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Surface Warfare Center Contributions for Addressing Warfare System Development Challenges and Goals

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Surface Warfare Center Contributions for Addressing Warfare System Development Challenges and Goals

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Preface & Acknowledgements

During his internship with the Graduate School of Business & Public Policy in June 2010, U.S. Air Force Academy Cadet Chase Lane surveyed the activities of the Naval Postgraduate School's Acquisition Research Program in its first seven years. The sheer volume of research products—almost 600 published papers (e.g., technical reports, journal articles, theses)—indicates the extent to which the depth and breadth of acquisition research has increased during these years. Over 300 authors contributed to these works, which means that the pool of those who have had significant intellectual engagement with acquisition issues has increased substantially. The broad range of research topics includes acquisition reform, defense industry, fielding, contracting, interoperability, organizational behavior, risk management, cost estimating, and many others. Approaches range from conceptual and exploratory studies to develop propositions about various aspects of acquisition, to applied and statistical analyses to test specific hypotheses. Methodologies include case studies, modeling, surveys, and experiments. On the whole, such findings make us both grateful for the ARP's progress to date, and hopeful that this progress in research will lead to substantive improvements in the DoD's acquisition outcomes.

As pragmatists, we of course recognize that such change can only occur to the extent that the potential knowledge wrapped up in these products is put to use and tested to determine its value. We take seriously the pernicious effects of the so-called "theory–practice" gap, which would separate the acquisition scholar from the acquisition practitioner, and relegate the scholar's work to mere academic "shelfware." Some design features of our program that we believe help avoid these effects include the following: connecting researchers with practitioners on specific projects; requiring researchers to brief sponsors on project findings as a condition of funding award; "pushing" potentially high-impact research reports (e.g., via overnight shipping) to selected practitioners and policy-makers; and most notably, sponsoring this symposium, which we craft intentionally as an opportunity for fruitful, lasting connections between scholars and practitioners.

A former Defense Acquisition Executive, responding to a comment that academic research was not generally useful in acquisition practice, opined, "That's not their [the academics'] problem—it's ours [the practitioners']. They can only perform research; it's up to us to use it." While we certainly agree with this sentiment, we also recognize that any research, however theoretical, must point to some termination in action; academics have a responsibility to make their work intelligible to practitioners. Thus we continue to seek projects that both comport with solid standards of scholarship, and address relevant acquisition issues. These years of experience have shown us the difficulty in attempting to balance these two objectives, but we are convinced that the attempt is absolutely essential if any real improvement is to be realized.

We gratefully acknowledge the ongoing support and leadership of our sponsors, whose foresight and vision have assured the continuing success of the Acquisition Research Program:

- Office of the Under Secretary of Defense (Acquisition, Technology & Logistics)
- Program Executive Officer SHIPS
- Commander, Naval Sea Systems Command
- Army Contracting Command, U.S. Army Materiel Command
- Program Manager, Airborne, Maritime and Fixed Station Joint Tactical Radio System

- Program Executive Officer Integrated Warfare Systems
- Office of the Assistant Secretary of the Air Force (Acquisition)
- Office of the Assistant Secretary of the Army (Acquisition, Logistics, & Technology)
- Deputy Assistant Secretary of the Navy (Acquisition & Logistics Management)
- Director, Strategic Systems Programs Office
- Deputy Director, Acquisition Career Management, US Army
- Defense Business Systems Acquisition Executive, Business Transformation Agency
- Office of Procurement and Assistance Management Headquarters, Department of Energy

We also thank the Naval Postgraduate School Foundation and acknowledge its generous contributions in support of this Symposium.

James B. Greene, Jr.
Rear Admiral, U.S. Navy (Ret.)

Keith F. Snider, PhD
Associate Professor

Panel 6 – Challenges in Developing and Delivering High Quality Software Intensive Products

Wednesday, May 11, 2011	
1:45 p.m. – 3:15 p.m.	**Chair: James Wolfe,** Head, Strategic and Weapon Control Systems Dept., Naval Surface Warfare Center Dahlgren Division ***Software-Intensive Acquisition Programs: Productivity and Policy*** Kathy Loudin, Naval Surface Warfare Center Dahlgren Division ***Lessons Learned in Applying Modular Open Systems Approach Requirements in an Acquisition Program*** Andrew Chen, NAVAIR ***Surface Warfare Center Contributions for Addressing Warfare System Development Challenges and Goals*** Joe Heil, Kevin Pitts, Scott Ruff, Mike Lim, and Andrew Orzechowski, Naval Surface Warfare Center Dahlgren Division

James Wolfe—Head, Strategic and Weapon Control, Systems Department (K). Mr. Wolfe is a native of Miami, FL. His government career began in 1978 after enlisting in the United States Air Force (USAF). After serving more than four years of active duty and five years as an Air Reserve Technician, he graduated from Florida International University in December 1987, receiving a Bachelor of Science degree in Computer Science. Shortly thereafter, he was commissioned in the USAF Reserve as an Aircraft Maintenance Officer and assigned to the 482 Tactical Fighter Wing at Homestead AFB. Mr. Wolfe's next assignment was with DISA as a Communications and Computer Systems Programmer Analysis Officer, where he developed software applications supporting the Worldwide Military Command and Control and Communications System (WWMCCS). He later wrote software to support the Global Command and Control System (GCCS) integration laboratory. Mr. Wolfe was then transferred to the DISA Joint Services Support Center in the Pentagon, where he was assigned as Command and Control Operations Officer in the National Military Command Center (NMCC), providing direct support to the Deputy Director of Operations during day-to-day, real-world crises. He also participated in exercise operations with National Command Authority, CINCS, and CJCS.

Mr. Wolfe's career at Dahlgren started in 1988 as a system software programmer. Soon after, he was selected as group leader of the SLBM Software Generation System (SGS). To further develop his career, he accepted a position as group leader of the Quality Assurance for SLBM Fire Control Support Software and then as the Group Leader of the Advanced Fire Control System Group. He was then selected as branch head of the SLBM Engineering and Facilities Branch, where he managed and directed the branch operations, which provided computer systems, Fire Control Engineering, and Facility Engineering support for 400 users. Mr. Wolfe was then assigned as branch head of the Weapons Software Engineering Branch. He was responsible for the development of several key components of the Tactical Tomahawk Weapon Control System (TTWCS), the Advanced Tomahawk Weapon Control System, and a number of key simulators used for development and testing. Mr. Wolfe was then selected as division head of the Strike Weapon Systems Division. His responsibilities include managing and directing scientific, engineering, technical, and administrative support personnel tasked with performing all areas of development—including system engineering, software development, and system integration and system test for all strike weapons systems and strike weapon control systems. Mr. Wolfe is presently the Department Head for the Strategic and Weapon Control Systems Department (K).

Surface Warfare Center Contributions for Addressing Warfare System Development Challenges and Goals

Joe Heil—Principal Software Engineer, NSWCDD Strategic and Weapons Control Systems Department (K). Joe Heil has worked as a Software Engineer for the Naval Surface Warfare Center Dahlgren Division (NSWCDD) for over 25 years. The majority of Mr. Heil's career was spent as the Software Integrated Product Team Lead for the Tomahawk Weapon Control System (TTWCS). As the TTWCS SW IPT Lead, he was responsible for defining the software development processes and coordinating the software development efforts for the TTWCS integrated industry and government software development team. As the current Principal Software Engineer for the NSWCDD Strategic and Weapons Control Systems Department (K), he is focused on improving DoD/navy software engineering, development, and acquisition. [Joe.heil@navy.mil]

Kevin Pitts

Scott Ruff

Mike Lim

Andrew Orzechowski

Abstract

The size, interdependencies, and complexity of Navy software intensive warfare systems are continuing to rapidly increase. Numerous studies and reports indicate that the majority of DoD/Navy warfare system development efforts are failing to consistently successfully deliver high quality software systems on schedule and within budget. This paper provides several examples of successful development efforts that utilized Naval Surface Warfare Center (WC) in-house expertise to successfully deliver open architecture (OA)–based multi-system and multi-platform capable software systems with reusable components. This paper also provides insight into how government in-house software expertise can be utilized to mitigate many of the documented software system acquisition challenges that prevent the successful development and delivery of high quality software systems on schedule and within budget.

Introduction

The definition and goals of OA within this paper means designing and implementing software-intensive systems that are scalable, reliable, portable, maintainable, modular, and reusable; and thereby lead to high system quality while also reducing cost and schedule. As shown in Figure 1, the DoD/Navy is not consistently delivering high quality OA warfare systems on schedule and within budget. This paper will provide insight into how several Navy software systems achieved the goals of OA via the utilization of in-house software expertise.

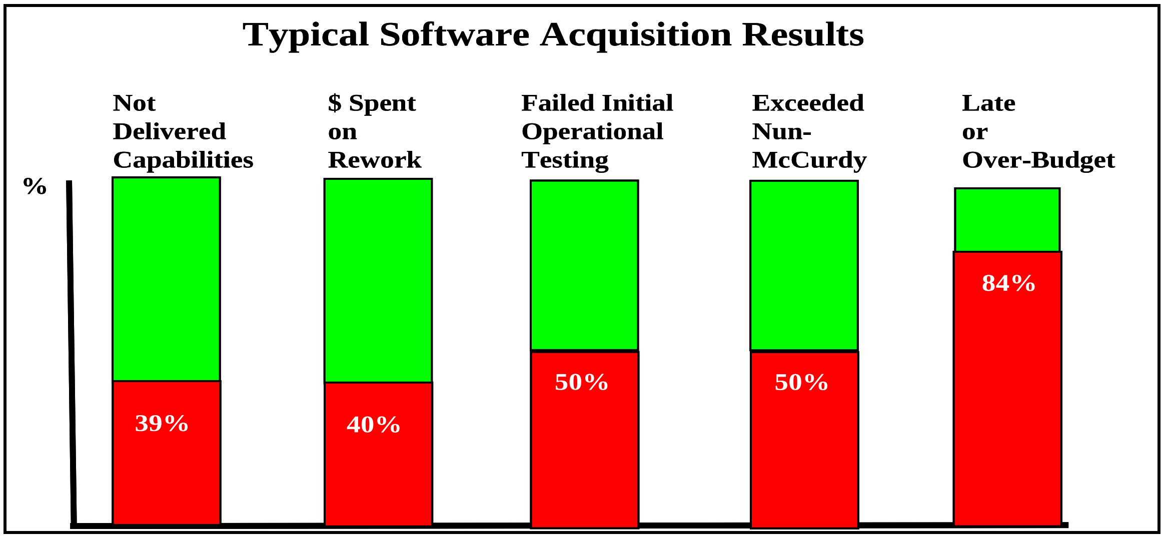

Figure 1. Typical Warfare System Acquisition Results

Current State: Development Approach and Results

This section provides a high-level overview of the typical software intensive system acquisition development approach and results.

In the typical software system acquisition approach, the government leads the initial identification of the needed warfighter capabilities but relies almost entirely on industry experts for the system and software architecting, designing, and implementation. Government engineers do not actually architect, design, nor develop any of the actual system and software components. Government insight into the architecture, design, and implementation is provided by a few software SMEs that participate during the reactionary (vice proactive) process of peer and milestone reviews. Following the system design and development performed by industry, the government then leads the system testing and certification efforts with industry being responsible for assessing and resolving problems found during system testing. The frequent unsuccessful results of this acquisition approach are well documented in reports from organizations such as the Defense Science Board (DSB) and the Government Accountability Office (GAO). Figure 1 reports the following statistics:

- In 2002, the DSB Task Force on Defense Software reported that only 16% are completed on schedule and within budget; 31% of programs are cancelled; 53% of the programs remaining have cost growth greater than 89%; and the average final product includes only 61% of the original intended features.
- In 2004, the GAO reported that the DoD spent 40% of its software development budget reworking software because of quality related issues (GAO-04-393, March 2004).
- In 2008, the DSB reported that the majority of DoD weapons systems are failing Initial Operational Testing.
- In 2009, Senator Carl Levin reported that since 2006 nearly half of DoD's largest acquisition programs have exceeded Nun-McCurdy, and that 95 major defense programs have had their acquisition costs grow by an average of 26% and have experienced an average schedule delay of almost two years.

Future State: Challenges and Improvement Goals

Figure 2 summarizes some of the key challenges and improvement goals for software intensive warfare system acquisition programs. The primary challenge is to consistently successfully deliver high quality, secure and safe software intensive weapon systems that fully meet the needs of the warfighter. Achieving OA systems will improve system quality, promote competition and innovation, and thereby reduce cost and schedule. Achieving OA systems and benefits is complicated by having to integrate rapidly evolving system and software technologies into existing large complex systems composed of varying levels of legacy technology while maintaining Information Assurance (IA). As demonstrated by the success examples in the next section, one approach to meet these software system acquisition improvement goals is to utilize in-house experts with the applied system and software engineering technical expertise, experience, and corporate knowledge required to successfully team with industry to achieve non-proprietary OA systems.

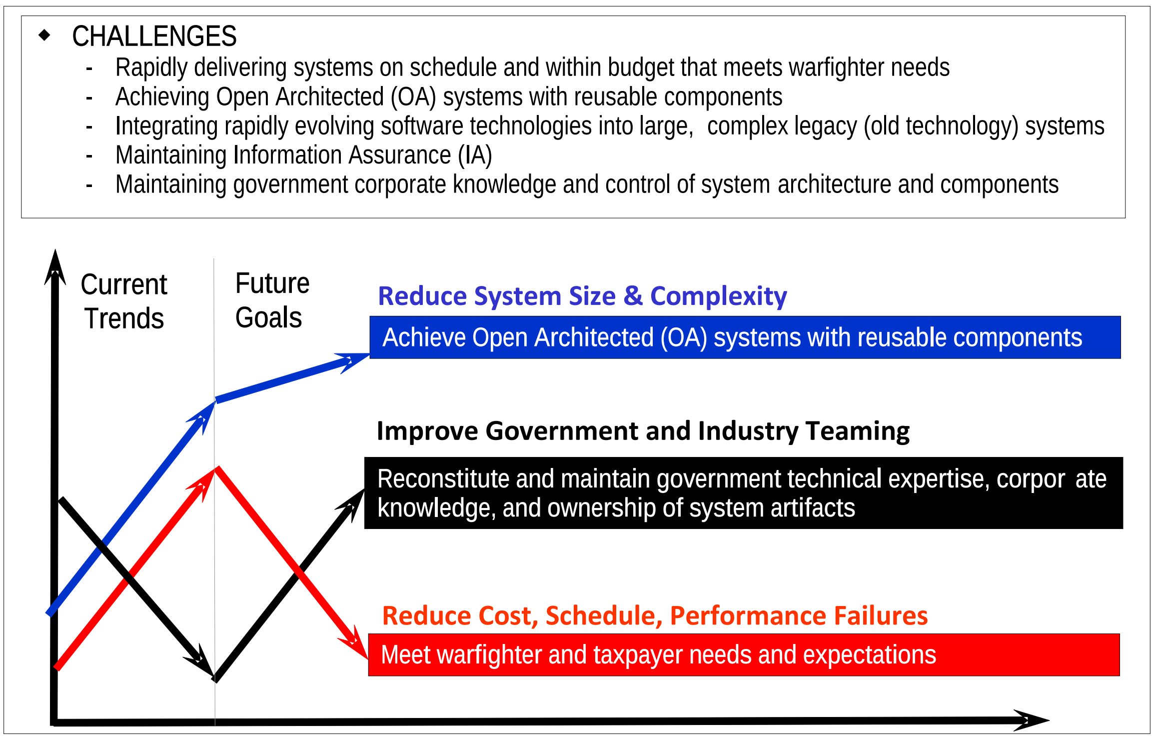

Figure 2. Challenges and Improvement Goals

Warfare System Development Success Examples

This section will provide several examples of software system development efforts that have resulted in high quality multi-platform capable systems with reusable components that have been consistently delivered within cost and schedule constraints. The common and significant contributing factor to the success of these warfare system development efforts is that government technical subject-matter experts were responsible for actually leading and developing some of the critical requirements, architecture, design, and software elements of these systems. Utilization of government expertise has been consistently successfully utilized by the Naval Surface Warfare Center Dahlgren Division (NSWCDD) for various strategic and tactical warfare systems. NSWCDD government software engineers have been, and still are, responsible for the architecting, designing, coding and testing of many of the most critical and complex (e.g. safety critical, real-time, complex algorithms) software components. The successful utilization of warfare center in-house experts has been utilized in various system development approaches that include:

- teaming with industry as part of an integrated system development team,
- prototyping and development of the initial engineering development module, and
- rapid development and delivery of reusable architectures or components.

The following specific success examples of the different uses of in-house expertise are provided in the next sections:

- Tomahawk Cruise Missile Weapon Control System (TTWCS),
- Generic Data Extraction, Analysis and Reduction (GeDEAR) Framework, and
- Cooperative, Communications, Control Core Engagement (4CE) framework for the Full Spectrum Effects Package (FSEP) and Gunslinger Package for Advanced Convoy Security (GunPACS) sniper sense, track, and engage systems.

The previously mentioned development efforts successfully achieved the following:

- delivered reliable, maintainable, scalable and reusable architectures, design, and code that provide multi-platform and/or multi-system capability.
- successfully integrated a mix of legacy components, new commercial-off-the-shelf (COTS) components, and government engineer developed reusable architectures and components, while maintaining Information Assurance (IA).
- successfully met complex, real-time, safety critical functional requirements and the associated challenging Key Performance Parameters (KPPs).
- maintained government corporate knowledge and control of the system architecture, design, and technology.
- maintained government applied technical expertise with current and emerging system and software technologies, methodologies, processes, and tools.
- delivered these systems on schedule and within budget.

Success Example 1: Tomahawk Cruise Missile Weapon Control System (TTWCS)

The Tomahawk Cruise Missile system has performed exceptionally well in thousands of operational events, and as noted in the 2004 GAO report on Defense acquisition, the Tomahawk Cruise Missile program was cited as one of the few successful DoD warfare system acquisition programs.

The current Tomahawk Cruise Missile system is composed of three major segments: the Tomahawk Command and Control System (TC2S), The Tactical Tomahawk Weapon Control System (TTWCS), and the All-Up-Round (the missile). The TTWCS segment is developed by an integrated government and industry development team. This integrated team approach has been successfully utilized since the early 1980s and is still employed today. The government and industry integrated development team (IDT) has succeeded in developing common reusable software components to support multiple Tomahawk firing platforms (United States submarine and surface ship variants, as well as United Kingdom Royal Navy submarines). As shown in Figure 3, the government engineers architected, designed, developed, and delivered the multi-platform capability via object-oriented design and implementation techniques at the Object/Class Level within one of the major TTWCS Computer Software Configuration Items (CSCIs).

Over the past several decades, the TTWCS IDT has consistently successfully delivered software upgraded to incorporate and integrate the latest technologies. Examples include the evolution from Mil-spec processors (ROLM 1666) to modern processors (HP744, X86), from mil-spec operating system (RMX/RDOS) to open system OS (LINUX), and from first generation programming languages (Assembly, Fortran) to modern languages (Ada, Java, C, C++). The design approach taken by the IDT has resulted in the development of a common baseline of TTWCS software that is installable on all platform variants. This approach significantly reduces the amount of software code that must be maintained over the lifecycle of the product, resulting in a reduced number of defects delivered to the fleet and a significant reduction in out-year sustainment costs.

The IDT has successfully incorporated new system/software development methodologies including the transition from functional design to object-oriented design, from waterfall development to spiral/increment development; from human-only generated coding to graphic-user-interface and auto-code generation tools, and from point-to-point interfaces to FDDI/ETHERNET H/W employing IP-based communications using Service Oriented Architecture standards.

The TTWCS IDT has achieved and demonstrated OA design and implementation. As shown in Figure 3, the TTWCS government software engineers utilized object-oriented design to achieve scalability and reusability with regards to the goal of easily interfacing with multiple platforms and their unique launching systems. The TTWCS has been easily upgraded to support not just U.S. surface ship vertical launching systems, but also U.S. submarine and United Kingdom Royal Navy submarine platforms. As the TTWCS has been upgraded to interface with the new platform launching systems, the government software engineers were able to define the software requirements and architecture, document the design modifications, implement and perform software level testing for the associated new launcher interface typically within a year timeframe. Reuse of existing software objects from the TTWCS software have been successfully integrated into new launching system software components contributing to reduced development time and reduced cost. The Navy's new surface combatant (Zumwalt Class Destroyer) is employing the above mentioned approach to integrate Tomahawk capability on that platform type.

For nearly 30 years, the development team responsible for the Tomahawk Weapon Control System has successfully met interdependency deliveries and provided the fleet with a reliable, high-quality product. The software quality of the TTWCS software has been consistently high with the integrated software for currently deployed systems averaging approximately one Defect/KSLOC, which compares favorably with available industry data. The TTWCS software developed by the government and industry team has consistently met all Key Performance Parameters (KPP) identified in its Operational Requirements Document (ORD) and, most important, has performed exceptionally well in tactical operations.

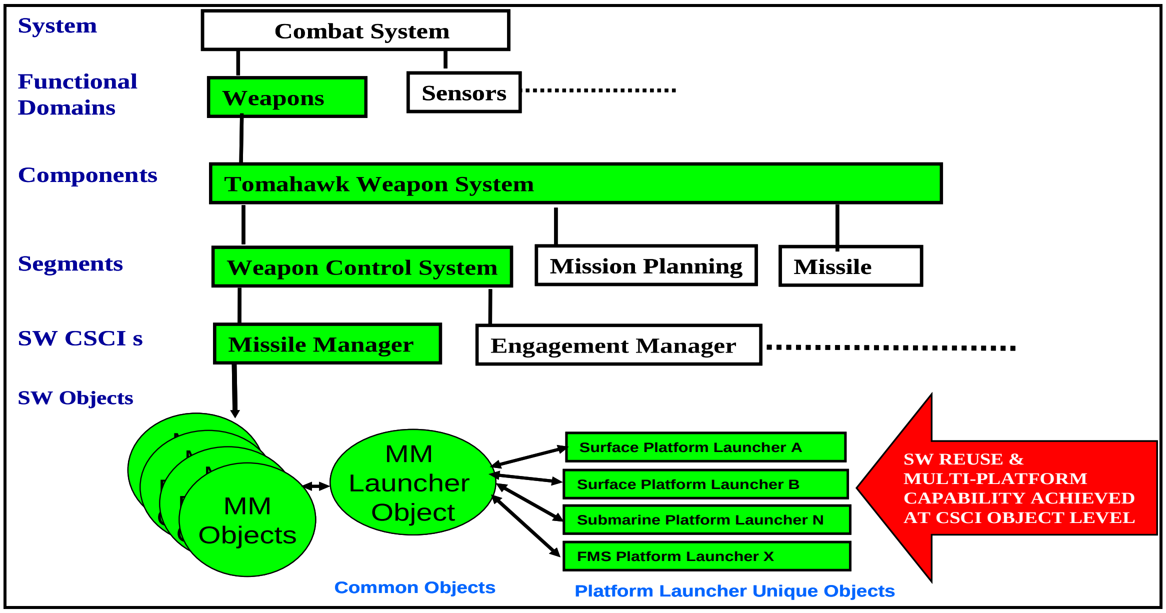

Figure 3. Tomahawk Multi-Platform Design

Success Example 2: Generic Data Extraction, Analysis and Reduction (GeDEAR)

The GeDEAR effort is an example of a software component that was successfully architected and implemented entirely by in-house experts to be easily integrated and utilized within different programs and systems. The GeDEAR framework has proven to reduce cost and schedule by providing a robust utility for quickly identifying the root cause of defects.

GeDEAR

- allows for integration of a software-based data extraction capability into a system with minimum cost or schedule impacts;
- works across many different data formats and interfaces through the use of plug-ins;
- supports a wide range of platforms and operating systems;
- provides a foundation for common data extraction, reduction, and analysis tools; and
- is freely available on forge.mil.

Figure 4 provides the architecture of GeDEAR, which enables users to utilize all or any of the three major components (Management Console, Extraction Server, and Reduction Program) to provide an integrated data extraction and analysis capability within their tactical, training or test system and software. GeDEAR utilized open architecture design to eliminate hardware, operating system dependencies, interface dependencies, and utilizes a plug-in design to enable users to quickly integrate and tailor the GeDEAR utility to meet the specific needs of the given system.

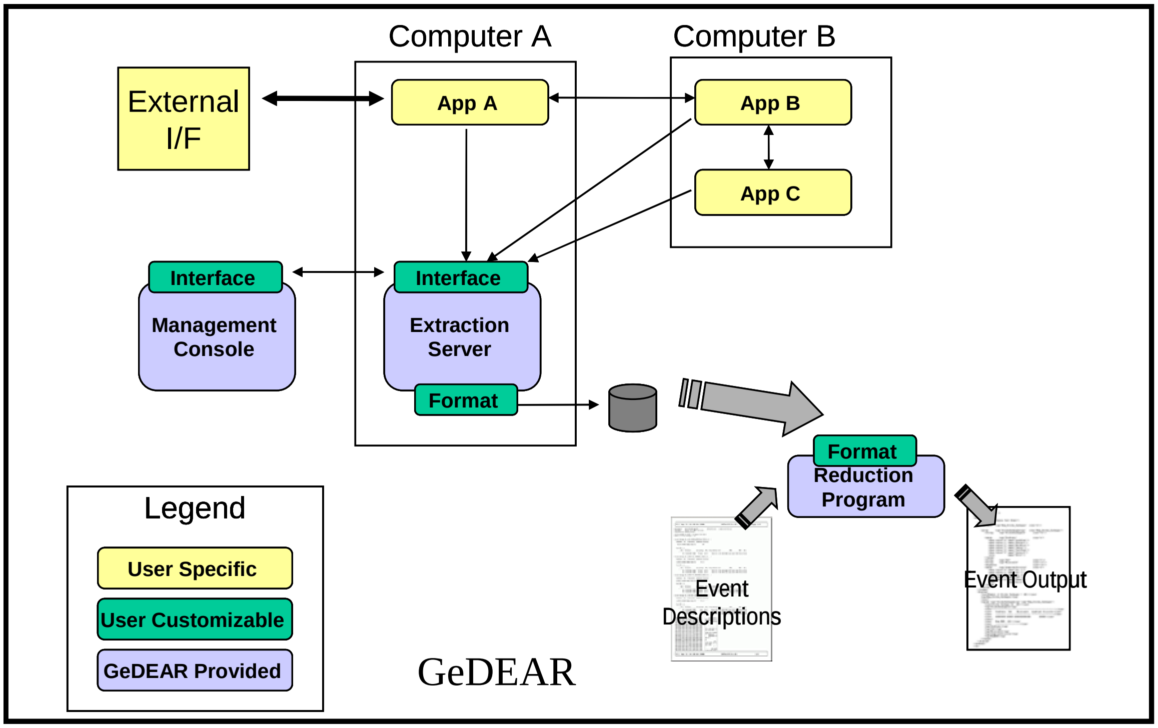

Figure 4. GeDEAR Multi-System Design

To date, the government expert developed GeDEAR component has been quickly, easily, and successfully integrated into the following systems:

- Tomahawk Weapon Control System (TWCS): 4 Week Effort. TWCS is an existing system and incorporated only the Reduction Program component of GeDEAR. The use of GeDEAR required the development of several plug-ins to the Reduction Program to modify the output of the reduced data and a small program that converted the file that describes how the events are structured from their legacy format to the GeDEAR format.
- Ship Protection System (SPS): 3 Month Effort. SPS was a new development effort and incorporated the entire GeDEAR framework. The use of GeDEAR required the development of a plug-in to the Extraction Server to allow it to automatically capture DDS traffic on the network and extract this information.
- Advanced Multi-Configuration Environment Simulator (AMES): 1 Month Effort.
- AMES is an existing system and incorporated the entire GeDEAR framework. The use of GeDEAR required the modification of how events were being extracted within tactical software and the updating of event definition files.

Success Example 3: Cooperative, Communications, Control Core Engagement (4CE) Framework

4CE is an example of utilizing government expertise and resources to rapidly develop and delivery critical systems to the warfighter. 4CE is an example of a successful OA based multi-platform and multi-system software framework. Government engineers have teamed with industry to utilize agile software development methodology to successfully deliver the integrated sensor and weapon capabilities for Marine Corps and Army vehicles such as Gunslinger, Full Spectrum Effects Platform (FSEP), and Wolfpack.

This integrated agile development team has also been utilized for the Naval Expeditionary Overwatch (NEO) Intelligence, Surveillance, and Reconnaissance (ISR) systems. These rapid development efforts were led by government engineers who quickly assessed and integrated multi-vendor hardware and software technologies to provide the deployed warfighters with much-needed capabilities that met emergent mission critical needs for the Navy, Marine Corps and Army.

This framework and its precursors have been used to deploy several vehicles to Iraq and soon Afghanistan. The Gunslinger vehicle deployed to Iraq for eight months. The three FSEP vehicles were deployed to Iraq in January 2007 and two are still in operation. GunPACS' four vehicles will deploy this year to Afghanistan. The urgent need for these systems made it necessary to produce these systems in a year or less. Therefore, minimizing redundant effort became of utmost importance.

Despite developing systems for various military Services and vehicle/vessel platforms, there were many opportunities for code reuse and architecture abstraction. Regardless of the program sponsor or user, all systems were encapsulated into three layers of abstraction, which are as follows:

- Presentation Layer—GUI, mapping engine, and video situational awareness.
- Middle Layer—behaviors, algorithms, and logic.
- Hardware Layer—interface with COTS and GOTS hardware.

As shown in Figure 5, the 4CE framework was developed to enable the reuse of these three layers. It was also developed to enable the fast integration of new sensors into the hardware layer. In the past, integrating a new sensor could take two to three months since software developers had to significantly modify code through all three layers. However, with the use of standard interfaces between layers and modularization, sensor integration was reduced to weeks and in some cases just a few days. The 4CE framework now provides a common software platform for all rapid integration projects.

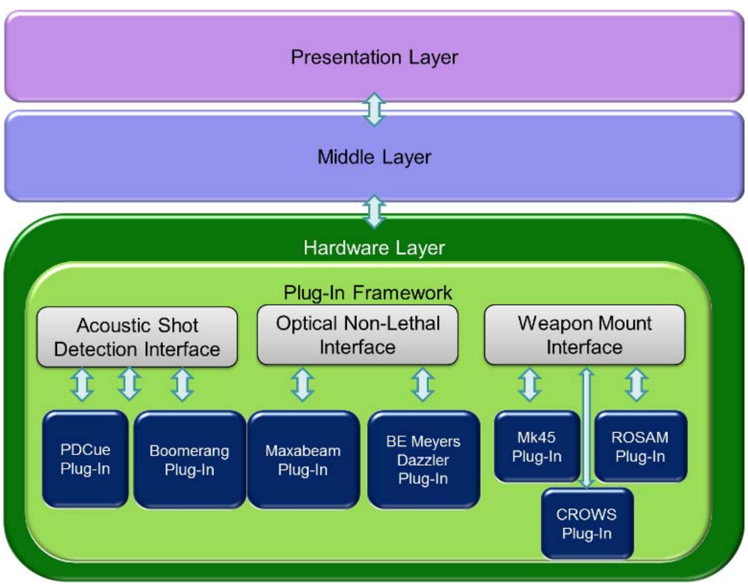

Figure 5. 4CE Multi-Platform Multi-System Architecture

The value of this common software platform includes

- increased code reuse,
- improved quality,
- shortened development cycle,
- rapid integration, and
- efficient developer resource utilization.

As shown in Figure 6, the single greatest benefit of the 4CE framework is the ability to deliver more capability for less cost and time. This agile software development team, in its early days, would surge to as many as 17 developers and a development duration of around one year. Conversely, as the 4CE framework matured, software development could be characterized as a 2–4 person team working for 3–6 months.

The value of this architecture and model for rapid integration and deployment has been further proven with the Command Control Module (C2M) project. NSWCDD will be developing a Technical Data Package and partner with industry to produce ~750 counter-sniper systems for the Army. In a possible second phase NSWCDD will team with an industry partner to produce another ~2000 systems.

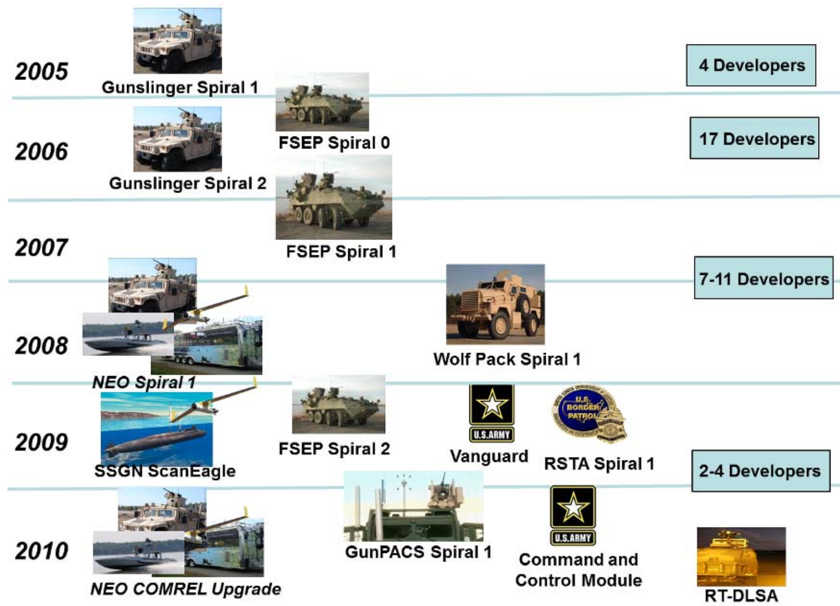

Figure 6. 4CE Reduced Development Time and Resources

As shown in Figure 7, the next stage in the evolution of 4CE is to increase its open architecture characteristics and transition to a service-oriented architecture (SOA)-based system. Moving to a SOA will separate capabilities and functions into services provided over a bus. In the current state of 4CE it is possible to compete out hardware plug-ins for new sensors. The transition to the SOA based arch will facilitate the plug-in and third-party integration in the Middle Application and Presentation Layers.

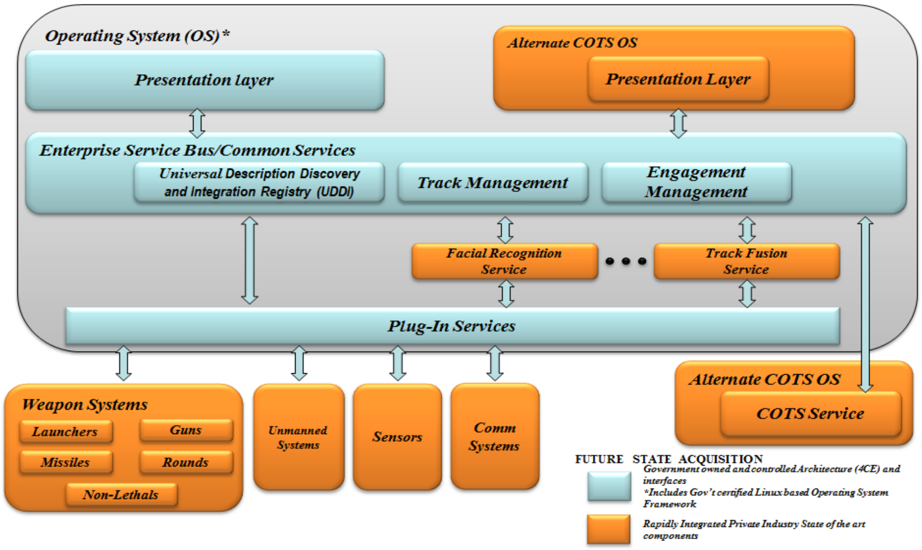

Figure 7. Future 4CE Architecture

Key Factor for Warfare System Development Success

A key factor in the previous success examples was the applied knowledge of the government SMEs at the lowest, most detailed levels of system abstraction. Although software has evolved into one of the most significant, complex, and critical elements of mission critical systems, the typical DoD/Navy acquisition strategy tends to treat the software components as black boxes with the internal software architecture and design development (and detailed understanding) left almost entirely in the hands of private industry SMEs. Figure 8 depicts a typical software intensive system with hundreds of system level requirements, interfaces, and components. This same system decomposed at the software level may include

- hundreds to thousands of software level requirements,
- hundreds to thousands of internal and external software interfaces,
- hundreds to tens of thousands computer software components (CSCs),
- thousands to tens of thousands internal software interfaces and interactions,
- millions to hundreds of millions of logic threads, and
- millions to hundreds of millions of source lines of code (SLOC).

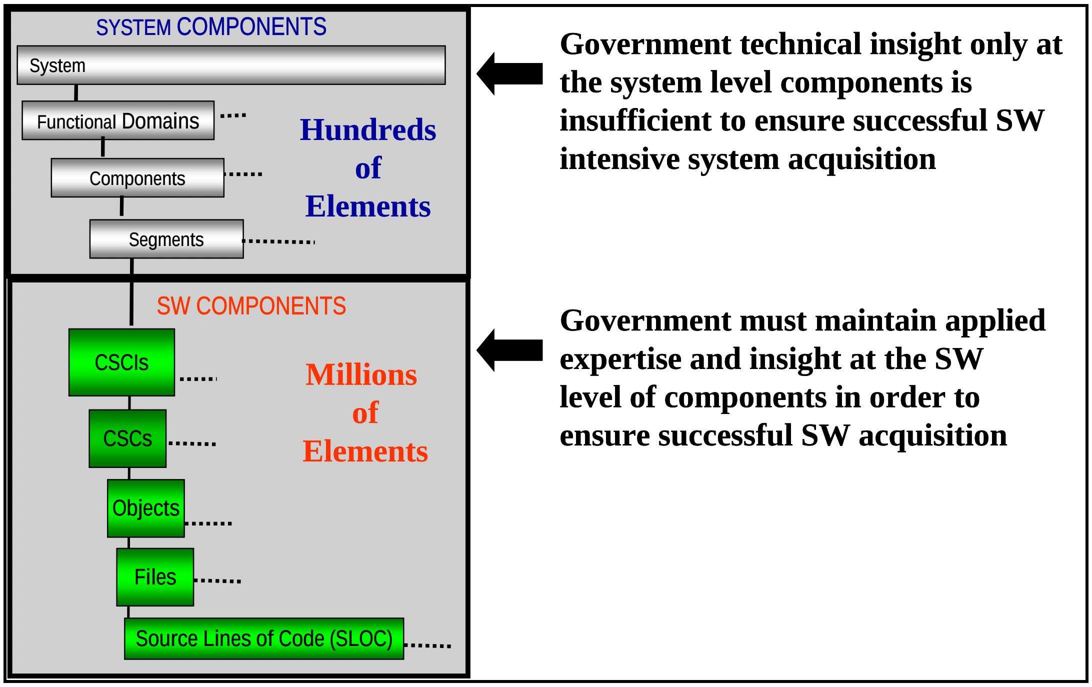

Figure 8. System and Software Complexity

The current typical acquisition approach often limits the government's technical understanding to a few pages of high level system and software architecture diagrams. The government understands and "controls" the interfaces between the software components only at the highest level of system abstraction. There is often limited government in-depth understanding of the architecture, design, and implementation of the software level components. The government SMEs are limited to participation via milestone review events (e.g., Requirement Reviews, Design Reviews, Test Readiness Reviews, etc.). Limiting government SME to just oversight roles and only milestone review event participation is ineffective for ensuring that the software components and artifacts fully meet the OA objectives of modularity, scalability, reliability, maintainability, and quality, it does not ensure that the implementation artifacts (i.e., code) and design artifacts remain consistent with each other.

As demonstrated by the success examples in the previous section, government and industry technical teams can be successful. Under this alternative acquisition approach, the government engineers serve as the technical lead for critical components, which includes being responsible for not just assessing industry developed architecture, design, and code artifacts, but actually developing a subset of the artifacts. The artifacts (requirement specs, design documents, code, etc.) are developed by integrated government and industry software development teams that utilize cross-organizational design/code peer reviews to ensure high-quality products and conformance to best-practices. Government system, software and test SMEs are responsible for developing and delivering a subset of the mission critical tactical system and software components and the associated technical artifacts, including requirements specifications, architecture, and design and interface documents, code, and test procedures.

The government software development engineers have the same expectations and requirements relative to cost, schedule, and technical performance as their industry peers. The government SMEs are also responsible for providing the critical management products as well including development process documents, metrics, schedules, progress indicators, interdependencies, and risks. This is required to develop and maintain in-house SMEs with the applied technical and programmatic experience required to be able to both successfully develop the system components and manage (accurately estimate and track cost, schedule, and risk) the development effort at all levels of the system decomposition (functional domain, component, segment, CSCI, and down to the CSCI sub-component object and class level). The following elements are critical for enabling success:

- A common set of industry and government processes and expectations,
- Well-defined, documented and maintained
    - roles and responsibilities; system development processes and metrics; cost, schedule, and performance expectations; Integrated Master Schedule (IMS); interdependency products and associated delivery dates; and risk management.
- Proactive integrated management of cost, schedule and performance.
- Government test team is independent from the government development team.
- Milestone reviews that include independent competency experts.
- Frequent (daily) and structured open team communication.

Integrated Government and Industry Development Team Benefits

This section describes the benefits of utilizing the expertise still available at the Navy Warfare Centers as part of a government and industry software intensive system development team. This alternative approach benefits the System Program Offices, the Industrial Base, and the warfighter.

In 2008, the ASN/RDA Software Process Improvement Initiative (SPII) Software Acquisition Management (SAM) focus team published a report that described the following critical problems that apply to the vast majority of DoD/Navy software intensive system program acquisition offices:

- lack of effective management,
- immature acquirer (program offices),
- ineffective requirements management,
- high personnel turnover,
- unrealistic cost and schedule estimates,
- ineffective utilization of Earned Value Management System (EVMS) for software, and
- failure to utilize lessons learned.

The utilization of in-house technical expertise has been demonstrated to mitigate the problems mentioned previously and provide the following benefits to the program offices:

Program offices will have access to in-house experts with the technical and acquisition process experience to aid the program offices in successfully managing the integrated government and industry development teams.

- The in-house experts will have the applied knowledge to assess industry technical approaches and also their software development processes. This includes having in-house experience and historical metrics from system and software cost and schedule estimates and will be able to provide support for independent cost and schedule assessments.

- The in-house experts will have applied experience developing and implementing system requirements at all levels, which will enable them to support program office requirement management and volatility risk reduction.
- The government engineers will have in-depth knowledge of various weapon system architectures and maintain the corporate knowledge required to mitigate the risk of program office leadership and personnel turnover, as well as changes in the industry development organizations.
- The in-house engineers will have applied experience with EVMS and can aid the program offices in setting up realistic and meaningful based software EVMS processes and tools.
- By maintaining engineers with applied experience in both previous and current complex development efforts, the program offices will have a source of objective lessons learned and metrics that can be applied to future development process improvement.
- Maintaining a team of in-house experts provides the program office with leverage over the contractor if the contractor is failing to meet program cost, schedule, or technical performance requirements. The program office leadership will have the option to augment the industry software team with on-site government software engineers, or transfer the responsibility for software component development from industry to government. This can be accomplished easily as the government software engineers are part of the software development team from the beginning. There will be no need to perform a costly re-competition to assign the work to another private industry team that would be unfamiliar with the program requirements and plan.
- Maintaining an experienced government software development organization mitigates the impact of program office leadership changes. Acquisition program office leadership transition may occur at any point during the system development effort. The system development organizations are faced with the challenge of still meeting the previously defined development milestones and delivery dates, while simultaneously changing organizational structures, reporting chains of command, tasking priority changes, funding reallocations, and development process changes directed by the new leadership. The experienced government development team can provide the following benefits to the acquisition office's new leadership:
    - Maintains critical corporate knowledge in order to aid the new leadership in quickly coming up to speed on the history of the program, the system's architecture and functionality, the various development organization's roles and responsibilities, current development process, and status of the current development efforts (schedule, progress, and risk).
    - Provide impact/risk assessment for new organizational or process changes.

Senior DoD/Navy system acquisition leaders have expressed the need to reconstitute and maintain in-house technical expertise. The government cannot attract the best talent, nor sustain highly motivated and high-quality SMEs by limiting their tasking to looking-over-the-shoulders of industry engineers. By assigning actual system and software development responsibility to in-house engineers, the government can reconstitute and maintain the software expertise pipeline, as shown in Figure 9, and thereby develop the senior-level expertise required to perform as technical and programmatic peer level teammates with industry.

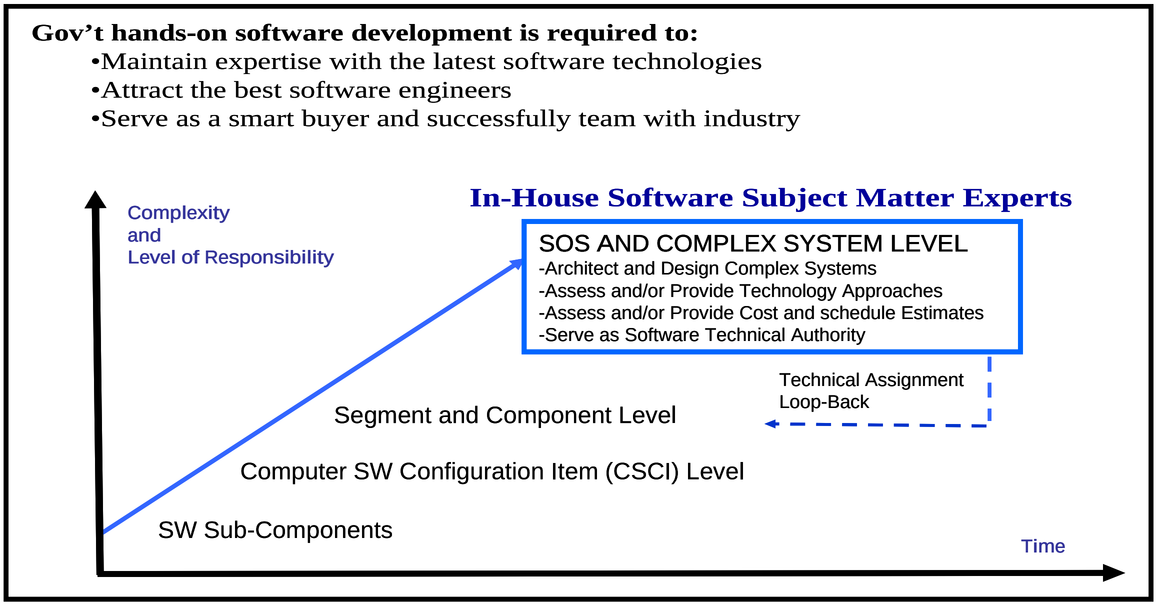

Figure 9. Government Expertise Pipeline

The successful systems described in the previous section assign government SMEs responsibility for software architecture, design, code, and test responsibility and thereby are able to consistently achieve the following:

- Maintain awareness and expertise in modern software technologies and methodologies necessary to understand and determine when/if/how these new technologies should be utilized.
- Successfully designing and implementing truly OA systems that fully meet the goals of standardized interfaces, scalability, reliability, portability, modularity, and reusability; thereby leading to higher system quality while also reducing cost and schedule.
- Successfully integrating the complex mix of legacy software components, new COTS software and hardware components and DoD/Navy developed highly specialized software components to provide integrated net-centric systems that can execute as systems-of-systems and fully meet mission-level objectives and KPPs.
- Successfully assessing and rapidly integrating the most advanced software technologies and methodologies into the software development processes, environments, and systems.

Strengthening the government in-house SME also benefits the industrial base, as industry will have a smarter buyer of warfare systems, which enables the following:

- The government will have technical SMEs with the continuing corporate knowledge and system expertise to provide industry with better requirements to enable more accurate cost/effort responses to Requests For Proposals (RFP).
- The in-house SMEs will be better able to assess industry technical and cost proposals. Contacts will be awarded on true best value (not just the lowest bid). The SMEs will have the expertise to validate that a contractor's higher cost is fair and value added as the technical and development processes

reflect current best-practices and meet the goals of non-proprietary OA based development.

- During development, the industry SMEs will have peer government SMEs that work proactively (versus reactively via just milestones reviews) to ensure sound technical approaches and acceptable technology/programmatic risk identification and mitigation. The government SMEs will have in-depth understanding and early insight into industry design/implementation to enable early risk identification and mitigation (e.g., accurately assess Technology Readiness of industry technical approaches).
- The resulting increase in quality and reduction of schedule/cost failures will increase industry profit by enabling the team to spend dollars on new capabilities and production versus fixing significant numbers of defects.
- The government SMEs will have an understanding and control of the overarching system architecture and resulting system artifacts and thereby enable an approach of contracting out smaller system components. This promotes more competition and enables smaller businesses to obtain contracts.
- Most important, this alternate approach has proven to better meet the needs of the warfighter by providing high quality and reliable systems that meet the warfighter's needs.

Summary/Recommendations

Figures 10 and 11 summarize the typical and alternative system acquisition and development approaches, respectively.

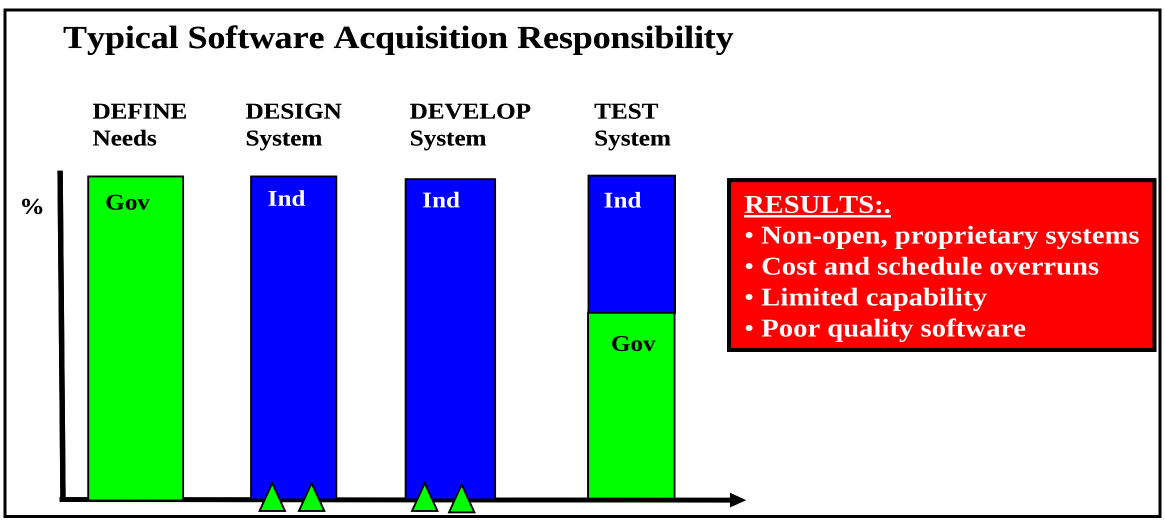

Figure 10. Typical Acquisition Responsibilities

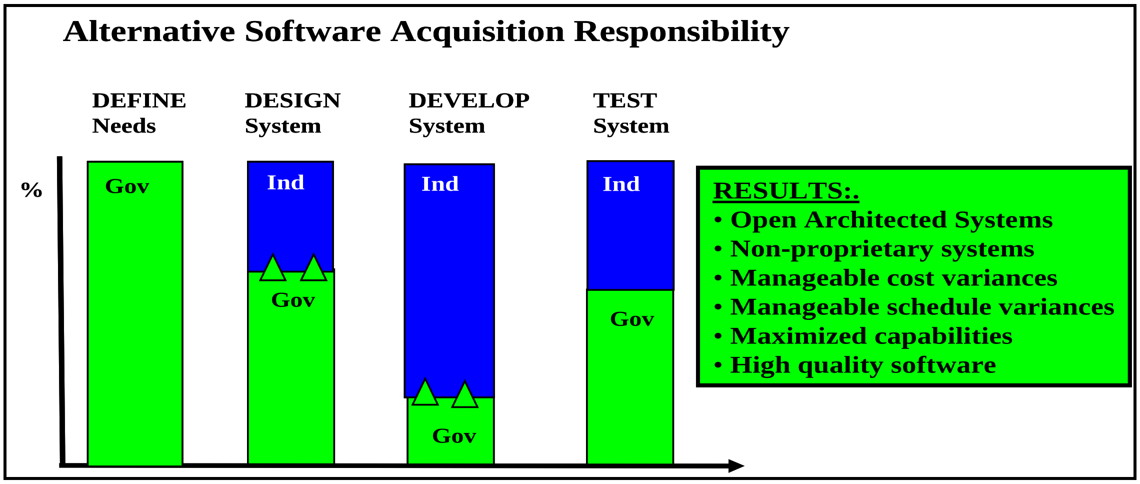

Figure 11. Alternative System Acquisition Responsibilities

As directed in the 2008 Mr. Donald Winter SECDEF memo,

> This combination of personnel reductions and reduced RDT&E has seriously eroded the Department's domain knowledge and produced an over-reliance on contractors to perform core in-house technical functions. This environment has lead to outsourcing the "hands-on" work that is needed in-house, to acquire our nation's best science and engineering talent and to equip them to meet the challenges of the future Navy. In order to acquire DON platform and weapon systems in a responsible manner, it is imperative the DON maintain technical domain expertise at all levels of the acquisition infrastructure.

The common critical factor in the success of the development efforts described in this paper was the utilization of government technical SMEs with hands-on expertise and development responsibilities.

The DoD/Navy must re-assume leadership of the system and software architecture and design. Government software architecture and technical authority must be demonstrated not just at the highest system composition level but must extend down into detailed software component levels as well. In order to attract and keep the best and brightest SMEs, the government must offer:

- challenging development and leadership responsibilities, and
- opportunities of architecting, designing, and implementing solutions to complex system functional capabilities and problems that address warfighter needs.

The DoD/Navy should increase the utilization of integrated government and industry technical development teams in order to develop truly open architected systems and thereby achieve the goals of delivering the warfighter with high-quality systems on schedule and within budget.

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