technology transition will require the same planning as that required by acquisition programs. The article further stated that a high enough TRL level in the new technology was essential for the integration into the acquisition program with minimal risk. This point was further illustrated in a memorandum released by the Undersecretary of Defense, Acquisition, Technology and Logistics, Ashton B. Carter, “the process for conducting technology readiness assessments (TRAs) has strayed from its original intent and should be reformed. TRAs should focus only on technology maturity, as opposed to engineering and integration risk and the responsibility for ensuring that technology maturity risk is adequately identified and mitigated should rest with the Program Manager (PM), Program Executive Officer and Component Acquisition Executive, subject to ASD(R&E) review” (Carter, 2011, p. 1). As illustrated by Figure 4, the acquisition life cycle looks straight forward, however, as previously stated, a high enough TRL is needed to ease the technology transition into the next stage with minimal risk.

Figure 4. DOD Acquisition Life Cycle

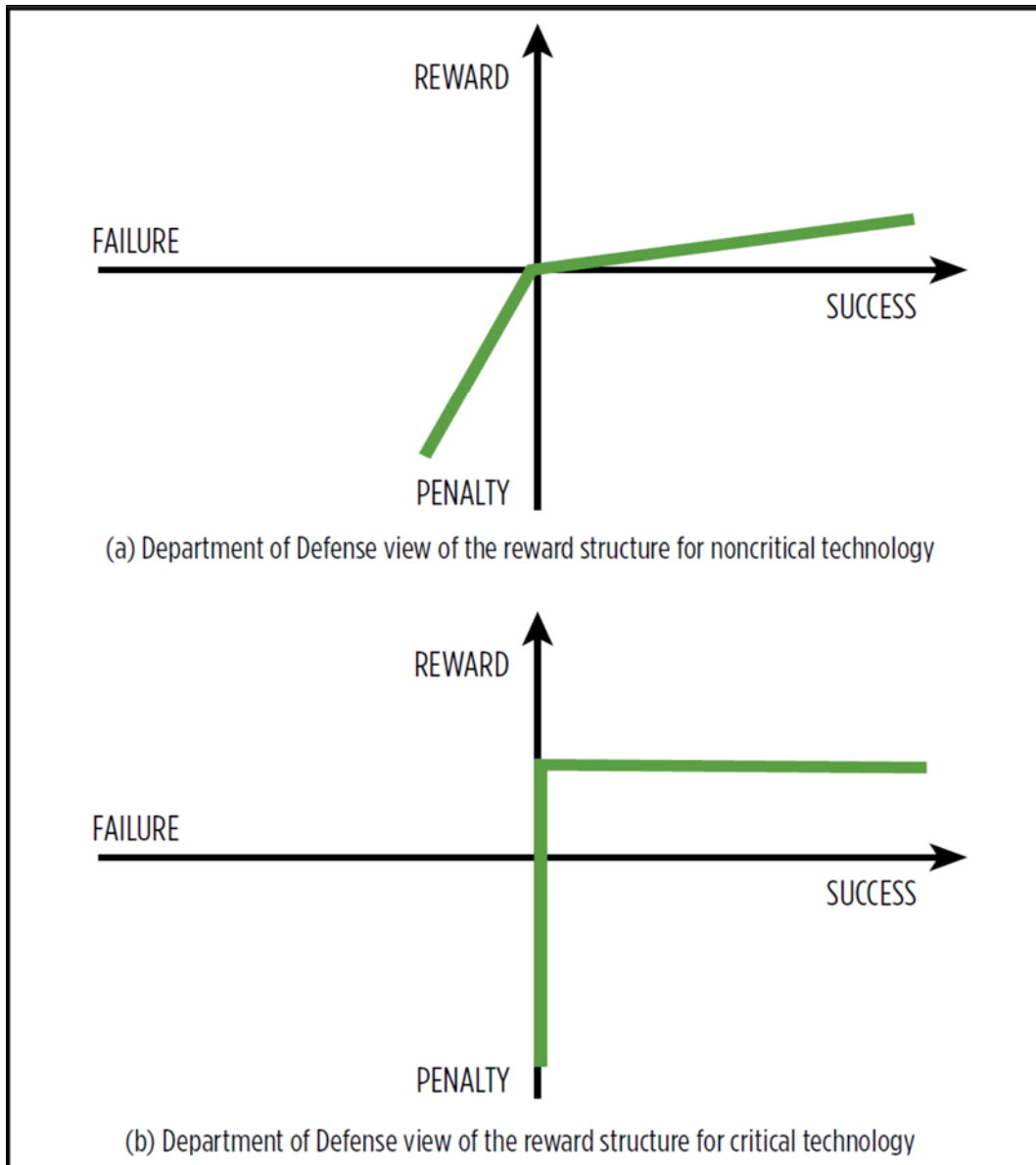


Source: Department of Defense. (2015, January 7). *Operation of the defense acquisition system* (DOD Instruction 5000.02). Washington DC: Author. Retrieved from [https://acc.dau.mil/adl/en-US/716926/file/78952/Instruction%20-%20USD%20\(AT L\),%20DoDI%205000.02,%20Operation%20of%20DAS,%207%20Jan%202015.pdf](https://acc.dau.mil/adl/en-US/716926/file/78952/Instruction%20-%20USD%20(AT%20L),%20DoDI%205000.02,%20Operation%20of%20DAS,%207%20Jan%202015.pdf).

Dobbins (2004) stated that the following factors were imperative to have a successful technology transfer: transition strategy, transition plan, requirements development, transition integrated product team, overarching IPT, understanding the technology readiness level, acquisition funding, contracting strategy, transition milestone events, critical elements of the management plan, military user test and evaluation, military user assessment, defense acquisition executive review, and metrics. Dobbins summed this up “in summary, we can say that good transition planning requires involvement and coordination among several people, establishment of IPTs, and the use of proper metrics; and while not always easy, it is critical to the success of technology transition” (p. 17).

Additionally, on a basic level, program management (PM) organizations were focused on balancing risk with reward to deliver products to the war fighter. Figure 5 demonstrates the fundamental relationship between risk and reward from a PM perspective. This helped us to understand how the S&T community needs to consider these factors when planning to transition.

Figure 5. Different Views of Reward Structure for New Technologies – Data Rights for Science and Technology Projects



Source: Arndt, C. & Muzzelo, L. (2014). *Data rights for science and technology projects*. Huntsville, AL: Defense Acquisition University. Retrieved from http://dau.dodlive.mil/files/2014/11/ARJ69_Muzzelo.pdf.

D. GAO REPORTS

In the report titled *Best Practices Better Management of Technology Development Can Improve Weapon System Outcomes*, GAO assessed the following: “(1) the impact of technology maturity on product outcomes, (2) best practices for managing new

technologies and incorporating them into products, and (3) ways DOD can adapt these practices to get better outcomes on weapon system programs” (1999, p. 2). This report determined that the incorporation of immature technologies into leading edge capabilities was a major “source of cost increases, schedule delays, and performance problems on weapon systems” (p. 69). Furthermore, evidence showed that leading commercial firms achieve higher quality products within smaller timeframes and budgets. These firms have managed to achieve these results by separating the development of the product and advanced technologies. This has allowed the product managers to put their whole energy into the production of the product and the increased ability to deliver a successful end item. If DOD were to adapt these techniques, it would reduce costs and decrease the time between transition and production, thereby allowing DOD to insert new technologies more rapidly into its programs. The report stated that the successful programs that were reviewed within DOD had S&T organizations or a team of S&T and product developers that managed and developed the technology until it was ready to be inserted into the program. In addition, the report also noted that these S&T organizations/managers had the knowledge, expertise, resources, processes, information flexibility and authority required to mature the technology to the point where it could be transitioned into a program (pp. 61–62).

The report stated that GAO had formerly suggested that technology development be separated from weapon system programs. The current report again recommended separation of technology development and weapon system programs. Moreover, GAO advised the Secretary of Defense to embrace DOD wide knowledge-based methods such as TRLs to evaluate technology maturity. GAO stated that DOD needed to match the key technology and systems requirements. In addition, DOD should provide the community with the appropriate resources and provide a commitment to a cost, schedule and performance baseline for the system. Lastly, the report recommended that analogous technology insertion points to those used by the commercial community such as TRL 7 be used to facilitate the insertion of new technologies into existing programs (GAO, 1999, p. 64).

In addition, the report recommended that the Secretary discover further approaches to allow the managers of weapon systems and new technologies more flexibility in finding ways of developing and acquiring new knowledge distinct from the delivery of a final product. Finally, the report also recommended S&T organizations be granted the ability to play a greater role in developing new technologies to higher technology readiness levels (GAO, 1999, p. 64).

In a different report, also authored by GAO and titled *Best Practices Stronger Practices Needed to Improve DOD Technology Transition Process*, it was determined that again, DOD needed more mature technologies before transitioning them to the product line. During this study, GAO determined that industry utilized Strategic Planning at the corporate level, gated management reviews and corroborating tools for all of its successful technology transitions. Although DOD utilized some of these same tools, it was still lacking. According to the report, “development of DOD’s new weapon systems depends on two distinct phases: technology development and product development” (GAO, 2006, p. 6). The GAO report recommended the following actions to improve technology transition throughout DOD: a gated process for developing and transitioning technologies and specific criteria to support continued funding. The report also recommended increased use of technology transition agreements (TTAs), relationship managers, metrics to demonstrate the readiness and risks of including the technology, and utilization of process-oriented metrics to assess the status and measure the improvement in transition (pp. 40–41).

Out of all of the recommendations above, DOD only concurred with two of the recommendations: establish gated reviews and increase the utilization of technology transition agreements (TTAs). Furthermore, DOD only partially agreed with the recommendations to incorporate further metrics in TTAs and expand the utilization of relationship managers. Moreover, DOD did not agree with the recommendations to develop additional process-oriented metrics or to allocate a section of advanced technology development for the S&T community (GAO, 2006, pp 50–53).

In 2007, the Director, Acquisition & Sourcing Management U.S. Government Accountability Office, Michael J. Sullivan presented *Review of Technology Transition*

Practices. In this presentation, GAO reiterated the key enablers for industry were as follows: First, robust strategic planning to prioritize technology needs and react to the market needs. Second, structured technology and development processes, utilization of TTAs, relationship managers and metrics. In addition, GAO also recommended a transition phase that combined technology development and product development, with the funding responsibility to gradually shift from the labs to the program during the last phase of the transfer (GAO, 2007, pp. 8–13).

GAO again released another report in March 2013, titled *Defense Technology Development, Technology Transition Programs Support Military Users, but Opportunities Exist to Improve Measurement of Outcomes*. This report brought to light that, although technology transitioning within DOD had improved, there were many improvements that still needed to be incorporated. Overall, the report found that transition managers did not track projects beyond their transition, thereby limiting management’s capacity “to know and report final outcomes for transitioned technologies and the associated benefits realized from those technologies” (GAO, 2013, Highlights). According to the GAO report, the DOD departments’ technology transition programs that were implemented did not follow all of the associated management processes and tools outlined in previous GAO reports. As a result, this led to issues and the inability to directly address the problems that arose. Of the more successful technology transition programs reviewed by GAO, the program officials stated that regular communication with the stakeholders was paramount to ensure a successful technology transition outcome. Additionally, many of those same officials also stated that tools such as TTAs were crucial in holding stakeholders accountable in facilitating successful technology transitions. The purpose of this GAO report was “to (1) determine what DOD programs exist that are dedicated to facilitating technology transition from the S&T base to military users, (2) assess the outcomes for these transition programs, and (3) identify practices among the programs that may facilitate technology transition” (GAO, 2013, p. 1). However, for the purposes of this JAP, we concentrated on what practices among the reviewed programs were identified that could facilitate technology transition. We took the positive outcomes on program structure, processes, transitioning tools and metrics used to keep track of transition outcomes for the 20 technology transitions

reviewed within the GAO report and compared them to ARDEC’s current processes and procedures. The report found that there were many tools used to aid communication between all the stakeholders. Of the 20 transition programs reviewed, it was found that nine used TTAs. Additionally, the report found that the TTAs at a minimum outlined “operation need, proposed technical solution, transition target information, transition requirements, integration strategy, business case, risk, cost and schedule, and project points of contact” (GAO, 2013, pp. 23–27). In addition, GAO determined that the Joint Capability Technology and Future Naval Capabilities programs used Transition Commitment Level (TCL) tools, such as the one illustrated in Figure 6, which provided an additional way to verify that possible system users were also highly invested in the transition of the projects (GAO, 2013, pp. 23–27).

Figure 6. Example of Transition Commitment Level Project Evaluation Tool

Transition Commitment - JCTD in execution/completion	
<p>(1) A capability is funded or scheduled to become funded as part of an existing acquisition program of record or activity has begun to initiate a new acquisition program of record.</p> <p>(2) Some or all the JCTD fieldable prototypes are fielded and sustained.</p> <p>(3) Some or all the JCTD demonstrated components are placed on General Services Administration Schedule.</p>	<p>Green – successful transition</p>
<p>(1) Negotiations are underway for incorporation into an acquisition program of record, use of fieldable prototypes, or placement on General Services Administration Schedule with no or partial funding.</p>	<p>Yellow – limited transition</p>
<p>(1) No transition occurred.</p> <p>(2) Technology returned to technology base (S&T).</p> <p>(3) Unable to determine if technology will transition to acquisition program of record, fieldable prototype, or General Services Administration Schedule.</p>	<p>Red – no transition</p>

Source: Joint Capability Technology Demonstration program.

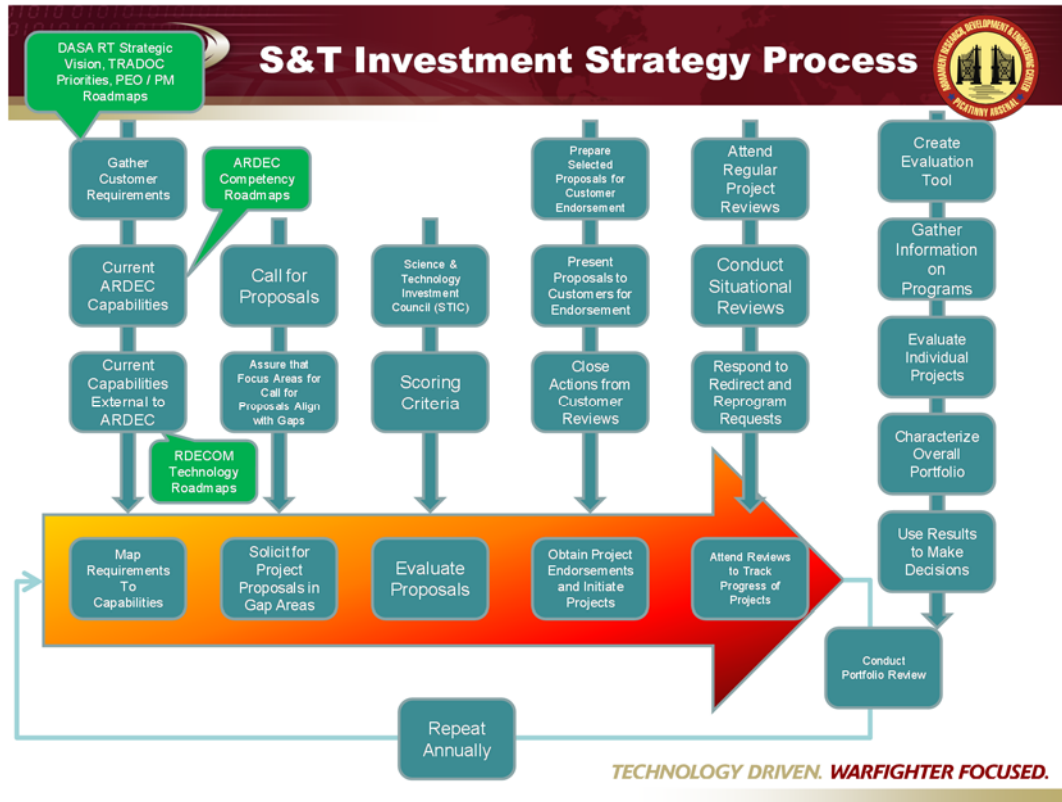
Source: Government Accountability Office (GAO) (2013). Defense technology development: technology transition programs support military users, but opportunities exist to improve measurement of outcomes (GAO-13-286). Washington, DC: Author. Retrieved from <http://www.gao.gov/products/GAO-13-286>.

The GAO concluded that, the technology transition programs it reviewed were reasonably successful in providing the user with the required and needed technologies. However, there were a limited number of programs that did not have established metrics to keep track of the transitioned programs or measure the benefits of the transitioned technologies into those programs. This lack of insight resulted in an inability to know if the technologies transitioned were the right technologies for the right users (GAO, 2013, p. 29). As a result, the GAO report recommended that all technology transition programs review and measure the outcome of the project. This included any long-term impacts such as benefits and disadvantages experienced by the program and the users in the field. In addition, the report also recommended that transition programs be assessed in order to increase the use of TTAs, technology commitment level evaluation mechanisms or other transition management tools (GAO, 2013, p. 30).

E. ARDEC AND PEO AMMO DOCUMENTATION

In their efforts to better transition technology from their S&T portfolio to the PM community, ARDEC has developed processes and documentation to meet those needs. Figure 7 depicts the over-arching process map that ARDEC used to execute and transition its S&T portfolio.

Figure 7. Office of the Director of Technology (ODoT) S&T Investment Strategy Process



Source: Pelino, J. (n.d.). S&T Investment Process. [Power Point slide]. Presented to the Office of the Director of Technology (ODoT). Picatinny Arsenal, NJ.

As you can see, it included alignment with the stakeholders including the requirements community in TRADOC and the PM customers throughout. Another key document was the Technology Transition Agreement (TTA) Template that ARDEC has developed with help from their resident (at Picatinny, NJ) customer, PEO Ammo. Summarized below are the sections within the TTA, a copy of the actual template is available in Appendix A.

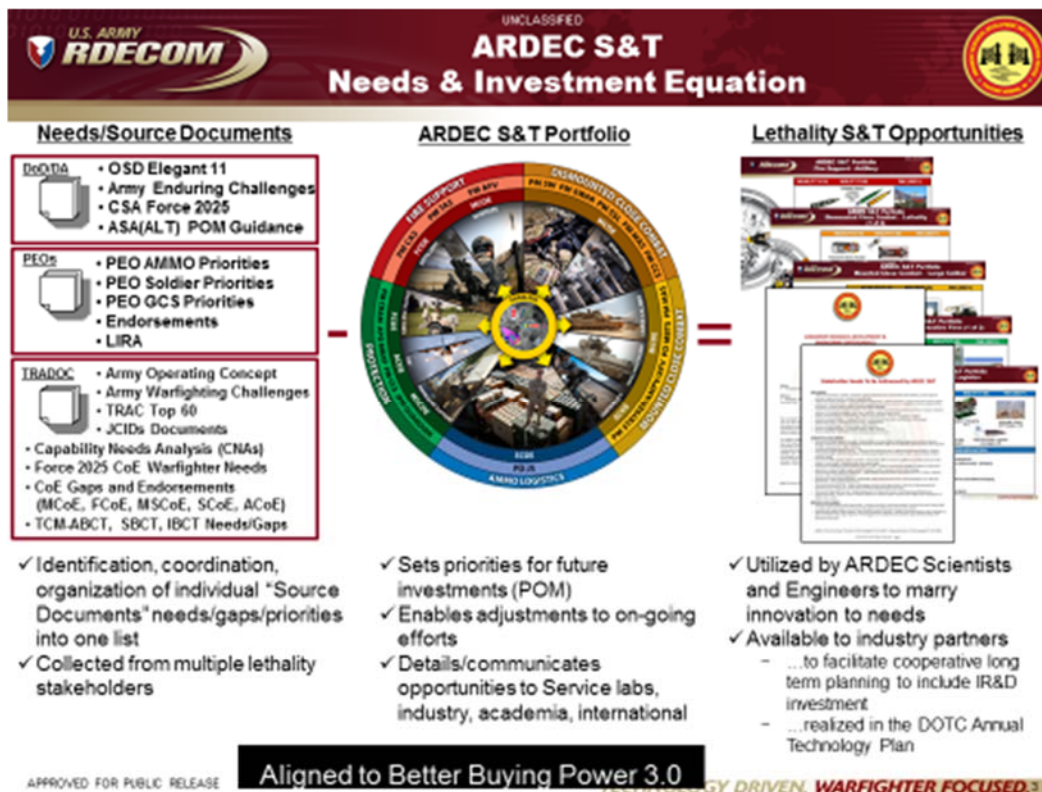
The TTA Template that ARDEC uses with PEO Ammo includes the following sections:

1. An introduction, with identification of the purpose, scope, background and key stakeholders.

2. A basic transition agreement, with a description of the technology for transition, the acquisition strategy for the gaining PoR and the integration strategy for the technology.
3. Technical details and programmatic, including the current status of the technology, key metrics and the funding adequacy.
4. Effective date, review and termination, which has the terms agreed to and concludes with the signatures of the relevant stakeholders.

The TTA Template included major aspects of the DOD Guidance such as; detailed descriptions of the deliverables from the S&T community and the risks that the S&T community will be mitigating and reporting during the transition. Additionally, the TTA includes the program plan that the S&T effort maps into the PM as well as signature blocks for all of the relevant Stakeholders in the technology transition process. The ARDEC Director of Technology identified the need to communicate routinely with Stakeholders across the DOD, taking input on priorities from the PEOs and TRADOC, and aligning to DOD initiatives, such as Better Buying Power 3.0 (see Figure 8). In Figure 8 below, ARDEC's alignment was seen through the portfolio of projects to both their PM and TRADOC customers through the lens of the DOD's Better Buying Power 3.0 initiative (Figure 8).

Figure 8. Aligned to Better Buying Power 3.0



Source: Pelino, J. (2015, April 22). Retaining Lethality Overmatch through Science & Technology. [Power Point slide] Presented at National Defense Industrial Association (NDIA). Picatinny Arsenal, NJ.

This chapter helped to illustrate the issues that DOD organizations had historically been faced with regarding technology transition. It also gave us some insight into recommended courses of action that an organization could take in order to address these issues and improve their technology transition to their customer organizations and ultimately the warfighter. It also showed the documentation that ARDEC and PEO Ammo had created in order to align with each other to achieve these technology transition goals. In the next section, we will compare and contrast how ARDEC implemented processes, organizational structure and communication methods in order to improve their own technology transition. We also explored where some holes may exist that can be addressed in the future.

III. ARDEC ANALYSIS

A. CHAPTER INTRODUCTION

We have seen what the S&T Affordability Workshop, the DOD, and GAO have recommended in order for research organizations to improve their technology transition, and what ARDEC and the PEO has documented for the same transition. In this chapter we will compare and contrast the current state of the ARDEC Technology Transition Process (TTP) and actions being taken by ARDEC to improve its TTP. First, we will examine how ARDEC's processes map to the recommended attributes that the S&T Affordability Workshop identified for successful technology transition. Then we will discuss what ARDEC has done to address these, including organizational structure, efforts in road-mapping, alignment with customers, and TTAs. Through this analysis, we will show how ARDEC's organizational structure, communication methods and processes are being matured to facilitate effective transition of technologies. We will also detail ARDEC's Science & Technology (S&T) commitment to having a portfolio that focuses on the transition of technologies from S&T to Programs of Record.

B. ALIGNMENT OF ARDEC S&T PROCESS TO HARGER AND KUBRICKY'S 2007 S&T AFFORDABILITY WORKSHOP, TRANSITION PANEL, JUNE 10–11, 1997

1. Similarities

A comparison of Harger and Kubricky's (2007) *Excerpt of S&T Affordability Workshop, Transition Panel* (Table 1) to Pelino's (n.d.) *ODoT S&T Investment Strategy Process* (Figure 7) demonstrates that ARDEC has incorporated into its S&T Process many elements that were recommended by the S&T Affordability Workshop. Some of those aspects were:

- Frequent communication with the warfighter is achieved through the input from the various TRADOC Centers of Excellence, as is depicted in the beginning of the ARDEC process in Figure 7. Additionally, ARDEC seeks endorsement for its S&T proposals from the applicable Center(s) of Excellence prior to scoring them in order to obtain customer prioritization. The TRADOC Centers of Excellence are also voting members and

participants in the annual Portfolio Reviews, helping to get that much needed feedback throughout the development cycle.

- Frequent Communication with the acquisition customer is achieved much in the same way as with the TRADOC Centers of Excellence. Using the PM Roadmaps as an input, ARDEC's S&T process similarly seeks endorsements from its PM and PEO during the proposal submission process. The PEO and PM customers are also voting members and participants in the annual Portfolio Reviews. The PM customers also are engaged to develop the funding strategies for the eventual transition of the technology from ARDEC to the PM customer. However, planning at this stage can always have changes due to budgetary constraints that impact transition.
- Early definition of requirements is apparent in the first major process step in Figure 8, the mapping of requirements to technology capabilities.
- Formal roadmaps are represented three times in that first major step in the process as well: having PM roadmaps, ARDEC competency roadmaps and RDECOM technology roadmaps all as inputs to the requirements mapping to capabilities.
- Honest peer review of the S&T Portfolio is conducted during the ARDEC Portfolio Review, where the review membership is made up of a significant number of voting members outside of ARDEC. This includes TRADOC requirements developers, acquisition customers, other government research and development agencies, and Joint Service representatives.
- Integrated Product Team, inter-disciplinary team, and associated Transition Team are identified early in the process and through the proposal review process; all competencies are part of the development of the S&T projects as they are formed.
- Inherent to the operations of ARDEC Headquarters and RDECOM Headquarters are that S&T Managers are selected in part due to their ability to be a marketer.
- Process capability is taken into consideration of the design of the S&T projects, and realism is inserted into the review process by having not only managerial voices in the decision-making process, but also the technical experts (usually the Army Senior Technologists – Senior Executive Service equivalents in specific technology areas).
- Metrics for S&T Transition have been defined at the RDECOM level and are reported through the TCI. However, there are issues with these metrics that are discussed in the next paragraph.

- Risk management is part of every S&T project and reported at the normal project reviews, both at the RDECOM level and the ARDEC level (Harger & Kubricky, 2007, p. 4; Pelino, n.d., p. 2).

2. Differences

As demonstrated by Pelino's (n.d.) in *ODoT S&T Investment Strategy Process* (Figure 7) ARDEC developed a process that encompassed many of the elements from Harger and Kubricky's (2007) *Excerpt of S&T Affordability Workshop, Transition Panel* (Table 1), however, there were still areas for improvement.

- While metrics for transition have been identified by RDECOM and are reported through the TCI, the meaningfulness and value of the metrics reported has not led to an increase in transition over the past decade. ARDEC is working, through the Portfolio Review Process and Strategic Planning Process, to better define, refine and track metrics that will be more useful for the organization.
- While “probability of transition” is one of the metrics used in the Portfolio Review, the goal for this metric changes each year, and has done so for the past four yearly reviews. Probability of transition has been a focus of the Portfolio Review planning, execution and after-action processes. However, currently probability of transition only measures if the project has an endorsement from the appropriate TRADOC CoE , an endorsement from the appropriate PM, and a TTA from the appropriate PM. There are no other metrics to quantify or qualify distinguish between projects in that area of “probability of transition.”
- The ARDEC Director of Technology requests to have all S&T projects report their status in order to estimate the projected costs associated with the technologies and systems that each S&T project seeks to develop. However, the project leads often have little to no information to report back, this is especially true during the early applied research phase. This lack of information is mostly due to the uncertainty inherent to the immature technology and lack of a current manufacturer.
- Industry routinely conducts Independent Research and Development (IRAD) reviews with government agencies. However, the establishment of timeliness and communication with industry partners is usually conducted at the technology competency manager level and therefore is not centralized and well collaborated across the entirety of the ARDEC Enterprise.
- According to Dam & Willis (2011) “‘-ilities’ refer to the developmental, operational, and support requirements a program must address (e.g., availability, maintainability, vulnerability, reliability, supportability, etc.)”

(p. 5). Inclusion of the “-ilities” in each S&T project is a focus area of ARDEC S&T project reviews. However, other than to report that these considerations are part of the IPT discussions and membership, no other real data is gathered by this metric. (Harger & Kubricky, 2007, p. 4; Pelino, n.d., p. 2).

As illustrated above, ARDEC’s S&T Process, depicted in Figure 7, has incorporated many of the elements that were recommended as “What’s Good” by the S&T Affordability Workshop. However, there were still areas that were either being developed further or that could not be addressed fully.

C. OFFICE OF THE DIRECTOR OF TECHNOLOGY (ODoT)

1. Establishment of ODoT

In 2011, ARDEC created the Office of the Director of Technology (ODoT) which provided dedicated personnel to the planning and execution oversight of S&T. The ODoT replaced the legacy ad-hoc system of coordinating all of these efforts with only two dedicated personnel. This resulted not only in the formulation of a group that was empowered to plan and manage the S&T budget for ARDEC, but also allowed the group to establish formal processes, procedures, plans and guidance for how they executed their mission and how they communicated that to the workforce effectively. As such, the ARDEC Director of Technology asked all relevant Stakeholders in ARDEC’s S&T community to provide senior-level representatives who would act as Subject-Matter-Experts (SMEs) from their organizations and be empowered to provide the viewpoint of that organization in decisions on planning or changes to current projects. These SMEs helped ARDEC with internal collaboration amongst the different technical competencies routinely communicate both in-person and electronically in order to align and focus technology development efforts.

The Director of Technology is responsible for the ARDEC S&T Portfolio.

The Office of the Director of Technology (ODoT) supports the Director of Technology in the execution of the ARDEC S&T mission. The Director of Technology is responsible for the ARDEC S&T Portfolio. ODoT supports the Director of Technology in Developing and overseeing the Army Armament S&T Investment Strategy by building the ARDEC S&T Investment Portfolio; Aids in the development of solutions to current and

projected Army armament needs; Performs initial coordination of the ARDEC Subject Matter Experts and higher headquarters for concept development and subsequent transition management of these projects to the Command Centers and/or PMs; Partners with the Technology community to determine status and provide future assessments and analysis of armament technology and systems concepts (“Office of the Director of Technology”, 2013).

D. INVESTING IN TECHNOLOGY MATURITY

Better Alignment with Stakeholders: Despite the noted transition barriers, the ARDEC Director of Technology had the mission to “coordinate, foster and manage technology transfer and transition with PEO, PM and TRADOC customers ensuring alignment of the S&T Portfolio with customer priorities. Streamline the fielding of new and innovative technologies to the Warfighter through understanding of the acquisition process and life cycle” (Mission and Major Functions of the U.S., Army Armament Research Development and Engineering Center, 2014, p. 31). This is evident by the many customer engagements and endorsements throughout the S&T Process, which are depicted in Figure 8 – Aligned to Better Buying Power 3.0. This included both the TRADOC and PEO command structures. The former created the requirements that could become a PoR, and the latter actually managed the PoR. The ODoT helped to provide the necessary manpower to adequately plan and execute communication and formal reviews, by mapping ARDEC technological capabilities to associated identified capability gaps. This process led to a better understanding by the TRADOC community of these capabilities. This allowed the community to develop Joint Capabilities Integration Development System (JCIDS) requirements that were better informed and more representative of the realm of the possible. As stated in GAO’s *Defense Management Guidance and Progress Measures are Needed to Realize Benefits from Changes in DOD’s Joint Requirements Process*, a formal JCIDS requirements document took to 17 months or more to approve (GAO, 2012, p. 27). As a result, this new process has not yet yielded any new approved requirements. New documents were drafted in multiple areas of ARDEC, which indicated more confidence in the future.

E. TECHNOLOGY TRANSITION AGREEMENT (TTA)

Technology Transition Agreement Template: technology transition agreements were always a part of the S&T planning process through DAU and RDECOM regulatory requirements. However, the level of confidence in the TTA Process was low because of the poor technology transition rates. ARDEC and PEO Ammo noticed that a lack of consistency in the signature authorities, content, and follow-on coordination of these TTAs were the main causes for this transition level. For these reasons the new TTA template, depicted in Appendix A was developed and approved in December 2012 for use between ARDEC and PEO Ammo (ARDEC's main customer).

The TTA in Appendix A illustrates that the signature authority was finally consistent with the process, and concurrence was needed from senior leadership across PEO and ARDEC. This ensured that all the relevant Stakeholders were involved in the process. Each stakeholder was held responsible for both developing the technology and associated deliverables stated within the TTA; it also ensured that the PM customer agreed to transition those technologies to the respective PoRs. Additionally, the TTA specified more detail about the hardware, software, technical data and other products that were to be delivered, as well as the schedule and milestones needed for successful technology transition. Five TTAs were approved since the TTA template was implemented. Two of those technologies were transitioned to the PM customer. Regular communication fostered by the PM and ARDEC has resulted in solid transition plans with defined transition criteria for the remaining three that have yet to complete their S&T development.

IV. PROGRAM MANAGER EXPECTATIONS ANALYSIS

A. CHAPTER INTRODUCTION

This chapter focuses on comparing the expectations of the program manager and its role in technology transition to the actual practices and deliverables explored through the previous sections. This chapter will address the responsibility for getting technology inserted into a PoR, statutory obstacles that the PM may face, goals to be met from the PM's perspective, and the importance of the research performed by the S&T community that informs these PoRs. Through the analysis of these areas, we can compare and contrast both the similarities and differences between the ARDEC processes and deliverables (and therefore, similar research and development organizations) and the expectations of PEO Ammo (and other Program Executive Offices and Program Managers).

B. RESPONSIBILITY

1. Program Manager

On July 25, 2012, the Program Executive Office of Ammunition (PEO AMMO) established policy and requirements that assigned responsibilities, and prescribed procedures for preparing, processing and approving requests of external S&T activities. This was implemented for the following purposes: align efforts across the PEO and eliminate redundancies; prioritize efforts across the PEO; and ensure senior leader concurrence with future commitments to expend resources. Effective as of the aforementioned date, all endorsements that require current or future commitments by PEO AMMO, or one of its subordinate organizations requires approval and signature by a General Officer or Senior Executive. The PEO AMMO Chief of Staff or Chief Scientist can sign any endorsements that do not require a commitment of resources by the PEO. However, in all cases, all endorsements are required to be issued via PEO versus one of its subordinate PM/PD/PdM organizations (Madux, 2012, pp. 1–2). Therefore, because of this policy, the PM must adhere to certain rules and responsibilities in order to successfully endorse any new S&T technology transition.

The Program Manager directs “the development, production ... initial deployment (at a minimum)”, and sustainment of new systems (Brown, 2010, p. 14). New systems are to be created within certain “cost, schedule, and performance constraints, as approved by the PM’s acquisition executive” (p. 14). “The PM’s role is to ensure the warfighter’s capability needs are met efficiently and effectively in the shortest possible time” (p. 14). The Program Manager’s job performance is measured by how they meet cost and schedule targets, and mitigate performance risk. All of this affects the way a PM supports technology transition.

The role of the PM, regarding technology transition, was found to be vitally important. As with all things the PM executes, prior to considering a technology for transition, a PM should consider cost, schedule, performance, and the risks associated with those three areas.

All of the statutory constraints placed on a P M have made it difficult for the PM to both perform its job duty and to consider “immature” and “unproven” technologies for transition. The PM’s risk-reward analysis has been biased toward minimizing cost and schedule risk, the areas most likely to be affected by inserting immature technologies.

2. Science & Technology Managers

S&T Managers have been responsible for developing and transitioning technologies that can be used as direct products to be matured, fielded, and supported by the PM based upon its PoRs. S&T Managers also have also been responsible for supporting those programs once the technology is transitioned throughout the entire life cycle.

As S&T Managers prepare their technologies for possible transition, they should assure alignment with their PM customers and provide deliverables (products or data) that will meet the expectations and needs in terms of cost, schedule, performance and the risks associated with those three factors.

Both the PM and the S&T manager have one thing in common – resource constraints and the resulting need for prioritization.

3. Risk Reward

“The risk–reward relationship for failure or success in military systems was noted as a primary barrier to the insertion of new technologies into military systems” (Committee on Accelerating Technology Transition, 2004, p. 4). “The risk–reward structures for military systems are shown schematically for noncritical and critical technologies in” Figure 5 of the Literature Review chapter (p. 24). The Committee on Accelerating Technology Transition report further states; that DOD breeds a culture that is averse to the risks associated with transitioning new technology at a rapid pace because the penalties for the failure of a critical technology program are incalculable. This is also evident by the perception that the rewards for success are considered exponentially smaller to the penalties for failure (p. 24). This mentality is especially difficult to comprehend given the uncertain nature of the S&T projects and the low technology readiness level associated with them.

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V. CONCLUSIONS AND RECOMMENDATIONS

A. CHAPTER INTRODUCTION

This chapter presents our conclusions and recommendations. We will discuss the answers to our research questions, reiterated below. We will also discuss our recommendations to the S&T community.

1. Primary Question

What are the strengths and weaknesses of the overall process whereby the ARDEC Headquarters transitions S&T into Acquisition Programs of Record?

2. Secondary Questions

- How can the communication structure and process between ARDEC and the S&T community be described, i.e., extent of effectiveness of inter-organizational communications and external stakeholder management.
- What is the relationship structure between ARDEC and relevant Program Managers (PM); and ARDEC and PEO Ammo concerning the transition of S&T technology into ARDEC, and how is that relationship changing?

B. ANSWERS TO QUESTIONS

1. Secondary Questions

- How can the communication structure and process between ARDEC and the S&T community be described, i.e., extent of effectiveness of inter-organizational communications and external stakeholder management?

As described within the Literature Review and the ARDEC Analysis sections, the ARDEC Director of Technology has identified the need to communicate routinely with Stakeholders across the DOD. The ARDEC process map includes up-front customer requirements discussions, takes input on priorities from the PEOs and TRADOC and aligns the portfolio of projects to the appropriate requirements. This ongoing communication aligns well with the findings depicted in Table 1, Excerpt of S&T Affordability Workshop's Transition Panel, and the GAO reports previously discussed which state that a best practice is the "early definition of requirements".

In addition, communication is further achieved through documentation such as the TTA Template contained in Appendix A. This document assures that all relevant stakeholders have a vested investment in the technology to be developed and the process in which it will transition into the PM . The TTA maps to specific practices identified by the previously identified GAO reports and Table 2, Excerpt of S&T Affordability Workshop’s Transition Panel, which contains “establish transition team from the beginning,” “mitigate / define risk” and “establish S&T metrics on transition”.

Furthermore, ARDEC has aligned its S&T process, as illustrated in Figure 7 – S&T Investment Strategy Process, to DOD initiatives such as the Better Buying Power 3.0 (depicted in Figure 8) and the development of formal roadmaps as demonstrated in the S&T Affordability Workshop’s Transition Panel in Table 1.

Additionally, ARDEC utilizes “honest peer reviews” in its Portfolio Reviews. This is another “What’s Good” S&T Affordability (Table 1) practice which is performed annually by ARDEC to provide and formulate objective feedback on the projects in the portfolio by ARDEC and its stakeholders.

The previous paragraphs in this section demonstrate many of the ways that ARDEC has worked with its customers in order to align and improve the probability of transition. However, “including industry” and “conduct affordability / cost analysis” are two elements identified in Table 3, Excerpt of S&T Affordability Workshop’s Transition Panel, that are not depicted in the ARDEC processes.

The absence of Industry Partners in the ARDEC S&T process illustrated in Figure 7 and the TTA Template contained in Appendix A could be an area in which ARDEC can improve its transition, based upon the findings of the S&T Affordability Workshop’s Transition Panel (Table 1). Additionally, including affordability metrics as part of the TTA Template may help to highlight the importance of affordability information to the success of the transition. The affordability metric may be applicable to be included in the section that currently discussed the funding strategy section of the TTA. This information should help to strengthen the probability of transition based upon the findings of the S&T Affordability Workshop’s Transition Panel (Table 1).

- What is the relationship structure between ARDEC and relevant Program Managers (PM); and ARDEC and Program Executive Officer Ammunition (PEO Ammo) concerning the transition of S&T technology into ARDEC, and how is that relationship changing?

As described in the ARDEC and PEO Ammo analysis contained within the Literature Review sections, the existing relationship between ARDEC S&T and PEO Ammo, specifically related to transition has become more focused during the past several years. This increased collaboration has resulted in quarterly reviews at the PEO-level and annual detailed project reviews at the PM-level. These reviews help to assure the alignment with the most up-to-date customer priorities, as well as help to provide a forum for any issues to be discussed and resolved.

For example, in a recent meeting between ARDEC S&T and Project Manager – Towed Artillery Systems (TAS), (one of the PMs under PEO Ammo) the two groups had to discuss and agree upon a path forward for the TTA involving the Future Artillery Survey System, targeted for an FY17 transition to PM-TAS and PEO Ammo. Discussions continue at the time this paper was written, with the goal of an approved TTA in the near future.

The TTA Template in Appendix A documents the formal relationship between ARDEC and PEO Ammo for S&T technology transition to programs of record. The inclusion of the PEO in the formal ARDEC S&T Process depicted in Figure 7 further shows the strength of this relationship. Constant contact between both organizations is paramount to the success of technology transition and aligns well with the S&T Affordability Workshop’s Transition Panel best practices in Table 1 and the GAO findings presented in the Literature Review. The evolution of this relationship is becoming more closely tied, as evidenced in the increased formal documentation, such as the TTA Template, and the process of including routine reviews and changes to the process.

2. Primary Question:

What are the strengths and weaknesses of the overall process whereby the ARDEC Headquarters transitions S&T into Acquisition Programs of Record?

As discussed in the ARDEC Analysis section that detailed the alignment with the S&T Affordability Workshop’s recommended attributes of successful technology

transition, ARDEC has worked closely with the Stakeholders in the S&T community to develop and improve their S&T Investment Process. There are still areas for improvement, but ARDEC seems aware of these areas and is working to address them, most prominently with its resident customer at Picatinny, PEO Ammo. This endeavor for improvement can be seen through all of the reasons described in the responses to the secondary questions such as the TTA Template and alignment to Better Buying Power 3.0.

To summarize the findings described in the responses to the secondary questions, the strengths ARDEC exemplifies as described by the “What’s Good” list from the S&T Affordability Workshop’s Transition Panel in Table 1 include;

- Early Definition of Requirements
- Establish Transition Team from the Beginning
- Mitigate / Define Risk
- Establish S&T Metrics on Transition
- Develop Formal Roadmaps
- Honest Peer Review

Using the same list from Table 1, the two gaps ARDEC has in its current process and documentation are:

- Including Industry
- Conduct Affordability / Cost Analysis

C. RECOMMENDATIONS

The below are recommendations for other Research and Development Organizations seeking to implement an S&T Process using ARDEC as a benchmark that uses these Best Practices as described in the ARDEC Section. These are tied back to the findings from the GAO and the S&T Affordability Workshop’s Transition Panel:

First, endorsement from current and future customers is critical to the identification that there is an interest in technology should be inserted. This endorsement should include the type of technology, the specific transition time frame, and how it will fit within the overall program framework. Many PEOs and PMOs have begun developing roadmaps for

their specific commodities to plan technology insertion points, quantify the number of spare parts for the lifetime of a system, and to identify a system's useful life requirements before it is planned to be replaced with an upgraded or new system/solution.

Second, to assist in the development of requirements up-front and early collaboration with the Soldier community and the respective CoE is essential. Without requirements, completed S&T projects have few avenues for proceeding as PoRs. Aside from participating in demonstrations to gain interest from SOCOM, Rapid Equipment Force (REF) or another organization with the ability to purchase systems independent of the normal Acquisition Life Cycle Process, there needs to be a requirement in order for S&T efforts to become PoRs. Collaboration will help make the CoE aware of the capabilities of S&T and make the CoE aware of the current technologies that are available or already being developed.

Third, alignment with currently identified Soldier needs and existing/staffed requirements documents is needed. Similar to the previous collaboration, this is a document review and match between existing identified gap areas from the Soldier community, such as War Fighter Outcomes (WFOs) and the prioritized gap areas from each CoE. Analyzing the WFOs and current requirements documents and then aligning S&T Portfolio with these documents can be very helpful in transitioning to a PoR. Having requirement documents already completed is a huge advantage in this matter. However, even without a requirements document it is important to at least be aligned with existing documentation of gap areas in order to justify the work that you do, while you can work with the CoE in order to develop a requirements document for transition when the effort is complete.

Fourth, up-front and early collaboration and communication between developing organizations is essential. Most projects require inter-operability and different development agencies to work in harmony in order to accomplish the successful, timely, and technical completion of a project. For example, the identified weapons experts must work with the platform experts and the communications experts. Without this collaboration, integration, functionality and logistics support technology transition would be at a very high risk and could easily lead to the transition failing or being delayed. Working

together and defining interfaces and controls for those interfaces is paramount to having the systems work together like they need to in today's System-of-Systems reality of the battlefield.

Fifth, having the ability to successfully leverage capabilities available to provide the best possible solution to the War Fighter is imperative. This includes being aware of and collaborating with academia, industry and foreign agencies. There are many ways to perform this collaboration; through attendance at conferences, Industry Research And Development reviews, Technical Information Exchanges, Foreign Technology Information Papers, and even Internet searches. All of these help us to leverage as much technological knowledge as possible when developing the solutions to War Fighter needs that can be transitioned to PoRs and ultimately the Soldiers themselves.

Finally, TTAs need to be in place and have explicit criteria for both the developing agency and the future customers. The two major issues with this currently is that the deliverables of the S&T efforts are not clearly defined and that the future customers make no commitments to use the developed technologies. This is why having a defined requirement is so important. Without a requirements document of some kind, it is difficult for a customer to transition the technology to a PoR. Additionally, regular status reviews between the PM and ARDEC are very important in assuring continued commitment, alignment and execution of the technology for transition.

The below are recommendations that ARDEC should continue to pursue or should incorporate into their S&T Process to improve the transition of technology to PEO and PM customers:

1. Focus on the transition and identify and track meaningful metrics associated with technology transition. The kind of metrics are situational dependent; however, the metrics should be agreed to up-front by all stakeholders and reviewed regularly.
2. Include industry in a systematic and routine way as part of the process, so that it is beneficial to both the industry and government sectors.
3. Address all "-ilities" in a meaningful way, rather than merely assuring membership on the S&T project IPTs. This means being able to identify

design and functionality changes and decisions that were influenced by these design considerations.

4. Conduct affordability and cost tradeoffs by updating the cost data as the technology matures and as relevant manufacturing and support costs become more evident.
5. Fill all key project management positions with qualified people. Individuals with technology transition experience would be the best choice.
6. Assure that program managers and transition managers remain assigned for the duration of the associated project(s).
7. Favor operational development over formal demonstrations.
8. Use service acquisition organizations to periodically evaluate and advise the project team.
9. Adapt the R&D project deliverables or tradeoffs in cost, schedule, performance and risk based upon the expectations of the PM transition partner.

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APPENDIX. TECHNOLOGY TRANSITION AGREEMENT (ARDEC)

Template

PEO AMMO/ARDEC
Technology Transition Agreement
for
Technology Name
(Include all aliases, prior names, identifying project numbers or acronyms)

As amended 19 Jul 2012

1. Introduction

1.1. **Purpose/Scope** Provide a brief statement. *[Example - The Program Manager and S&T Organization mutually agree to enter into this Technology Transition Agreement (TTA) for the purpose of defining technology deliverables from the appropriate name technologies development program, to appropriate name program. This TTA defines the functional responsibilities and support relationships between the parties signing this agreement. It ensures a clear understanding of the responsibilities of all parties to ensure a successful transition of technology from S&T organization to the program of record name.]*

1.2. **Summary/Background** Provide a brief overview of 1-3 paragraphs length summarizing what this project will provide to the program of record. Describe any previous technology development that was leveraged. Also describe how this effort was approved.

1.3. Key Stakeholders

1.3.1. **Program Manager/Project Officer** Identify the individual in the program office who is the primary point of contact for the APO. This person will provide their acquisition strategy to the APO to better communicate the subject weapons system's decision milestone schedule, coordinate subject project's information to all contractors completing for the subject weapon system's contracts, and include mention of the subject project's technology in the subject weapons systems' roadmaps, Acquisition Strategies and/or Integrated Master Schedule

1.3.2. **RDEC Technology Manager** Identify the individual designated to be the coordinator and day-to-day manager of the development of the technology to be transitioned (T2BT).

1.3.3. **Resource Sponsor/Requirements Officer** Identify the resource sponsor and requirements officer responsible for resourcing and establishing requirements for the capability. Include contact information.

2. Basic Transition Agreement

2.1. **Description of Technology or Capability to be Delivered** Specific, technical description of what the S&T Program or Source-Program Manager intends to develop for transition to the primary acquisition program, to include numbers of prototypes or test items.

2.2. **Target Acquisition Program** Brief description of the acquisition program intended to receive the T2BT. Include major program objectives, ACAT level, current phase of acquisition life cycle, next milestone decision review (and anticipated date), and projected initial operational capability date. Also identify the governing source of the capability requirement: the ICD, CDD, or other official reference documenting the capability need.

2.3. **Acquisition Program Technology Need** Brief description of the benefit that this T2BT will bring to the acquisition program, or need satisfied. State whether the T2BT is a critical technology, risk reduction or has some other attribute; explain how the T2BT will benefit the program. (Evolutionary acquisition, block upgrade, etc.)

2.4. **Integration Strategy** Describe the process for integrating the T2BT into the acquisition program. Include the following elements of the acquisition strategy based upon conversation(s) between the PM representative and the APO:

2.4.1. Identify the specific planned insertion points (s) of the technology into the PM roadmap. State the planned dates of appropriate Program of Record major design reviews, ECP, contract award, etc. Identify the strategy for inserting the technology into the acquisition program contract(s), including any required contractor to contractor agreements. State whether the PM is committing to insert this technology (assuming transition criteria are met), or is only interested in possible insertion.

2.4.2. Identify the highest 3-5 risks that are roadblocks of this technology's successful transition and their mitigations (include funding, schedule, system integration, schedule, etc)

2.4.3. Identify the planned periodic progress reviews. State the type and frequency, i.e. ARDEC Level 1 reviews, quarterlies, etc. At a minimum, these reviews should include technical progress, funding and schedule status, and an assessment of transition risk/probability. (The PM/item manager should become an Integrated Process Team member; the PM Representative should attend ARDEC's periodic progress reviews.)

3. Technical Details and Programmatic

3.1. Current Status of Technology

3.1.1. **Current Status** Summarize the current state of the development of the T2BT. Identify primary areas where additional development is required. Provide estimate of current Technology Readiness Level (TRL).

Manufacturing Readiness Level (MRL) and Software Readiness Levels (SRL) ratings and how those ratings were assessed.

3.1.2. **Risk Analysis** Identify the 3-5 major areas of technical risk, prioritized, with planned mitigation activities.

3.1.3. **Product Data/Intellectual Property** State what rights to the data/IP the government currently has and will have when it is transitioned. If developed outside the government, state how the government will acquire the appropriate rights. Also state how the government will acquire the actual data (i.e. TDP) upon transition.

3.2. **Technology Development Strategy** Outline planned approach. Describe current efforts and efforts required beyond those currently underway. Detail integration plans if multiple projects are planned. Include planned ATD or ACTD developments, and Technology Enabled Capability Demo's (TECDs) if applicable. Discuss in-house vs out-of-house efforts.

3.3. **Key Measures of Transition Readiness** Identify the key parameters or attributes (performance and cost) that will be used as exit criteria to measure whether or not the T2BT effort is proceeding as scheduled (recommend depicting in a table). Include parameters to be tracked, current state, interim progress estimates and final objective. Provide dates when each higher TRL/MRL/SRL rating is expected to be achieved. These measures will be the basis of periodic reporting described in paragraph 2.4.3.

3.4. **Program Plan** Show major activities/efforts of the T2BT technology development activity, with milestones. A standard quad chart can be attached.

3.5. **Funding Adequacy** State whether the combined sources of all funding are adequate to achieve the maturity and quantity of the T2BT required by the receiving PM in the timeframe(s) required by the PM and as specified in this document. If not, specify what additional funding is required and where it is expected to come from.

4 . Effective Date, Periodic Review and Termination

a. This TTA is a living document that will take effect on the date of the last approving signature. It will remain in effect until all transition activities are complete unless terminated or revised by earlier mutual agreement.

b. This TTA will be reviewed and updated at any time at the request of one of the signing authorities or their successors, at a minimum annually.

(Example Signature Page)

Prepared by:

APO

Date

Chief Engineer, Program Manager

Date

Concurrences:

APO Competency Manager

Date

Project Integrator

Date

ARDEC Director of Technology, ESIC

Date

R&D Coordinator, PEO-Ammo

Date

Approved by:

Executive Director, Enterprise & Systems Integration Center

Date

Commander, PEO-Ammunition

Date

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