



Software Intensive Systems



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

**23 June 2006
SSC San Diego**

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The Terms of Reference

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Rcmds

Three steps

Summary

- 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

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- 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
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- 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

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- 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

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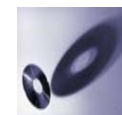
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The playing field

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- “...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, DUSDA&T, 2000





More capability and lower cost

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Summary

- 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

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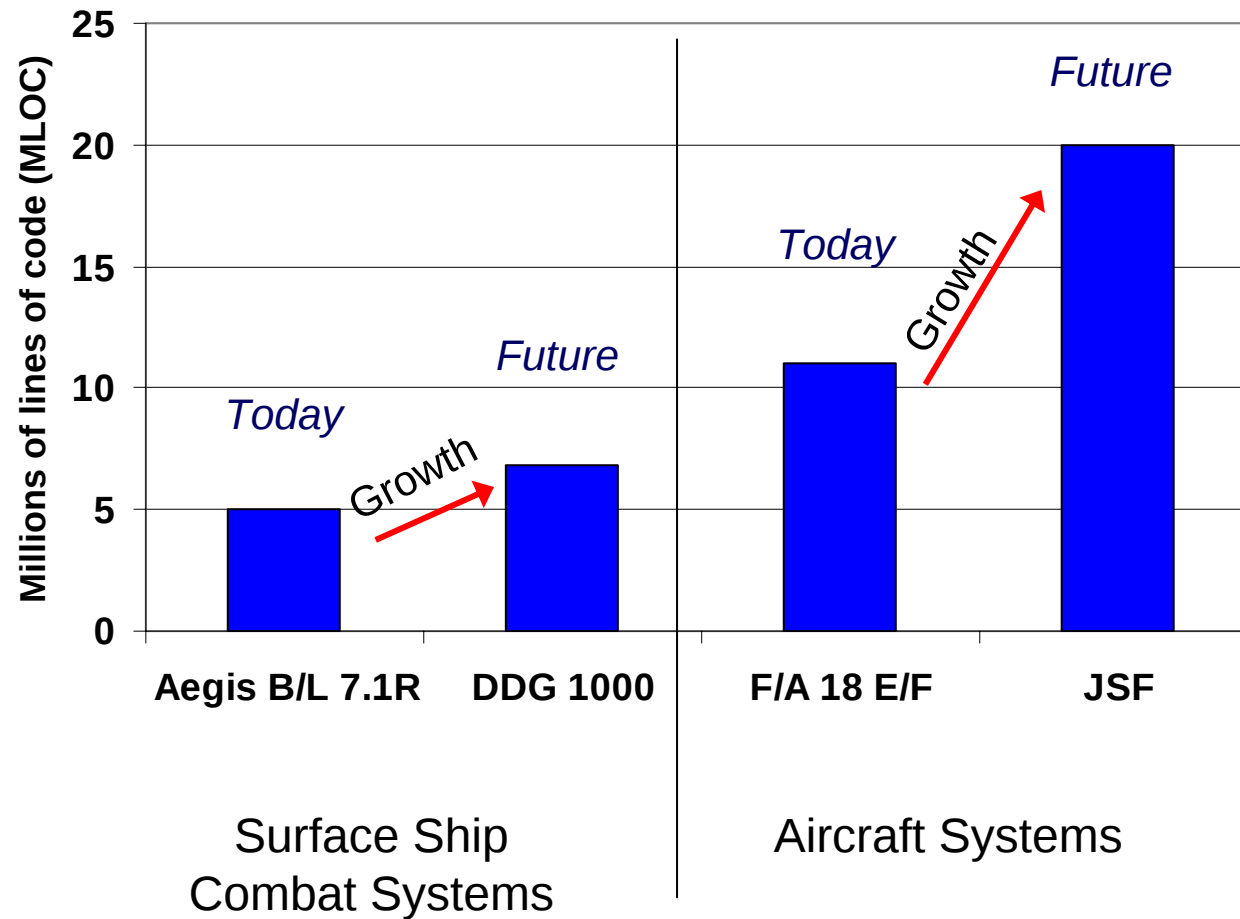
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Human resources

The pipeline is running dry

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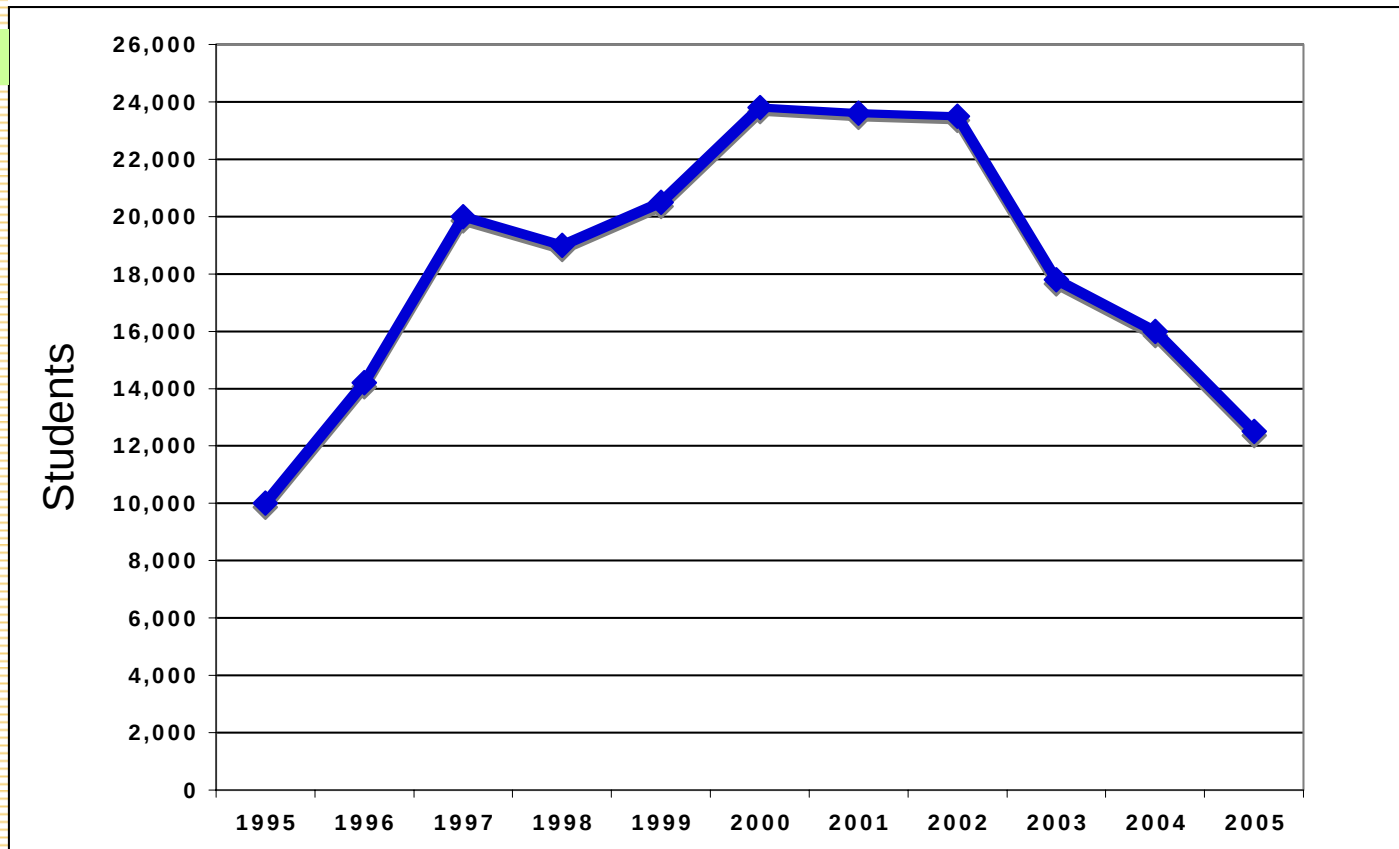
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US CS/CE Undergraduate Majors



May 2006 Computing Research News



Globalizing of Software and Hardware

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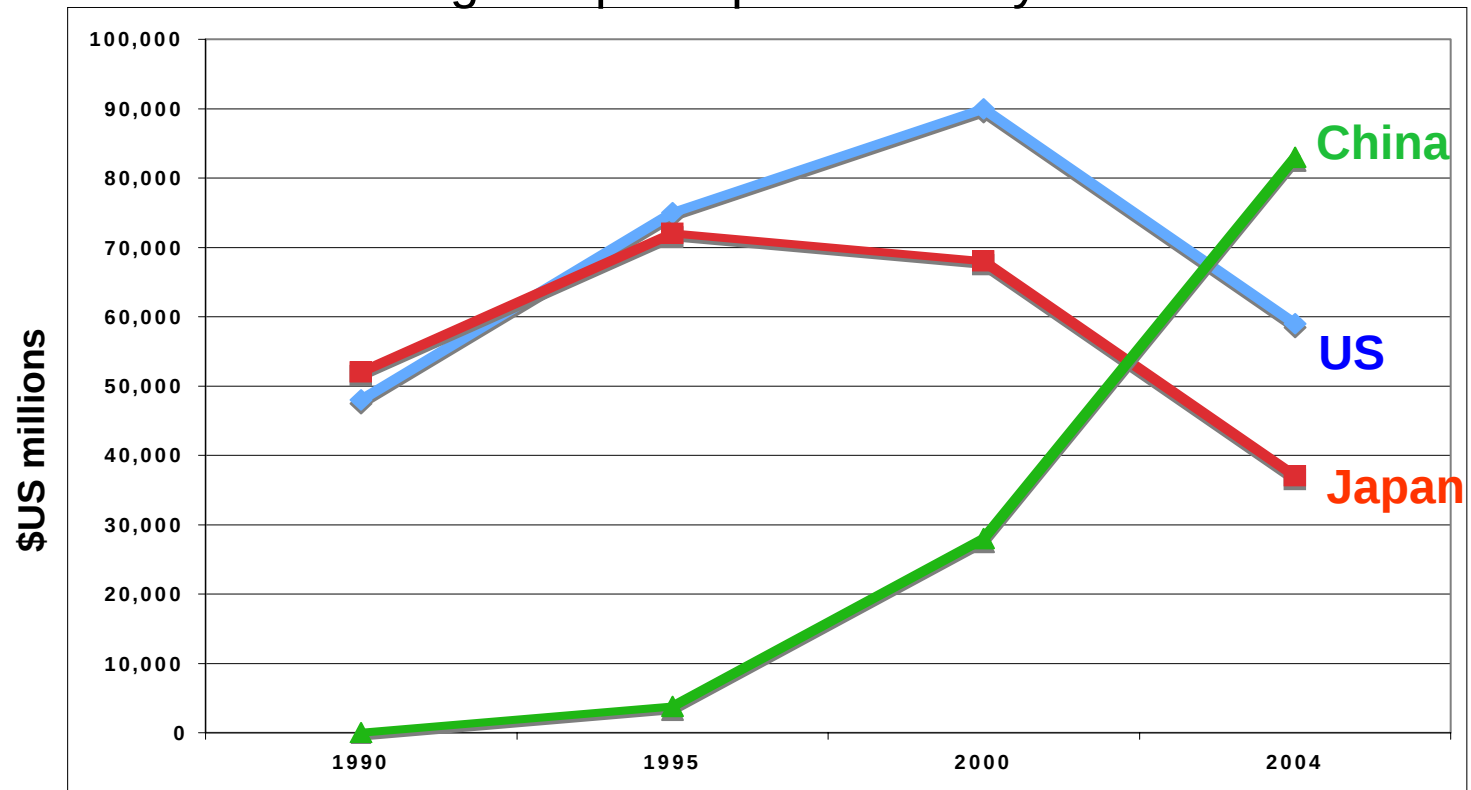
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Summary

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

Leading computer producers by location



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Source: Reed Electronics Research, *Yearbook of World Electronics Data*



History of study

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Summary

- 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

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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)

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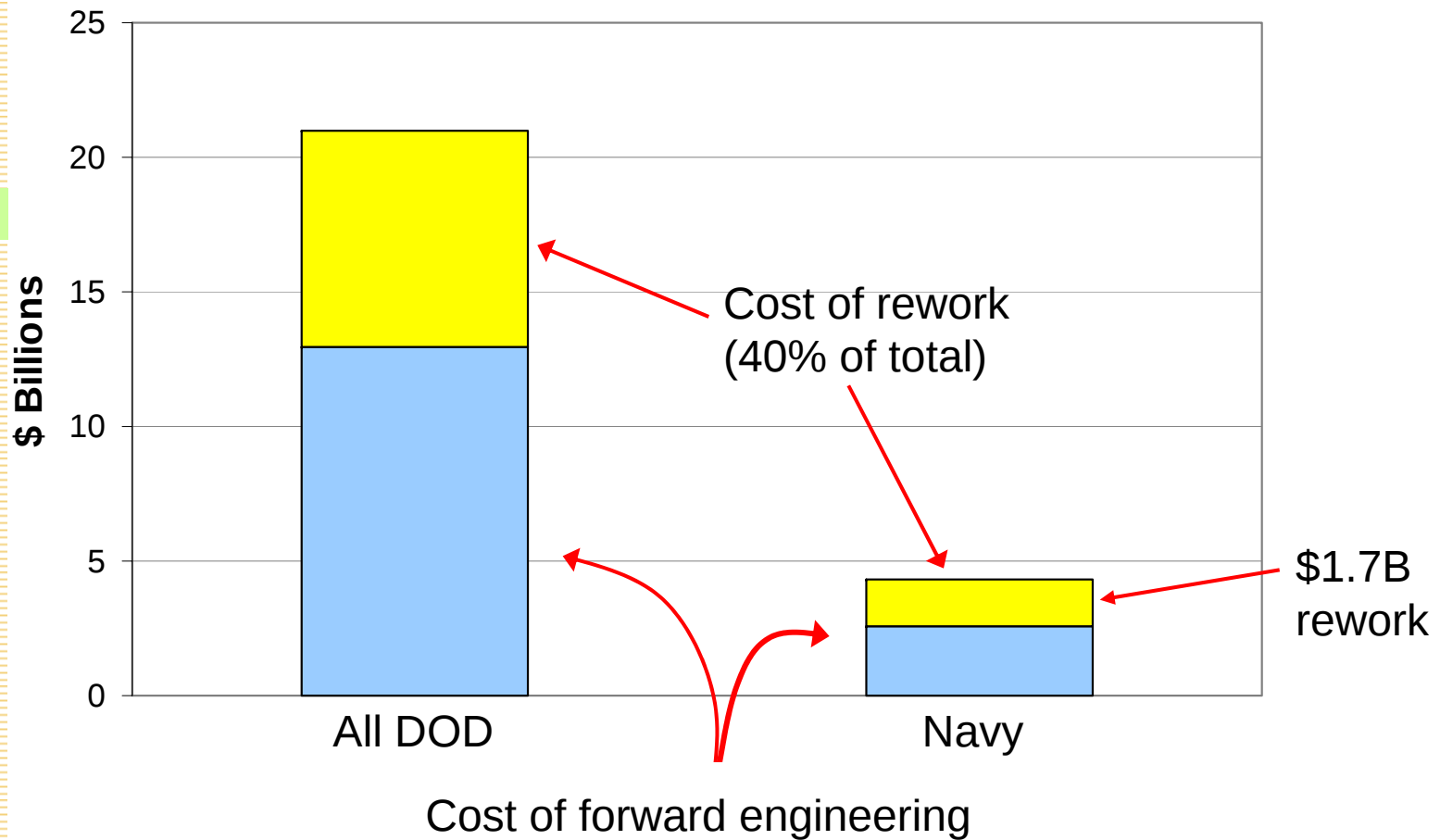
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Problems with Naval software intensive systems

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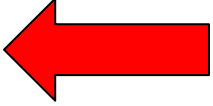
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- Specifying 
- Developing
- Acquiring
- Testing
- Life-cycle maintenance
- Focused research



Representative Findings

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- 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

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Summary

- 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

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Summary

- 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



Recommendation focus: the user-requirements loop

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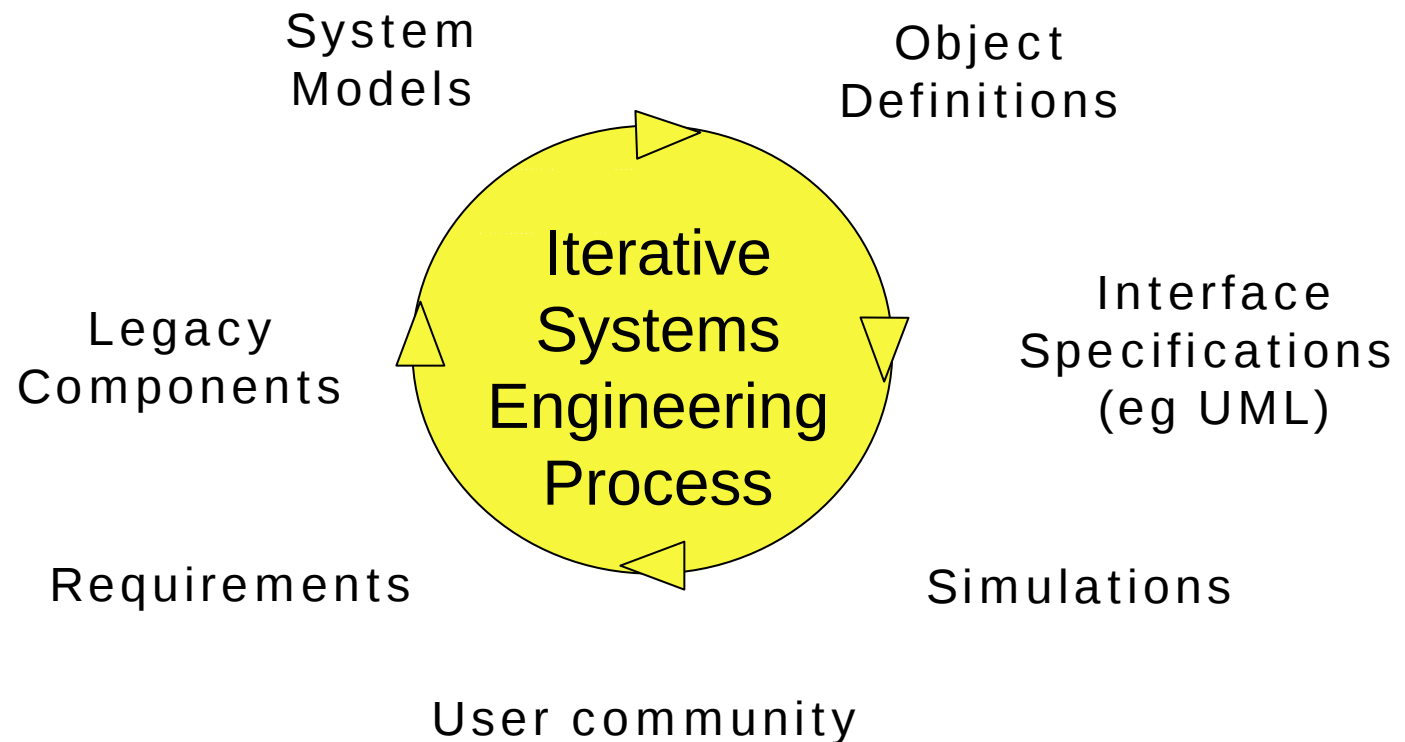
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**Model driven tools can stimulate and enforce
iterative systems engineering**





Naval S&T program recommendations

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- 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)



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- 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

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- 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

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- 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

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Summary

- 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

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- 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

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- 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

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



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- 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**

