Software Intensive Systems

2006 summer study
Out brief for
Assistant Secretary of the Navy (RD&A)

23 June 2006
SSC San Diego
## Software Intensive Systems

### Summary

**Title:** Software Intensive Systems  
**Authors:** [Names]  
**Sponsoring Organization:** [Organization Name]  
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**Available:** Approved for public release; distribution unlimited

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### Notes

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- The form is approved by OMB No. 0704-0188.

### Distribution/Availability Statement

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The Terms of Reference

- Review relevant DOD and government programs
- Review industry tools, practices, and standards
- Identify potential benefits of best practices
- Recommend changes in Naval acquisition management, systems engineering, training, education, and business practices
- Suggest S&T investment
- As appropriate, evaluate emerging tools for specifying, bidding, and engineering software-intensive systems and suggest strategies for use across multiple organizations
Study panel and sponsor

- Chair - Dr. Patrick L. Winston
  Professor of Computer Science, MIT
- Co-Chair - Ms. Teresa B. Smith
  Director Strategy, SD&T, Northrop Grumman Electronic Systems Sector
- Dr. Eric Horvitz
  Principal Researcher and Research Area Manager, Microsoft
- VADM Douglas J. Katz
  USN (Ret.), Consultant
- Mr. Richard L. Rumpf
  President Rumpf Associates International
- Dr. Howard Shrobe
  Principal Research Scientist, MIT
- Dr. George E. Webber
  Consultant
- Dr. Walton E. Williamson, Jr.
  Professor and Chair Department of Engineering Texas Christian University
- Mr. James L. Wolbarsht
  President & CEO, DEFCON®, Inc.

Study Sponsors:
  RADM Michael Frick - PEO-IWS
  Mr. Carl Siel - CHENG

Executive Secretaries:
  Dr. William Bail, MITRE
  Ms. Cathy Ricketts, PEO-IWS
  Mr. Fred Heinemann, EDO
Briefings and visits

- Briefings, programs and defense industry
  - Naval Focus: PEO-IWS; DASN-IWS; LMRS; Aegis; DD(X); FORCEnet; ARCI
  - Army Focus: FCS, SW Improvement Program (Bolton)
  - Joint Focus: SIAP, JSF; JTRS; GIG
  - OSD/Agency Focus: Missile Defense Agency, NSA, Quadrennial Defense Review, NII/GIG

- Other briefings
  - Government: GSA
  - FFRDC: SEI
  - Industry: Raytheon, Microsoft, Lockheed Martin

- Site visits:
  - SIAP Program Office
  - GIG Testbed (JHU/APL)
  - Microsoft Corporation
Joint Vision 2020

- Background
- Context
- Structure
- Findings
- Rcmds
- Three steps
- Summary
“...the continued development and proliferation of information technologies will substantially change the conduct of military operations. These changes in the information environment make information superiority a key enabler of the transformation of the operational capabilities of the joint force and the evolution of joint command and control... Information superiority is the critical enabler of the transformation of the Department...”

From Joint Vision 2020
General Henry Shelton, CJCS, 2000

“Key to achieving this full spectrum dominance will be the ability of U.S. forces to acquire information superiority and the technologies that enable it.”

Delores Etter, DDR&E, DUSD&A&T, 2000
More capability and lower cost

- Software enables new capabilities, such as:
  - Information gathering, fusion, and distribution
  - Coalition collaboration
  - Intelligence gathering
- Software advantages relative to hardware
  - Zero cost replication
  - Greater flexibility
  - Easier upgrade
  - Superior SWAP (Size, Weight, and Power)
Size of typical Naval combat systems

- **Background**
- **Context**
- **Structure**
- **Findings**
- **Rcmds**

### Chart Details
- **Title:** Size of typical Naval combat systems
- **X-axis:**
  - Aegis B/L 7.1R
  - DDG 1000
  - F/A 18 E/F
  - JSF

- **Y-axis:** Millions of lines of code (MLOC)
- **Legend:**
  - **Today**
  - **Future**
  - **Growth**

### Systems
- **Surface Ship Combat Systems**
- **Aircraft Systems**

- **Aegis B/L 7.1R**
- **DDG 1000**
- **F/A 18 E/F**
- **JSF**
Human resources
The pipeline is running dry

US CS/CE Undergraduate Majors

May 2006 Computing Research News
Globalizing of Software and Hardware

- 470,000 IT jobs outsourced overseas, ~25%
- 80% of 300mm fabrication factories are overseas

Leading computer producers by location

Source: Reed Electronics Research, Yearbook of World Electronics Data
• DSB Task Force on Military Software (1987): “Many previous studies have provided an abundance of valid conclusions and detailed recommendations. Most remain unimplemented.”

• DSB Task Force on Defense Software (2000): “The Task Force reviewed six major DoD-wide studies that had been performed on software development and acquisition since 1987. These studies contained 134 recommendations, of which only a very few have been implemented.”

Is anybody listening?
Our central recommendation: structural innovation

1. **Mobilize** in the short term: Rapid Evolution Software Engineering Teams (RESET)

2. **Transform** in the midterm: A Naval Software System Center

3. **Consolidate** in the long term:
   - Status quo after step two?
   - A Naval warfare center?
   - A joint warfare center?
Impact of rework costs (FY2005)

Cost of rework (40% of total)

$1.7B rework

Cost of forward engineering

All DOD

Navy

$ Billions

0 5 10 15 20 25

Background
Context
Structure
Findings
Rcmds
Three steps
Summary
Problems with Naval software intensive systems

- Specifying
- Developing
- Acquiring
- Testing
- Life-cycle maintenance
- Focused research
Representative Findings

- Inadequate system engineering—particularly, requirements definition and system requirements flow-down
- Model driven methods (MDD and MDA) valuable when matched to a task—they are not universal silver bullets
- Few experienced software acquisition professionals
- Programmer productivity varies enormously
- Inadequate application of existing process methodologies
- Inadequate incentives for openness
- Testing, security, and interoperability often too late
- Lack of investment in software engineering research
Leadership recommendations

- Put somebody in charge:
  - Establish acquisition educational standards
  - Promote basic process improvements
  - Increase awareness of software problems, technology, and opportunities
- The ASN (RDA) is already engaged (memo of 15 May 2006)
Acquisition and practice recommendations

- Create software acquisition specialty within the Navy
- Develop real incentives to share specifications, interfaces, models, and software (e.g. ARCI program)
- Apply emerging software engineering tools to appropriate problems
- Deploy system engineering methods that enable specification, implementation, and testing to evolve together
Model driven tools can stimulate and enforce iterative systems engineering
Naval S&T program recommendations

• Start focused effort
• Leverage existing software engineering research and practice
• Develop, for example:
  – Software tools for evolutionary systems engineering
  – Practices for automated daily build, test, and evaluation
  – Domain-specific model languages
  – Technology for dealing with legacy systems
  – Means to exploit lessons-learned and best-practices knowledge bases (such as those of NASA, DOE, FAA, and ONR activity at University of Maryland)
Assessment

- Information dominance central to defense, but at risk
- Lots of opportunity, but little decisive action to date, for lack of structure
- Visionary action and structural innovation needed
Step one: Rapid Evolution
Software Engineering Teams

- Staff each with 10-20 full time equivalents
- Complete user-requirements loop
- Promote use of system engineering tools, policies, and practices
- Champion best-practice software methodology emphasizing commonality, evolution, adaptation, reuse, reliability, interoperability, security and rapid response to changing defense needs
- Identify open systems needs and ensure compliance
- Recommend contract incentives
- Monitor progress and sustain support
Step one: Implementation

- Embed on contractor site in two or more representative programs (to promote commonality), such as CG(X), BAMS, Aegis upgrade, LCS
- ASN RDA provides seed money to selected PEO to initiate activity
- Staff with expert personnel from ONR, NRL, UARC, FFRDC (such as SEI), Warfare Centers, National Laboratories, government agencies, academia, and noncompeting contractors
- Report to ASN through PEO
Step two: Naval Software System Center

- Staff with ~50 full time equivalents
- Institutionalize and staff RESET teams
- Build models and assist in building models
  - Complete requirements---users loop
  - Complete model---VV&A loop
  - Solve ownership problem
  - Ensure compliance with lessons learned
- Maximize Naval commonality
- Manage and staff independent expert reviews
- Recommend incentives and acquisition policy
- Manage innovation through programs, such as SBIRs, ATDs/JCTDs, …
Step two: Implementation

- Embed in SYSCOM, NRL, or existing warfare center
- ASN RDA funds for FY08 via redirection, then for FY09 as line item
- Report to a PEO, DASN to ASN, and OPNAV
- Enterprise coordination
Step three: Consolidation

- A cross-cutting, horizontally integrated, possibly joint activity that ensures information dominance
- Size and structure to be evolved from experience with steps one and two
Risks and challenges: steps one–three

- Human resources difficult to obtain
- Cultural resistance
- Budget priorities
- Industry pushback
- Contracting difficulties
- Multiyear sustenance
Summary

- Assessed situation and articulated concerns
- Listed findings and recommendations
- Established need for innovative structure
- Identified risks and challenges
- Proposed three-step plan for ASN RDA action

To maintain information dominance, inaction is not an option