

**Would Consolidation of Army Software Engineering Organizations Help
to Control Software Costs for Current and Future Systems?**

Gary M. Lichvar



April 16, 2015

PUBLISHED BY
The Defense Acquisition University
Project Adviser: Dr. Craig Arndt
The Senior Service College Fellowship Program
Aberdeen Proving Ground, MD

Table of Contents

Table of Contents	iii
List of Figures	vii
List of Tables	ix
Abstract	xi
Chapter 1 – Introduction	1
Overview	1
Background	1
Problem Statement	3
Purpose of This Study	3
Significance of This Research	3
Overview of the Research Methodology	4
Research Questions	5
Research Hypothesis	5
Objectives and Outcomes	5
Limitations of the Study	5
Validity of the Research	6
Reliability of the Responses	6
Chapter 2 – Literature Review	7
Current Software Sustainment Problem	7
Findings and Recommendations from ASA(ALT)	8
Software Sustainment	8
AMC Software Support Transformation Strategy	11

Analysis of AMC Software Support Transformation Strategy	13
Assessment of Software Sustainment Processes	13
Study of Software Best Practices	14
Evaluation of Centralized Versus Decentralized Organizational Structure	15
Literature Review Summary	17
Chapter 3 – Research Methodology.....	21
Research Hypothesis	21
Research Process	21
Data Collection.....	22
Summary	23
Chapter 4 – Findings.....	25
Population & Sample Size.....	25
Collected Data	25
Demographic Data.....	26
Summary of Demographic Data.....	32
Questions Specific to Work and Organization	32
Summary of Questions Specific to Work and Organization.....	39
Questions Specific to AMC Current Software Engineering Organizational Structure.....	40
Summary of AMC Current Software Engineering Organizational Structure Questions	44
Additional Analysis of the Results.....	44
Chapter 5 – Conclusions and Recommendations.....	49
Conclusions	49
Recommendations	50

References.....	55
Glossary of Acronyms and Terms	59
Appendix A – Survey Instrument	61
Appendix B – Responses to Question 16.....	69
Appendix C – Responses to Question 21.....	71

List of Figures

Figure 1 – System Acquisition Framework	9
Figure 2 – Impact of Software Sustainment Over Time.....	10
Figure 3 – Results for Survey Question 3.....	27
Figure 4 – Results for Survey Question 4.....	28
Figure 5 – Results for Survey Question 5.....	29
Figure 6 – Results for Survey Question 6.....	30
Figure 7 – Results for Survey Question 7.....	31
Figure 8 – Results for Survey Question 8.....	32
Figure 9 – Results for Survey Question 9.....	33
Figure 10 – Results for Survey Question 10.....	34
Figure 11 – Results for Survey Question 11.....	35
Figure 12 – Results for Survey Question 12.....	36
Figure 13 – Results for Survey Question 13.....	37
Figure 14 – Results for Survey Question 14.....	38
Figure 15 – Results for Survey Question 15.....	38
Figure 16 – Results for Survey Question 17.....	40
Figure 17 – Results for Survey Question 18.....	41
Figure 18 – Results for Survey Question 19.....	42
Figure 19 – Results for Survey Question 20.....	43
Figure 20 – Median Selection by Organizational View.....	45
Figure 21 – Median Selection by IT Experience	45
Figure 22 – Median Selection by Major Command (MACOM)	46

List of Tables

Table 1 – Potential Impact of AMC Reimbursable Rate and Section 219 Funding in FY12..... 52

Abstract

Software sustainment costs continue to rise as the Army increases use of complex software-intensive systems to support military operations and associated business functions. Various studies have identified potential processes and procedures to help control software costs; however, no study has been undertaken to determine whether organizational changes to the Army Materiel Command's (AMC) software support centers can improve performance and reduce costs.

This study attempts to determine whether cost controls and improved software management techniques can be achieved through changes in AMC's software support organizations. Current software sustainment issues and concerns are also examined to determine whether organizational changes could address long-standing performance issues with software development and sustainment.

AMC software and information technology (IT) project leaders, supervisors and managers within their software support centers were surveyed to determine whether they possessed the required expertise to lead software/IT projects. These software leaders were asked whether their current organization provides the resources necessary for their projects to be successful and whether the consolidation of software centers could enhance AMC's ability to build and maintain software-intensive systems.

Specific recommendations to optimize software acquisition, development, and sustainment have been suggested and captured in this study. The primary goal for the study is to determine whether centralization of software sustainment organizations can improve the effectiveness and efficiency of AMC software programs, thus minimizing the escalation of software sustainment costs.

Chapter 1 – Introduction

Overview

As software sustainment and maintenance costs escalate across the software industry, it was only a matter of time before senior leaders began to question the Army's projected software sustainment costs. That's exactly what happened In 2012, when the Secretary of the Army saw the projected costs across the Program Objectives Memorandum for the Post Production Software Support (PPSS) requirements. While the Army investigates multiple opportunities to address this complex issue, there has yet to be any real structural changes applied to the organizations responsible for the PPSS mission within the Army Materiel Command. Could structural changes, if implemented properly, provide opportunities for the Army to help control these escalating costs? Software-intensive systems will continue to grow for the foreseeable future, so every possible solution to reduce the long-term sustainment costs of these systems must be examined.

Background

In a 2012 memorandum, the Secretary of the Army requested the Assistant Secretary of the Army for Acquisition, Logistics, and Technology (ASA[ALT]) to recommend policies, procedures, and organizational changes to maximize the Army's ability to develop and sustain software more efficiently (McHugh, 2012). In response to this request, the ASA(ALT) prepared a report (published in 2013), and the Army Materiel Command (AMC) was asked to provide the ASA(ALT) with comments on the draft, which they completed on October 21, 2013 (Nerger, 2013). Although AMC (2011) recommended organizational changes to their software support centers in an internal software support transformation strategy, no such recommendations were included in their comments to the ASA(ALT) (Nerger, 2013).

Current software support centers are distributed throughout the Army Materiel Command, primarily assigned to two major commands: the Research Development and Engineering Command (RDECOM) and the Communications and Electronics Command (CECOM). The RDECOM software assets are decentralized across its subordinate research and development centers: Communications and Electronic Research, Development and Engineering Center (CERDEC); Aviation and Missile Research, Development and Engineering Center; Armament Research, Development and Engineering Center (ARDEC); and Tank and Automotive Research, Development and Engineering Center. CECOM has centralized its software engineering resources into a single organization named the CECOM Software Engineering Center (SEC).

While the software tasks across the AMC software centers appear to be similar, the systems supported are quite different. Each organization specializes in specific Army domains and programs—aviation and missile, communications and electronics, armaments, tank and automotive. In fiscal year (FY) 1998, consolidation of Army software resources did occur as a result of the Signal Organization Mission Alignment (SOMA)/Information Management Functional Area Assessment (IMFAA; Smith, 1996). Software resources within the Information Systems Command were realigned to the Communication and Electronics Command. At that time the Software Engineering Directorate from CERDEC was realigned and merged with these new assets to create the CECOM SEC as an organization directly reporting to the CECOM commanding general. This event essentially added several combat-support major automated information systems (MAIS) and other information technology–specific responsibilities to the CECOM SEC inventory of systems. The SOMA/IMFAA study (Smith, 1996), combined with

AMC commander's decision to consolidate wholesale logistics automation support, realigned more than 1,500 military and Government civilian positions to CECOM.

Problem Statement

Would the consolidation of AMC software engineering organizations enable the Secretary of the Army to maximize the Army's ability to develop and sustain software efficiently? Can consolidation enhance synergy, eliminate redundancy, improve integration, and improve prioritization similar to what was pursued with the 2004 consolidation of AMC's research, development, and engineering centers?

Purpose of This Study

The purpose of the study is to examine the impact of structural changes within the AMC software engineering organizations to determine whether structural changes can decrease software sustainment costs and lead to better control of software costs for current and future software-intensive systems.

Significance of This Research

This study investigates the benefits and challenges of implementing organizational changes in an effort to improve performance and reduce life-cycle costs of software sustainment within the Army. A number of studies and research papers have been published that address software and information technology (IT) acquisition shortfalls; however, none of the previous studies addressed the impact of structural/organizational changes to control software costs better and improve performance. This study adds specific knowledge regarding the financial or performance impact of organizational change and optimization to the Army software sustainment process.

Overview of the Research Methodology

An examination of published reports and research papers was conducted to determine the validity of the research question and hypothesis. Initial examination indicated interest in identifying organizational changes within the Army that could maximize the Army's ability to develop and sustain software efficiently. The AMC's 2011 draft strategy did identify organizational changes; however, a review of current organization charts indicates no changes were implemented. Initial research also identified centralization as a potential cost savings. The consolidation of the AMC research, development and engineering centers into the RDECOM in 2004 was reviewed to determine whether stated efficiencies were achieved and, if so, whether these could also be possible with the AMC software centers/directorates. General Kern, then AMC commander, stated the consolidation of AMC science and technology (S&T) programs "will enhance synergy across technology organization, eliminate redundancy, improve the capability to do program and system integration, and improve prioritization of programs" (Kern, 2003, p. 2).

In addition to the published information briefings, papers, and studies, an online survey via SurveyMonkey.com was developed. This survey was used to identify current practices at the AMC software engineering centers and to solicit input from existing IT project leaders, supervisors, and managers. Approximately 200 AMC software leaders were targeted to participate in the survey. A total of 40 IT project leaders, supervisors, and managers provided responses. The survey was used to collect current information from AMC software organizations to determine whether adequate practices, expertise, and facilities exist. Numerous Government Accountability Office (GAO) reports detailed in the literature review identify best practices,

which were evaluated against user survey results to determine possible implementation recommendations for AMC.

Research Questions

Would better software cost controls be established and maintained if AMC consolidates software engineering centers into a single major command? Will consolidation result in improved software engineering sustainment and development processes that can also address shortfalls identified in GAO and industry reports?

Research Hypothesis

Organizational change through consolidation of AMC software centers/directorates will lead to better control of software costs for current and future systems, as well as more consistent software practices across all AMC software organizations.

Objectives and Outcomes

There are a number of possible outcomes based on the information gathered and the detailed literature review. Although the consolidation of software engineering assets across Army Materiel Command elements may reduce redundancy, it may not create the cost controls required to substantially lower the projected software sustainment costs identified by the Secretary of the Army, or stabilize the software sustainment processes significantly enough to enhance cost, schedule, and performance improvements.

Limitations of the Study

The primary limitation was adequate time to collect, analyze and verify all the applicable information from each and every software organization within AMC. The time limits of the study prevented detailed exploration; however, several viable ideas were discovered and highlighted. Limitations include assumptions that the work identified in the software center's

mission and functions manual (10-1; CECOM, 2011) as well as in public facing web pages is accurate and currently being executed as documented. The approach to consolidation would be similar to the established process that produced RDECOM. The focus was on the movement of positions based on the position job series, not on the work that was actually being performed. For the purposes of this study, it is assumed these positions include all those that are supporting the software development and sustainment missions currently being executed by the individual directorates and centers.

Validity of the Research

Survey questions were provided to project leaders, supervisors, and managers of the software engineering centers/directorates within the Army Materiel Command to validate the approach currently being used to perform the software sustainment mission within AMC. The survey questions provided a realistic view of the work being performed by these organizations, and the experience and expertise of AMC's software leaders. Questions also assessed the GAO and industry findings and other literature compiled for this effort to determine whether software intensive programs and IT projects are experiencing the cost, schedule, and performance issues highlighted by these reports.

Reliability of the Responses

The survey questions focused on objective criteria and were linked to previously obtained information via the organization's mission and functions manual, GAO reports, and/or other literature reviewed/compiled for this effort. The nature of the objective questions provided the researcher the ability to assess similarities in a consistent fashion.

Chapter 2 – Literature Review

A literature review was first conducted to build background knowledge of the issues surrounding the research hypothesis and question. Caution was taken to ensure the initial review did not bias the thinking or approach to the study. After sufficient background information was obtained and understood, the literature review continued with a concentration on the issues and concerns identified. During the second phase of the review, the information collected focused on understanding the data and assisted in organizing the material for this study. This chapter presents an assortment of information and data to highlight the current issues with the escalating software sustainment costs within the Army, what organizational constructs have been considered to improve performance and reduce cost, and the problems currently being experienced in developing and sustaining large-scale software-intensive systems.

Current Software Sustainment Problem

Software sustainment costs continue to escalate as the use of software grows in the Army. Over the last 27 years, the number of software-intensive systems has increased by 1,008% (ASA[ALT], 2013). The number of software lines of code has increase by 4,700% over the last 29 years. Software releases increased by 634% over the last 12 years and software licenses have increased by 268% over just the last five years. PPSS costs are projected to increase by 630% over the next 14 years. The extent of the software sustainment cost increases failed to be adequately projected just a few years ago (ASA[ALT], 2013). The costs, if uncontrolled, will be unaffordable. The Secretary of the Army believes the projected software sustainment costs can be decreased and that carefully thought out changes in requirements, development, and sustainment processes can lead to better control of software costs for current and future systems (McHugh, 2012). He requested ASA(ALT) to recommend policies, procedures, and

organizational changes that would maximize the Army's ability to develop and sustain software efficiently.

Findings and Recommendations from ASA(ALT)

In April of 2013, ASA(ALT) presented the Secretary of the Army the findings in a report. The ASA(ALT) report stated the "lack of executive data and the utilization of a valid cost model leads to poor estimates of costs for decisions" (p. 3). The report went on to recommend a thorough review of the portfolio of systems in order to divest those systems no longer required or needed. Although a number of recommendations were suggested for policy and procedure changes that could provide significant cost savings, no specific recommendations were made to address organizational changes. In fact no integrated product team (IPT) was even established to consider organizational changes.

Software Sustainment

So what is software sustainment and why is it so costly to perform? While Government organizations refer to this phase of the acquisition life cycle as sustainment (Figure 1) and view it as the last phase, the commercial software industry refers to it as the maintenance phase. According to Forrester Research, the software maintenance phase can consume 80–90% of the total lifetime cost of software (Kilner, 2009). In 2009 Jones identified approximately 9 million active software maintenance projects and only 5 million software development projects. The data indicates software maintenance is the most expensive and time-consuming aspect of any software project, and more companies today are choosing to maintain their existing software products rather than replacing them with new software development efforts.

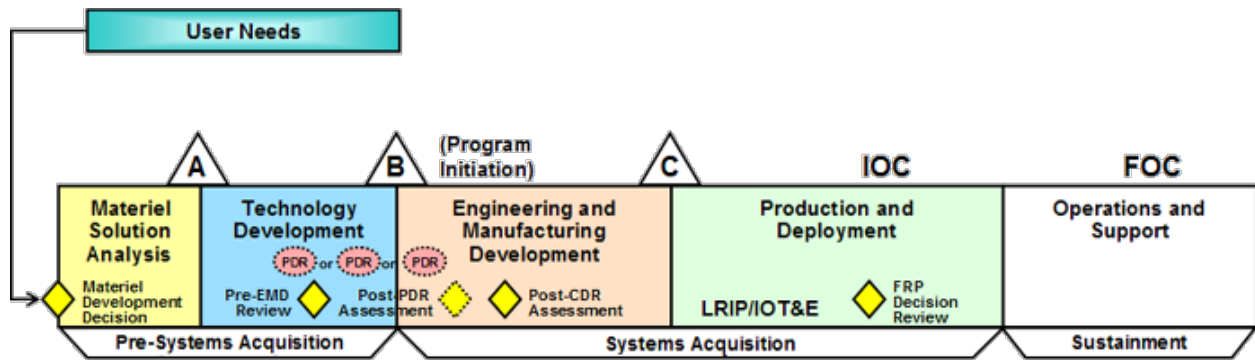
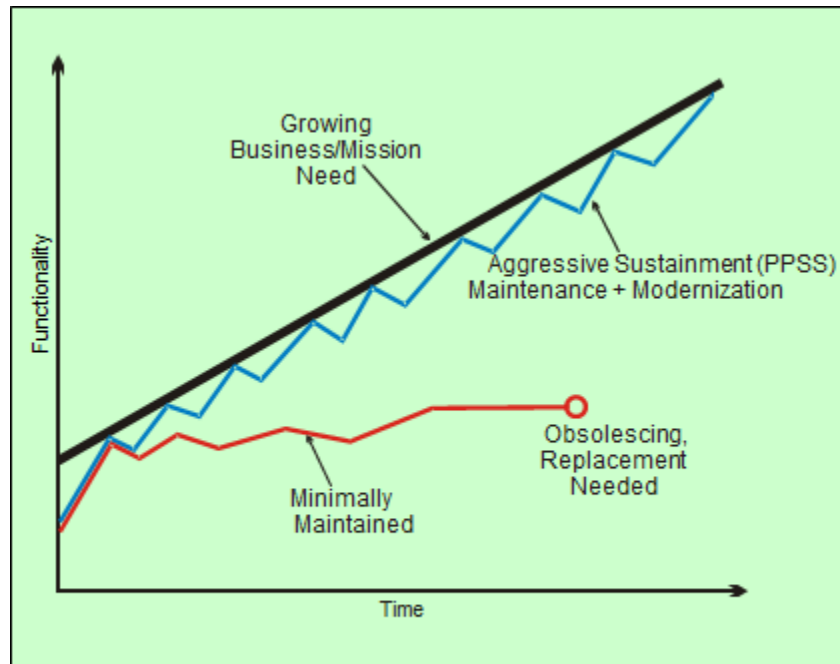


Figure 1 – System Acquisition Framework
 (Source: Adapted from Defense Acquisition Portal
<https://dap.dau.mil/aphome/das/Pages/Default.aspx>)

There are a number of work efforts involved in software maintenance. While Jones (2009) identified 21 specific software maintenance functions that are executed during this phase. Most of these functions can be placed into four major categories:

- Adaptive maintenance—keep the software usable in a changing environment. Enhance the software to make sure it supports the changing needs of the user.
- Corrective maintenance—fix software “bugs,” correcting identified problems in the code.
- Perfective maintenance—improve performance or maintainability of the code.
- Preventive maintenance—correct latent faults in the software before they become effective faults.

If software is not properly maintained, it can quickly become obsolete. Figure 2 illustrates the importance of the software sustainment process. If the software is not continually updated in concert with the changes in business/mission need, the software will degrade over time and eventually become obsolete, requiring a complete replacement, which is expensive and time consuming.



(Source of Graph: Software Engineering Center)

Figure 2 – Impact of Software Sustainment Over Time
 (Source: Adapted from CECOM Software Engineering Center [n.d.]

Don Reifer of Reifer Consultants (2010) teamed with the Army and Air Force to perform a study of software operations, maintenance, and sustainment—the mission of life-cycle software centers. The study surveyed 200 projects and visited 6 Army and Air Force software centers. Over 70 interviews were conducted. While the objective of the study was to find smarter, quicker and more effective ways to maintain and sustain software, it provided a good overview of the work that is performed at AMC software centers (Reifer, 2010). The study found that 70% of the work performed at these software organizations involved maintenance, sustaining engineering, and independent verification and validation. The remaining 30% was devoted to acquisition management and software development. The maintenance team consists of both Government and in-house contractor personnel, and the team supports up to four different software baselines in

parallel. The following sustainment functions and issues were briefed by Mr. Reifer at the March 2010 Center for Systems and Software Engineering Annual Research Review (Reifer, 2010):

- Maintenance centers do more than just software updates and repairs.
- Testing is the major maintenance activity.
- Transition and transfer of software systems is done poorly, which causes additional work during the sustainment phase.
- Estimates and budgets don't cover all the work that is required.
 - Sustaining engineering
 - Product fielding and user support
 - Regression testing
- Efficiencies are needed to cope with workload.

AMC Software Support Transformation Strategy

In 2011, AMC surveyed the software organizations within their command and documented the findings. The survey was directed by the executive deputy to the commanding general to support the Task Force Drive to Fiscal Reality (TF DFR). At the time, the Secretary of the Army directed AMC to conduct a review of materiel development and sustainment to create a more agile and cost-effective research development and acquisition system by analyzing work flow and optimizing organizations, processes, and procedures to support the work. The report analyzed the current operations of AMC software support organizations in relationship to ASA(ALT) and provided recommendations for process changes, organizational realignment, and other transformative changes that would better align the ASA(ALT) and AMC customer-supplier relationship. The objective was to create an AMC organization that is both effective and

efficient, and that leverages industry best practices for the fast-growing and complex world of IT and software (AMC, 2011).

Two separate data calls were used to collect information from all AMC software centers regarding software functions, customers, funding, IT workforce, and organizational core competencies. Analysis of the collected data identified a lack of strategic software planning within AMC, poor governance of AMC software processes/organizations, and deficient oversight of AMC software organizations. AMC suggested the lack of oversight created duplication of capabilities and increased costs resulted from these redundant capabilities. A number of strategic recommendations were made regarding software support, including collaboration with ASA(ALT) to ensure synchronization of strategic initiatives such as Common Operating Environment, Lead Material Integrator, and DoD Section 804 IT Acquisition Reform (AMC, 2011). Organizational realignments were also recommended to achieve greater efficiency and effectiveness across both AMC and ASA(ALT).

The AMC strategy suggested that realignments would establish software support centers of excellence by consolidating research and development with the CECOM SEC sustainment laboratories at Aberdeen Proving Ground. The strategy essentially suggested the SOMA/IFMAA organization that was created at CECOM in 1998 be dismantled and pieces be relocated to other CECOM organizations, with the majority of the resources being relocated to RDECOM CERDEC. While no specific software support center was identified to assume the MAIS that came to CECOM in 1998 as a result of the SOMA/IFMAA study, the strategy recommended that this work, and the resources to support it, transition to the Program Executive Officer for Enterprise Information Systems. Essentially AMC was divesting itself from any software support for Army large-scale management information systems. While the recommended organizational

changes primarily affected the CECOM SEC, AMC's largest software engineering center, to date no organizational changes have been implemented. AMC's commitment to the recommended changes in their strategy is questionable. When asked to comment on ASA(ALT)'s report before it was finalized, AMC suggested no structural or organizational changes, nor offered insight into any planned organizational changes within AMC (Nerger, 2013).

Analysis of AMC Software Support Transformation Strategy

The Software Management Subgroup–TF DFR reviewed the AMC (2011) strategy. Their white paper provides an assessment of the strategy and recommendations for further action in order to identify potential efficiencies in the areas of software development, management, and sustainment. While the subgroup recognized important initiatives and best practices were articulated in AMC's strategy, they were concerned the study did not include input from any of the Army Program Executive Offices as well as other relevant organizations across the Army. The subgroup determined the strategy contained many good ideas and served as a great starting point for discussing the complex area of software. Further, the subgroup recommended that AMC leadership establish a strategic working group under the auspices of TF DFR to review the data collected, fill known data gaps as identified, and collectively develop recommendations for efficiencies within the TF DFR constraints. The subgroup commented that the suggestion by AMC to increase headquarters staff to support execution runs counter to the desire to move execution out of the HQ and reduce overhead (Morrison, 2013).

Assessment of Software Sustainment Processes

A review of GAO reports highlights that software and IT projects continue to be viewed as risky, costly, and full of unproductive mistakes (GAO, 2011). These projects frequently incur cost overruns and schedule slippages. GAO has recommended the services document a standard

acquisition process that includes software metrics and the necessary knowledge, skills, and abilities required to lead and manage software-intensive programs. The GAO reports that DoD's large-scale software-intensive system acquisitions continue to fall short of cost, schedule, and performance expectations. Delays range from 2 to 12 years and cost increases range from \$530 million to \$2.4 billion (GAO, 2009). Of the nine success factors identified by GAO for IT programs, two focused on software organizations/structures: "#2 Program staff had necessary skills and #6 Government and contractor staff was consistent and stable" (GAO, 2011, p. 19).

While the GAO reports concentrate on the state of government software projects and organizations, the Standish Group, in their 2013 *Chaos Manifesto*, reported that only 39% of all commercial software projects in 2012 were delivered on time, on budget, and with required features and functions. The study went on to report that 43% were late, over budget, and/or delivered less than the required features and functions, while 18% were cancelled before completion or were delivered but never used (The Standish Group, 2013). The Standish Group (2013) claims the 2% improvement in the industry's success rate noted in the report can be linked to project management as a profession and the use of trained project management professionals. These findings resemble those recommended in GAO reports. However, the success comes with an increase in project overhead, along with reduction in value and innovation. The use of project health checks, retrospectives, dashboards, and tracking systems provides for an early warning system so corrective actions can be taken (The Standish Group, 2013).

Study of Software Best Practices

In 2006, CECOM SEC conducted a study, at the direction of Army leadership, to determine whether the Army software centers should adopt commercial best practices in order to

improve management of their software engineering business processes. The study examined the software management practices of successful commercial companies and identified practices that would potentially benefit the Army. The commercial companies selected for participation in the study were chosen because they did not produce a significant amount of Government-driven software. These companies provided a synopsis of software business practices that are generally independent of the influence of Government acquisition practices. While CECOM SEC (2006) highlighted a number of findings, the significant ones that are applicable to this study include the following:

- All companies had clearly identifiable, highly visible “software champions.”
- All companies provide stable, well-supported core funding for their organic software-engineering centers. The lifespan of software ranged from 10 to 30 years.
- Industry believes it is more effective to sustain existing systems than build new ones. Industry spends up to 80% of its annual software budget on sustainment activities.
- Industry invests in and maintain an in-house, core-funded software-engineering workforce to develop and sustain its core software.

Evaluation of Centralized Versus Decentralized Organizational Structure

In centralized organizations, the detailed operational decisions go to the top for resolution. Whether the decision involves expense rates, hiring practices, or project negotiation, the final decision is determined by the senior leader of the organization. On many occasions individual project leaders and division managers can provide input to the decision maker, and may even be permitted to provide recommendations; however, the decision authority remains with leadership of the organization. Centralization provides standardization, consistency, and control across the entire organization (Bott, Coleman, Eaton, & Rowland, 2000). Alternatively,

in a decentralized organization, as many decisions as possible are settled at the local level. Responsibility and authority is granted to those closest to the project and the customer (Bott et al., 2000).

There are advantages and disadvantages to both approaches. By transferring decisions to the lowest level at which the knowledge and ability exists, it is likely that better decisions will be made and performance will be improved (Bott et al., 2000). Additionally, the motivation of the supervisors and mid-level managers are likely to be improved by giving them greater responsibility for the operation of their organizations. On the other hand, this can lead to wasteful duplication. It can also mean that best practices will be slow to spread throughout the organization. There are many organizations in which you find one division using good modern software design methodologies and programming techniques, while another division is still using hand-drawn flowcharts and archaic languages (Bott et al., 2000).

As previously mentioned, the Army did consolidate some of its software engineering organizations in 1998 as a result of the SOMA/IFMAA study (Smith, 1996). In establishing CECOM SEC, CECOM created the first centralized software engineering organization that provided unified support across the acquisition life cycle and established a focal point for all C4ISR software support (Smith, 1996). In 2004, GEN Kern transformed AMC's S&T programs by creating RDECOM. An advisory group made up of Army S&T senior leaders, industry, academia, and other Services, recommended the establishment of the new command in order to transform AMC's S&T programs to align better with the Army's S&T vision (Kern, 2003). The new AMC S&T organization was created to enhance synergy across technology organizations, eliminate redundancy, improve program and system integration, and improve the prioritization of programs (Kern, 2003). Could similar improvements be achieved within the Army software

domain to achieve better control of escalating software sustainment costs and substantially improve the software business practices and structure to meet the needs of the Army and their program executive offices? Is it time to break down old barriers and transform the way the Army acquires, develops, and sustains software intensive systems?

While creating another RDECOM-like organization may seem like a logical step at this time, for the very reason GEN Kern implemented it in 2004; we may want to rethink that strategy based on an analyses of RDECOM's first 7 years. In 2011 the Secretary of the Army established an independent group to study the Army's acquisition system. The group investigated specific concerns that the Army acquisition efforts had become less effective and efficient (Decker & Warner, 2011). The panel's executive summary provided a number of recommendations to "substantially alleviate the problems preventing effective, efficient and timely acquisition of materiel and services required by warfighters" (Decker & Warner, 2011, p. 1). One of those recommendations focused on the impact RDECOM has had on the process. The panel stated the expected benefits never materialized and recommended the individual research development and engineering centers (RDECs) be returned to their respective Life Cycle Management Command (LCMC) commanders (Decker & Wagner, 2011). The panel found "no evidence of major eliminations of redundant effort, significant leveraging of defense and commercial technology advancements or more products" (Decker & Wagner, 2011, p. 11).

Literature Review Summary

The use of software-intensive systems across the Army continues to grow. As the software-intensive system inventory grows, so do the costs associated with sustaining those systems. Without appropriate controls, oversight, and understanding, the software sustainment mission within the Army will soon be unaffordable. While several studies and initiatives have

been undertaken, no single solution has been identified. It will take a number of actions across the Army's requirements, development, and sustainment processes to provide acceptable relief. While there has been agreement among many of the Army organizations on necessary process changes, such as the creation of a valid cost model for estimation and the divestiture of systems that provide duplicate capabilities, no organizational or structural changes have been explored in any great detail. While AMC (2011) examined organizational changes in response to ASA(ALT)'s request for input, they neither recommended nor suggested any organizational changes.

Currently AMC employs a decentralized organizational structure for their software support organizations, with the majority of the centers belonging to RDECOM. While RDECOM has the majority of individual software support activities, CECOM SEC has the largest software center. The CECOM SEC was established in 1996 when the SOMA/IFMAA study realigned the software support activities from Information Systems Command to CECOM, and AMC used this opportunity to realign their business-information-systems software support to CECOM. Although centralization of AMC software-support activities may provide standardization, consistency, and control, will that be enough to improve control of costs and provide more predictable software processes. The challenge to centralization comes from the findings in the Decker and Wagner (2011) study, which suggested the expected benefits from the consolidation of the Army's S&T organizations would never materialize.

While a number of studies proposed improvements to the Army's software sustainment processes to lower costs, the most comprehensive recommendations were found in the ASA(ALT)'s 2013 recommendations to the Secretary of the Army, highlighted below:

- Implement a process that examines current system inventories and divest systems where the operational risk is justified.
- Review software sustainment costs and processes early in the life cycle—pre-Milestone B.
- Improve the life-cycle cost models used to track total cost of ownership.
- Optimize software support in the field.
- Establish processes to track and manage software license purchases and use across the Army.
- Improve the ability for the Army to obtain data rights to software developed by vendors.
- Improve guidance on the use of COTS to include the potential impact on long-term sustainment costs.
- Examine the use of the common operating environment and the agile or similar development processes to determine whether potential cost savings can be achieved. Consider using Government resources for software development and sustainment, and eliminate redundancies between the RDEC and the LCMC.
- Establish transparency in tracking PPSS expenditures.
- Improve the management of software within a delivered system.

The literature review provided good insight into what the Army has attempted in order to improve control of software costs and the management of software projects. A few studies suggested organizational changes; however, to date nothing has been implemented. This study expects to add additional insight regarding the potential contribution of organizational changes,

specifically addressing the potential benefits derived from the consolidation of software resources.

Chapter 3 – Research Methodology

Research Hypothesis

For this research project, four potential research hypotheses were identified:

- (H₀) No worthwhile effectiveness and efficiencies can be gained through consolidation/centralization.
- (H₁) Major efficiencies and effectiveness can be obtained through the consolidation of software engineering support activities.
- (H₂) Some efficiencies and effectiveness can be obtained; however, the limited savings aren't worth the effort it would take to consolidate the organizations.
- (H₃) Efficiencies and effectiveness of AMC software-support activities can be achieved; however, consolidation/centralization isn't required in order to obtain them.

Research Process

An examination of published reports and research papers was conducted to determine the validity of the research question and hypothesis. Initial examination indicated interest in identifying organizational changes within the Army that could maximize the Army's ability to develop and sustain software more efficiently (e.g., AMC, 2011). Initial research also identified centralization as a potential cost savings. The consolidation of the AMC Research, Development and Engineering Centers into the Research, Development and Engineering Command (RDECOM) in 2004 was reviewed to determine whether similar efficiencies could be achieved by consolidating the AMC software centers/directorates.

In addition to the published information, an online survey, via SurveyMonkey.com, was developed and used to fill any "gaps" identified in the review of published information. The survey was also used to collect current information from AMC software and IT project leaders,

supervisors, and managers to determine current experience, expertise, and perspective. Questions attempted to validate the work being performed in the organization and the resources available to support the software sustainment mission. Numerous GAO reports detailed in the literature review identify best practices, which were evaluated against user survey results to determine implementation recommendations for AMC.

Data Collection

Through research and analysis of written and published material, and the development and distribution of a SurveyMonkey questionnaire, significant information was gathered. The survey questionnaire asked 21 questions (Appendix A). Questions 1–8 captured demographic information about the respondents. Questions 9–16 captured information about the type of work the participant leads and the support provided by the individual’s organization. Questions 17–21 addressed the participant’s viewpoints concerning the current AMC structure and perspective regarding the benefits of centralization. Two questions (#16 and #21) were open-ended. The exact responses to these questions are provided in Appendixes B and C.

The respondents provided essential data as the key leaders required to navigate Army and AMC policies and practices on a daily basis to ensure Army software projects are successful. A pilot survey was initially developed and distributed to one division within CECOM SEC to assess their understanding of the questions and the required responses. Pilot respondents were also asked to provide feedback regarding potential bias (e.g., whether any of the questions were specific to a particular organization, expertise, or domain). The pilot respondents reported no bias based on their understanding of the questions and proposed responses. The feedback provided was used to modify some of the questions and clarify potential responses. Feedback from the pilot concentrated on the last three questions of the

survey, which focused on the study's hypotheses and research question. Rewording was suggested to ensure respondents clearly understood the intent of these questions. The pilot respondents clearly understood these three questions were the heart of the survey. Survey questions included demographic data to ensure the right audience was responding. One question was worded in a negative fashion specifically to test the respondent's careful reading of each question.

Summary

The literature review and survey information were instrumental in identifying the current state of AMC software-support centers and insight into their current operations. While more participation would have been advantageous, the responses coupled with the unsolicited written comments provided essential information from those software experts that understand the AMC software domain.

Chapter 4 – Findings

Population & Sample Size

Survey distribution was limited to software leaders in the five AMC software engineering centers. Each center was contacted and provided with an overview of the study and the required participants. Although a count of the exact number of project leaders, supervisors, and managers was not possible, the anticipated population for this study was approximately 200 individuals currently performing leadership functions in support of AMC software development and sustainment projects, teams, divisions, or organizations. One organization elected to limit the distribution to only non-union members, which targeted supervisors and managers. Another elected to not participate at all. No specific reason was provided why the organization opted out. The coordination effort required for this particular survey was fairly extensive and took a considerable amount of time. To date, 40 responses were received from three different AMC software engineering organizations. Considerable participation came from two organizations that also provided key information during the literature review phase of the study.

Collected Data

As previously stated, 40 responses were received, with one respondent electing to skip multiple questions. That respondent failed to address any of the questions/statements in section three of the survey, dealing with viewpoints regarding the current AMC structure and benefits regarding centralizing the software centers. Just two other respondents skipped one question each, which may have been an oversight. One question that was skipped concerned demographic data and another addressed AMC's current oversight of the software centers. Of the possible 760 responses (19 questions per survey) for these forty respondents, 754 were provided—a 99% completion rate. Two open-ended, optional questions were included in the survey for the

respondents to provide additional or clarifying information. On the first question, 16 of the 40 respondents provided responses. These are included in Appendix B. For the second question, 21 of the 40 respondents provided responses. All 21 responses are given in Appendix C. The voluntary comments were valuable in helping to develop the study's conclusions and recommendations.

Specific responses to question 1 and question 2 are not recorded in the report. Question 1 was a grant of consent to participant in the survey, and question 2 was used to identify the participant's organization, which has already been summarized above.

Demographic Data

Demographic data was used to capture the knowledge, expertise, and experience of the individuals currently leading software projects, teams, divisions, and organizations within AMC. While software leaders can be involved in a number of different software projects, question 3 attempted to determine the respondent's primary expertise. A summary of the responses indicates the majority of experience is in supporting software sustainment activities or directly providing software sustainment services (Figure 3). The survey targets leaders in software sustainment, software development, and activities that support software development and sustainment. Although limited, the results indicate the projected audience for the study was obtained.

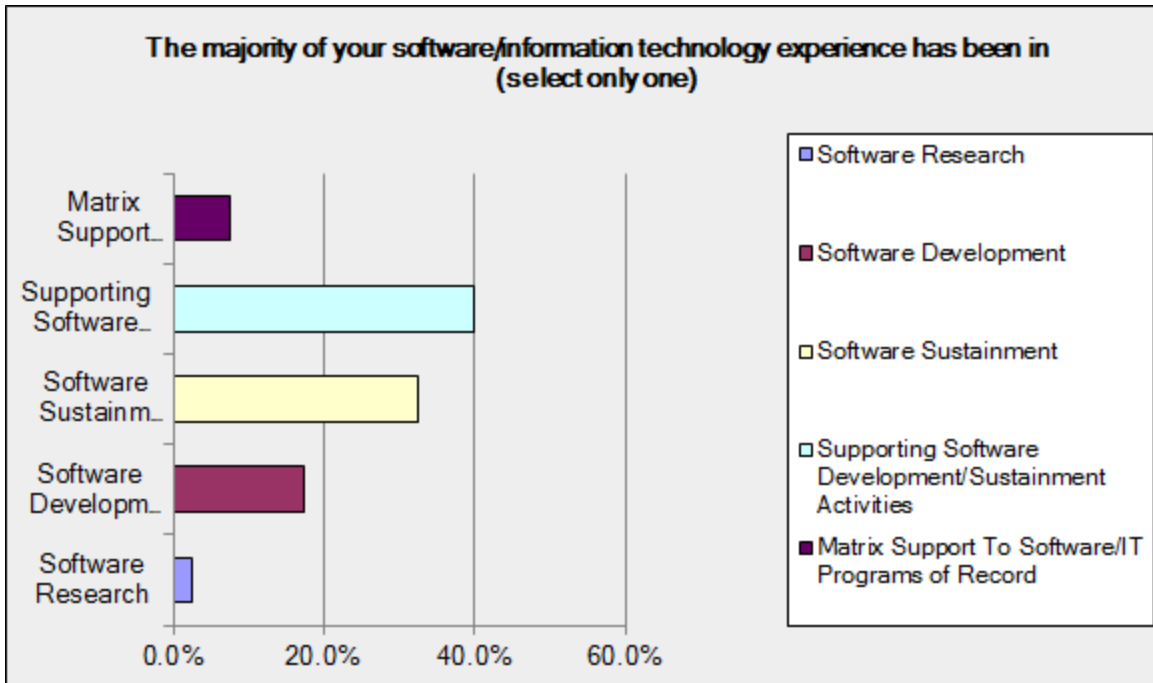


Figure 3 – Results for Survey Question 3

Question 4 captured the number of years the respondents have been in their current organizations. This is an attempt to understand the respondents' familiarity with how their organizations operates and how familiar they may be with their current organizations, as well as with the AMC software engineering structure. Figure 4 shows that over 50% of the respondents have more than 10 years of experience in their current organizations, with 30% having more than 20 years' experience in their current organizations.

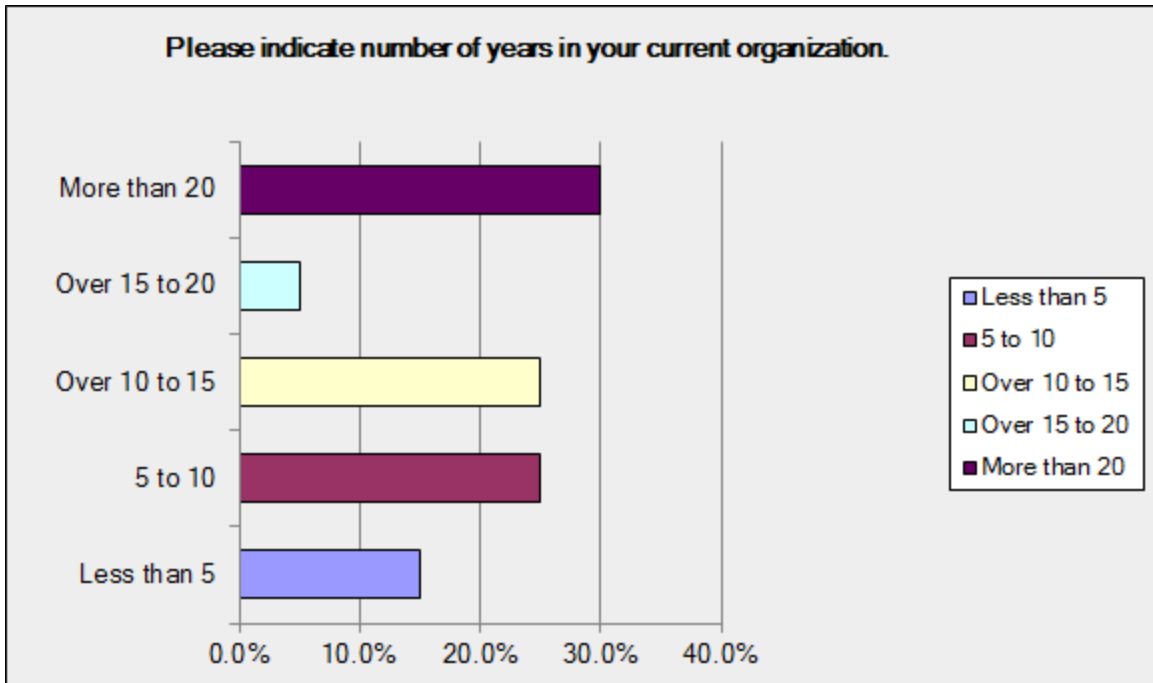


Figure 4 – Results for Survey Question 4

Question 5 captures the years of experience leading software and/or information technology projects. The results indicate that more than half of the respondents have less than 15 years' experience in leading software projects (Figure 5). Many of those have only 5 to 10 years' experience. Again, the focus of question 5 was the number of years "leading" software and/or information technology projects. The responses indicate the respondents possess the familiarity and experience necessary to deal with the challenges of leading Government software-intensive systems.

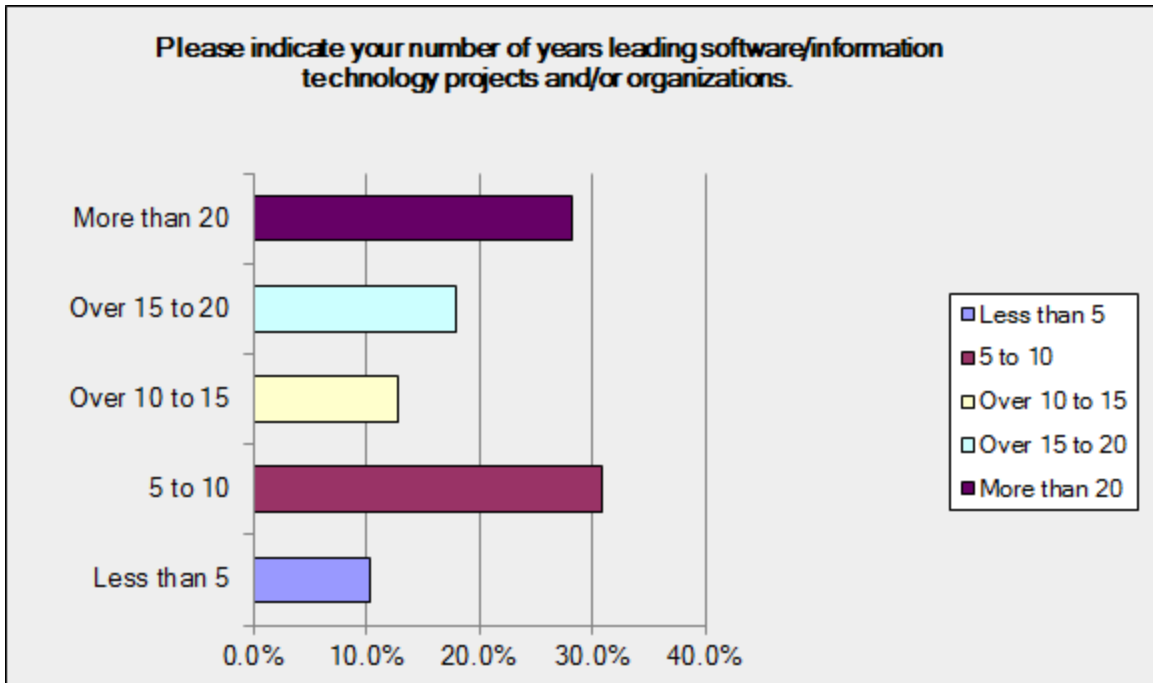


Figure 5 – Results for Survey Question 5

Question 6 provides an overview of the respondents' years of Federal service. The data reveals the majority of respondents have more than 20 years of Federal service (Figure 6). The results show the respondents are very familiar with the Federal employment system and can give solid insight in identifying barriers that could be driving software costs within the Army.

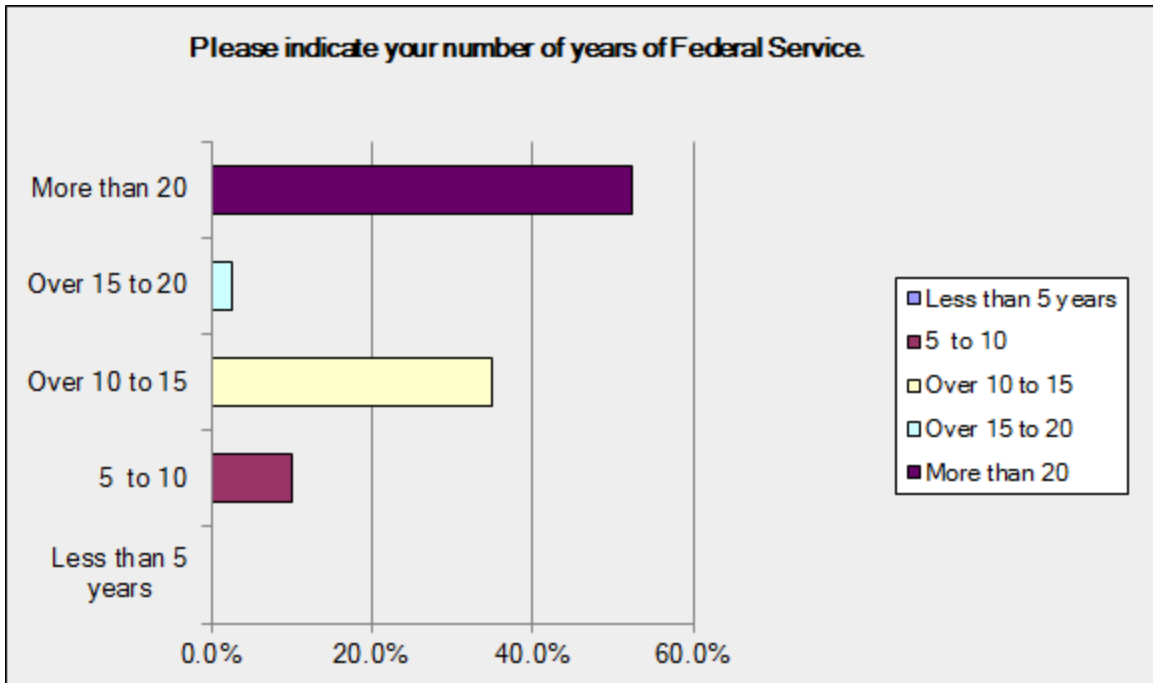


Figure 6 – Results for Survey Question 6

Question 7 assesses the respondents' familiarity with the Army's acquisition process, specifically whether the respondent possessed the required acquisition career field certification level. Level III certification at this level of leadership would be expected. The results highlighted in Figure 7 confirm the respondents have a thorough understanding of the Army's acquisition process and are skilled acquisition professionals.

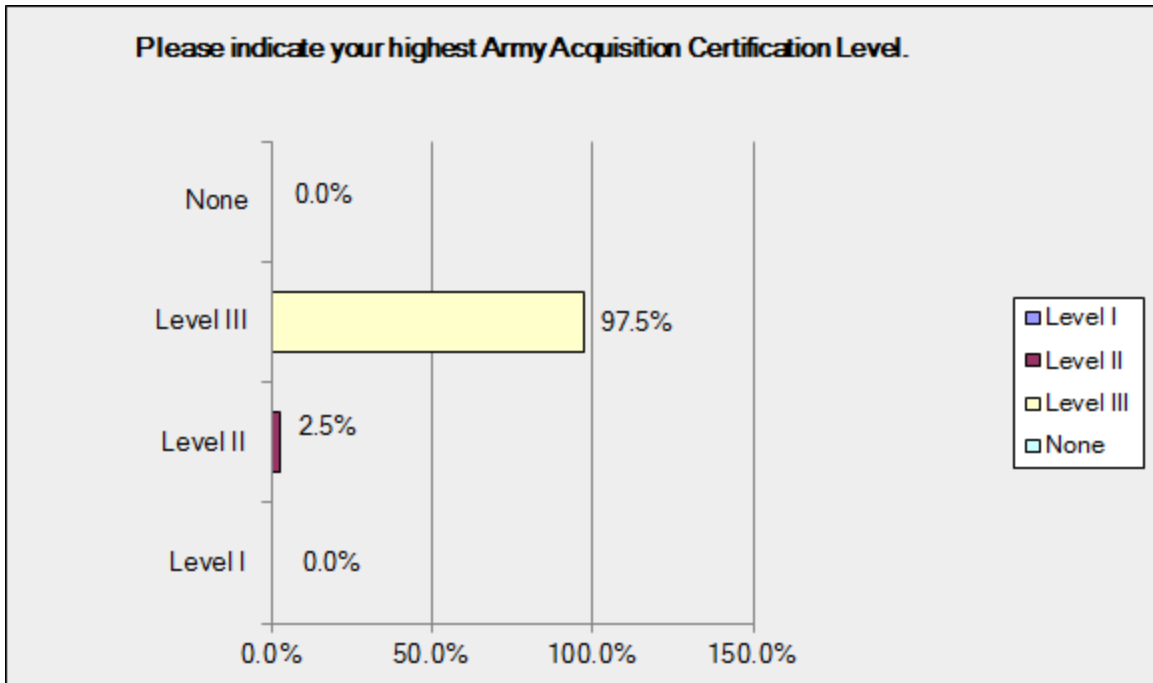


Figure 7 – Results for Survey Question 7

As identified by the results in Figure 8, the survey respondents included a good cross-section of leaders from senior level directors to nonsupervisory project leaders. However, the project leader input may be biased, because the survey excluded this part of the workforce for one of the organizations. The respondents include a mix of expertise and current experience at different levels of a software organization. The perspective presented is not dominated by a view of one particular group.

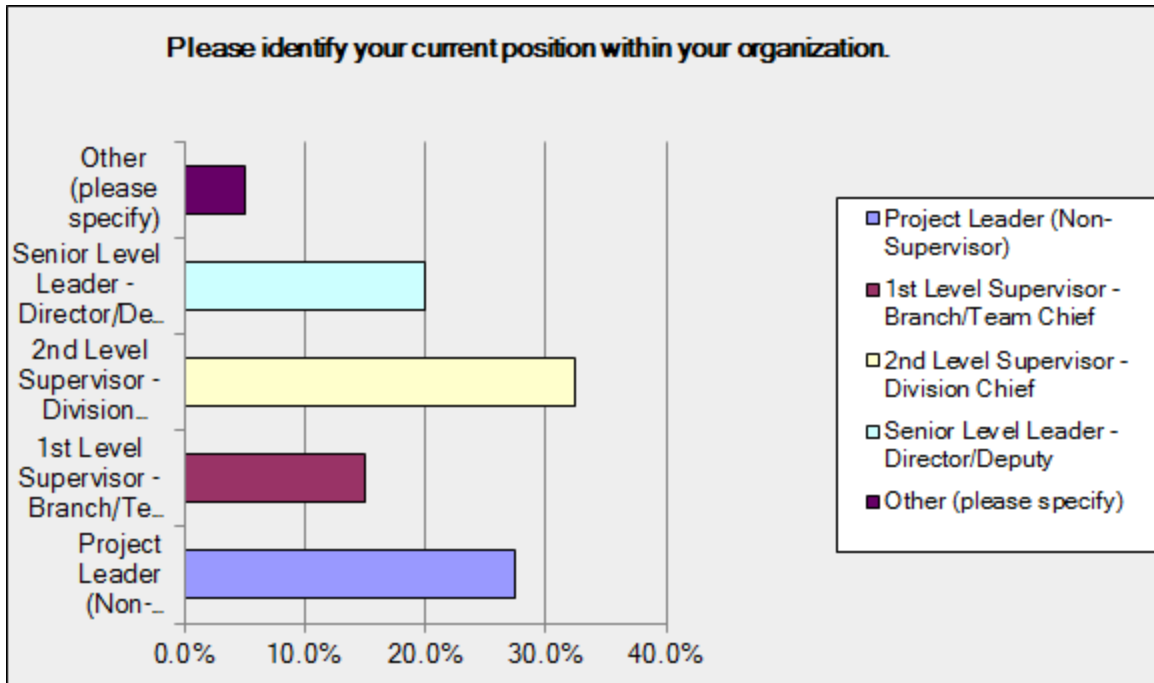


Figure 8 – Results for Survey Question 8

Summary of Demographic Data

While the survey was able to capture a variety of leadership perspectives ranging from senior leaders/directors to nonsupervisory project leaders, the majority of responses were concentrated from two AMC software organizations. The years of experience leading software or information technology projects were also widely distributed from 5 to over 20 years. Based on the responses provided, the survey captures input from experienced acquisition professionals representing a long history of work in AMC software engineering organizations performing software sustainment activities. The target respondent was successfully achieved.

Questions Specific to Work and Organization

The overall goal of these questions was to capture the respondents' assessment of their current working environment. Does the current AMC software engineering structure provide the necessary resources, tools, and systems required to support the work being performed?

Although subjective, question 9 attempts to determine whether the current project leaders feel confident they have the ability to accomplish their assigned missions. The results captured in Figure 9 reveal the vast majority of AMC software leaders feel their current organization provides them the necessary structure, processes, technology, and people to be successful.

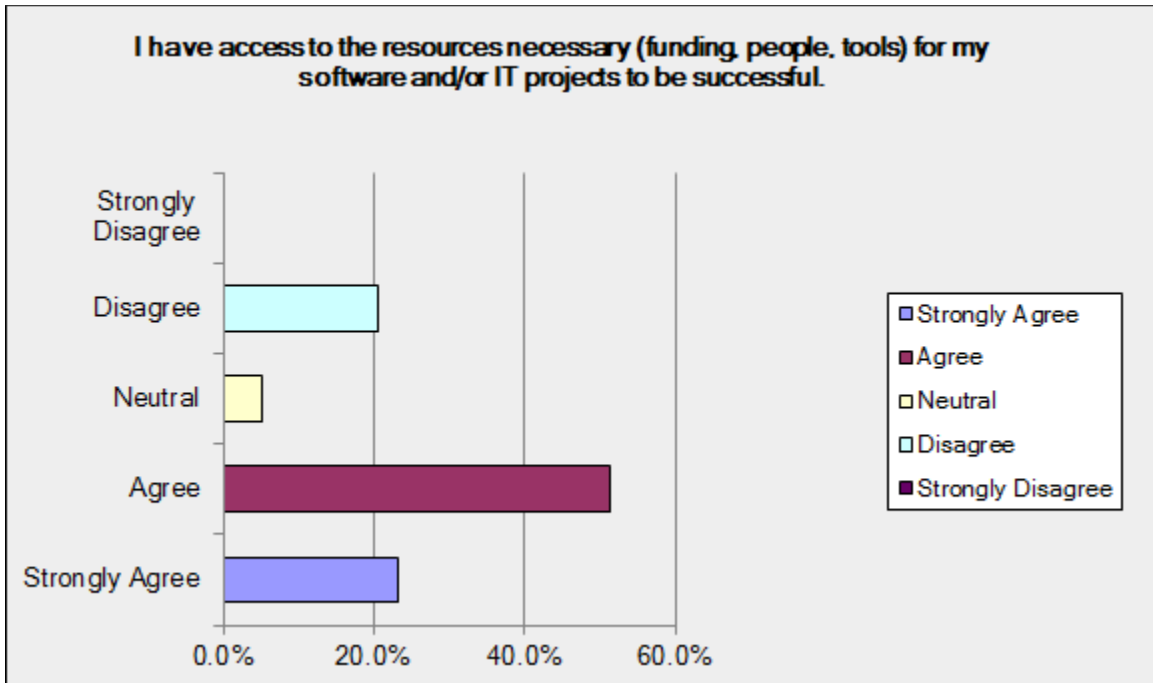


Figure 9 – Results for Survey Question 9

Many may assume a leader’s authority is always commensurate with the leader’s assigned responsibility; however, that may not always be the case. However, Figure 10 shows the vast majority (79.5%) of software leaders feel they have been given the appropriate authority to execute their assigned duties and responsibilities.

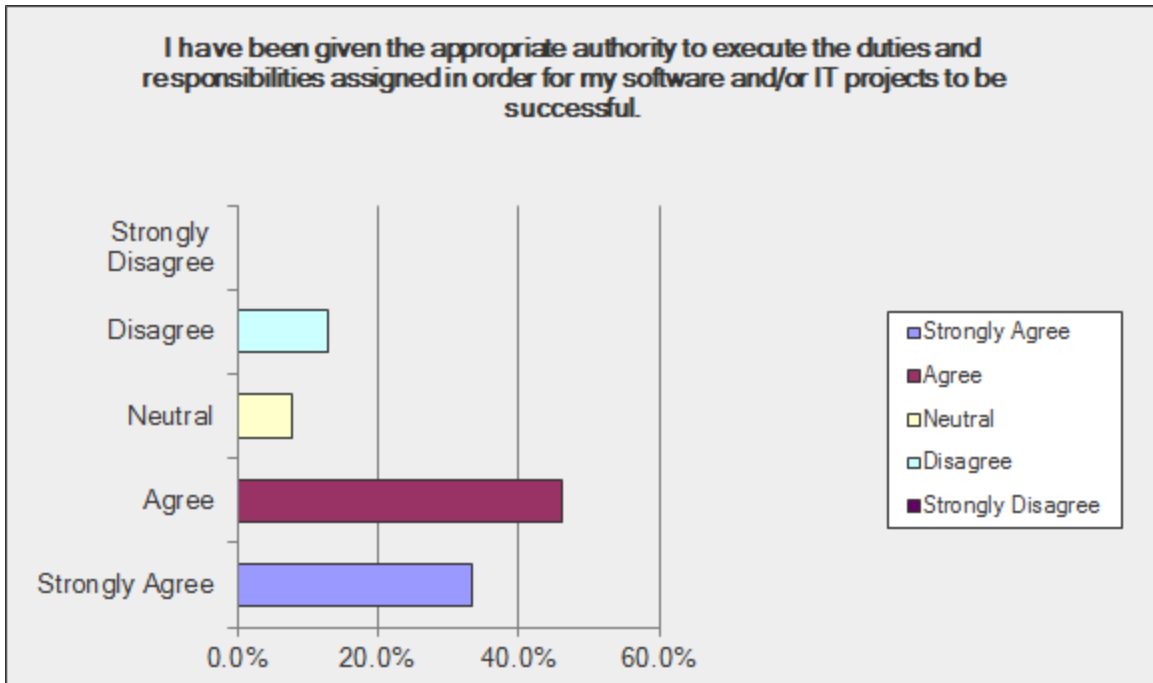


Figure 10 – Results for Survey Question 10

While the majority of leaders feel they have the appropriate authority to be successful, the results highlighted in Figure 11 indicate 82% believe they have the freedom and authority to make necessary improvements to support cost savings or process improvements. The previous two questions indicate most leaders feel decision authority for software success has been delegated to the appropriate level.

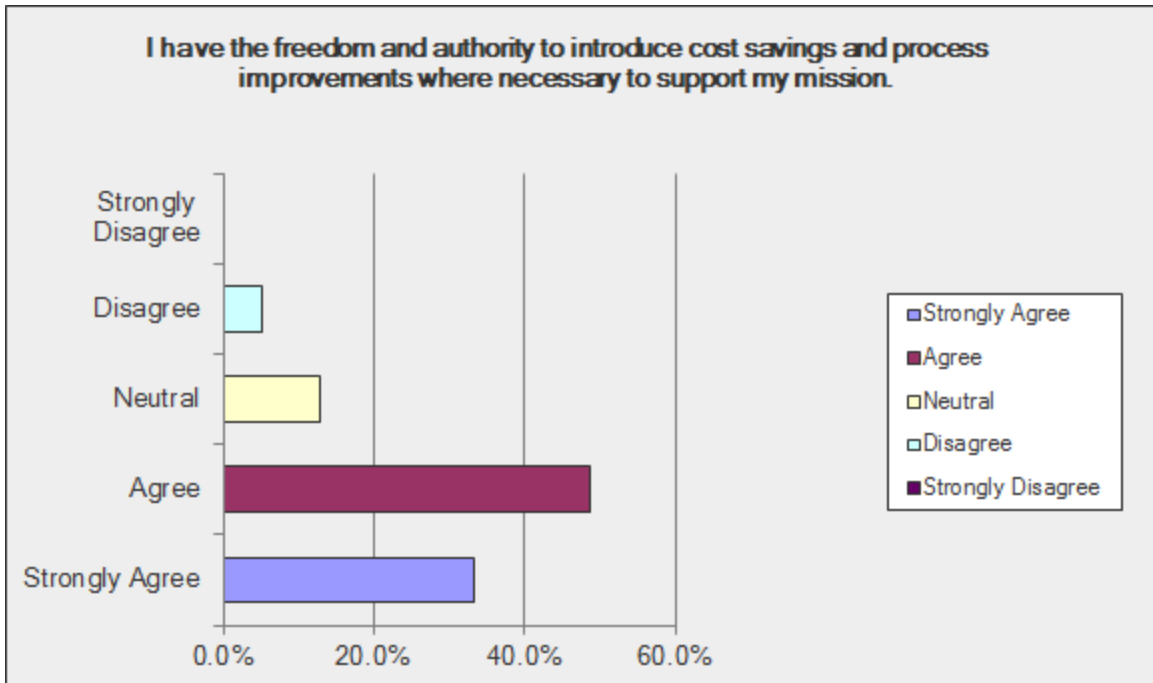


Figure 11 – Results for Survey Question 11

Question 12 is another opportunity to determine whether the current organizational structure is able to provide the software projects a standard set of tools and methods to perform their assigned mission. The results again indicate the current organizational structure provides the tools and standards necessary to support the successful implementation of their responsibilities (Figure 12).

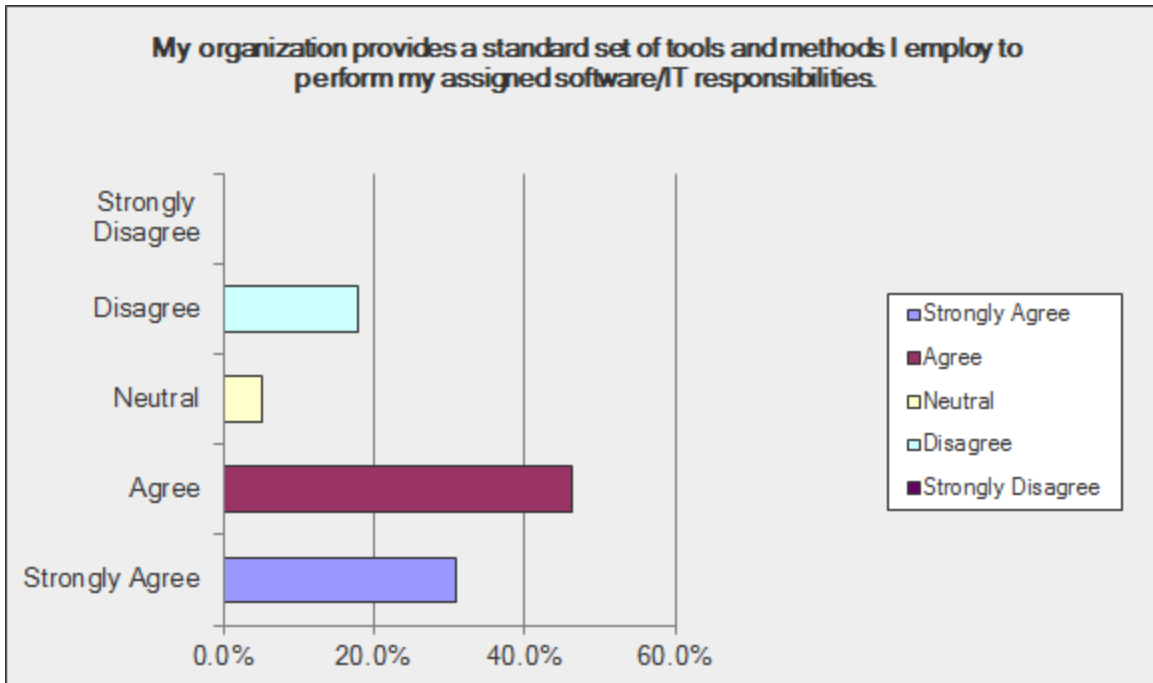


Figure 12 – Results for Survey Question 12

Question 13 is yet another attempt to assess the responsiveness of the organization to support the unique needs of a particular project. The results in Figure 13 again highlight the view that the current structure is very responsive to the needs of the individual projects. The strong results indicate these leaders feel confident that their organization has the resources necessary to support emergency and/or special needs of their projects. The responses provide another indication that the organizational structure facilitates the specific responsibilities of the organization. Resources and expertise are readily available when needed.

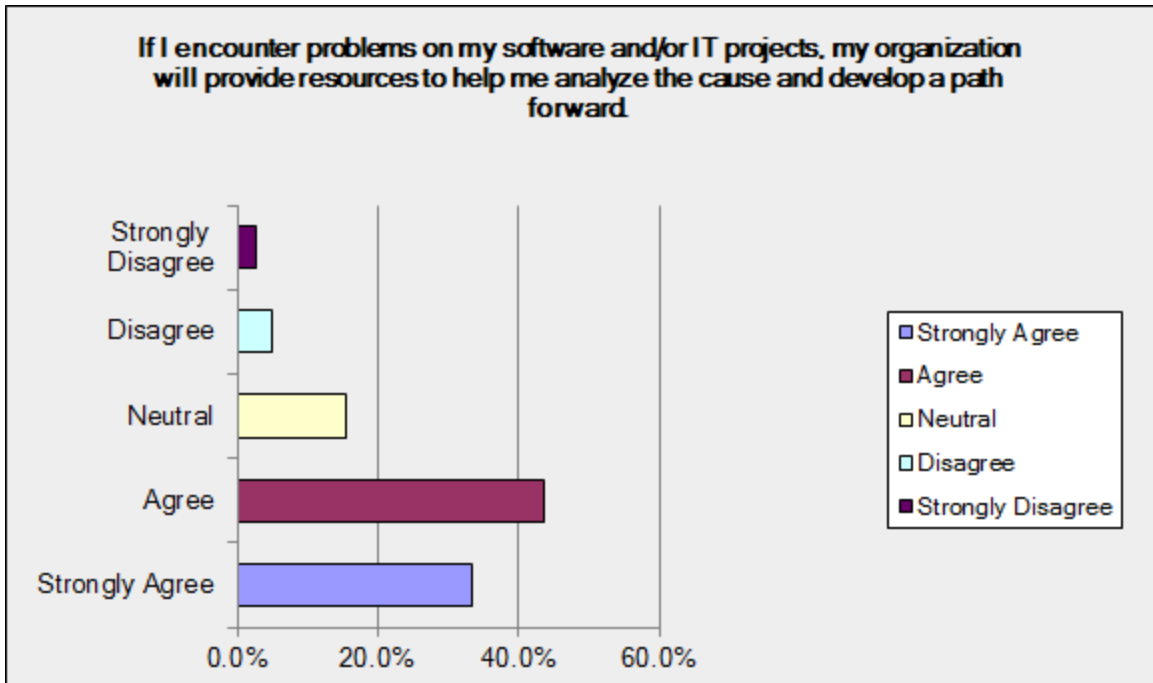


Figure 13 – Results for Survey Question 13

During the literature review it was suggested the individual software centers competed with each other for work. Questions 14 and 15 were specifically included in the survey to determine the validity of this assumption. While the responses to question 14 clearly reveal the majority of the work (89.7%) being performed is in direct support of the LCMC’s mission (Figure 14), the results for question 15 reflect only 42.1% are discouraged by their leadership to pursue work outside their immediate Life Cycle Management Command (Figure 15). This is the only question in the survey where the neutral response (42.1%) outscored every other selection.

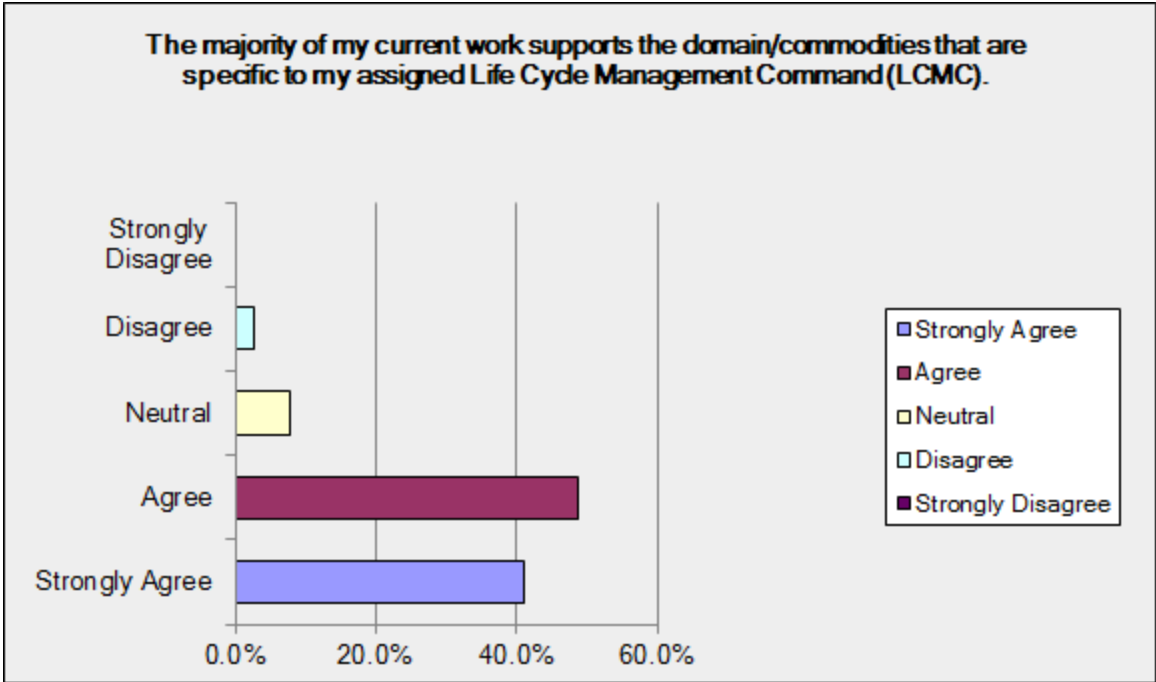


Figure 14 – Results for Survey Question 14

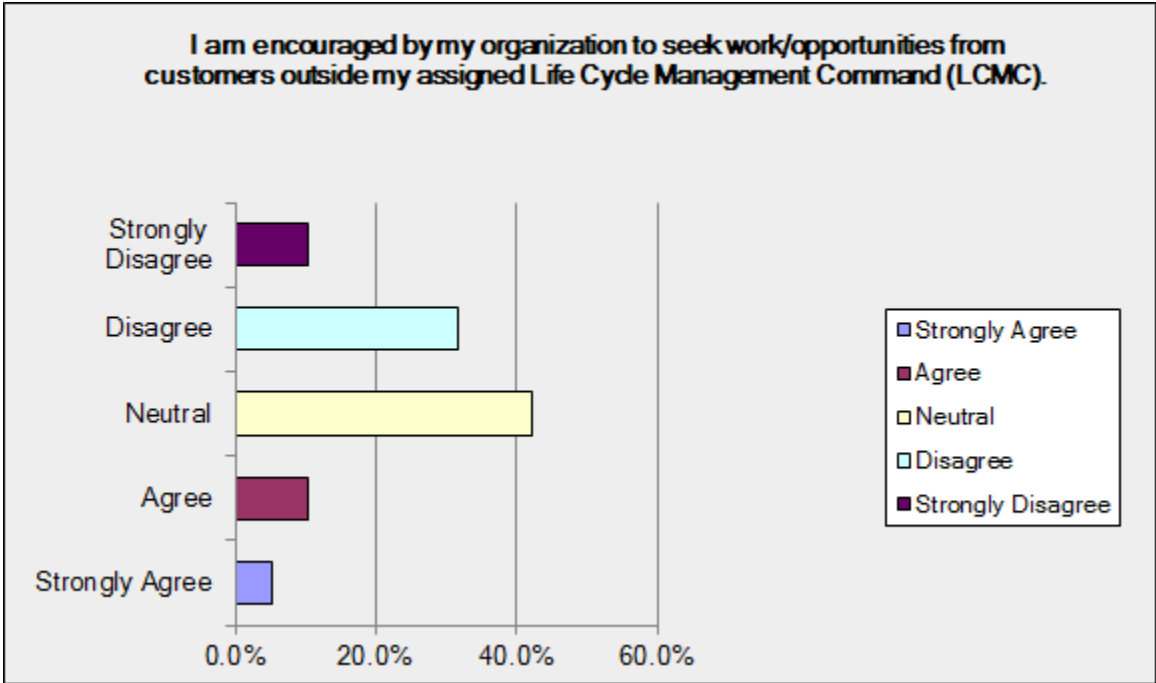


Figure 15 – Results for Survey Question 15

Question 16 asked the respondents to provide additional comments or explanations for their responses to questions 9 through 15. Sixteen respondents elected to provide additional comments. While the 16 specific comments will not be included here (see Appendix B for all responses to Question 16), the following summary of their comments highlights consistent topics:

- Negative impact of hiring restrictions and resourcing
- Customer demand for the Capability Maturity Model Integrated (CMMI) Level 5 organization support
- CMMI Level 5 organizations provide predictable/well-established tools and processes
- Administrative work (ITMP, AKM Goal 1 Waivers and hardware/software acquisitions) consuming the majority of the software expert's time

Summary of Questions Specific to Work and Organization

These questions centered on the assessment of current work being performed and the organizational support that leaders are receiving while performing their assigned duties and responsibilities. Results indicate the leaders feel they have the appropriate authority to execute their responsibilities and that their organization is responsive to their needs. Standard tools and processes are available and used to perform the technical work. While attempts to work beyond their immediate specialties are discouraged, well-performing organizations are consistently sought out to perform non-LCMC customer work. Specific comments captured in this section raised concerns regarding recent fiscal and Table of Distribution and Allowances (TDA) constraints. These leaders are concerned that Government resources are not available to perform the customer work being requested.

Questions Specific to AMC Current Software Engineering Organizational Structure

Questions in this area focused on the study's specific research question and hypothesis. Does the current decentralized structure, focused on specific commodities, provide sufficient software support for current and future systems? Can the centralization of the AMC software engineering assets deliver efficiencies that result in better control of software sustainment costs?

Question 17 asked whether the current software engineering organizational structure within AMC is sufficient to support the immediate and future software/information technology needs of the Army. The responses are presented in Figure 16. The majority (60.5%) of the respondents agreed the current decentralized structure was sufficient to support the current and future needs of the Army. Only 21% felt the organization was insufficient.

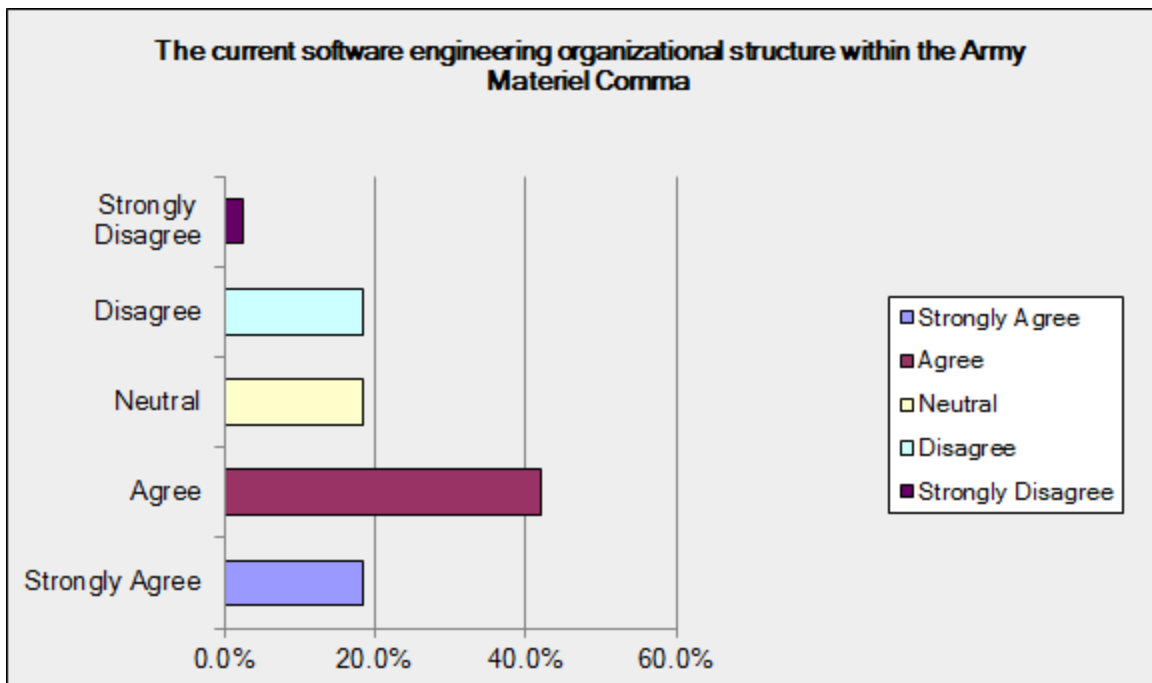


Figure 16 – Results for Survey Question 17

Question 18 sought to identify how active AMC is in integrating the software organizations across their command. Only 16% of the respondents disagreed with this statement

(Figure 17). The majority (62.2%) of respondents indicated they agree that AMC is not actively engaged with the AMC software support centers. These responses are similar to the findings highlighted by AMC (2011). The question is the only negative-directed question in the survey and was worded in that way to validate that the respondents were reading and understanding each survey question. The responses indicate the question was carefully read and the response was carefully selected. This provides confidence that the other questions were also thoughtfully addressed.

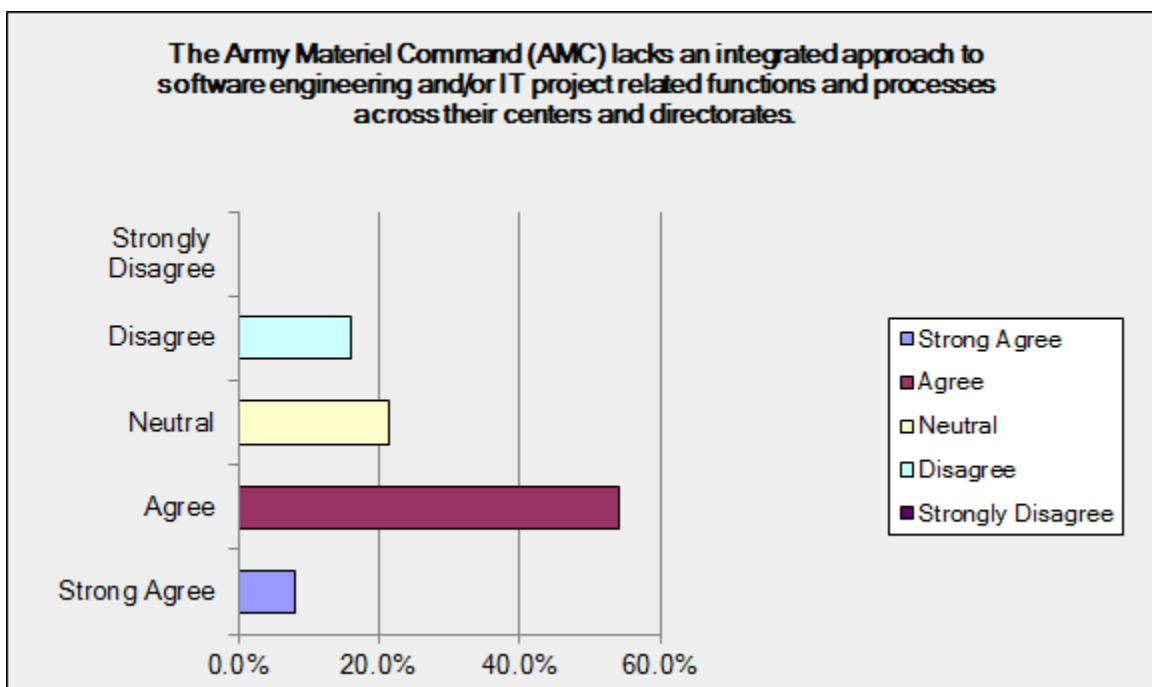


Figure 17 – Results for Survey Question 18

Questions 19 and 20 were included to solicit AMC software leaders regarding the consolidation or centralization of AMC software centers as an effective way to lower software sustainment costs and provide better control over escalating software expenses. In Figures 18 and 19 the results indicate the respondents’ rejection of consolidation or centralization as a means to improve control of and lower software sustainment costs. Only 15% of the respondents agreed

centralization can provide lower sustainment costs, and approximately 10% believe consolidation will result in lower software sustainment costs.

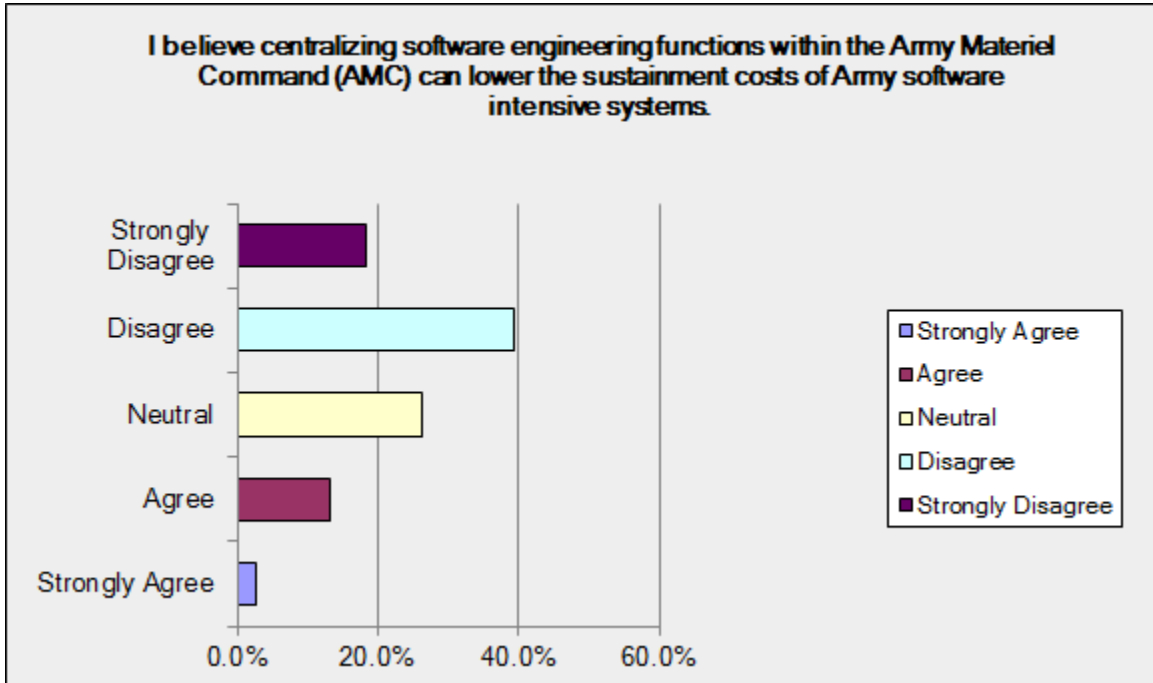


Figure 18 – Results for Survey Question 19

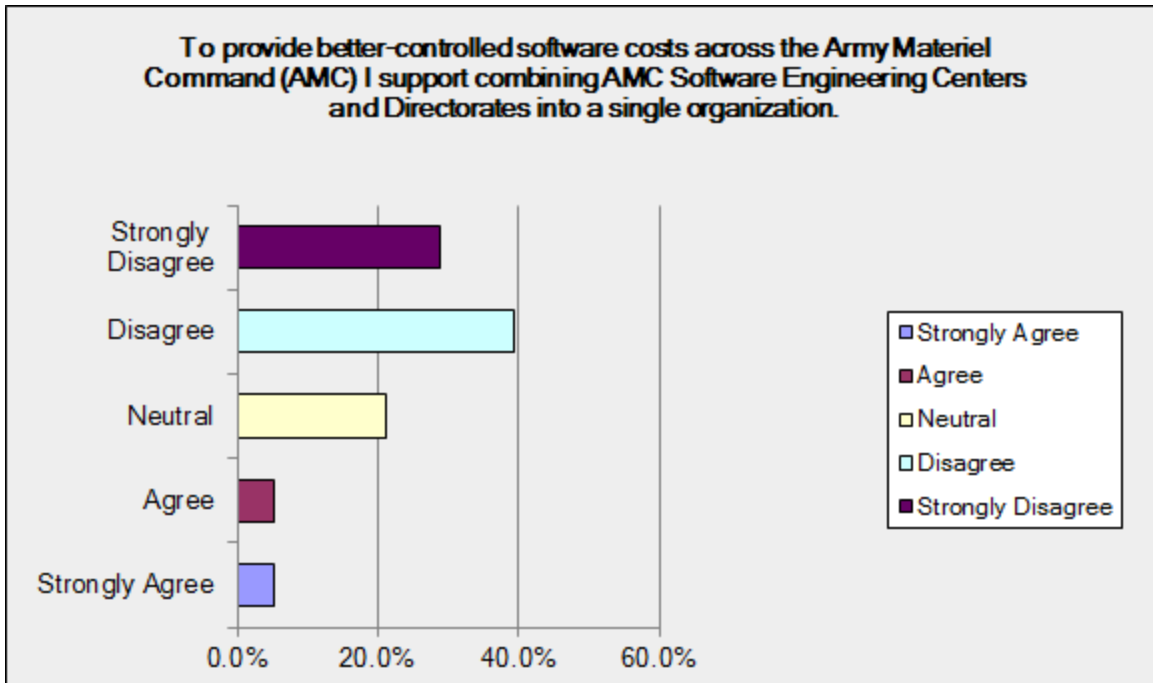


Figure 19 – Results for Survey Question 20

Question 21 asked respondents to provide additional comments or explanations. Twenty-one respondents elected to provide comments. While the specific comments will not be included here (see Appendix C for all responses to Question 21), the following summary of their comments highlights consistent topics:

- Commodity-focused software centers enhance workforce expertise.
- Process improvement, standardization (CMMI), and state-of-the-art software development tools/techniques lower costs.
- Program managers’ decisions drive sustainment economies.
- Centralization adds layers, increases costs, and lowers productivity.
- Collocations with LCMCs allow cross-fertilization.
- LCMCs collocation provides closer coordination with customer and enhances decisionmaking.

- A move toward Government-owned/Government-developed software is recommended.

Summary of AMC Current Software Engineering Organizational Structure Questions

This section of the survey attempted to obtain feedback from those Federal employees currently leading AMC software projects, teams, and organizations. The primary objective was to obtain their perspective and insight regarding the study's research questions and hypothesis. The respondents' written comments were perhaps the most informative. The comments elucidated the rationale for their previous responses. While the respondents supported the current organizational structure within the AMC software centers, the majority agreed AMC leadership provided little insight about integrating the work of the individual centers. It was difficult to identify leaders who supported consolidation or centralization as a benefit in any aspect of software development or sustainment. Their comments offered more insight into their thought process. Centralization would add layers, cost, and lower productivity. Smaller, more focused organizations provide greater flexibility to the LCMCs, allowing them to create and sustain the required expertise to be responsive to their customer's software needs. The respondents believe standard processes and practices that focus on software technologies and state-of-the-art methodologies will create the required economies-of-scale the Army is attempting to achieve.

Additional Analysis of the Results

Additional analysis of the data was performed to determine whether particular views were biased based on the respondent's position and experience. Three views were examined: (1) The respondent's position in the organization (project leader/1st line supervisor versus 2nd line supervisor/director), (2) The years of IT experience (15 years or less versus more than 15 years), and (3) major command perspective (responses from those software centers in RDECOM

compared to the software center in CECOM). The median score was calculated for each question and a comparison of scores between the identified groups was determined. The results appear in Figures 20, 21, and 22.

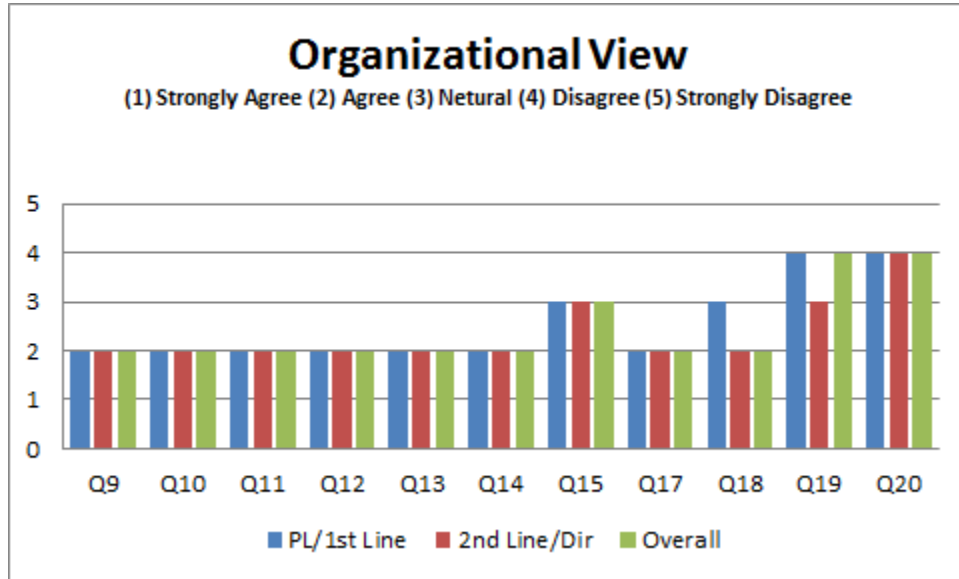


Figure 20 – Median Selection by Organizational View

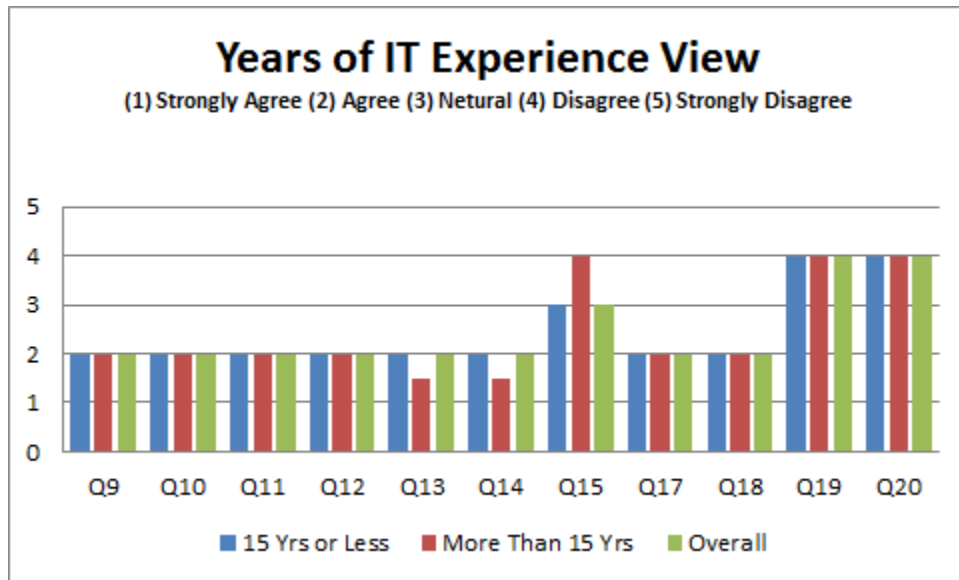


Figure 21 – Median Selection by IT Experience

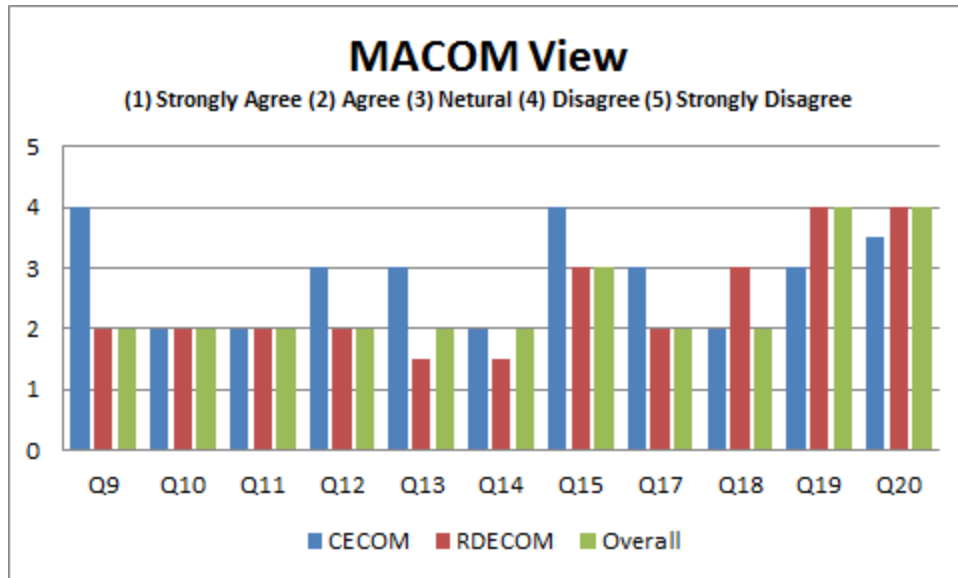


Figure 22 – Median Selection by Major Command (MACOM)

The analysis revealed no significant difference in responses based on where the respondent worked in the organization or the amount of IT experience the respondent possessed. Of the 11 questions analyzed, the median selections for the majority of the responses were identical. However, when examining the responses based on the major command, significant differences appear. Only two of the questions had similar responses, the remaining nine were different. A significant statistical difference occurred for question 9 (“I have access to the resources necessary (funding, people, tools) for my software and/or IT projects to be successful”). While the RDECOM software centers agreed with the statement, the CECOM software center disagreed with this statement. Several comments were received regarding the ability to hire the necessary resources to support the demand of the work. This potential resourcing shortfall could account for the wide gap between the two organizations. Additionally, funding shortfalls in the overall sustainment program could explain the gap. Essentially the overall assessment of the responses indicates a more positive perspective of the current work within the RDECOM software centers. Neither supported consolidation as a means to provide

better control of software sustainment costs; not one positive answer was provided by either organization. In fact RDECOM organizations were slightly more negative about consolidation than the CECOM software center.

Chapter 5 – Conclusions and Recommendations

Conclusions

The findings in this study indicate consolidation of the Army Materiel Command software support activities will not provide significant improvements in the Army's ability to develop and sustain software more efficiently. AMC's existing decentralized structure serves as a better foundation to implement required changes in requirements, development, and sustainment processes in order to improve control of software costs. The decentralized structure currently in place actually centralizes the software development and sustainment activities by commodity. This provides a number of benefits to the individual software support activities, particularly to their ability to cross-fertilize the workforce in a specific domain and expand upon their expertise. This cross-fertilization process creates software domain experts who possess both a tactical and strategic perspective. This type of expertise was highlighted by GAO and industry as a primary means to improve the outcome of software-intensive projects.

The decisions made by program managers in the early stages of a program's life cycle are the primary determinants of long-term software sustainment costs. These decisions include the use of commercial-off-the-shelf software and equipment, the type of license agreement implemented, and the type of contract used to procure and sustain commercial products. While consolidating these decisions can provide standardization, consistency, and control, the decisions are ultimately the responsibility of the program manager, not AMC. As suggested in ASA(ALT)'s response to the Secretary of the Army, AMC can provide the mechanism to purchase and sustain these commercial products for the Army; however, ASA(ALT) must provide the guidance and policy to mandate its use.

The survey results indicate the AMC software support centers and the software-intensive projects they support are led by experienced and professionally certified individuals. The literature review that was conducted for this study found no specific examples of failures within the software centers that could be attributed to the knowledge, skills, and abilities of the organization's workforce. As highlighted earlier, one of the reasons why software-intensive projects fail in both Government and commercial organizations can be linked to the knowledge and expertise of the project staff. The procedures and processes used by the existing software centers are providing the expertise needed to ensure software-intensive systems are staffed with the knowledge and experience to make them successful. Current staffing strategies for software activities support the best practices highlighted in CECOM SEC's (2006) study: a stable and well-trained workforce provided the company with their competitive edge.

While structural changes have been identified in the past, specifically in AMC's (2011) study, no structural changes have been implemented to date. Based on the information gathered through the survey of AMC software and IT leadership, as well as the assessment in Morrison (2011) and the feedback provided in the Decker and Wagner (2011), one can conclude that AMC's structural recommendations were questionable at best and not in the best interest of the Army.

Recommendations

Sustaining software-intensive systems within the Army will continue to grow as more and more software systems are developed to support the tactical and operational forces of the military. The ASA(ALT) recommendations to the Secretary of the Army were well researched, comprehensive, and realistic. AMC should establish an ongoing relationship with ASA(ALT) to

implement their 2013. AMC should include their existing software support centers in the implementation planning and execution of these recommendations.

AMC should focus on developing policy that supports standardization, consistency, and control across their software support activities. Policy should include a standard set of software metrics, software project health checks, dashboards, and other tracking systems to assure the integrity and appropriate management of software-intensive systems currently being sustained. Use of commercial best practices and tools should be encouraged and integrated with the acquisition life-cycle model.

Software support activities that are not in compliance with the CMMI (CMMI Institute, 2015) should develop an implementation strategy to become compliant. Funding should be provided by AMC Headquarters to support this effort, and software-support-activity leadership should be held accountable for its timely implementation. The CMMI is an industry-accepted model to measure a software organization's capabilities.

Additional studies should be done to determine the impact of AMC policies on the current software sustainment activities and the impact current staffing models have on software sustainment costs. The current *AMC Reimbursable Support Rate Guide*, developed and distributed by the AMC Deputy Chief of Staff for Resource Management, G8, allows AMC organizations to establish their own embedded and nonembedded reimbursable matrix support costs (Boddorf, n.d.). A review of FY12 reimbursable rates for the AMC software support activities reveals an annual reimbursable rate that ranges from \$5,000 in one organization to approximately \$80,000 in another. Additionally, DoD laboratories are permitted to collect Section 219 Funding. Section 219 of the FY09 National Defense Authorization Act directs the Secretary of Defense to develop a mechanism to allow DoD laboratories to charge customers a

maximum of 3% to invest in infrastructure, training, or research and development (Hunter, 2008). Table 1 illustrates the effect these policies could have on the software support activities in FY12. Reimbursable rates could vary by as much as 80%. These policies, along with pay-for-performance systems, appear to be another factor contributing to the rising cost of software sustainment. For this study the exact impact was not quantified. Therefore, a follow-on study is recommended to explore the impact of these policies on the escalating software sustainment costs.

Table 1 – Potential Impact of AMC Reimbursable Rate and Section 219 Funding in FY12

<i>AMC</i>	<i>GS13</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Minimum</i>	<i>Maximum</i>	<i>Section</i>	<i>Minimum</i>	<i>Maximum</i>
<i>Software</i>	<i>Step</i>	<i>5</i>	<i>Overhead</i>	<i>Overhead</i>	<i>Salary</i>	<i>Salary</i>	<i>219</i>	<i>Customer</i>
<i>Centers</i>	<i>Salary in</i>	<i>Rate</i>	<i>Rate</i>	<i>Cost</i>	<i>Cost</i>	<i>Funding</i>	<i>Cost</i>	<i>Cost</i>
	<i>FY12</i>							
SEC A	\$81,230	\$22,900	\$79,533	\$104,130	\$160,763	3%	\$107,254	\$165,586
SEC B	\$81,230	\$39,520	\$39,520	\$120,750	\$120,750	3%	\$124,373	\$124,373
SEC C	\$81,230	\$29,500	\$42,777	\$110,730	\$124,007	3%	\$114,052	\$127,727
SEC D	\$81,230	\$69,976	\$69,976	\$151,206	\$151,206	3%	\$155,742	\$155,742
SEC E	\$81,230	\$5,290	\$16,037	\$86,520	\$97,267	N/A	\$86,520	\$97,267

It is also evident the majority of the software work in AMC is performed by a workforce that consists of software engineers and computer scientists. In fact, AMC (2011) highlights this as a competitive advantage of the RDECOM software support centers. While the knowledge of relevant mathematical and statistical sciences may be necessary for some Army applications, I suspect the majority of software systems in the Army may only require knowledge of IT principles, concepts, and methods. The knowledge and skills required to support application software, systems analysis, data management, network services, enterprise architecture, or

systems administration. A separate follow-on study should determine whether AMC software centers are staffing their responsibilities with the correct occupation series rather than staffing with a more advanced, and more costly, occupational series.

In conclusion, this study attempted to determine whether the consolidation of AMC's software support centers could provide significant cost savings for current and future PPSS. While consolidation may initially eliminate redundancies, often these efficiencies are outweighed by a reduction in effectiveness. AMC software support centers are successful today because they are allowed to operate autonomously in conjunction with their commodity-centric Life Cycle Management Commands. These structures allow these organizations to communicate directly with the customer and to sustain a workforce that understands both the tactical and strategic implications of their decisions. While these autonomous relationships may result in a variety of cost models that could negatively impact the cost of sustaining Army software-intensive systems in the long-term, the current decentralized structure is more effective for the PPSS mission. Until additional studies can be undertaken to analyze the impact of the cost/price variance and staffing models, no organizational changes are recommended. As the primary provider of Army software expertise, AMC should begin working closely with their software support centers in order to establish a comprehensive strategy to address standardization, consistency, and control of the ongoing software sustainment activities within their organization. AMC should also begin to exert themselves as the "software champion" for the Army.

References

- Army Materiel Command. (2011). *Army Materiel Command software support transformation strategy. Version 1.4 (Draft)*. Redstone Arsenal, AL: Author.
- Assistant Secretary of the Army for Acquisition, Logistics, and Technology. (2013). *Optimization of software acquisition, development, and sustainment: Recommendations to the Secretary of the Army*. Pentagon: Author.
- Boddorf, G. M. (n.d.). *Army Materiel Command (AMC) reimbursable support rate guide* [Memorandum]. Fort Belvoir, VA: Deputy Chief of Staff for Resource Management, G8
- Bott, F., Coleman, A., Eaton, J., & Rowland, D. (2000). *Professional issues in software engineering*. London: CRC Press.
- CMMI Institute. (2015). *Home page*. Retrieved from <http://cmminstitute.com/>
- Communications and Electronics Command. (2011). *U.S. Army Communications-Electronics Command (CECOM) organization, mission, and functions* (Regulation 10-1). Aberdeen Proving Ground, MD: Author.
- Communications and Electronics Command Software Engineering Center. (n.d.). *Sustainment & evolution of fielded systems: The need for software sustainment* [Briefing Slide]. Aberdeen Proving Ground, MD: Author.
- Communications and Electronics Command Software Engineering Center. (2006). *Comparisons of software business activities and management practices between the U.S. Army and leading industrial companies—A white paper*. Ft. Monmouth, NJ: Author.

- Decker, G. F., & Wagner, L. C. Jr. (2011). *Army strong: Equipped, trained and ready, Final report of the 2010 Army Acquisition Review, Executive summary*. Pentagon: Secretary of the Army.
- Government Accountability Office. (2009). *Information technology: DOD needs to strengthen management of its statutorily mandated software and system process improvement efforts* [GAO-09-888]. Washington, DC: Author.
- Government Accountability Office. (2011). *Information technology: Critical factors underlying successful major acquisition* [GAO-12-7]. Washington, DC: Author.
- Hunter, D. (2008). *Duncan Hunter National Defense Authorization Act for Fiscal Year 2009*. Retrieved from http://www.dtic.mil/congressional_budget/pdfs/FY2009_pdfs/S3001.pdf
- Jones, C. (2006). *The economics of software maintenance in the twenty first century*. Retrieved from <http://www.compaid.com/caiinternet/ezine/capersjones-maintenance.pdf>
- Kern, P. (2003, May-June). AMC's new Research, Development and Engineering Command, *Army AL&T*, pp. 2-3
- Kilner, S. (2009). *Unsolved problems of software maintenance*. Walnut Creek, CA: vLegaci Corp.
- McHugh, J. M. (2012, October 1). Optimization of software acquisition, development and sustainment [Memorandum]. Pentagon: Headquarters, Department of the Army.

- Morrison, M. (2011). *White paper—Army software business strategy*. Aberdeen Proving Ground, MD: Software Management Subgroup, Task Force Drive to Fiscal Responsibility.
- Nerger, J. B. (2013). Optimization of software acquisition, development and sustainment. [Memorandum for Assistant Secretary of the Army Acquisition, Logistics and Technology]. Redstone Arsenal, AL: AMC HQ.
- Reifer, D. (2010, March 8). *Total cost of software maintenance workshop*. Presentation at the 2010 Center for Systems and Software Engineering Annual Research Review.
- Smith, L. A. (1996). *Information paper—Signal organization mission alignment (SOMA) analysis/information management functional area assessment (IMFAA)*. Fort Monmouth, NJ: CECOM Program Analysis and Evaluation.
- The Standish Group. (2013). *Chaos manifesto 2013: Think big, act small*. Retrieved from <http://www.versionone.com/assets/img/files/ChaosManifesto2013.pdf>

Glossary of Acronyms and Terms

AMC	Army Material Command
ARDEC	Armament Research Development Engineering Command
ASA(ALT)	Assistant Secretary of the Army for Acquisition, Logistics, and Technology
CECOM	Communications Electronics Command
CERDEC	Communications Electronics Research Development Engineering Command
CMMI	Capability Maturity Model Integrated
FY	fiscal year
GAO	Government Accountability Office
H ₀	null hypothesis
H ₁	alternate hypothesis 1
H ₂	alternate hypothesis 2
H ₃	alternate hypothesis 3
HQ	headquarters
IFMAA	Information Management Functional Area Assessment
IPT	integrated product team
IT	information technology
LCMC	Life Cycle Management Command
MACOM	major command
MAIS	major automated information system
PEO	Program Executive Office

PPSS.....Post Production Software Support
RDEC.....Research Development Engineering Center
RDECOMResearch Development Engineering Command
S&T.....science and technology
SECSoftware Engineering Center
SOMA.....Signal Organization and Mission Alignment
TDATable of Distribution and Allowances
TF DFR.....Task Force Drive to Fiscal Reality

Appendix A – Survey Instrument

Consent

1. INFORMED CONSENT AGREEMENT

As an adult 18 years of age or older, I agree to participate in this research about Achieving Better-Controlled Software Costs Through Consolidation of AMC Software Engineering Centers. This survey is being conducted to support research efforts being performed by Gary Lichvar, a student of the Senior Service College Fellowship Program of the Defense Acquisition University.

- 1. The purpose of the research is to examine the impact centralization of software engineering organizations might have on controlling software costs within the Army Materiel Command. Should I choose to participate in the survey, I am aware that my feedback will be consolidated with other participants and the analysis will be briefed to Army leadership allowing them to potentially take action on my recommendations.**
- 2. If I choose to participate in this research, I will be asked to continue the online questionnaire. The questionnaire includes items related to software development, software sustainment and Information Technology (IT) project management and oversight. The questionnaire will take approximately 15 minutes to complete.**
- 3. There is no incentive for participation.**
- 4. All items in the questionnaire are important for analysis and the data 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.

END OF INFORMED CONSENT

Survey Question #1. I have read the Informed Consent Agreement and will participate voluntarily.

- YES
- NO

Specific To Your Work and Organization

2. Please identify your current organization.

- Armament Research Development and Engineering Center (ARDEC)
- Aviation Missile Research Development and Engineering Center (AMRDEC)
- Communications and Electronics Command (CECOM)
- Communications and Electronics Research Development and Engineering Center (CERDEC)
- Tank Automotive Research Development and Engineering Center (TARDEC)
- Other (please specify)

3. The majority of your software/information technology experience has been in (select only one)

- Software Research
- Software Development
- Software Sustainment
- Supporting Software Development/Sustainment Activities
- Matrix Support To Software/IT Programs of Record

Other (please specify)

4. Please indicate number of years in your current organization.

- Less than 5
- 5 to 10
- Over 10 to 15
- Over 15 to 20
- More than 20

5. Please indicate your number of years leading software/information technology projects and/or organizations.

- Less than 5
- 5 to 10
- Over 10 to 15
- Over 15 to 20
- More than 20

6. Please indicate your number of years of Federal Service.

- Less than 5 years
- 5 to 10
- Over 10 to 15
- Over 15 to 20
- More than 20

7. Please indicate your highest Army Acquisition Certification Level.

- Level I
- Level II
- Level III
- None

8. Please identify your current position within your organization.

- Project Leader (Non-Supervisor)
- 1st Level Supervisor - Branch/Team Chief
- 2nd Level Supervisor - Division Chief
- Senior Level Leader - Director/Deputy
- Other (please specify)

Specific To Your Work and Organization

9. I have access to the resources necessary (funding, people, tools) for my software and/or IT projects to be successful.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

10. I have been given the appropriate authority to execute the duties and responsibilities assigned in order for my software and/or IT projects to be successful.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

11. I have the freedom and authority to introduce cost savings and process improvements where necessary to support my mission.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

12. My organization provides a standard set of tools and methods I employ to perform my assigned software/IT responsibilities.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

13. If I encounter problems on my software and/or IT projects, my organization will provide resources to help me analyze the cause and develop a path forward.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

14. The majority of my current work supports the domain/commodities that are specific to my assigned Life Cycle Management Command (LCMC).

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

15. I am encouraged by my organization to seek work/opportunities from customers outside my assigned Life Cycle Management Command (LCMC).

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

16. Please add any related comments/explanations for questions 9 - 15.

AMC Current Software Engineering Organizational Structure

17. The current software engineering organizational structure within the Army Materiel Command (AMC) is sufficient to support the immediate and future software/information technology needs of the Army. (Decentralized Software Engineering Centers tied to specific commodities - Aviation/Missile, Armament, Communication/Electronics, Tank/Automotive)

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

18. The Army Materiel Command (AMC) lacks an integrated approach to software engineering and/or IT project related functions and processes across their centers and directorates.

- Strong Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

19. I believe centralizing software engineering functions within the Army Materiel Command (AMC) can lower the sustainment costs of Army software intensive systems.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

20. To provide better-controlled software costs across the Army Materiel Command (AMC) I support combining AMC Software Engineering Centers and Directorates into a single organization.

- Strongly Agree
- Agree
- Neutral
- Disagree
- Strongly Disagree

21. Please add any additional comments/explanations here.

A horizontal text input field with a scroll bar on the right side. The field is currently empty and has a light gray background.

Appendix B – Responses to Question 16

#15 - Seek new business areas from outside established LCMC without lane violations.

#9 + 13 - The current fiscal climate has made it harder to properly resource (this is above AMC level). #11-12 - We are a CMMI Level 5 organization and process improvement is part of our culture which has reduce cost for SW Development as well as supporting SW Acquisitions.

the work I have done is within our lane of work and within our LCMC

Almost all work is within my assigned LCMC. Occasionally, a non-customary customer outside will approach my organization about addressing a specific challenge. This is not typical and is usually of limited duration.

Q9 - Overall, I have access to the resources that are needed. However, given the current hiring restrictions, it is sometimes challenging to find the right people for some software projects.
Q15 - I am encouraged to seek opportunities from customers outside my assigned LCMC provided those opportunities do not result in a known "lane violation." The Army on the one hand discourages "lane violations" yet on the other hand encourages competition. This is a catch-22. Organizations are not truly free to seek opportunities and customers are not truly free to choose the organization that they (the customer) feel best meet their needs.

Having CECOM as the only non-RDECOM center in question #1, and specifically listing IT throughout the survey (as if it is the only application of SW) makes this survey INCREDIBLY BIASED toward CERDEC. 9. High demand for ARDEC SW services can occasionally out pace our hiring authority, but our CMMI Level 5 organization-wide processes ensure that SW or Systems Engineering expertise can be pulled from any ARDEC domain and reassigned with limited additional training of the employee. 10. The strong foundation of common CMMI level 5 best practices at ARDEC, allows leaders to trust and empower our supervisors and employees with little risk. 11. The CMMI Level 5 process at ARDEC offers well-established methods that foster innovation and a continuous improvement mind set 12. As the only Federal organization rated Level 5 in CMMI, and the only Federal Baldrige Recipient, the ARDEC SEC is a nationally recognized leader for its Organizational Standard Processes (OSP) 15. RDECOM has well established domain authority assigned to each of its Centers. As a national Leader, ARDEC frequently receives unsolicited business opportunities that are not within its RDECOM assigned domain areas. In the event that an opportunity falls within the domain of other Centers, ARDEC mandates that its employees notify the responsible center so that they may capitalize on the opportunity. In the event that a business opportunity is not assigned to a particular Center, ARDEC employees are directed to notify senior leadership to decide if it should be added to ARDECs portfolio. However, our assigned domain areas and customers always remain the #1 priority.

15. We are encouraged to find work outside our LCMC provided that it does not violate any pre-positioned working lanes with other LCMCs.

Within the last year, we have been highly discouraged in pursuing new work/opportunities outside of the assigned LCMC.

None

Acquisition of IT hardware and software is convoluted, slow, bureaucratic, inefficient and takes too much time away from engineers. The ITMP, AKM Goal 1 Waiver process, and acquisition of HW & SW needs to be streamlined, expedited and much more efficient. If we were a private enterprise we would go out of business. Also, management of Enterprise Software Licenses is broken.

There is more work than can be accomplished by existing TDA. We are actually being forced to prioritize and turn work away.

We are not encouraged or instructed to seek work or opportunities from customers whose mission is assigned to another LCMC. If a mission is not assigned specifically to an LCMC, we can engage with the customer. In addition, the customer is free to choose who they want to work with if, for example, they are displeased with previous performance.

My organization has a well-defined, mature process which offers a set of processes and tools which are tailorable to each project. Common software tools are available as well as support to the projects to enable their usage. We discourage encroachment on other SEC's mission areas. My customers include more than a just a single LCMC - I support both PEO Ammo (JMC MSC) and PEO GCSS (TACOM LCMC). I believe we have customers outside the 3 LCMCs of Aviation & Missiles, TACOM, and CECOM. I am not sure whether they approached us, or we sought them out.

#11 - Can only propose cost saving then it is up to decision makers to take it to the next level.

My organization gives me the resources I need. There is of course ways it can work better, but as a CMMI 5 organization, this office has more tools and standard processes than any other software organization I have worked at.

Quite often we are approached by PM offices that we have worked with in the past to support new projects and initiatives they are developing.

There are external influences that contribute to resource shortages ie hiring freeze and T DA allocations. The split between CERDEC and SEC has created an additional layer of bureaucracy that stifles flexibility and wastes resources on an additional layer of management.

Appendix C – Responses to Question 21

#18, #19 & #20: A common set of process for the AMC SECs to follow would be beneficial, not necessarily a single organization. (e.g., all follow a common set of CMMI Level 5 processes).

19. Each system has different sustainment needs. Further, each domain (Armaments, Aviation/Missiles, Communication/Electronics, Take/Automotive) have different needs and technical challenges. Combining could cause a top heavy organization taking away the specialization of each individual center. 20 - Not sure if there is any analysis that could show this.

more research would need to be done to determine how centralizing functions would affect costs

I believe that commodity-based Software Engineering Centers allow better and more efficient responses to customers' need within the LCMCs. Establishing a high-level council that meets regularly (quarterly) could provide a mechanism for better coordination and issue resolution. Centralization would do little to address current issues and would probably lead to a decrease in efficiency and quality of work.

The different software centers, for the most part, deal in different domains. Combining into a single organization will likely result in sub-optimization. The key to lowering development and sustainment costs is in process improvement (using the CMMI model, for example) and maximizing the use of the latest software development tools and techniques. The software centers should strive for, at a minimum, a CMMI level 3 rating. Collaboration among the software centers should be encouraged to the maximum extent possible. Also, often, high sustainment costs are a result of decisions made by Program Managers without consulting appropriate software experts. Program Managers should be required to consult software experts for any systems that contain software.

17. Having domain authority assigned to each RDECOM center helps to foster continuous improvement within the domain. It would be advantageous for RDECOM to establish internationally recognized STANDARDS and PROCESSES across all centers to ensure consistent, high quality SW products and services throughout the command, but to centralize the SW function, or mandate poor practices (IE Non-CMMI, Non-PMI or Non-Baldrige) to centers who are already recognized leaders in these areas would be a recipe for failure across the board. 18. ARDEC has frequently been called upon to fix SW/IT projects that have failed due to poor SW practices, management and execution by undisciplined contractors and Government agencies alike. 19. Centralizing the SW function, especially if centered around organizations that are undisciplined, too heavy in contractors, and with little organic SW expertise, would be devastating to the morale, capability and reputation of AMC organizations who are nationally recognized as true SW leaders. 20. Unless all centers are required to be assessed at CMMI Level 5, prior to becoming added to the proposed centralized SW organization, control would be lost, not gained. In many cases PMs and other customers have fired their contractors and/or other AMC SW Centers and hired ARDEC to manage and

develop their SW products in-house by ARDEC personnel, as Government owned/developed. This has generally resulted in a significant cost savings. Partnering with these failed organization without first improving their competency, should be discouraged.

17. - 20 - If the Software Engineering Centers were to be combined, it would be the most efficient to allow ARDEC to take the lead since they are the single center that has earned the Software CMMI level Five accreditation. At the attained level of five, the rigorous engineering methods have proven themselves to attain high levels of Return on Investment for projects.

Centralization within the directorates/organizations under AMC to this point has proven to be more costly in that there was no apparent analysis of the work being performed, but directorates slashed to get down to certain numbers, functions moved from one directorate to another like pawns on a chess board causing a break in the support links, an increased workload on the organizations formed as a result of reorganization/centralization causing havoc, lack of support by senior management, constant frustration and lack of morale. It will take years of work and constant change to come to a place where what has already occurred works efficiently. Centralization has caused morale issues to the very bottom of the workforce with an unmanageable workload to get done. Things are just falling off the plate. I believe it has led to a number of personnel issues as well due to the stress the workforce feels and is being manifested in bad behavior. The workload leaves very little time to deal with the personnel issues. So in the long run, centralization cripples the very fiber of the greatest resource needed for an organization to be successful--that is the people. We proclaim people are important, but that is just words. \$ are the driving force.

I believe combining will increase costs because AMC will just add layers of management and stifle some of what freedom exists in the commodity commands

Centralization normally slows things up. It is good for the organization in that they have control, but the user usually suffers because of red tape.

At a minimum, the following needs to happen: 1) a merging of the SEC and SED (and even related S&T organizations) within the C4ISR community; 2) keep each commodity are in the defined mission lane.

I support combining AMC Software Engineering Centers and Directorates into a single organization under the highest CMMI Level certified organization. It is only through adoption of the organization with the highest CMMI maturity Level processes that AMC can lower the software development and sustainment costs. No organization should be allowed to develop or sustain software without at least a CMMI Level 3, and the minimum CMMI level for all software centers must be level 5. If AMC is to develop an integrated approach it only makes logical sense to go with the center with CMMI level 5. Just as we have DAU certifications, Information Assurance certifications and software developer certifications for individuals within the workforce, all organizations as a whole should be required to attain CMMI certification demonstrating their capability to develop and sustain software. CMMI rated organizations provide quality, consistency, and continuous improvement for software intensive warfighter systems.

I believe that AMC is the controlling hand over the SECs in matters which are common to all, and ensuring Army regs, public law, and policies are implemented. I do not believe that additional layers of management at the AMC level would decrease costs. I believe that costs would increase if the SECs were consolidated. Each center is supporting a specific commodity with subject matter expertise built up over the organization's history. My organization provides very specific support to armaments, fire control systems, and ammunition. Close physical proximity to the supported organizations keeps TDY costs down by allowing project IPT participation with no or minimal TDY. The migration of staff between the commodity areas and the SEC, either by details, rotations, or reassignments, fosters development of subject matter expertise which minimizes costs and enhances efficiency and performance. Any center which might have to relocate its personnel in a consolidation would suffer a significant loss of personnel in a move, with a commensurate loss in corporate knowledge and subject matter expertise. Also, moving the software engineering center away from the customer base would require additional travel costs to both customer and contractor locations to support projects. Putting all the Army software engineering expertise in a single geographical area would leave it vulnerable to attack or natural disaster.

In my experience, when things are centralized it tend to cost more in lost productivity and wait times for products or service escalate.

#19 Sustainment should be built in during development not during production or post production support.

Each software center specializes in their field. Here at ARDEC, our skills on mission essential safety critical engineering is unmatched due to the long length of direct experience.

Consolidation of software engineering centers will generate unnecessary risk to the Software Engineering Centers and its readiness/capability to provide high quality products to the Warfighter.

Centralizing functions usually sounds like a good idea, however takes away direct customer interaction and won't serve customers as well or as efficiently. Such as centralizing mail services, what we see is degraded service (from quick local support to having to go through chain of personnel to get issues resolved.) and the whole mail system seems to run more slowly and this can be a single point of failure issue when things happen.

17: the key word to me is "sufficient", I think there is always room for improvement. We should all be doing what is best to support the warfighter's needs with the best resources and abilities that AMC has to provide. 18: I disagree because of the word "lacks", I don't know if there is an integrated approach across all centers, or if that information has been disseminated to all levels of the work force. 19: One main factor to consider is the cost of travel, to have the right personnel at the right location at the right time to do the task. If someone is local but not the subject matter expert, is that the best thing to do? 20: I am not sure just "combining" will work. I think we need to know what makes each organization different and unique, and look for the best attributes. Then you have to consider will all personnel be centralized and have

additional travel to support customer needs. How would a customer at any Army location needing new software engineering support for a new effort or initiative go about getting that support? I don't know how this would save money and time in getting a product to the warfighter.

AMC should host on a rotating basis quarterly SEC meetings to support the warfighter

layers of management add costs to every software release. Eliminating redundant processes and combining like efforts, such as IAVA development will lower lifecycle costs.