Examining a Paradigm Shift in Organic Depot-Level Software Maintenance for Army Communications and Electronics Equipment

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Abstract

In the current fiscal environment, Department of Defense (DoD) budgets and resources are being constrained and strategic decisions are being considered to gain efficiencies across the enterprise. In the realm of the Army's Life Cycle Management Command for Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) materiel, the U.S. Army Communications and Electronics Command (CECOM) is one of those enterprises looking for efficiencies. Resource constraints and diverging hardware and software sustainment trends at Tobyhanna Army Depot (TYAD) and the Software Engineering Center (SEC), respectively, are proving to be a quandary for CECOM in terms of how to cost-effectively conduct software maintenance of Army communications and electronics equipment.

The intent of this paper is to investigate whether there is an opportunity for CECOM to use the organic, hardware-maintenance-focused TYAD workforce to supplement the SEC contractor software-maintenance workforce, in lieu of SEC adding more contractor support. This paper presents the findings of an assessment of the feasibility, benefits, and challenges of such a functional realignment of maintenance responsibilities. The results indicate that this paradigm shift in software maintenance responsibilities is feasible and does have some promising aspects, but not without some clear challenges that require additional investigation.

Chapter 1 – Introduction

In the current fiscal environment, Department of Defense (DoD) budgets and resources are being constrained and strategic decisions are being considered to gain efficiencies across the enterprise. At the same time the commercial electronics industry is rapidly advancing in terms of hardware reliability, a focus on consumable product lines, and ever-intensive software systems. With defense acquisition having little influence on electronics parts technologies and designs, these factors should be of concern for military sustainers. In fact these factors are proving to be a quandary for the effective and efficient conduct of organic-level maintenance of Army communications and electronics equipment by the U.S. Army Communications and Electronics Command (CECOM).

Preliminary evidence from CECOM suggests an increasing trend in software-intensive systems coming under Post-Production Software Support (PPSS) requiring more resources to address software maintenance demands. These demands include mission enhancements to support operational needs (responding to new threats or requirements; maintaining interoperability with other changing systems; accommodating new weapons, systems or munitions; and supporting new doctrine/tactics), requirements for field service engineers (FSEs), more complex fixes for information assurance and cybersecurity requirements, technology advancements or refresh, and certifications/accreditations for network connectivity (Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance [C4ISR] Center of Excellence, 2014). In particular a net of 24 new C4ISR systems will enter PPSS from fiscal year (FY) 2015 to 2019, driving an increasing Software Engineering Center (SEC) workload demand during a time when Overseas Contingency Operation (OCO) funding is being eliminated, organic authorized manpower authorizations are being capped, and information

assurance is becoming more critical to cybersecurity (CECOM SEC, 2013). CECOM data also suggest that the hardware maintenance demands of communications and electronic equipment at Tobyhanna Army Depot (TYAD) are decreasing. In particular, the organic hardware-maintenance work years at TYAD are projected to decrease by 61% (FY08–16), while software workload at SEC is projected to increase by 80% during the same period (C4ISR Center of Excellence, 2014).

At the present time, due to an ever-increasing demand for software maintenance and capped government manpower authorizations, the vast majority of the SEC workforce is contracted to conduct the required software-maintenance actions. In fact, currently 88% of depot maintenance of software at SEC is completed by contractors, a major contributor to CECOM's increasing difficulty to maintain compliance with the Hunter-Hollis Law (10 USC 2466 50/50 mandate, see Appendix E), which establishes a 50% limit on contracting for depot maintenance by a Military Department or Defense Agency (CECOM SEC, 2013). Conversely at TYAD, which utilizes a primarily wage-grade workforce for hardware maintenance, funding challenges and decreasing hardware maintenance demands have required the shedding of almost one-third of its workforce over the last two years, and they are currently looking for work opportunities (Haggerty, 2014). As the maintenance demands of these two organizations continue to diverge, is there an opportunity to use the organic TYAD government workforce to supplement the SEC contractor software-maintenance workforce? Would this functional realignment of maintenance responsibilities solve TYAD's funding and workload demand issues while simultaneously providing SEC with a government workforce to help with increasing software maintenance demands and to help move CECOM closer to meeting the requirements of the Hunter-Hollis 50/50 mandate?

In the current and projected resource-constrained environment of the DoD, and with an increasing ratio of required software-to-hardware maintenance of communications and electronics equipment, can CECOM continue to operate under a paradigm of two distinct depots for software and hardware sustainment?

Background

CECOM is one of Army Materiel Command's (AMC's) four Life Cycle Management Commands. It executes a sustainment and logistics integration mission across a very broad and complex set of C4SIR systems and capabilities (CECOM, 2013). CECOM is the Army's critical link for life-cycle support of the communications-electronics systems and equipment used by the joint warfighter (CECOM, 2013). The command accomplishes its mission by providing eight major functions, including supply chain management, field support, logistics sustainment planning and execution, information technology systems engineering and integration, foreign military assistance, interoperability certification, software sustainment, and depot-level manufacturing repair and overhaul (CECOM, 2013). Organic depot-level maintenance of communications and electronics equipment is currently conducted at two separate depot locations within CECOM, primarily based on whether the maintenance action is hardware or software in nature. Currently the Tobyhanna Army Depot is responsible for hardware-centric maintenance of this equipment, while the Software Engineering Center is responsible for software maintenance of such systems.

CECOM SEC, as the largest software center in the Army, delivers software products and services in support of Army C4ISR, as well as logistics, business and enterprise systems in the modern digital environment (CECOM SEC, 2014b). SEC supports more than 90 unique systems in PPSS totaling over 280,000 individual platforms. SEC employs information specialists,

computer engineers, and scientists in the conduct of the following core competency activities (CECOM SEC, 2014b):

- *Software Development*—System development and Post-Deployment/Post Production Software Support for systems in the following domains: tactical communications, satellite communications, joint networks, mission command, intelligence and electronic warfare, air and ground force protection, fires, logistics systems, business systems, and enterprise solutions.
- *Software Testing*—SEC supports software and system testing using common processes for early detection of software faults and defects.
- *Software Acquisition Support*—SEC provides efficient centralized purchasing and management of commercial off-the-shelf (COTS) software licensing through software asset management/centralized acquisition and licensing management services.
- *Army Net-Centric Data Strategy*—As the Army's net-centric data strategy Center of Excellence, SEC provides the Army Chief Information Office with data administration and technical expertise to implement DoD's net-centric data strategy across the Army.
- *Cyber Security/Data Forensics*—Using common processes to detect various performance-degrading design and coding practices, SEC determines code vulnerability to potential hackers or other threats.
- *Independent Verification and Validation*—Ensures software and system releases fielded to warfighters satisfy all approved requirements.
- *Software Field Support*—SEC provides 24/7 worldwide field-software-support services for a wide variety of C4ISR systems. Field software engineers work onsite

keeping software systems battle ready, deploying with units to support contingencies, exercises, and combat operations.

- *Electronic Warfare Software Reprogramming*—As the Army's Executive Agent for Force Protection Systems, SEC's Army Reprogramming Analysis Team Program Office performs development and testing of software/threat reprogramming for Army ground and airborne force protection as well as for electronic warfare systems.

TYAD is the largest, full-service electronics maintenance facility in the Department of Defense and is the Army Center of Industrial and Technical Excellence for Command, Control, Communications, Computers, Intelligence, Surveillance, and Reconnaissance and for Electronics, Avionics, and Missile Guidance and Control. TYAD's mission is to "Provide Superior Logistics Support including Sustainment, Fabrication, Integration and Field Support to Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance (C4ISR) Systems for the Joint Warfighter-Worldwide" (TYAD, 2015, p. 13). TYAD is the DoD's recognized leader in the areas of automated test equipment, systems integration, and downsizing of electronics systems. This includes satellite terminals, radios, radars, counter improvised explosive devices and systems, electro-optics, night vision and anti-intrusion devices, airborne surveillance equipment, navigational instruments, electronic warfare, and guidance/control systems for tactical missiles (TYAD, 2015).

TYAD is an industrial operations activity of the Army Working Capital Fund (AWCF). Congress established working capital funds to provide more effective control and accounting of the cost of programs and work performed in the DoD. Unlike profit-oriented commercial businesses, the revolving fund seeks to break even by returning any monetary gains to appropriated fund customers through lower rates or to collect any monetary losses from

customers through higher rates. The basic tenet of the revolving fund structure is to create a customer-provider relationship between military operating units and support organizations (Department of the Army, 2014).

Problem Statement

With the increasing amount and complexity of software in the Army's communications and electronics equipment requiring PPSS, and with OCO funding cuts creating a projected 50% reduction in CECOM funding for PPSS in Program Objectives Memorandum 15-19 and capped manpower authorizations, it's imperative that CECOM re-examine how and where its software maintenance is conducted (CECOM SEC, 2013) . This re-examination is necessary to remain effective in meeting an increasingly complex PPSS requirement while becoming more efficient to eliminate a widening cost-to-funding gap for PPSS and to improve current PPSS organic-to-contractor workforce-ratio imbalances as required by congressional mandates and applicable laws.

Purpose of This Study

This paper specifically investigates these diverging hardware and software maintenance trends for communications and electronics equipment at CECOM SEC and TYAD and examines whether a retooled TYAD organic workforce is feasible and beneficial to support the increasing software maintenance demands of SEC. In addition the research addresses the workforce requirements at TYAD to meet SEC software maintenance demands and examines the potential benefits and challenges of such a possible strategic transition in maintenance focus for the CECOM enterprise.

Significance of This Research

The effective and efficient utilization of the organic depot maintenance enterprise is key to maintaining the necessary capabilities and capacities for defense of the nation in a time of increasingly lean budgets. In this study the current technical capability and capacity of the TYAD is compared with expected demands and complexity of PPSS for communications and electronics equipment. The results of the research confirm the perceived gap in software maintenance capabilities, support the requirement(s) for adding organic software maintainers at TYAD to support SEC requirements, and address the overall benefits, challenges and feasibility of a hardware to a software maintenance paradigm shift of the TYAD organic workforce. These results will be of significant interest to CECOM as it wrestles with how to manage, effectively and efficiently, the sustainment of communication and electronics equipment for the Army as resources are restricted and software maintenance demands increase.

Overview of the Research Methodology

This study used quantitative and qualitative analytical methods in the examination of software versus hardware maintenance trends and forecasts, human and financial resources at TYAD and SEC, and overall compliance with Title 10 mandates (e.g., 10 USC 2466). Quantitative methods were executed by analysis of data trends of software and hardware maintenance demands of communications and electronics equipment, and forecasted trends to assess future maintenance demands and capacities of Army organic depots in comparison to resources. This data was used to clarify the significance of the impending software maintenance gap between demands and resources in support or denial of the research hypothesis. This data was provided by HQ CECOM, TYAD, SEC, and the U.S. Army Materiel Systems Analysis Agency (AMSAA).

In addition an online survey was developed and used to collect data from Government respondents regarding their perceptions of projected demand-resourcing gaps of TYAD and SEC. The survey also addressed the possible benefits and challenges of implementing a paradigm shift, from a hardware-to software-maintenance focus at TYAD. The survey used numbered responses on a Likert scale to provide numerical data to verify or reject the perceived gap at TYAD in capability and capacity to meet increasing software maintenance demands. There were also open-response questions to help develop additional insights and comments on possible depot-level maintenance transition concepts and requirements, as well as to investigate the secondary and tertiary effects (on processes, procedures, people, materiel, equipment, facilities, and required information) of these possible new concepts at TYAD. The survey was provided to senior management officials with the most knowledge of depot-level maintenance and PPSS at Headquarters Army Materiel Command, Headquarters CECOM, TYAD, SEC, Program Executive Office Command Control Communications-Tactical (PEO C3T), Program Executive Office Intelligence Electronic Warfare & Sensors (PEO IEW&S), and PEO Enterprise Information Systems (PEO EIS).

These methods will provide quantitative-based analysis on which to base and justify trends and gaps, as well as qualitative methods to investigate, develop, and comment on the benefits, challenges, and possible effects of changes to maintenance strategies at TYAD.

Research Questions

Q1: Do trends in software-centric maintenance demands of communications and electronic equipment suggest the need for a paradigm shift at TYAD, from a hardware- to a software-maintenance focus, to supplement the software maintenance demands on SEC?

Q2: If so, are there capability and capacity for such changes at TYAD.

Q3: What are the potential benefits and challenges of such a possible transition in maintenance focus?

Research Hypothesis

A hardware-to-software maintenance paradigm shift at TYAD, in support of SEC PPSS requirements, is feasible and will ultimately provide benefits and efficiencies for CECOM, AMC, the Assistant Secretary of the Army (Acquisition, Logistics, and Technology), and the U.S. Army overall, while improving the ability of CECOM to comply with Title 10 50/50 mandates (10 USC 2466) and provide more effective support to CECOM customers.

Objectives and Outcomes

It was anticipated that this research would in fact provide quantitative and qualitative evidence to suggest or reject the idea that a strategic shift in how maintenance of communications and electronics equipment is conducted at TYAD, to help alleviate an increasing software maintenance demand at SEC, is necessary and beneficial in an era of decreasing funds and frozen Government resources. These results will provide CECOM leadership with a basis for follow-on studies to examine more closely the anticipated maintenance efficiencies, benefits, and challenges. The study will also provide a context in which to examine similar software maintenance collaboration opportunities across all DoD Life Cycle Management Commands.

Limitations of the Study

Due to the time limitations of this research, the quantitative analysis was limited by the software and hardware maintenance trends data readily available at CECOM. In addition the robustness of the examination of the feasibility of future maintenance concepts, benefits, and challenges on TYAD and SEC was limited by the responsiveness of survey participants.

A major assumption is that trends in the reduction of the Nation's wartime footing and associated reductions in funding for maintenance, and the CECOM SEC Table of Distributions and Allowances (TDA) restrictions, will continue for the foreseeable future.

Validity of the Research

The key independent variable is the degree to which CECOM uses organic resources to maintain software on communications and electronics equipment. The key dependent variables are Title 10 (50/50) compliance and expected efficiencies (cost, turn-around time) and effectiveness of software maintenance actions.

Trend data was received from multiple sources (TYAD and SEC), including independent agencies (AMSAA), which helped to reduce or eliminate discrepancies in the quantitative data. Bias may have been introduced through the survey process, but it is believed that the number of responses (74) reduced any bias, or at least enabled identification of where biases may exist.

Reliability of the Responses

The use of standardized maintenance data at CECOM makes the quantitative element of this research easy to replicate. The qualitative nature of the survey may be less likely to be replicated, although the nature of the survey questions is such that any significant population of similarly qualified respondents should provide similar findings or insights.

Chapter 2 – Literature Review

This chapter provides an overview of the literature review conducted for this research topic. The review uncovered sources that can be grouped into two general categories of topical areas germane to the research question and problem statement: (1) hardware and software sustainment trends and (2) the future of the organic industrial base. What follows is a summary of the most relevant research references that address baseline elements of the research question and problem statement.

Hardware and Software Sustainment Trends

***A Survey of Electronics Obsolescence and Reliability* (O'Dowd, 2010).** This report, published by the Air Operations Division of the Australian Defence Science and Technology Organisation, provides a comprehensive review of the state of commercial electronics and factors that affect their reliability and obsolescence. The report starts by introducing the 1994 instruction by then U.S. Secretary of Defense William Perry for the U.S. Armed Forces to adopt commercial products and standards to reduce costs. This action was said to contribute to the further increase in the use of COTS products and, in particular, caused the electronic component manufacturers to focus on high-volume production lines and eliminate those low-volume lines primarily used in the Aerospace and Defense sectors. By 1999 the Aerospace and Defense sectors represented only 0.3–0.4% of the total market.

The author goes on to state that the increasing growth of the commercial business and individual consumer market for electronics equipment, and hence the renewed focus of the electronic component manufacturers on this market, made the Defense sector vulnerable to the whims of the design philosophies intended for the commercial sector. This shift towards commercial products, specifications, and standards has put the military in less control over

reliability and obsolescence of its electronics systems. One consequence of this shift is that electronics components now rarely have design periods longer than five years, whereas military systems have service lives for multiple decades. In addition, to coincide with Moore's law principles of electronics technology advancement and consumer expectations for continual performance improvements in the commercial sector, the electronics parts industry has implemented physics-of -failure techniques purposely to create reliability that minimizes design margins to coincide with required commercial warranty periods.

These design and manufacturing practices consequently produce electronic components that have a life cycle significantly shorter than the life cycle of the systems themselves. Even though this should be of some concern for the military, the author goes on to emphasize that software remains a dominant cause of unreliability of electronic systems. This is primarily due to the difficulty of software development and verification and the fact that software is now more often used to implement functionality that cannot be achieved by other means and the trend in the utilization of multi-core processors.

***CECOM SEC Depot Maintanence Post Production Software Support* (CECOM SEC, 2013).** This briefing developed by CECOM SEC provides an update on PPSS from the perspective of applicable laws, challenges, depot maintenance 50/50 compliance, and software sustainment cost growth. Its primary purpose is to provide a command update on PPSS challenges and actions taken to date to comply with C4ISR depot maintenance 50/50 requirements and to reduce the growth in software sustainment costs.

PPSS is defined in this briefing as being one of the following efforts:

- Resolution of anomalies preventing mission accomplishment
- Fixes to address information assurance vulnerability alerts (IAVAs)

- Changes to support operational needs
- Responding to new threats or requirements
- Maintaining interoperability with other changing systems
- Accommodating new weapons, systems, or munitions
- Supporting new doctrine/tactics
- Acquisition of COTS software licenses
- Providing field support
- Incorporating technology advancements and/or refresh

The document begins by describing the challenges that CECOM SEC faces, including a net of 24 new systems entering PPSS in FY15–19; the pending elimination of OCO funding, which had been used to supplement PPSS manpower requirements through contract support; capped manpower authorizations for Department of the Army civilian employees; and Milestone B/C decisions driving PPSS strategies. With an increasing workload and static organic workforce, CECOM envisions a widening workload gap filled with contractors. The result of this is a continuing imbalance in the command's 50/50 requirement, in which software sustainment is the driving force. The document states that, for FY13, 88% of PPSS was conducted by contractors, while only 12% was conducted by organic Department of the Army civilians (DACs).

In light of these challenges, several studies were initiated by CECOM to focus on PPSS efficiencies, policies, processes, and strategic enterprises to ultimately reduce costs, reduce license fees, and improve decisionmaking and planning. One of the highlights of the study was the potential savings associated with transitioning FSEs from contractor to Government, estimated at $13 million annually. Although the potential savings of this effort were quantified

for this specific PPSS activity, and a pilot project was initiated using TYAD as the Advanced Field Artillery Tactical Data System FSE provider, none of the other elements of PPSS were considered. In fact the feasibility, challenges, and benefits of transitioning the TYAD workforce to support these other sustainment tasks were not fully assessed.

***PPSS Workforce Study Final Results* (U.S. AMSAA, 2014).** This study out-brief, conducted by AMSAA for the director of SEC, provides the results of a workforce structure study. The purpose of the study was to examine the SEC Intelligence, Surveillance, and Reconnaissance Directorate's (ISRD) current workforce structure and skill sets and provide insights into how to organize the ISRD better to accommodate current and incoming PPSS workload. The study was commenced because it was unclear whether the current ISRD skills sets, workforce structure, and TDA are appropriate to support the current and future increase in PPSS workload. The study found that 83% of ISRD direct labor funds were to be contractually spent on IAVAs, licenses, CAT I/II fixes, and FSEs, while 79% of ISRD's total direct labor PPSS work years were for contractor support of IAVAs, CAT I/II fixes, and FSEs.

The study found that the workload for ISRD is expected to increase substantially in FY15–18, with 18 PPSS systems transitioning into ISRD, the majority of which will transition during FY16 and FY17. No systems currently in PPSS are expected to transition out. The study goes on to investigate several courses of action to address this projected increase in workload by doing the following:

- Option 1: Maintaining the status quo— no now government personnel added
- Option 2: Maintaining the current ratio of Government personnel to contractor personnel

- Option 3: Adding the required number of Government personnel to support 50% of the workload
- Option 4: Adding the required number of Government personnel to perform all IAVAs and CAT I/II fixes, in addition to current workload requirements

All the options, other than status quo, were found to require additional Government employees in five critical job series, but Options 3 and 4 promised significant cost savings as compared to contractor support even though they required the hiring of hundreds (and in some cases over 600) of additional Government employees.

Software Depot Maintenance (PPSS) Manpower **(CECOM SEC, 2014a).** This presentation was developed in response to a Department of the Army G4 request for CECOM SEC to provide a business case analysis (BCA) identifying the cost impact of using contractors in lieu of Government employees to meet PPSS core requirements (Title 10 section 2464). According to this document the CECOM SEC's overarching objective guiding this BCA has been to improve C4ISR PPSS 50/50 compliance and build/maintain Government technical expertise to perform the PPSS core mission. The BCA derived short-, mid-, and long-term recommendations to achieve the above strategic objective in the face of the significantly increasing PPSS workload and declining resources. The short-term FY15 recommendation was for Headquarters AMC to approve direct over-hires for systems entering PPSS in FY15. The mid-term recommendation was to convert contractor manpower equivalents to DACs. This course of action was found to be critical in meeting core capabilities for software depot maintenance, establishing an in-house technical expertise to perform PPSS and substantially reducing program risk for complex C4ISR systems as service contracts are re-competed. In fact the study estimated that this mid-term course of action (COA) would provide a cost savings of

$275 million over FY16–20. The long-term recommendation was for CECOM to manage depot maintenance PPSS manpower levels according to available funding and workload. This would enable sufficient Government technical expertise as systems transition, and it provides all the benefits of the mid-term COA. The only negative aspect of this long-term COA is that TDAs would be unrestricted.

***JASR: Organic Industrial Base—C4ISR Community Insights* (C4ISR Center of Excellence, 2014).** This briefing was developed by Team C4ISR at Aberdeen Proving Ground for the September 2014 Joint Acquisition Sustainment Review (JASR), which includes senior representatives of ASA(ALT) and AMC and is intended to create a better partnership and increased synchronization between ASA(ALT) and AMC in support of a better materiel enterprise.

The C4ISR community insights presented at this meeting were all very relevant to the topic of this paper. The briefing begins by laying out the current state of the organic depot workload for C4ISR systems by stating that TYAD anticipates a 61% reduction in hardware sustainment work-years between FY08 and FY16, while the SEC anticipates a 59% increase in PPSS for the same time period. The briefing suggests that C4ISR systems are transforming to be more software intensive and provides an example of the Q53 radar replacement of the Q36/37 Firefinder radar, resulting in an order-of-magnitude reduction in hardware direct labor hours (DLHs) at TYAD simply due to modernization of systems. Other C4ISR hardware sustainment challenges cited include the requirement for OCO funding to meet core hardware depot requirements and less predictability of TYAD workload without a predictable Army Force Generation cycle.

The briefing continues by calling out the fact that Team C4ISR has been historically challenged in meeting 50/50 requirements. Primarily due to a significant contractor contribution to depot software maintenance (90% of PPSS) in response to the transition of quick reaction capabilities to organic depots without depot workload planning and the increased use of COTS hardware and software, which limits access to technical data.

In terms of software depot challenges, the briefing emphasizes that the mission continues to grow, including a net of 24 new systems entering PPSS in FY15–20. This PPSS growth is driven by the software-intensive nature of systems in general and the increasing number of systems in PPSS. Additional software depot challenges include the ability to define software core capabilities, the number of licenses required, and IAVA becoming more critical to cybersecurity. In addition the briefing calls out the fact that cyber defense sustainment is implemented on a system-by-system basis and no holistic strategy is being implemented.

Tobyhanna Army Depot Has Shed a Third of Workforce in Two Years **(Haggerty, 2014).** This article details the fact that TYAD has shed almost one-third of its workforce over the last two years, down almost 1,700 employees since early 2012, and plans more staffing cuts in the near future. Most of the cuts were attributed to cuts in the defense budget due to sequestration and the reduced operational tempo (OPTEMPO) of military forces. According to Dr. Loren Thompson, a defense analyst at a Washington think tank, TYAD may be able to weather these immediate cuts and even see some long-term benefits because of a reduction to the Army equipment budget and the pending cancellations of many current programs due to these cuts. Hence he surmises that the Army will have to put more money into existing systems to keep them operational longer. This ultimately could increase the workload at TYAD to sustain these legacy systems longer.

The Future of the Organic Industrial Base

Future Capability of DOD Maintanence Depots **(Logistics Management Institute [LMI], 2011).** This independent report, conducted by LMI Government Services in support of a DoD contract, was in response to the Duncan Hunter National Defense Authorization Act for FY09. The report was conducted in two phases. The first phase addressed primary laws, regulations, and policies guiding depot maintenance performance and financial reporting. The second phase assessed the organic depot maintenance enterprise and analyzed what is required for an efficient and enduring set of capabilities through FY15 and beyond. The study concludes that, as the nation moves away from a war footing, the high levels of organic depot maintenance activity will not be sustained, primarily due to reduced OPTEMPO of combat operations and the replacement of older systems with newer ones. In addition, potential reductions in the overall defense budget and reduction or elimination in war-supplemental funding could further decrease depot activity. The study suggests these factors could signal an uncertain future for the organic depot maintenance system.

The study recommends several changes to address the challenges that the organic depots face due to this uncertain future. These recommendations include revising the statutory framework of depot maintenance, linking acquisition and sustainment policies and outcomes, strengthening the core determination process, and improving depot maintenance reporting. In addition the study provides specific goals for improving the execution of DoD depot maintenance. The following goals are offered for an efficient and effective DOD depot maintenance enterprise, especially in an uncertain future:

- Optimize use of available depot maintenance capability across all organic depots in peacetime.

- Attain maximum utilization of existing depot capacity and execute expanded capabilities across the depots to meet mobilization and surge requirements.
- Respond consistently to reductions in overall maintenance resource availability.
- Achieve the optimum level of overhead costs relative to total organic costs.
- Minimize unnecessary duplication of systems, facilities, and production capabilities across organizational military service boundaries.
- Achieve the most efficient and effective application of new technologies and modernized automated systems across all depots.

The study then recommends imperatives to achieve these goals, including the following:

1. *Balancing Workload*—The changing resource availability, end-item availability, and reduced OPTEMPOs will have workload effects on the depots. Future depots should be postured to meet mobilization and surge requirements in a more balanced, responsive, and consistent manner.
2. *Facilitating skill upgrades and technology modernization*—Changes in technology may require different training and skill mixes at the depots. Implementation of modern computer, software, and information systems must be accelerated significantly with less cost and minimal redundant initiatives.
3. *Maintaining a viable organic industrial base*—The depot enterprise should be postured organizationally to respond quickly and effectively to unanticipated requirements, minimize divisive internal competition within depot organizations, and maximize size and capabilities of the organic workforce. These steps will ensure a reputation for the rapid and scalable application of cutting edge technologies.

4. *Responding to changing resources*—With likely significant resource reductions the depot community must be capable of adjusting to shortfalls without undue reliance on contingency operations funding.
5. *Supporting joint operations and long-term force projection*—The depots must be capable of providing long-term support for overseas in-theater depot sites and onsite multidiscipline teams to meet emerging repair requirements at forward locations.

In terms of depot organizational structures, the study suggests that the DoD cannot deal with underutilized organic capability while continuing to increase outsourcing of depot workload. In addition the study states that a diversified organic workforce requires flexibilty to accommodate changes in required skill sets, employee retirement and attrition levels, and new processes and technologies.

Army Depot Maintanence Enterprise Strategic Plan (2008–2025) (**Headquarters, Department of the Army [HQDA], 2008).** This plan discusses three categories of challenges to the depot maintenance enterprise (DME). The first is the immediate short-term challenge of supporting Reset/Army Force Generation to support an Army at war, which requires the DME to reset equipment as quickly as possible so it is available for training the next deployers. The next challenge is to ensure that core capabilities are established and sustained. This intermediate challenge (FY10–15) centers on how the DME will reduce current production levels while retaining the ability to meet surge requirements in the future. The final challenge was to ensure life-cycle readiness by modernizing the depot enterprise's capabilities to keep current with technology so that the DME can support the sustainment of future equipment and weapon systems. It goes on to say that to meet this longer term challenge the DME must pursue initiatives to provide life-cycle support more efficiently. Although condition-based maintenance,

value-stream analysis, and public-private partnerships are the initiatives discussed specifically in the document, the concept of repurposing depot skill sets at TYAD to focus on more advanced PPSS activities certainly could be envisioned as a step in addressing this longer term challenge.

Critical Analysis

The vast majority of the literature uncovered for this research topic was of a Defense, or a Defense-sponsored, variety. These references provide key background into the current state of challenges for organizations such as SEC and TYAD, and potential paths forward to address these strategic challenges.

The overall diverging trends in software and hardware maintenance at SEC and TYAD were supported by the government briefings and papers (C4ISR Center of Excellence, 2014; CECOM SEC, 2013; CECOM SEC, 2014a; U.S. AMSAA, 2014), while the current focus of the commercial electronics industry, and its effects on Defense electronics and sustainment, was well established in the Australian report by O'Dowd (2010). One element of O'Dowd's report did counter the initial hypothesis that the increasing reliability of commercial electronics components and assemblies is a factor in the reduced amount of hardware maintenance required of Defense electronics. In fact O'Dowd's report implied that the commercial sector is designing for minimal reliability margins in their products to achieve only the initial warranty period, since the commercial customers expect upgraded hardware as well as software when additional capabilities are released. Although the reliability assumption was counter to the initial hypothesis regarding increased hardware reliability, the fact that the commercial consumer expects upgraded equipment on a regular basis does support the trend of the increasingly consumable nature of consumer electronics equipment.

The references that addressed the future of the organic depot (HQDA, 2008; LMI, 2011) provided key insights and confirmed current trends. These references recognize an upcoming challenge for organic depots with reductions in OPTEMPO and corresponding defense budget constraints. Both documents focus on the future capabilities and capacities of the depot enterprise in this environment and promote a modernization in facilities and capabilities in response. Implementing new initiatives to upgrade technologies, processes, and the skill sets of the workforce were specifically recommended. These strategic concepts support the notion of this paper that transitioning the TYAD workforce to support software sustainment support is in the best interest of the DME.

Conclusion of Literature Review

Although the literature was fairly convincing in terms of the current trends in the commercial electronics and Defense sustainment enterprises, it did not address the feasibility of a strategic shift in maintenance at TYAD, nor the potential benefits or challenges of such a shift. Hence the survey used for this study was designed to try to address the feasibility, benefits, and challenges of such a paradigm shift in maintenance focus. This included many open-response questions to allow the survey respondents to provide direct narrative feedback.

Chapter 3 – Research Methodology

The purpose of this study was to assess the current and future trends in communications and electronics sustainment, both hardware and software, and determine whether there is divergence of these trends. In addition, if divergence was found, the study would assess a potential paradigm shift in maintenance focus at TYAD to support a more software-specific sustainment mission in support of SEC. This assessment would address the feasibility, benefits, and challenges of such a strategic shift.

To address the diverging hardware and software sustainment trends, the study used a quantitative approach in analyzing historical maintenance data at TYAD and SEC as well as projections for the foreseeable future. This data was be supplied by TYAD and SEC, as well as from the AMSAA, and analyzed to ascertain the extent of the pending issue.

To address the feasibility, benefits, and challenges with a potential corrective course of action, including a paradigm shift in maintenance focus at TYAD to support SEC, the study used a qualitative survey instrument. Utilizing the SurveyMonkey (www.surveymonkey.com) online survey tool, a survey was designed to capture perceptions from key senior logisticians, managers, sustainers, and program managers with the most knowledge of the sustainment operations of TYAD, SEC, and the Army depot enterprise. The survey was distributed to targeted populations, including project managers, logisticians and senior managers, within AMC Headquarters, CECOM Headquarters, CECOM SEC, TYAD, PEO C3T, PEO IEW&S, and PEO EIS.

Every attempt was made to reduce the bias in the design and distribution of the survey. The design of the survey included a demographics section, and sections focused on the maintenance trends of military communications and electronics equipment, and the feasibility, benefits, and challenges of using TYAD resources to supplement SEC workload. The survey

utilized a limited 5-point Likert scale to gain relative agreement or disagreement from respondents regarding the perceived trends, as well as the feasibility, benefits, and challenges of the course of action. This provided some element of numerical data to verify or reject the hypothesis and support statistical analysis of the responses of different respondent populations. In addition the survey was designed to allow open-response answers for the sections on feasibility, benefits, and challenges, as well as a final open-response question where the respondent could supply any additional information or perspectives relevant to the study.

The distribution of the survey targeted those organizations and particular subject matter experts who could provide the most relevant feedback and minimize the undercoverage bias. Since the survey was distributed from headquarters elements at each organization, the number of responses by organization was out of the author's control. The final response of 74 respondents, based on the limited number of subject matter experts with direct knowledge of this topic, provides a sample size sufficient to have relatively high confidence in the data, supports statistical analysis of respondent population sets, and reduces nonresponse biases.

Research Hypothesis

For this research project the hypothesis is that a hardware-to-software maintenance paradigm shift at TYAD, in support of SEC PPSS requirements, is feasible and will ultimately provide benefits and efficiencies for CECOM, AMC, ASA(ALT) and the U.S. Army while improving the ability of CECOM to comply with Title 10 50/50 mandates (10 USC 2466) and provide more effective support to CECOM customers.

Research Process

The research process was initiated through direct conversations with senior leadership at CECOM, SEC, and TYAD. These conversations set the background for the study topic, provided

initial perceptions of the problem set based on their vast experience, and considered several possible courses of action that may begin to address the problem set in the future. From this point of departure, literature research was conducted to investigate the topic further to uncover academic, military institution, and industrial perceptions of the topic. From this literature research the overall framework for the study was derived, including a focus on assessing hardware and software maintenance trends at TYAD and SEC respectively, and investigating the feasibility, benefits, and challenges with repurposing elements of the TYAD workforce to support SEC PPSS requirements.

Data Collection

The data collection process for the study consisted of several steps to obtain sufficient data required for analysis. The first step was to request and obtain historical and projected workload and workforce data from TYAD, including work-year expenditures by system and workforce demographics. The next step was to request the same historical and projected workload data from SEC by software maintenance type. The final step was to use a survey to collect perceptions and narratives regarding the study hypothesis from relevant subject matter experts.

Chapter 4 – Findings

The objective of this research is to verify diverging hardware and software maintenance trends at SEC and TYAD, and assess the feasibility, benefits, and challenges of retooling the TYAD workforce to support the SEC software maintenance mission. The first section of this chapter will present the workload and resource trends of TYAD and SEC, while the following section will provide the results of the survey.

The survey results will include a summary of demographics, a presentation and summary of the resultant statistics from the respondents by question, and a discussion of the narrative responses received to the open-ended questions, which were designed to get direct input from the respondents.

Maintenance Trends

To investigate the first research question and determine whether diverging trends in hardware and software maintenance demands for communications and electronics equipment are valid, data was collected from multiple sources and analyzed. Data sources included SEC, TYAD, AMSAA, and other sources uncovered during the literature research process. The purpose of this analysis was simply to determine whether software and hardware maintenance requirements were diverging, and to what extent. The intent was to investigate higher-level rollups of maintenance labor requirements, both historical and forecasted, to answer research question1 and validate the need for CECOM to consider a paradigm shift in how software maintenance is conducted within the command.

During the initial literature review, data was uncovered that described the nature of the increased complexity of software coding over time in terms of the lines of code and the number of functions performed by software in systems. This graph, which was developed by CECOM

and NAVAIR and presented at the 2012 DoD Maintenance Symposium (DoD, 2012), is presented in Figure 1. It shows the linear growth in software-based functionality over time and

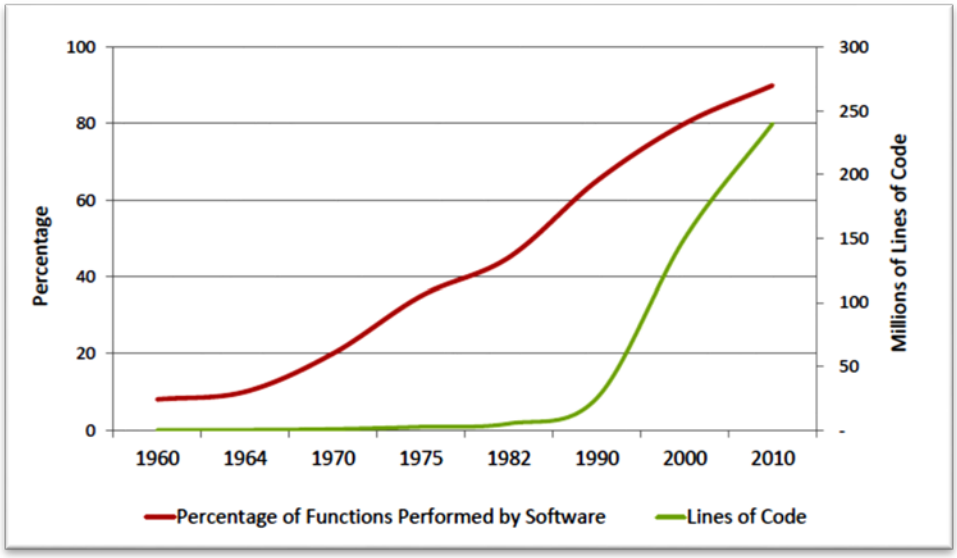

Figure 1 – Software Trends Over Time
(Source: Adapted from DoD, 2012, p. 5)

the exponential growth in lines of code since the early 1990s. Although this graph presents these software characteristics in general terms, there is every indication that these trends would certainly apply to Army communications and electronics equipment, that they will continue into the foreseeable future, and that have a positive correlation with increasing the complexity of software maintenance.

The literature research also uncovered historical and forecasted software maintenance data for both the DoD and the Army. Again the source was from the 2012 DoD Maintenance Symposium (DoD, 2012). Figure 2 displays DoD and Army-specific software maintenance resource requirements since 2010 and forecasts those requirements, based on Program Objectives Memorandum 2014 PB-45 data, through 2018. The increasing trend in software maintenance

requirements is very evident, as well as the overall reliance on contract support across the DoD to sustain our defense electronics.

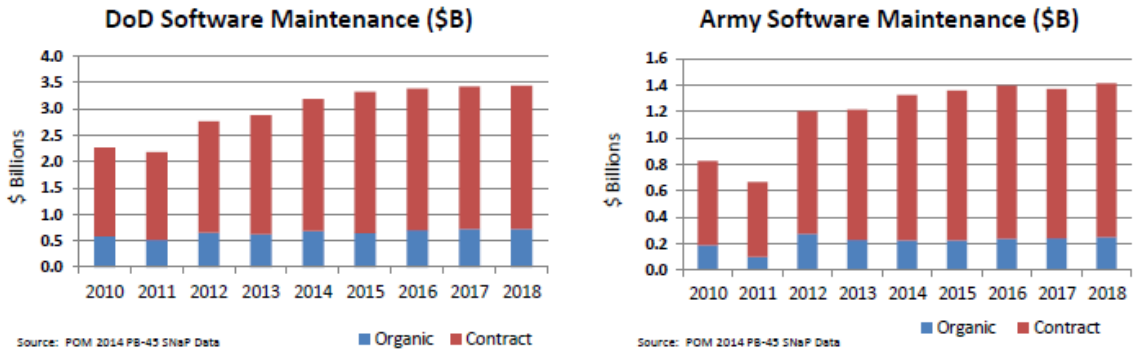

Figure 2 – DoD and Army-Specific Software Maintenance Resource Requirements Trends
(Source: Adapted from DoD, 2012, p. 7)

This data source adds credibility to the initial problem statement and answers part of research question 1 in terms of actual DoD and Army software maintenance resource requirements trends.

To obtain more relevant data to address the specific hardware and software maintenance trends within CECOM for communications and electronics systems, maintenance execution and projected requirements data was requested from TYAD and SEC for the period FY12–20. In addition, elements of the data used in the 2014 U.S. AMSAA study were reviewed to verify trends.

The data supplied from TYAD included execution data, in terms of hardware maintenance DLHs and associated monetary orders for TYAD support from 2004 through 2014 and projections for 2015 and 2016. This data included a rollup of all TYAD functions conducted on C4ISR equipment, including overhaul, repair, fabrication, technical assistance, and other functions. Of these functions, overhaul and repair were confirmed from TYAD sources to

generally account for 55–60% of TYAD's DLHs, depending on the year. Therefore, for the purposes of this study and to determine hardware sustainment-specific trends, 60% of the yearly total of DLHs and orders were assumed to be directly associated with communications and electronics sustainment activities.

Data supplied by SEC included software sustainment execution data, in work-years, from 2014 and projected FY15 execution data and Program Objectives Memorandum FY16–20 requirements by system and maintenance function. The FY15 data accounts for a net of 10 new communications and electronics systems entering PPSS during FY15 alone, and the projected requirements-data accounts for a net of 16 new systems that will be entering PPSS during this period.

The historical executed resources and forecasted resource requirement data, from both TYAD and SEC, are plotted together in Figure 3. The TYAD data simply show resources (in DLHs) for overhaul and repair (again ~60% of their total expenditures) over time, while the SEC data show the data for all labor PPSS functions, in work-years, delineated by contractor versus Government execution.

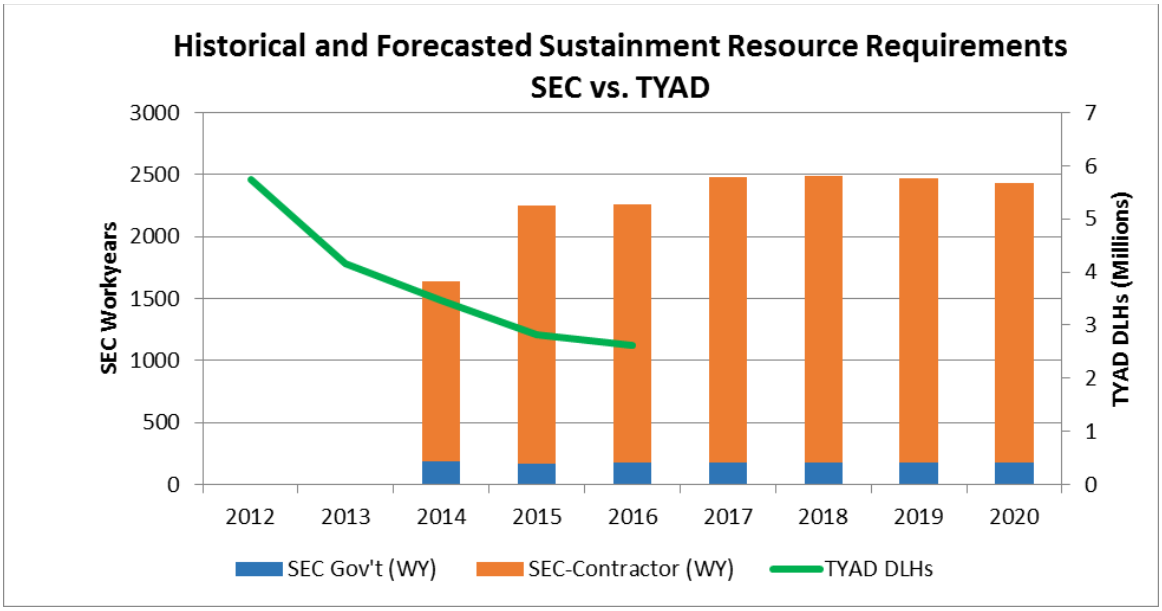

Figure 3 – Comparisons of TYAD and SEC Sustainment Trends

The diverging trends initially uncovered in the literature review are very evident in the above graph, and they correlate with the overall DoD and Army PPSS trends, thus providing validity to the initial problem statement and answering research question 1. In addition the continuing significant reliance of SEC on contractor labor to support increasing requirements into the future is very evident in this data.

Survey Results

As previously mentioned the survey instrument was used to capture the relevant communities' perspective on the feasibility, benefits, and challenges of a paradigm shift in maintenance focus at TYAD to support SEC. In addition to collecting demographic data for each respondent, the survey used a 5-point Likert scale (strongly agree, agree, neutral, disagree, or strongly disagree) to attain their level of agreement to statements regarding maintenance trends and the feasibility, benefits, and challenges of implementing the subject paradigm shift in maintenance focus at TYAD. The respondents were also given the opportunity to provide narrative responses to several questions. This section will present the demographics of the

respondents and the results of each Likert-scale and open-ended question, including the relevant statistical analysis for each Likert-scale question. The complete structure of the survey instrument, as experienced by the respondents, can be found in Appendix D.

Demographics. Questions 1–5 of the survey were intended to capture the demographics of the respondents. A summary of that data follows. The vast majority of respondents to the survey were from SEC, as shown in Table 1. Other significant contributors were from affected PEOs and Project Manager/Product Manager (PM/PdM) offices, as well as AMC headquarters. Respondents from the "Other" organizations identified their organizations as the Communications-Electronics Research Development and Engineering Center (CERDEC) Software Engineering Directorate (SED) (3), PEO C3T (1), Defense Acquisition University (1), and CECOM SEC EIS (1).

Table 1 – Survey Respondents by Organization

Which of the following best describes your current organization?		
Answer Options	**Response Percent**	**Response Count**
CECOM SEC	39.2%	29
PM/PdM	17.6%	13
HQ AMC	10.8%	8
Other	8.1%	6
PEO Staff	6.8%	5
CECOM TYAD	5.4%	4
HQ CECOM	2.7%	2
HQ DA	1.4%	1
answered question		**68**
skipped question		**6**

The next demographic question of the survey asked about the respondents areas of expertise. As shown in Table 2, the vast majority of respondents have a software maintenance, logistics or program management background. Many of the "Other" respondents indicated that

they were software or systems support engineers, information assurance/system administrators, or cybersecurity experts.

Table 2 – Survey Respondents by Area of Expertise

Please identify your area of expertise?		
Answer Options	**Response Percent**	**Response Count**
Software Maintenance	40.6%	28
Program Management	18.8%	13
Logistics	18.8%	13
Other	14.5%	10
Organic Industrial Base/Depot Maintenance	4.3%	3
Materiel Sustainment Policy	2.9%	2
answered question		**69**
skipped question		**5**

More than 60% of the respondents indicated that they had over 15 years of experience in their area of expertise, and more than 65% were at the GS-14 or 15 equivalent grade levels. The complete set of demographics data can be found in Appendix A.

Collected Data. The survey was designed to address four elements of the study question at hand: verification of the hardware and software maintenance trends, the feasibility of the TYAD workforce supporting SEC, the benefits of this cross-command collaboration, and the challenges of doing so. The questions were specifically designed to address each topic, and narrative responses were allowed for the final three topics. The results of those questions follow.

Question 6: *Please agree or disagree with the following:*

- *Q6a. Military electronics will become increasingly software intensive*
- *Q6b. Software for military electronics assemblies is increasingly becoming more of a maintenance COMPLEXITY driver.*

- *Q6c. Software for military electronics assemblies is increasingly becoming more of a maintenance EFFORT driver.*
- *Q6d. Software for military electronics assemblies is increasingly becoming more of a maintenance TIME driver.*
- *Q6e. Software for military electronics assemblies is increasingly becoming more of a maintenance COST driver.*
- *Q6f. Hardware for military electronics assemblies are becoming more reliable, thus requiring less and less maintenance at the depot level.*

As seen in Figure 4, the vast majority (70-90%) of respondents agreed, or strongly agreed, that military electronics is increasingly becoming more software intensive and that software is becoming a maintenance driver for programs in terms of cost, time, effort, and complexity.

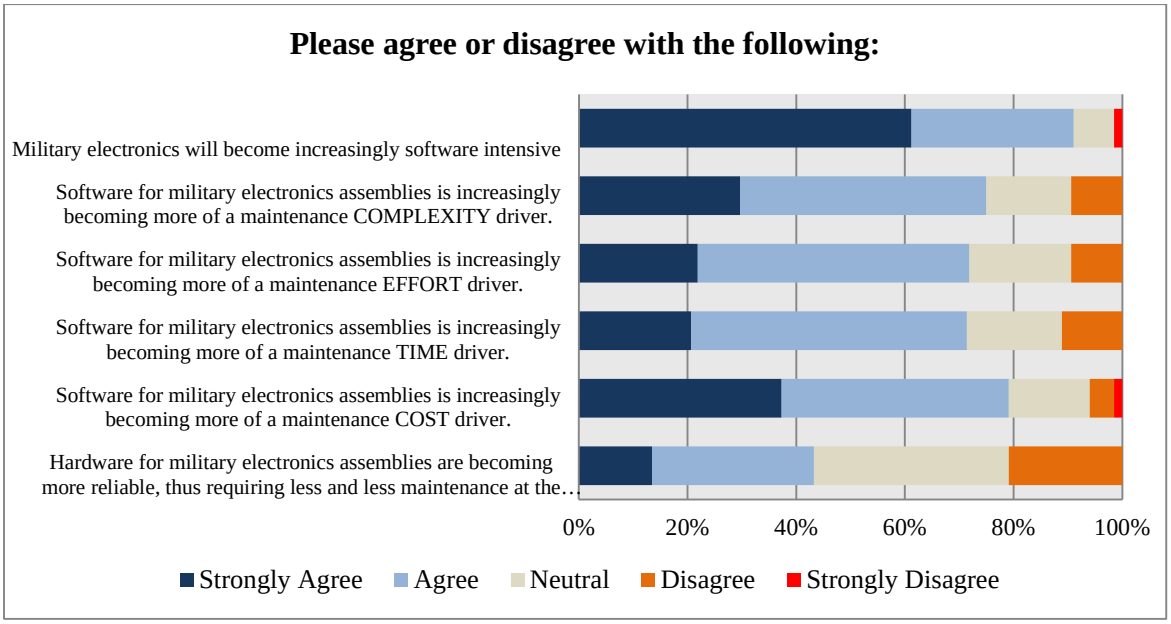

Figure 4 – Survey Response to Question #6

These results are in line with the software maintenance workload trends being reported by SEC. The question regarding hardware maintenance of military electronics assemblies and

their increased reliability was more polarizing in terms of respondents agreeing or disagreeing with this statement. Although more than 40% of respondents agreed to some extent with this statement, a significant number (35%) chose to respond “Neutral” and 21% disagreed. Of those that agreed, 3 of the 4 TYAD respondents responded that they “Strongly Agree” with the statement. These TYAD respondents would be expected to have the most intimate knowledge of trends in this area. This result also aligns with the decreasing hardware maintenance requirements experienced at TYAD and displayed in Figure 3. The results from the TYAD respondents’ answers to this question, along with the TYAD trend data in Figure 3, add some level of confidence to a decreasing hardware maintenance requirement and trend. The polarizing result of this particular question (Q6f) may indicate an unknown in the community as to the validity of such a trend and perhaps lends some credence to the opposite trend as discussed in the report by O’Dowd (2010), which indicates that the consumer electronics industry is actually reducing or not focusing on their reliability margins to focus more on consumable electronics components.

Since the largest group of survey respondents (39.2%) is from SEC, and/or indicated their area of expertise as software maintenance, additional analysis was conducted to determine whether the responses from these populations differed significantly from the rest of the survey respondents. Using the means of the responses to the 5-point Likert scale, a 2-sided *t*-test was conducted to determine whether there were statistical differences, with 90% confidence, in the responses from each population. The complete statistical analysis for each Likert scale question in the survey can be found in Appendix C. The results of the *t*-test for Question 6 indicated that only subquestion f (Q6f) had a statistical difference in results between the SEC respondents and the rest of the respondents. Although both populations tended to agree with the statement, the

SEC population was less confident than the rest of the respondents in agreeing with the statement. This makes sense since SEC respondents would be expected to have less insight regarding hardware maintenance issues than perhaps the other respondents.

Question 7: *The complexity of software maintenance is increasing due to requirements for:*

- *Q7a. IAVA and cybersecurity*
- *Q7b. Incorporating technology advancements or refresh*
- *Q7c. Mission enhancements to support operational needs*

This question was trying to get agreement from the respondents on the underlying requirements that may be driving the increased complexity of software maintenance. As seen in Figure 5, the overwhelming majority of respondents agreed with the assertion that software maintenance complexity is being driven by all three elements: mission enhancements to support operational needs, incorporating technology advancements or refresh, and IAVA and cybersecurity. IAVA and cybersecurity was the one requirement that received the most responses of “Strongly Agree,” almost 60%, perhaps indicating that this particular requirement is a primary maintenance driver. The statistical tests showed no statistical differences in level of agreement among the SEC and software maintainer populations and the rest of the respondents.

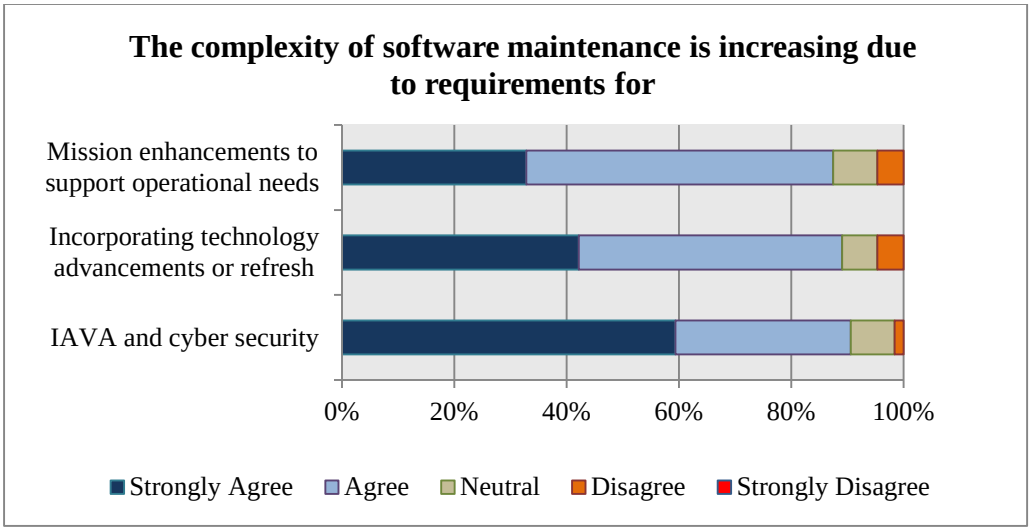

Figure 5 – Survey Response to Question #7

Question 8: *Are there other contributors to the increasing complexity of software maintenance?*

This question was included as an open-response question to allow the respondents to provide direct narrative feedback on what other factors they perceived were contributing to the increasing complexity of software maintenance. The individual responses to this question are displayed in Table B1 (see Appendix B), without edits, for each of the 30 respondents to the question to provide the most unbiased set of raw data. As part of the analysis process, each response was reviewed and categorized according to the primary issue discussed in the narrative. These categories are displayed to the left of the narrative responses. Some responses overlapped several categories, but were assigned to what was felt to be the primary category for the issue discussed in the narrative.

The individual narrative responses to this question fell into four primary categories that contribute to the increasing complexity of Army software maintenance/sustainment: COTS, Data Rights/Licensing, Interoperability, and Design/Baseline Creep. The overwhelming majority of those who responded to this question felt that COTS and data rights/licensing issues drove

sustainment complexity. The respondents felt that the over usage of COTS software drives data rights and licensing issues, costs, and complexity of the sustainment mission. The Interoperability category had comments regarding issues with forward, backward, and cross-platform compatibility requirements and upgrade requirements for outdated systems. Other responses addressed sustainment challenges due to initial software design complexity and baseline creep, requirements for easier human interfaces, and military-specific code requirements (e.g., IAVA).

Question 9: *Post-Production Software Sustainment (PPSS) is most cost-effectively accomplished by:*

- Q9a. A Government/contractor mix tailored to the specific type of software support required
- Q9b. A Government/contractor team composed of mostly organic Government employees
- Q9c. A Government/contractor team composed of mostly contractors.

This question was presented to the survey respondents to try to ascertain whether they ultimately believed that the skills and talent available to accomplish an increasingly complex software sustainment mission was readily available in the Government, or whether they believed that contractors were more suited for this type of work. As seen in Figure 6, less than 40% of respondents agreed, or strongly agreed, that software sustainment work should be done by a team consisting of primarily organic Government employees. In addition less than 20% agreed in some manner that this mission should be done primarily by contractors. In fact nearly 50% disagreed, or strongly disagreed, that contractors should have the primary responsibility for software sustainment. Interestingly, the vast majority of the respondents, over 80%, believed that

software sustainment should be accomplished by a mix of government and contractor employees tailored to the specific type of support required.

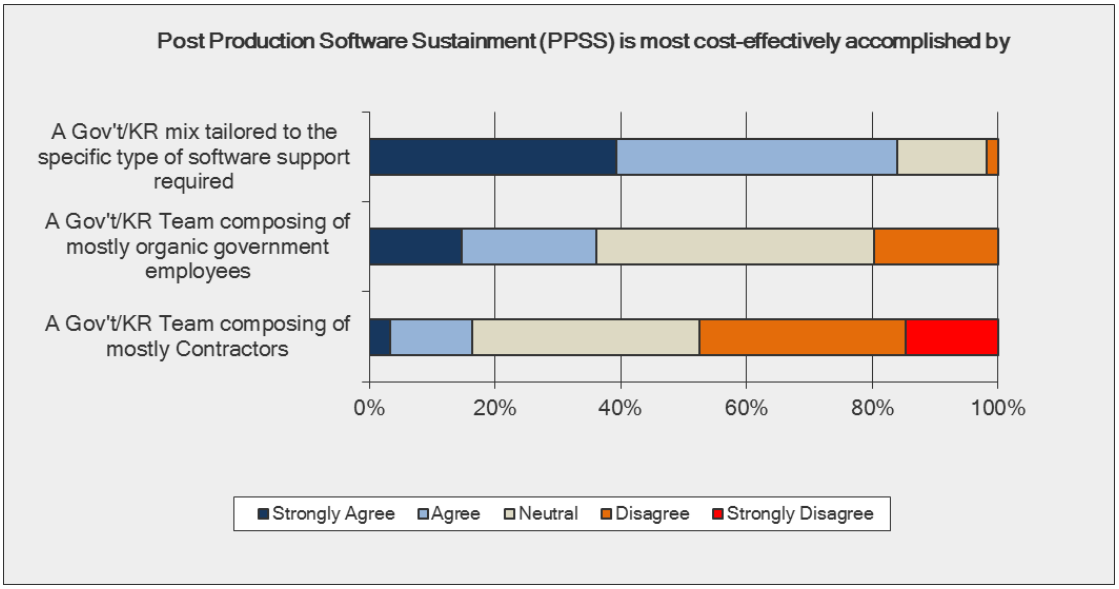

Figure 6 – Survey Response to Question # 9

The results from the statistical analysis (Appendix C) did indicate statistically different Likert-scale means between SEC–software-maintainer responses and the rest of the survey respondent population for Question 9a and 9c. For Q9a the SEC and software-maintainer populations were more likely to agree more strongly that a tailored mix of Government employees and contractors was most appropriate for PPSS, while for Q9c the SEC and software-maintainer populations were more likely to strongly disagree that PPSS should be conducted by mostly contractors.

From these results one cannot discount the idea of using organic Government TYAD employees as part of a Government/contractor team to support the SEC software-sustainment mission. In fact the sense from these results is that using primarily contractors for PPSS is not the most cost-effective course of action, and perhaps the unique organic skills that TYAD could

bring to the software sustainment mission could be valuable based on the specific type of software support required for a particular system.

Question 10: *Please indicate your level of agreement to the following statements:*

- *Q10a. CECOM SEC APG is currently well postured to more efficiently conduct software sustainment for electronics systems if additional government civilian personnel resources are allocated or matrixed to the organization*
- *Q10b. Recruiting software technicians and engineers to work at CECOM SEC APG using TYAD TDA for PPSS is feasible*
- *Q10c. Software maintenance can be effectively performed following the existing hardware-centric depot maintenance process model*
- *Q10d. Tobyhanna Army Depot is currently well postured to take on a more software-focused maintenance role for electronics systems*
- *Q10e. Recruiting software technicians and engineers to work at Tobyhanna Army Depot for PPSS is feasible*
- *Q10f. Transitioning a primarily wage-grade depot workforce from hardware-focused maintenance to software maintenance is feasible*

Question 10 was designed to collect the survey respondents' level of agreement on different elements of the feasibility of continuing the status quo, enhancing the status quo by utilizing TDA from TYAD in the recruitment of employees to work at SEC-Aberdeen Proving Ground (APG), and transitioning TYAD and its employees to support the SEC software sustainment mission.

As seen in Figure 7, the majority of the respondents (approximately 60%) agreed to some degree that SEC-APG is currently well postured to conduct more efficient software sustainment

if additional organic Government resources are provided to support the mission. Only a handful of respondents actually disagreed with this statement. In a related question, more than 60% of respondents agreed to some degree that recruiting appropriate software technicians and engineers to work PPSS at SEC-APG, using the TYAD TDA, is feasible. The majority agreement to these statements indicates a level of qualitative confidence that SEC-APG, in its current business structure and posture, would be effective in using additional organic Government personnel regardless of its source to support its mission.

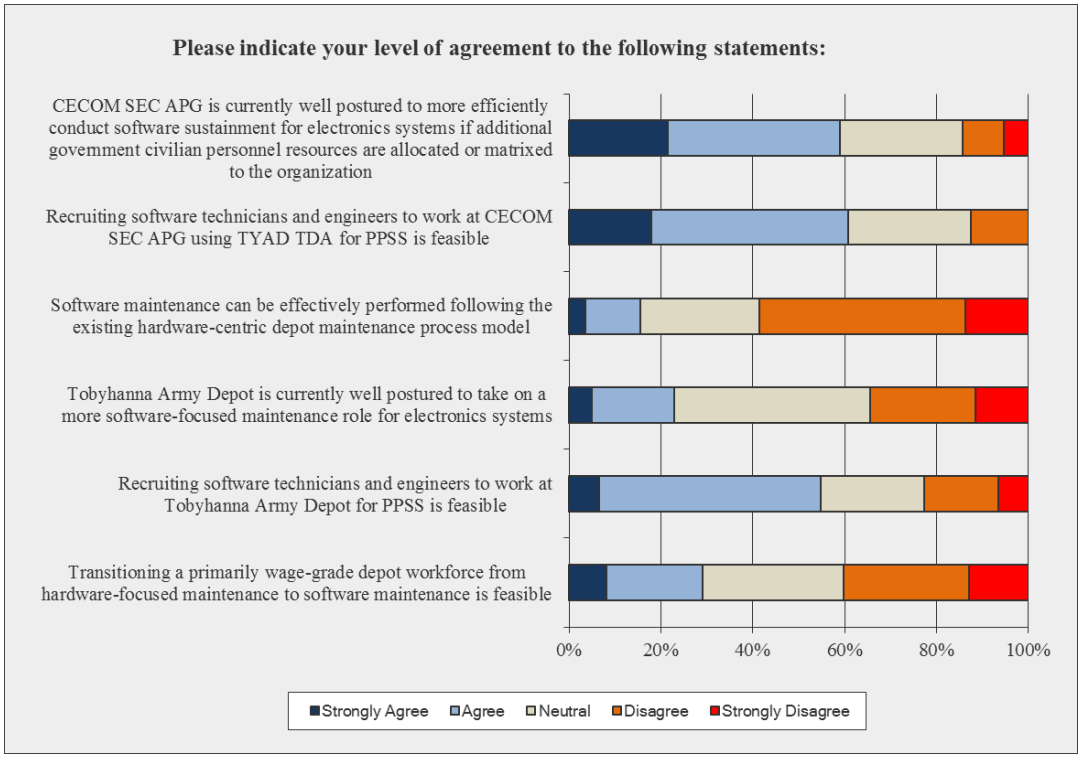

Figure 7 – Survey Responses to Question #10

There was much more disagreement from the respondents that software maintenance could be effectively performed at TYAD following the hardware-centric depot maintenance process model. In fact nearly 60% of the respondents disagreed to some degree with this statement. This perhaps indicates that the business model for TYAD would have to change to

some degree to support cost-effective software sustainment as a line of business. In a related question regarding the posturing of TYAD to take on a more software-focused maintenance mission, the results were more inconclusive as a nearly equal number of respondents agreed, disagreed, or remained neutral when responding to the statement.

For the two questions related to the feasibility of developing or recruiting personnel to support any TYAD PPSS mission, there was some level of agreement on one and an inconclusive result for the other. There was some level of agreement (approximately 55%) that that software technicians and engineers could in fact be recruited to work at TYAD in Tobyhanna, Pennsylvania. This was an interesting result since there were some contacts, presurvey, who speculated that recruiting these skill sets would be a challenge for TYAD due to the geographical separation from software engineering academia and institutions. The respondents were more uncertain regarding the feasibility of TYAD transitioning their wage grade employees from hardware-focused maintenance to software-focused maintenance. Nearly 40% of respondents disagreed to some degree with the statement, nearly 30% agreed to some degree, and 31% chose a neutral response.

The statistical analysis of the mean responses to this question did indicate some level of statistical differences in the level of agreement or disagreement of the SEC and software-maintainer populations versus the remaining respondent population. As shown in Appendix C, statistical differences in the means were found for Questions 10a, and 10c–f. The SEC and software maintainer populations were found to be

- in more agreement than the rest of the population that SEC was well postured to conduct PPSS with additional government resources (Q10a),

- in more disagreement than the rest of the population that PPSS can be conducted effectively using the existing hardware-centric depot maintenance process model (Q10c),
- in significantly more disagreement than the rest of the population in terms of TYAD being well postured to take on a more software-maintenance focus (Q10d),
- in significantly more disagreement than the rest of the population regarding the feasibility of recruiting software technicians and engineers to work at TYAD (Q10e),
- in significantly more disagreement than the rest of the population in terms of the feasibility of transitioning the existing hardware-maintenance-focused, organic, TYAD workforce to be more software-maintenance focused.

Question 11: *Transitioning Tobyhanna Army Depot (TYAD) to be more software maintenance focused, by leveraging the existing organic government workforce at TYAD in lieu of additional contractor support at SEC, will have the following BENEFITS:*

- *Q11a. Supports Title X (50/50) Compliance*
- *Q11b. Reduced Costs*
- *Q11c. Improved maintenance turnaround times*
- *Q11d. Improved throughput*
- *Q11e. More effective implementation of IAVA/Cyber Security across a breadth of C4ISR systems in sustainment*
- *Q11f. Facilitates establishment of in-house/organic technical expertise to perform software sustainment mission*
- *Q11g. Reduces program risk for complex C4ISR systems as service contracts are re-competed*

This survey question was designed to gain respondents' agreement or disagreement on the potential benefits of leveraging the TYAD workforce to support the SEC software-maintenance mission. The questions were designed to be cover topics of command compliance with Title X requirements, cost-effectiveness, human capital, and programmatic risk. Since these topics are not all encompassing of the potential benefits, a follow-up open-response question (Question #12) was used to capture any other potential benefits from the respondent's perspective. As seen in Figure 8, there was a preponderance of agreement from the respondents that Title X (50/50) compliance would benefit from developing a software-sustainment support mission at TYAD, that program risk would be reduced as complex C4ISR system service contracts were re-competed, and the benefit of establishing additional in-house organic software-support expertise was valuable.

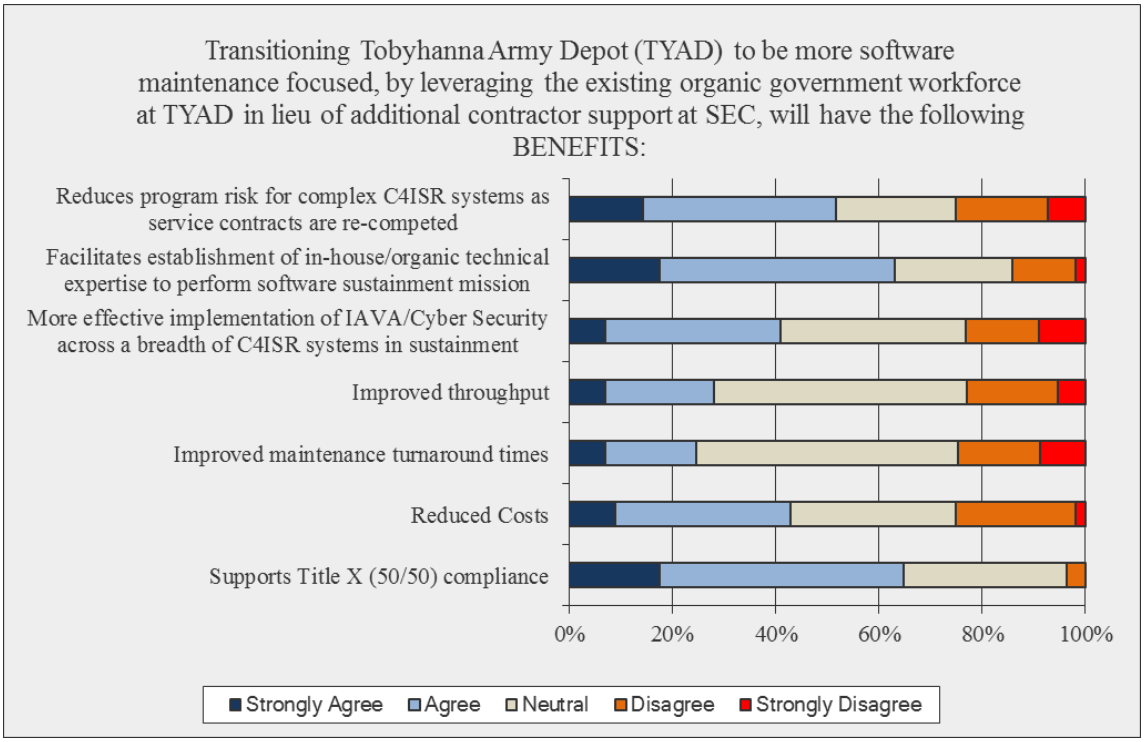

Figure 8 – Survey Responses to Question #11

There was less agreement on the cost-effectiveness benefits. No more than 45% of respondents agreed, or strongly agreed, that there would be benefits in terms of more effective implementation of IAVA or cybersecurity patches, improved throughput, improved turnaround times, or reduced overall costs. The fact that over 50% of the respondents indicated that they were neutral in terms of assessing throughput or turnaround times may indicate that many of the survey respondents felt unqualified to answer those particular questions.

The statistical analysis of this question again revealed some level of differences in mean responses between the SEC and software-maintainer populations as compared to the rest of the survey respondents (see Appendix C). Statistical differences in the means were found for Questions 11a, 11c–e, and 11g. The SEC and software maintainer populations were found to be

- in less agreement than the rest of the survey respondents that compliance with 50/50 mandates would be a benefit (Q11a),
- in more disagreement than the rest of the survey respondents in terms of benefits to turnaround times (Q11c), improved throughput (Q11d), and reduced risk during contract re-competes (Q11g), and
- in significantly more disagreement than the rest of the survey respondents in terms of perceived benefits from more effective implementation of IAVA and cybersecurity measures across the breadth of C4ISR systems while in sustainment (Q11e).

Question #12: *Are there other potential BENEFITS of utilizing and leveraging the organic government workforce at TYAD, and transitioning TYAD to be more software maintenance focused, in collaborative support of increasing CECOM SEC software sustainment requirements?*

This question was another open-response question that allowed the survey respondents to provide a narrative response regarding the potential benefits of leveraging the TYAD workforce in support of the SEC PPSS mission. The individual responses to this question are displayed in Table B2 (Appendix B) for each of the 22 respondents to the question, without edits, to provide the most unbiased set of raw data. As in every open-response question on the survey, the responses were reviewed and categorized according to the primary issue discussed in the narrative. These categories are displayed to the left of the narrative responses.

The vast majority of the 22 respondents who answered the question provided narratives that focused on benefits associated with the potential efficiencies to CECOM and the depot enterprise as a whole. The respondents mentioned potential efficiencies such as combining hardware and software field support representatives/FSEs for given programs, the ability to leverage other depots through a materiel enterprise approach, coordinated hardware and software maintenance actions for given systems, and more efficient distribution of software. In addition, several of these respondents also mentioned risk reduction benefits as well. More specifically the ability to maintain a more stable and technically capable organic workforce to surge support as needed in the future and fill gaps when specific support contracts are re-competed. In addition, two respondents emphasized that it made sense, and could provide benefits, to leverage the existing hardware maintenance knowledge base at TYAD.

Question 13: *Transitioning Tobyhanna Army Depot (TYAD) to be more software maintenance focused, by leveraging the existing organic government workforce at TYAD in lieu of additional contractor support at SEC, will have the following CHALLENGES:*

- *Q13a. Using the Army Working Capital Funding model for software sustainment*
- *Q13b. Developing appropriate facilities*

- *Q13c. Re-training wage-grade employees*
- *Q13d. Recruiting software career fields*

In order to be fair and gain a complete understanding of the concept being proposed, this question concentrated on the potential challenges in transitioning TYAD to be more software maintenance focused. The statements aimed at getting a level of agreement or disagreement on challenges with utilizing the AWCF, developing facilities at TYAD to support PPSS, and retraining or recruiting employees at TYAD. The survey responses to these specific challenge statements appear in Figure 9.

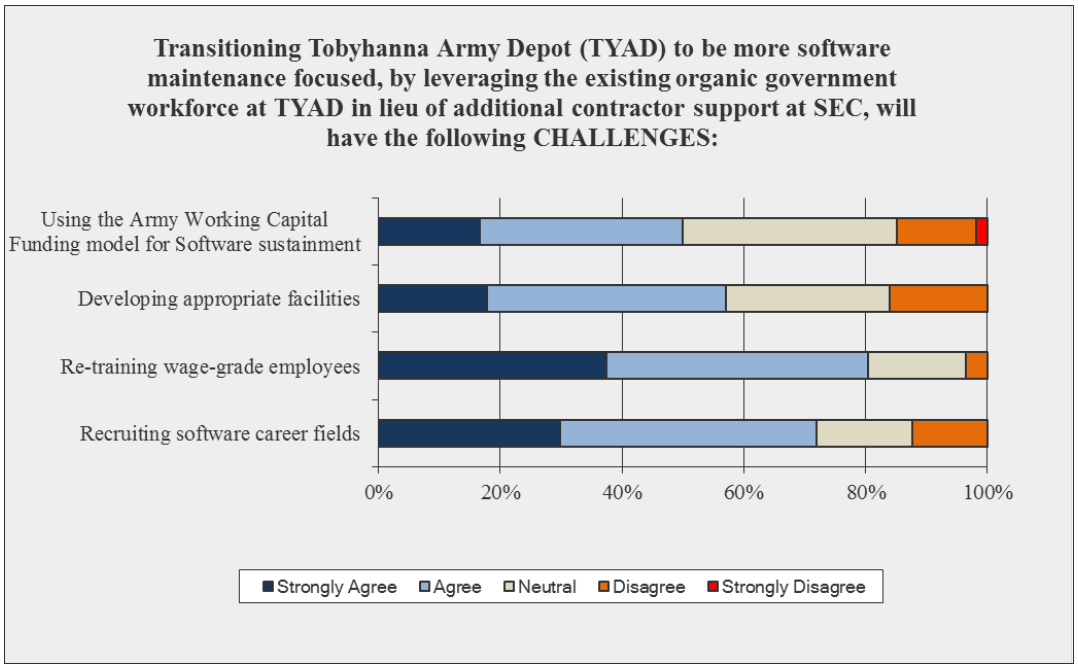

Figure 9 – Survey Response to Question #13

In terms of using the AWCF model for software sustainment, the respondents generally agreed to some degree (approximately 50%) that this model would be a challenge, while nearly 30% were neutral, and less than 20% disagreed. An additional percentage of respondents (nearly 60%) agreed to some degree that developing appropriate facilities at TYAD to support this

mission would be a challenge. In terms of retraining wage grade employees at TYAD to support software sustainment mission of some sort, the vast majority of respondents (80%) agreed to some degree that this would be a challenge. In fact nearly 40% responded that they "Strongly Agreed" that this would be a challenge. The respondents also were in general agreement that recruiting software career fields to TYAD would be a challenge. Nearly 72% of the respondents agreed to some degree with this being a challenge, including 30% who strongly agreed. This result is interesting because in Question 10 over 50% of the respondents agreed that recruiting software professionals to TYAD was feasible. Hence these results suggest that recruiting software professions to work at TYAD may be feasible, but not without challenges.

The statistical analysis of this question revealed differences in mean responses between the SEC and software maintainer populations as compared to the rest of the survey respondents for only one question (Appendix C). Statistical differences in the means were found only for Question 13b, in which the SEC and software maintainer populations were more agreeable than the rest of the population in terms of TYAD being challenged to develop appropriate facilities to support PPSS. No statistical differences were found in the response means for Questions 13a, c, or d.

Question 14: *Are there other potential CHALLENGES of utilizing and leveraging the organic government workforce at TYAD, and transitioning TYAD to be more software maintenance focused, in collaborative support of increasing CECOM SEC software sustainment requirements?*

This was another open-response question that allowed the respondents to provide narrative answers. The individual responses appear in Table B3 (Appendix B), without edits, for each of the 22 respondents to the question to provide the most unbiased set of raw data. Each

response was reviewed and categorized according to the primary issue discussed in the narrative, and these categories are displayed to the left of the narrative responses. As in the other open-response questions, some responses overlapped several categories, but were assigned to what was felt as the primary category for the issue discussed in the narrative.

The responses to Question # 14 fell into six primary categories: Costs/AWCF, Education/Training, Geographical Separation, Human Capital, Loss of Flexibility, and Readiness. The respondents in the Costs/AWCF category emphasized the perception of challenges with using the AWCF business model and cost of the overhead requirements for the software sustainment mission, as well as the costs of establishing capability at TYAD. Those respondents in the Education/Training category, which was the most referenced category, emphasized the challenge with training and certifying the existing TYAD workforce to accomplish an ever more complex software sustainment mission. The remainder of the responses focused on the challenges of creating inefficiencies due to the geographical separation of SEC and TYAD, the recruitment and sustainment of the human capital qualified to conduct the software sustainment mission, and concerns with the loss of flexibility and readiness as fewer contractor employees are used to conduct PPSS.

Question 15: *Are there any other secondary or tertiary effects on existing processes, procedures, people, materiel, equipment, or facilities (that may not be intuitively obvious) if Tobyhanna Army Depot were to take on this Post Production Software Sustainment (PPSS) mission by leveraging existing government employees in support of increasing CECOM Software Engineering Center (SEC) software sustainment requirements*?

This final question was designed to capture from the respondents any and all additional secondary or tertiary effects of transitioning TYAD to support the SEC PPSS mission. The intent

here was to try to uncover issues that may not be readily apparent at first glance. The individual responses are displayed in Table B4 (Appendix B), without edits, for each of the 15 unique responses to the question to provide the most unbiased set of raw data. Each response was reviewed and categorized according to the primary issue discussed in the narrative, and these categories are displayed to the left of the narrative responses.

The responses to this question identified potential effects of this concept in the following areas: cooperative processes and procedures, costs of establishing the capability, business costs, effects on contractors, potential customer effects, and human capital effects. In terms of processes and procedures, the concern was with the effects on existing cooperative relationships (e.g., CECOM/CERDEC) and establishment of new processes/procedures that would work for the TYAD workforce. Several respondents also noted that PPSS mission effectiveness could suffer during the transition phase as TYAD is trained, processes and procedures are established, and contracts are eliminated. The elimination of contract positions also was a concern for several respondents as they noted that congressional pressures may increase and the institutional knowledge of contract personnel with specific units or systems may be too valuable to replace. One respondent thought that the customer base (e.g., program managers) might look to alternative sources for support if the business model of TYAD creates less than cost-effective PPSS solutions. The example described a local C4ISR system program manager at APG who might seek support from CERDEC in lieu of CECOM if significant challenges manifested themselves, or inconvenience was realized, during the establishment of the PPSS mission at TYAD. The final category of potential effects dealt with the human capital at both SEC and TYAD. Respondents identified an aging, retirement-eligible workforce that may hinder

necessary institutional knowledge transfers, and the potential increase in turnover rates of newly trained younger employees moving to more lucrative external positions.

Chapter 5 – Conclusions and Recommendations

This research paper examined the diverging trends associated with hardware and software maintenance of Army communications and electronics equipment. It also assessed the feasibility, benefits, and challenges with CECOM using a hardware-maintenance-focused organic TYAD workforce to supplement the SEC software-maintenance-focused contractor workforce to meet increasing PPSS demands, in lieu of adding more contractor support. Per the initial literature research, this conceptual paradigm shift in how the TYAD enterprise is used within CECOM to support PPSS requirements appeared to have some merits. This research study was designed to explore those merits, uncover the associated potential challenges, and provide a launching point for a cost-benefit study to further investigate and quantify the cost-effectiveness and risks with this concept.

The analysis of the available maintenance requirement trend data and the resultant data from the implementation of the survey appear to support the research hypothesis. The data support diverging hardware- and software-maintenance requirements for Army communications and electronics equipment at TYAD and SEC respectively. The increasing PPSS requirements at SEC, when combined with the heavy use of COTS software by the acquisition community and ongoing restrictions on organic Government resources at SEC, have created a heavy reliance on the use of contractors to supplement the organic workforce for PPSS. The literature review indicated that this phenomenon has created a challenge for CECOM to meet 50/50 mandates and, with impending reductions to OCO funding to support increasing PPSS requirements at SEC, CECOM will also be challenged with supporting PPSS in a cost-effective manner.

One take-away from the survey was that it provided some level of confidence, from those that know hardware and software maintenance of communications and electronics systems the

best, in the diverging hardware- and software-maintenance trends and some rationale for the trends. Respondents in the survey overwhelmingly agreed that software was becoming increasingly complex and more prominent in military electronics systems, and hence was an effort, time, and cost driver in terms of PPSS. In addition the respondents believed that PPSS was becoming more complex because of requirements for IAVA and cybersecurity, the pace of refresh requirements, and the need for mission enhancements due to recent OPTEMPO in OCO. The narrative responses to the survey also uncovered the following PPSS complexity and resource drivers:

- Over usage of COTS software and associated data rights/licensing issues
- Forward, backward, and cross-platform compatibility requirements
- Upgrade requirements for outdated platforms
- Initial software design complexity and baseline creep
- Requirements for easier human interfaces
- Military-specific code requirements

These survey results, along with the data analysis and insights from the literature review, confirmed that diverging trends in software and hardware maintenance along with resource restrictions at SEC in terms of TDA restrictions and reduced OCO funding, suggest a need for a paradigm shift to more cost-effectively execute PPSS within CECOM.

The other significant value of the survey was that it provided key insights into the feasibility, benefits, and challenges with retooling TYAD to support PPSS, thus helping to answer research questions 2 and 3. In terms of addressing the feasibility of “retooling” the TYAD workforce to accomplish some element of the PPSS mission in support of SEC, the survey respondents were in general agreement that recruiting appropriate critical PPSS job series

to work at TYAD was feasible. Yet the respondents generally disagreed that TYAD was currently well postured to take on this new mission and were pessimistic that the business model currently being used for hardware maintenance could be effective for the PPSS mission. The majority of the respondents also did not believe that simply transitioning (e.g., retraining) the current TYAD workforce, which is currently hardware-maintenance focused, to execute PPSS was feasible. In fact the respondents were for the most part in more agreement that the SEC itself, given certain privileges, was in a better position to support the increasing PPSS mission. Those additional privileges included additional TDA allocations to SEC directly and/or recruiting software maintainers using TYAD's TDA to work at SEC-APG, as well as the flexibility to apply the appropriate mix of DACs and contractors tailored to specific PPSS requirements. Based on these survey responses one could conclude that retooling TYAD employees to conduct the PPSS mission in support of SEC may be feasible, but doubts about the readiness and capability of TYAD to conduct this mission exist. The survey results indicated that other options for creatively utilizing the flexibility of the TYAD hiring authority to support SEC in other capacities are perhaps just as feasible and should be explored.

In terms of the potential benefits of using TYAD to support the SEC PPSS mission, the survey respondents generally agreed that the following would be benefits derived from this concept:

- Improves ability for CECOM to comply with 50/50 mandate
- Establishes a more adept in-house organic PPSS capability
- Reduces program risks as service contracts are re-competed (i.e., reduced chance of lapses in support capability)

What the survey respondents were less certain about were benefits in terms of more effective IAVA/cybersecurity implementation across systems, improved throughput, turnaround times, or cost savings. In the narrative responses, the survey respondents also provided some additional potential benefits, including the following:

- Improved efficiencies and value added for AMC sustainment efforts
- Reduced risk through a more stable and capable organic workforce
- Leveraging the extensive electronics background/experience of TYAD workforce for more effective PPSS

From these survey responses there appear to be specific potential benefits to implementing PPSS at TYAD, but a detailed cost-benefit study is probably necessary to uncover whether any of these benefits outweighs the potential risks to implementing it.

Concerning the challenges with implementing a supportive PPSS mission at TYAD, the survey respondents agreed that there were plenty. In particular the respondents overwhelmingly agreed that they perceived retraining wage grade and GS employees at TYAD to work PPSS, and/or recruiting software sustainment career fields to work at TYAD, would be a challenge. In the open-response section of the survey regarding other perceived challenges with implementing the PPSS concept at TYAD, the respondents provided the following potential challenges:

- The costs of implementing/maintaining the initiative, in terms of education/training and certifications for TYAD employees
- The cost-effectiveness in using the AWCF business model for PPSS
- Geographical separation of TYAD from SEC-APG
- Loss of flexibility, readiness, and the advanced capability achieved through the use of the contractor PPSS workforce

The respondents' perceived challenges were not surprising, and they again lead back to the need to conduct a detailed cost-benefit study to determine the extent to which the risks associated with each challenge weigh against potential benefits.

Recommendations

The tightening fiscal environment across the DoD, including the elimination of OCO funding as the OPTEMPO of the military is reduced, dictates that Army commands and activities take a hard look at how their units conduct business to determine whether there are opportunities to become more cost-effective. Meanwhile in the communications and electronics world, evidence suggests that electronics systems will continue to become more software intensive and that maintenance trends at TYAD and SEC are diverging. When the resource pressures are considered in conjunction with these trends, a golden opportunity is exposed for CECOM to investigate whether a more unified, collaborative, and organic communications and electronics depot concept would be effective.

Evidence from this study, as well as from previous CECOM studies, has demonstrated potential benefits to implementing elements of this more collaborative CECOM depot concept. For instance the CECOM-initiated studies suggested that significant cost savings could be obtained if contractors were converted to DACs, specifically for FSE support, CAT I/II fixes, and IAVA support. What has not been fully investigated, other than some cursory evidence from this study, is what the overall effectiveness of the TYAD PPSS concept would ultimately be for CECOM and CECOM's customers when the risks and challenges are weighed against the benefits in their entirety. Hence, as previously mentioned throughout this paper, the primary recommendation from this study is for CECOM to conduct a follow-on cost-benefit analysis (CBA) study. Although some narrowly focused CBAs have been conducted on elements of this

concept, the evidence from this study suggests the concept is feasible and provides more specific elements of the concept to explore. Therefore the recommendation is to take a deep dive into specific elements and concepts through a CBA to include a complete assessment of the risks, both short- and long-term. Based on evidence uncovered in this study, the follow-on CBA should focus on the following aspects of the "unified organic depot" concept:

- Utilize existing pilot projects where TYAD is taking on a limited supportive PPSS role (e.g., FSE support or IAVA support to the Multiplexor Integration and Digital Communications Satellite Subsystem Automation System) as a model to explore costs (facilities, training, etc.) and benefits (e.g., throughput/turnaround times/follow-on CAT I-Vs), risks, and training requirements.
- Explore the use of the AWCF business model for PPSS through several case studies.
- Compile assessment of currently available critical job series.
- Explore hybrid concepts (TYAD employees at APG, TYAD TDA at APG, etc.).
- Characterize the risks of impending contract re-competes and the potential value added of more organic-based PPSS concepts.
- Survey the TYAD workforce to understand interest/desire for training re-certifications and determine the time required to do so.

This paper investigated whether there is an opportunity for the CECOM to use the hardware-maintenance-focused, organic, TYAD workforce to supplement the SEC software-maintenance-focused contractor workforce, in lieu of SEC adding more contractor support. This paper also presented findings regarding diverging hardware- and software-maintenance trends at TYAD and SEC respectively, and an assessment of the feasibility, benefits, and challenges of such a functional realignment of maintenance responsibilities. The results indicate that this

paradigm shift in software maintenance responsibilities is perceived as feasible and does have some beneficial aspects, but not without some clear challenges that require additional investigation.

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Glossary of Acronyms and Terms

APG.....Aberdeen Proving Ground

AMC .....Army Materiel Command

AMSAA .....Army Materiel Systems Analysis Agency

ASA(ALT) .....Assistant Secretary of the Army (Acquisition, Logistics and Technology)

AWCF.....Army Working Capital Fund

BCA .....business case analysis

C3T .....Command Control Communications-Tactical

C4ISR.....Command, Control, Communications, Computers, Intelligence, Surveillance and Reconnaissance

CAT.....Category (or level of software fix, e.g., I–V)

CBA .....cost-benefit analysis

CECOM…….Communications and Electronics Command

CERDEC.....Communications-Electronics Research Development and Engineering Center

COA .....course of action

COTS .....commercial off the shelf

DAC .....Department of the Army civilian

DLH .....direct labor hour

DME.....depot maintenance enterprise

DoD.....Department of Defense

EIS.....Enterprise Information Systems

FY .....fiscal year

FSE.....field service engineer

GS .....General Schedule

HQDA.....Headquarters, Department of the Army

IAVA.....Information Assurance Vulnerability Alert

IEW&S.....Intelligence Electronic Warfare & Sensors

ISRD .....Intelligence, Surveillance, and Reconnaissance Directorate

JASR .....Joint Acquisition Sustainment Review

OCO .....Overseas Contingency Operation

OPTEMPO.....operational tempo

PdM.....Product Manager

PEO.....Program Executive Office

PM.....Project Manager

PPSS.....Post-Production Software Support

SEC .....Software Engineering Center

TDA .....Table of Distribution & Allowances

TYAD .....Tobyhanna Army Depot

USC.....United States Code

Appendix A – Demographics Data

Which of the following best describes your current organization?		
Answer Options	**Response Percent**	**Response Count**
HQ DA	1.4%	1
HQ AMC	10.8%	8
HQ CECOM	2.7%	2
CECOM SEC	39.2%	29
CECOM TYAD	5.4%	4
PEO Staff	6.8%	5
PM/PdM	17.6%	13
Other (please specify)	8.1%	6
answered question		68
skipped question		6

Please identify your area of expertise?		
Answer Options	**Response Percent**	**Response Count**
Materiel Sustainment Policy	2.9%	2
Program Management	18.8%	13
Logistics	18.8%	13
Organic Industrial Base/Depot Maintenance	4.3%	3
Software Maintenance	40.6%	28
Other (please specify)	14.5%	10
answered question		69
skipped question		5

How many years of experience do you have in your area of expertise?		
Answer Options	**Response Percent**	**Response Count**
0-5	4.3%	3
6-10	15.9%	11
11-15	17.4%	12
>15	62.3%	43
answered question		69
skipped question		5

What is your current Rank/Grade?		
Answer Options	**Response Percent**	**Response Count**
O-3/GS-12 or equivalent	2.9%	2
O-4/GS-13 or equivalent	22.9%	16
O-5/ GS-14 or equivalent	25.7%	18
O-6/GS-15 or equivalent	40.0%	28
GO/SES	1.4%	1
Other (please specify)	7.1%	5
	answered question	**70**
	skipped question	**4**

Appendix B – Answers to Narrative Response Questions

Table B1 – Individual Narrative Responses to Survey Question #8

Categories	Response Text
COTS	Density of systems, decisions made at the arly stages of the acquisition cycle that are impacting the O&M costs, reliance on COTS licenses
	COTS software requires growing sustainment costs that guarantee the automatic provision of upgrades. GOTS software requires specific capabilities for code writing which in turn require extensive knowledge of the software and capabilities in order to effectively maintain and sustain.
	Unsupported software such as OS upgrades by vendors
	Over usage of COTS and ASAALT Acquistion Approaches.
	Over Using of COTS as well as various system versions
	Over Usage of COTS
Data Rights/Licensing	Data rights issues and development/sustainment environments becoming obsolete
	Availability of data rights, Significantly higher amount of requirements being implemented in sw rather than hw requires increased reliance on automated testing etc.
	Reliance on third party or proprietary software
	1. Lack of SW support during system development. Often systems come into PPSS with problems that make it difficult to maintain. Most blatant is lack of data rights, but there are often problems with the structure of the software as well. 2. Lack of consistent SW maintenance teams and system specific experience due to rotating staff. Inability to hire and retain Govt staff combined with flipping contracts every two years.
	Licensing Agreements, multiple configuration support
	Software Licensing/ Procurement Procedures/Command Policy/Resource Accountability(i.e ITMPs, GW, APMS, etc.)
	The red tape we have to go through to get software before you get to the point of installing and implementing
Interoperability	Requirement for interoperability with other systems
	funding to upgrade or replace older hardware is more difficult to obtain
	Not keeping up with technology advancements, and as a result having to support out-dated software/platforms
	interoperability, and compatibility (backward and future)
	Older systems are no longer produced
Design/Baseline Creep	Too many fielded software versions or baselines.
	design, requirement creep
	agile development process
	The complexity of the software.
Human Factors Req	Requirement for easier user interface
IAVA/Cyber Req	military code requirements
Lack of Training	Lack of technical training offered to required support personnel
Other	I don't know
	Yes
	Software Distribution
	no
	no

Table B2 – Individual Narrative Responses to Survey Question #12

Categories	Response Text
Enterprise Efficiencies	cooperation within CECOM
	Potential to leverage other depots/arsenals across the Army Organic Industrial Base through a materiel enterprise approach.
	Combining Software and Hardware support for CGS under a single FSR/FSE
	Field Level MWO Coordination Needs if done from top down.
	The only benefit is that you reduce the number of supervisory positions by putting all support under one structure.
	Software Distribution
	theorehtically, utilzation of TYAD, an organic workforce should benefit the software sustainment mission within the ARMY, with all those identified above.
	Such a move would result in a greater utilization of existing facilities at Tobyhanna Army Depot resulting in increased value to the Army for its facilities investment.
Enterprise Efficiencies,Risk Reduction	Infrastructure already in place Can be done in coordination with hardware maintenance actions. Sustaining TYAD workforce to support surge requirements in the future.
	Although I disagreed on the above in general terms, whether or not there would be a benefit depends on the implementation. I don't see HW maintainers being trained to perform all of the PPSS activites, but the soft tasks such as configuration management, replication and distribution, ... may be feasible. 2. I think benefits can be gained by having a stable workforce with the right skill sets regardless of whether it is at TYAD or APG.
Risk Reduction	Use of gov resources anywhere reduces risk. The PPSS mission can't allow support gaps when contracts are recompeted.
Leveraging Experience	Hardware maintenance background may be a major benefit for retraining current employees
	I believe that the workforce at TYAD can be training to support PPSS missions at CECOM/SEC if properly trained. They defifinitely have the background where adding this to their resume would make them an asset to the organization. The question is, does our organization want to do what is necessary to take care of the people that have been taking care of the mission of the organization for years or does it just want to throw them by the wayside.

Table B3 – Individual Narrative Responses to Survey Question #14

Categories	Response Text
Costs/AWCF	AWCF model does not support SW maintenance strategy due to management/overhead costs
	A few of our PMs use the AWCF model for software intensive equipment. I haven't seen this work well without solid, strong software warranties in place. If AWCF is being examined, recommend that warranties be considered as part of the equation.
	Facilitizing the depot with test equipment□ Attaining the right amount of Govt Purpose Rights□ Adding or modification of DFARs clauses within DOD 5000.02□ Changing the mindset of how PMs do contrcating business.□ modification of the Acquisition Process in general.
	Possible duplication of effort: Historically, EIS supported the software sustainment requirement.
	Fluid workforce moves where the money is. Sequestration could hobble the ability to sustain this initiative.
Education/Training	DEVELOPING AND PROVIDING EDUCATION/TRAINING/CERTIFICATION REQUIREMENTS AND FINDING INDIVIDUALS THAT MEET THESE REQUIREMENT RATHER THAN HIRING WARM BODIES.
	Ensuring the workforce remains trained with the latest technologies.
	not properly defining the requirement up front, under estimating the time needed to train
	Organic Workforce at TYAD is hardware concentric and would require resources necessary to retrain the force assuming they have a desire and understanding of software
	There are details relevant to this discussion that are not known to me, and I understand for the purpose of this survey would be difficult to convey. I imagine some of the TYAD workforce could adapt and be productive on PPSS missions with transition plans and guidance from leadership, whereas others may find it difficult to make the transition.
	Keeping governmeent WG employees current on the latest software trends and capabilities will result in very large continuous training bills and could lead to a higher turnover rate of employees as they find themselves more competitive in the commercial environment.
	transitioning wage-grade employees to be software maintainers is not very feasbile. Also - the challenge of the "quality" (eg code complexity") of software is real - and is likely all over the map
	Lack of required certifications i.e. (IAT)
Geographical separation	Being geographically dislocated will NOT help things (i.e. CTSF). Highly recommend TYAD workforce be resident at APG, MD or it may not be worth the effort.
	The proximity to Team C4ISR's PM will certainly be counter-productive to teh Campus concept established during BRAC.
Human Capital	impacts of sequestration...ie future reductions in workforce
	Human Capital will be the most challenging.
	Software maintenance is a difficult area to recruit qualified engineers to perform. It is not a cutting edge area therefore most of the SW sustainment base is an aging group. Relocating qualified and interested personnel will be difficult. Without those senior level qualified SW engineers cost will increase while "throughput" will diminish.
Loss of Flexibility	Coordination increased with government organization.□ Decreased flexibiity....contractors sometimes can have ability to do things goverment employees can not.
	You don't get truly qualified software engineers to support military formations with deployments and hardship assignments for WG or <GS12 wages. The personnel that you get can barely hold their own in installing and configuring software. Diagnosis of advanced problems and monitoring systems to detect issues before they happen doesn't happen at this level.. While contract personnel cost more, they provide an advanced level of troubleshooting and monitoring.
Readiness	Field Level Upgrades.□ Ensuring that all Unit own Equipment is using the latest and Greatest Software upgrades.□ Inventory Control once on Storage Shelf.
	Can be more responsive without contracting out requirements

Table B4 – Individual Narrative Responses to Survey Question #15

Categories	Response Text
Cooperative Processes/Procedures	Replication of lab environments and cooperative efforts between CERDEC and CECOM that are currently in place may be difficult if the organizations weren't colocated.
	Processes and proceedures would have to be clearly defined for the TYAD workforce and the transition could work smoothly
Costs of Establishing Capability	A significant cost of initial sustainment effort is the setup, configuring and dry running of the development/sustainment environment, test benches, and configuration of tactical and test assets. Those costs may be repeated by moving the mission. While the mission is moving the sustainment effort will suffer lower success.
	The costs/time associated with IA level II certification. Common CM environment for SW development.
	Reduction of capabilities as initial workers are retrained from hardware to software maintenance efforts.
Costs-Negative	RELOCATION/TDY COSTS FOR APG BASED SEC SUPPORT
	DLA Controled Owned Warehouse that adds additional Cost drivers.
	PCS cost of either a contract or GOV't workforce transition.
Loss of Contractor Jobs	Industry will most likely complain to their lobbyists and Congressmen about the insourcing of work.
	Government employees overseas are limited by the 5 year rule. Contractors in many cases have far more institutional knowledge of the units they support and mission of those units. Many have been on site for over 10 years and know more about the unit than the soldiers deploying in. They are the continuity for systems and operations.
PM response (Neg)	Considering above (14), we may see PM collaborating more with RDECOM even on efforts that should be a CECOM one (promimity/presence (like possession) will be nine-tenth of the law).
Human Capital	age of workforce....many are eligable for retirement
	Need to incorporate an intern program that can continue to attract and maintain the appropriate talent pool.
	long term sustainment if economy recovers and civilian sector starts hiring at a higher pay scale
	Workforce mix/population: What is the avg age of the TYAD workforce? What is the cost benefit analysis related to retaining retirement eligible employee. Will training younger employees lead to higher turnover rates? How will moving from WG to more "scientific" labor categories affect the surrounding labor market?

Appendix C – Statistical Analysis of Survey Data

This appendix includes a summary of the data analysis conducted on the survey data, including the 5-point Likert scale that was used, the means for each question, and results of the *t*-test used to assess any differences between the SEC population and all others, as well as between those software maintainers and all others. *P*-values of less than 0.1 (indicated by yellow highlighted cells in the tables below) indicate statistical significance, with 90% confidence, in the differences in the means that is not due to chance.

Likert Scale	
Strongly Agree	1
Agree	2
Neutral	3
Disagree	4
Strongly Disagree	5

Question 6 **Please agree or disagree with the following:**

Q6a Military electronics will become increasingly software intensive

Q6b Software for military electronics assemblies is increasingly becoming more of a maintenance COMPLEXITY driver.

Q6c Software for military electronics assemblies is increasingly becoming more of a maintenance EFFORT driver.

Q6d Software for military electronics assemblies is increasingly becoming more of a maintenance TIME driver

Q6e Software for military electronics assemblies is increasingly becoming more of a maintenance COST driver.

Q6f Hardware for military electronics assemblies are becoming more reliable, thus requiring less and less maintenance at the depot level

	Q6a	Q6b	Q6c	Q6d	Q6e	Q6f
Overall Mean	**1.50**	**2.05**	**2.16**	**2.19**	**1.91**	**2.67**
Overall Median	**1.00**	**2.00**	**2.00**	**2.00**	**2.00**	**3.00**
Overall Mode	**1.00**	**2.00**	**2.00**	**2.00**	**2.00**	**3.00**
SEC-only mean	**1.48**	**2.17**	**2.07**	**2.24**	**2.03**	**2.93**
Others mean	**1.51**	**1.94**	**2.23**	**2.15**	**1.81**	**2.46**
t-test p-value (SEC vs all others)	**0.873**	**0.322**	**0.473**	**0.680**	**0.333**	**0.044**
Soft Maint-only mean	**1.44**	**2.15**	**2.22**	**2.37**	**2.04**	**2.89**
Others mean	**1.55**	**1.97**	**2.11**	**2.06**	**1.82**	**2.50**
t-test p-value (Soft Maint vs all others)	**0.582**	**0.459**	**0.625**	**0.177**	**0.349**	**0.107**

Question 7 **The complexity of software maintenance is increasing due to requirements for:**

Q7a IAVA and cyber security

Q7b Incorporating technology advancements or refresh

Q7c Mission enhancements to support operational needs

	Q7a	Q7b	Q7c
Overall Mean	**1.51**	**1.73**	**1.84**
Overall Median	**1.00**	**2.00**	**2.00**
Overall Mode	**1.00**	**2.00**	**2.00**
SEC-only mean	**1.41**	**1.90**	**1.93**
Others mean	**1.59**	**1.59**	**1.76**
t-test p-value (SEC vs all others)	**0.339**	**0.122**	**0.395**
Soft Maint-only mean	**1.44**	**1.81**	**1.96**
Others mean	**1.56**	**1.67**	**1.75**
t-test p-value (Soft Maint vs all others)	**0.546**	**0.464**	**0.279**

Question 9	**Post Production Software Sustainment (PPSS) is most cost-effectively accomplished by:**			
Q9a	A Government/Contractor mix tailored to the specific type of software support required			
Q9b	A Government/Contractor team composing of mostly organic government employees			
Q9c	A Government/Contractor team composing of mostly contractors.			

	Q9a	Q9b	Q9c
Overall Mean	1.78	2.68	3.43
Overall Median	2.00	3.00	3.00
Overall Mode	2.00	3.00	3.00
SEC-only mean	1.52	2.64	3.64
Others mean	2.00	2.72	3.25
t-test p-value (SEC vs all others)	**0.019**	**0.764**	**0.136**
Soft Maint-only mean	1.54	2.63	3.70
Others mean	1.97	2.73	3.21
t-test p-value (Soft Maint vs all others)	**0.039**	**0.700**	**0.061**

Question 10	**Please indicate your level of agreement to the following statements**						
Q10a	CECOM SEC APG is currently well postured to more efficiently conduct software sustainment for electronics systems if additional government civilian personnel resources are allocated or matrixed to the organization						
Q10b	Recruiting software technicians and engineers to work at CECOM SEC APG using TYAD TDA for PPSS is feasible						
Q10c	Software maintenance can be effectively performed following the existing hardware-centric depot maintenance process model						
Q10d	Tobyhanna Army Depot is currently well postured to take on a more software-focused maintenance role for electronics systems						
Q10e	Recruiting software technicians and engineers to work at Tobyhanna Army Depot for PPSS is feasible						
Q10f	Transitioning a primarily wage-grade depot workforce from hardware-focused maintenance to software maintenance is feasible						

	Q10a	Q10b	Q10c	Q10d	Q10e	Q10f
Overall Mean	2.40	2.35	3.53	3.18	2.69	3.16
Overall Median	2.00	2.00	4.00	3.00	2.00	3.00
Overall Mode	2.00	2.00	4.00	3.00	2.00	3.00
SEC-only mean	1.96	2.44	3.85	3.64	3.21	3.75
Others mean	2.77	2.27	3.23	2.78	2.24	2.67
t-test p-value (SEC vs all others)	**0.006**	**0.495**	**0.019**	**0.001**	**0.0001**	**0.0001**
Soft Maint-only mean	2.29	2.33	3.85	3.48	3.19	3.81
Others mean	2.48	2.35	3.26	2.94	2.29	2.65
t-test p-value (Soft Maint. vs all others)	**0.525**	**0.933**	**0.026**	**0.042**	**0.001**	**0.00003**

Question 11	**Transitioning Tobyhanna Army Depot (TYAD) to be more software maintenance focused, by leveraging the existing organic government workforce at TYAD in lieu of additional contractor support at SEC, will have the following BENEFITS:**						
Q11a	Supports Title X (50/50) Compliance						
Q11b	Reduced Costs						
Q11c	Improved maintenance turnaround times						
Q11d	Improved throughput						
Q11e	More effective implementation of IAVA/Cyber Security across a breadth of C4ISR systems in sustainment						
Q11f	Facilitates establishment of in-house/organic technical expertise to perform software sustainment mission						
Q11g	Reduces program risk for complex C4ISR systems as service contracts are re-competed						

	Q11a	Q11b	Q11c	Q11d	Q11e	Q11f	Q11g
Overall Mean	2.21	2.76	3.02	2.93	2.84	2.36	2.67
Overall Median	2.00	3.00	3.00	3.00	3.00	2.00	2.00
Overall Mode	2.00	2.00	3.00	3.00	2.00	2.00	2.00
SEC-only mean	2.43	2.86	3.30	3.22	3.36	2.57	3.00
Others mean	2.06	2.70	2.82	2.73	2.48	2.21	2.44
t-test p-value (SEC vs all others)	**0.077**	**0.542**	**0.073**	**0.057**	**0.002**	**0.187**	**0.075**
Soft Maint-only mean	2.32	2.95	3.32	3.27	3.36	2.73	3.05
Others mean	2.15	2.64	2.82	2.71	2.48	2.12	2.42
t-test p-value (Soft Maint. vs all others)	**0.427**	**0.242**	**0.070**	**0.028**	**0.002**	**0.022**	**0.050**

Question 13	**Transitioning Tobyhanna Army Depot (TYAD) to be more software maintenance focused, by leveraging**							
	the existing organic government workforce at TYAD in lieu of additional contractor support at SEC,							
	will have the following CHALLENGES:							
Q13a	Using the Army Working Capital Funding model for software sustainment							
Q13b	Developing appropriate facilities							
Q13c	Re-training wage-grade employees							
Q13d	Recruiting software career fields							
		Q13a	**Q13b**	**Q13c**	**Q13d**			
	Overall Mean	**2.49**	**2.40**	**1.85**	**2.11**			
	Overall Median	**2.00**	**2.00**	**2.00**	**2.00**			
	Overall Mode	**3.00**	**2.00**	**2.00**	**2.00**			
	SEC-only mean	**2.33**	**2.13**	**1.74**	**1.96**			
	Others mean	**2.62**	**2.61**	**1.94**	**2.21**			
	t-test p-value (SEC vs all others)	**0.299**	**0.065**	**0.385**	**0.344**			
	Soft Maint-only mean	**2.39**	**2.17**	**1.82**	**1.91**			
	Others mean	**2.57**	**2.56**	**1.88**	**2.24**			
	t-test p-value (Soft Maint. vs all others)	**0.529**	**0.146**	**0.793**	**0.221**			

Appendix D – Actual Survey Instrument

The following is the actual survey instrument presented to the respondents.

Informed Consent Agreement

1. RESEARCH INTENT

The purpose of this research is to investigate diverging hardware and software maintenance trends within CECOM and examine whether developing a supplementary software maintenance-focused mission using government civilian workforce at Tobyhanna Army Depot (TYAD) is a feasible and beneficial concept to support the increasing software maintenance demands of the CECOM Software Engineering Center, in lieu of utilizing additional contractor support.

INFORMED CONSENT AGREEMENT

As an adult 18 years of age or older, I agree to participate in this research about "Examining a Paradigm Shift in Organic Depot-Level Software Maintenance for Army Communications and Electronics Equipment". This survey is being conducted to support research efforts being performed by Randy Wheeler, a student of the Senior Service College Fellowship Program of the Defense Acquisition University.

I understand that my participation is entirely voluntary; I can withdraw my consent at any time. By agreeing to participate in this study, I indicate that I understand the following:

1. Should I choose to participate in the survey, I am aware that my feedback will be consolidated with other participants and the outcome will be briefed to Army leadership allowing them to potentially take action or further study this issue.

2. If I choose to participate in this research, I will be asked to complete an online questionnaire. The questionnaire will include items relating to the trends mentioned above, and to the benefits and challenges of developing a more organic software maintenance workforce at TYAD. The questionnaire will take approximately 10-15 minutes to complete.

3. There is no incentive for participation.

4. All items in the questionnaire are important for analysis and my data input will be more meaningful if all questions are answered. However, I do not have to answer any that I prefer not to answer. I can discontinue my participation at any time without penalty by exiting out of the survey.

5. This research will not expose me to any discomfort or stress beyond that which might normally occur during a typical day. There are no right or wrong answers; thus, I need not be stressed about finding a correct answer.

6. There are no known risks associated with my participating in this study.

7. Data collected will be handled in a confidential manner. The data collected will remain anonymous.

8. The purpose of this research has been explained and my participation is entirely voluntary.

9. I understand that the research entails no known risks and by completing this survey, I am agreeing to participate in this research.

I HAVE READ THE INFORMED CONSENT AGREEMENT AND WILL PARTICIPATE VOLUNTARILY

- ○ YES
- ○ NO

Demographics

2. Which of the following best describes your current organization?

- CECOM SEC
- HQ DA
- PM/PdM
- PEO Staff
- HQ AMC
- HQ CECOM
- CECOM TYAD
- Other (please specify)

3. Please identify your area of expertise?

- Materiel Sustainment Policy
- Program Management
- Logistics
- Organic Industrial Base/Depot Maintenance
- Software Maintenance
- Other (please specify)

4. How many years of experience do you have in your area of expertise?

- 0-5
- 6-10
- 11-15
- >15

5. What is your current Rank/Grade?

- O-3/GS-12 or equivalent
- O-4/GS-13 or equivalent
- O-5/ GS-14 or equivalent
- O-6/GS-15 or equivalent
- GO/SES
- Other (please specify)

Trends

6. Please agree or disagree with the following:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Hardware for military electronics assemblies are becoming more reliable, thus requiring less and less maintenance at the depot level.	○	○	○	○	○
Software for military electronics assemblies is increasingly becoming more of a maintenance COST driver.	○	○	○	○	○
Software for military electronics assemblies is increasingly becoming more of a maintenance TIME driver.	○	○	○	○	○
Software for military electronics assemblies is increasingly becoming more of a maintenance EFFORT driver.	○	○	○	○	○
Software for military electronics assemblies is increasingly becoming more of a maintenance COMPLEXITY driver.	○	○	○	○	○
Military electronics will become increasingly software intensive	○	○	○	○	○

Software maintenance

7. The complexity of software maintenance is increasing due to requirements for

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
IAVA and cyber security	○	○	○	○	○
Incorporating technology advancements or refresh	○	○	○	○	○
Mission enhancements to support operational needs	○	○	○	○	○

8. Are there other contributors to the increasing complexity of software maintenance?

Cost-Effectiveness

The intent of this research is to investigate whether CECOM Software Engineering Center (SEC) can leverage Tobyhanna Army Depot (TYAD) government civilian resources, perhaps in lieu of additional contractor resources, to support some level of SEC software sustainment work as part of a cross command collaboration effort. The following questions are being asked in the context of this collaborative concept:

9. Post Production Software Sustainment (PPSS) is most cost-effectively accomplished by

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
A Gov't/KR Team composing of mostly Contractors	○	○	○	○	○
A Gov't/KR Team composing of mostly organic government employees	○	○	○	○	○
A Gov't/KR mix tailored to the specific type of software support required	○	○	○	○	○

10. Please indicate your level of agreement to the following statements

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Transitioning a primarily wage-grade depot workforce from hardware-focused maintenance to software maintenance is feasible	○	○	○	○	○
Recruiting software technicians and engineers to work at Tobyhanna Army Depot for PPSS is feasible	○	○	○	○	○
Tobyhanna Army Depot is currently well postured to take on a more software-focused maintenance role for electronics systems	○	○	○	○	○
Software maintenance can be effectively performed following the existing hardware-centric depot maintenance process model	○	○	○	○	○
Recruiting software technicians and engineers to work at CECOM SEC APG using TYAD TDA for PPSS is feasible	○	○	○	○	○
CECOM SEC APG is currently well postured to more efficiently conduct software sustainment for electronics systems if additional government civilian personnel resources are allocated or matrixed to the organization	○	○	○	○	○

Benefits/Challenges

The intent of this research is to investigate whether CECOM Software Engineering Center (SEC) can leverage Tobyhanna Army Depot (TYAD) government civilian resources, perhaps in lieu of additional contractor resources, to support some level of SEC software sustainment work as part of a cross command collaboration effort. The following questions are being asked in the context of this collaborative concept:

11. Transitioning Tobyhanna Army Depot (TYAD) to be more software maintenance focused, by leveraging the existing organic government workforce at TYAD in lieu of additional contractor support at SEC, will have the following BENEFITS:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Supports Title X (50/50) compliance	○	○	○	○	○
Reduced Costs	○	○	○	○	○
Improved maintenance turnaround times	○	○	○	○	○
Improved throughput	○	○	○	○	○
More effective implementation of IAVA/Cyber Security across a breadth of C4ISR systems in sustainment	○	○	○	○	○
Facilitates establishment of in-house/organic technical expertise to perform software sustainment mission	○	○	○	○	○
Reduces program risk for complex C4ISR systems as service contracts are re-competed	○	○	○	○	○

12. Are there other potential BENEFITS of utilizing and leveraging the organic government workforce at TYAD, and transitioning TYAD to be more software maintenance focused, in collaborative support of increasing CECOM SEC software sustainment requirements?

13. Transitioning Tobyhanna Army Depot (TYAD) to be more software maintenance focused, by leveraging the existing organic government workforce at TYAD in lieu of additional contractor support at SEC, will have the following CHALLENGES:

	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
Recruiting software career fields	○	○	○	○	○
Re-training wage-grade employees	○	○	○	○	○
Developing appropriate facilities	○	○	○	○	○
Using the Army Working Capital Funding model for Software sustainment	○	○	○	○	○

14. Are there other potential CHALLENGES of utilizing and leveraging the organic government workforce at TYAD, and transitioning TYAD to be more software maintenance focused, in collaborative support of increasing CECOM SEC software sustainment requirements?

15. Are there any other secondary or tertiary effects on existing processes, procedures, people, materiel, equipment, or facilities (that may not be intuitively obvious) if Tobyhanna Army Depot were to take on this Post Production Software Sustainment (PPSS) mission by leveraging existing government employees in support of increasing CECOM Software Engineering Center (SEC) software sustainment requirements?

16. This concludes the survey. If you have any additional insight regarding this study topic, that you would like to share for consideration and possible inclusion in the analysis, feel free to include it below and/or contact the study POC at randolph.l.wheeler.civ@mail.mil

Appendix E – Laws Applicable to Depot-Level Maintenance

A summary of the laws that apply to depot-level maintenance follows:

- **10 USC 2460 – Definition of Depot-Level Maintenance and Repair**
  - Any action performed on materiel or software in the conduct of inspection, repair, overhaul, or the modification or rebuild of end-items, assemblies, subassemblies, and parts, that requires extensive industrial facilities, specialized tools and equipment, or uniquely experienced and trained personnel …not available in lower echelon-level maintenance activities
  - Independent of any location or funding source—may be performed in the public or private sectors (includes ICS/CLS arrangements)
  - Includes:
    - Fabrication of parts, testing, and reclamation, as necessary
    - Repair, adaptive modifications or upgrades, change events made to operational software, integration and testing; and in the case of either hardware or software modifications or upgrades, the labor associated with the application of the modification.
- **10 USC 2464 – Core Depot-Level Maintenance and Repair Capabilities**
  - Department of Defense maintain a core depot-level maintenance and repair capability that is: Government-owned and Government-operated (including Government personnel and Government-owned and Government-operated equipment and facilities)

- Ensure a ready and controlled source of technical competence and resources necessary to ensure effective and timely response to a mobilization, national defense contingency situations, other emergency requirements
- The Secretary of Defense shall assign sufficient workload to ensure efficiency and technical competence
- Capability must be established within four years of IOC, or fielding
- Commercial items excepted following congressional notification
- SECDEF waivers possible for: Equipment that is not an enduring requirement of the national defense strategy

- **10 USC 2366a – Certification Required Before MS A Approval for Major Defense Acquisition Programs**
  - A major defense acquisition program may not receive Milestone A approval…until Milestone Decision Authority certifies a determination of applicability of core depot-level maintenance and repair capabilities requirements has been made
- **10 USC 2366b – Certification Required Before MS B Approval for Major Defense Acquisition Programs**
  - A major defense acquisition program may not receive Milestone B approval…until Milestone Decision Authority certifies: an estimate has been made of the requirements for core depot-level maintenance and repair capabilities, as well as the associated logistics capabilities and the associated sustaining workloads required to support such requirements

- As part of the requirement for Low-Rate Initial Production the Secretary of Defense shall ensure that the detailed requirements for core depot-level maintenance and repair capabilities, as well as the associated logistics capabilities and the associated sustaining workloads required to support such requirements, have been defined.

- **10 USC 2466 – Limitation on Performance of Depot-Level Maintenance of Material (aka Hunter-Hollis 50/50 Law**)
  - Establishes the 50 percent limit on contracting for depot maintenance by a Military Department or Defense Agency
  - Requires annual reporting to the Congress
  - Allows waiver by SECDEF based on reasons of national security (may not be delegated)
  - Definition of depot-level maintenance basically says what is included and what is excluded
- **10 USC 2469 – Requirement for Competition – "The $3 Million Rule"**
  - Cannot change location of performance for workloads at DoD depots valued at $3 million or greater (including labor & materials) unless the following are implemented: Merit-based selection procedures for competitions among DoD depots and competitive procedures for competition among public and private sector entities

- **10 USC 2476 – Minimum Capital Investment for Certain Depots**
  - Military Departments must make annual 6% capital investments. Includes investment funds spent on depot infrastructure, equipment, and process improvement
  - Applies to all major depots and arsenals
- **10 USC 2472 – Prohibition on Management by End Strength**
  - Civilian employees of the DoD who perform depot-level maintenance and repair workloads may not be managed on any constraint or limitation in terms of Man Years, End Strength, Full Time Equivalent Positions, Maximum Number of Employees
  - Shall be managed solely on the basis of available workload and funds made available