Modernizing Systems and Software
- How Evolving Trends in Future Trends in Systems and Software Technology Bode Well for Advancing the Precision of Technology

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Overview

• Transformational Trends
  – Development
  – Acquisition
  – Human Element
  – Risk Management
  – Communications
• Ten Future Trends
• Wrap-up
Development: Need for Space, Air, Ground, Water, Underwater Software-Intensive Systems that are Interconnected

- Several million SLOC programs; “Hybrid” systems combining legacy re-use, COTS, new development
- Multi-contractor teams using different processes; dispersed engineering, development & operational locations
- New technologies create opportunities/challenges; products change/evolve, corporations mutate
- Business/operational needs change - often faster than full system capability can be implemented
- Skillset Shortfalls; Cost and schedule constraints
- Demands for increased integration, interoperability, system of system capabilities
- Enterprise perspectives/requirements; sustainment concerns

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Software Engineering Trends That Impact Systems Engineering

<table>
<thead>
<tr>
<th>Traditional</th>
<th>Future</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Standalone systems</td>
<td>• Everything connected-maybe</td>
</tr>
<tr>
<td>• Mostly source code</td>
<td>• Mostly COTS components</td>
</tr>
<tr>
<td>• Requirements-driven</td>
<td>• Requirements are emergent</td>
</tr>
<tr>
<td>• Control over evolution</td>
<td>• No control over COTS evolution</td>
</tr>
<tr>
<td>• Focus on software</td>
<td>• Focus on systems and software</td>
</tr>
<tr>
<td>• Stable requirements</td>
<td>• Rapid change</td>
</tr>
<tr>
<td>• Premium on cost</td>
<td>• Premium on value, speed, quality</td>
</tr>
<tr>
<td>• Staffing workable</td>
<td>• Scarcity of critical talent</td>
</tr>
</tbody>
</table>

Emerging Dynamics of Bringing Systems and Software Engineering in Continued Partnership
The Acceleration of Innovation in the 21st Century: - Impacting Both Defense and Society

The Amount of New Technological Innovation is Doubling Every Two Years

- Requires More Upfront SE/SW Engineering to Leverage Trends

Ray Kurzweil, et. al

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Augustine’s Law: Growth of Software - Order of Magnitude Every 10 Years

In The Beginning

1960’s

F-4A
1000
LOC

1970’s

F-15A
50,000
LOC

1980’s

F-16C
300K
LOC

1990’s

F-22
1.7M
LOC

2000+

F-35
>6M
LOC

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Trend & Implications: Augustine’s Law Will Hold

2080?

F-50 - 4.7B Lines of Code

Need for increased functionality will be a forcing function to bring the fields of software and systems engineering closer together.
Moore's Law: The Number of Transistors That Can Placed on an Integrated Circuit is Doubling Approximately Every Two Years
Increased Technological Rate of Adoption

- **Automobile**: 56 years (1886)
- **Telephone**: 36 years (1876)
- **Television**: 26 years (1926)
- **VCR**: 18 years (1952)
- **Microwave**: 18 years (1953)
- **Cell Phone**: 14 years (1983)
- **PC**: 32 years (1975)
- **Internet**: 32 years (1975)

- **Electricity**: (1873)
- **Radio**: (1905)
- **Automobile**: (1886)

Source: Rich Kaplan, Microsoft

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Relationship Between Complexity and Acquisition Success Improving and More Improvements are on the Way

Software is Growing in Complexity
- 80% of some weapon system functionality is dependent upon software
- Consequences of software failure can be catastrophic

Software Acquisition is Difficult
- 46% are over-budget (by an average of 47%) or late (by an average of 72%)
- “Successful projects” have 68% of specified features

Software is Pervasive
- IT Systems, C4ISR, Weapons, etc

On-going Changes to the Acquisition Process Targeted at Correcting this Issue

Standish Group CHAOS Report

<table>
<thead>
<tr>
<th>Year</th>
<th>On-time</th>
<th>On budget</th>
<th>Cancelled</th>
<th>Late and Over budget</th>
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<tbody>
<tr>
<td>2006</td>
<td>35%</td>
<td>19%</td>
<td>46%</td>
<td></td>
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<tr>
<td>2004</td>
<td>29%</td>
<td>18%</td>
<td>53%</td>
<td></td>
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<tr>
<td>2002</td>
<td>34%</td>
<td>15%</td>
<td>51%</td>
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<td>2000</td>
<td>28%</td>
<td>23%</td>
<td>49%</td>
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<td>1998</td>
<td>26%</td>
<td>28%</td>
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<td></td>
</tr>
<tr>
<td>1996</td>
<td>27%</td>
<td>40%</td>
<td>33%</td>
<td></td>
</tr>
<tr>
<td>1994</td>
<td>16%</td>
<td>31%</td>
<td>53%</td>
<td></td>
</tr>
</tbody>
</table>
A Key Challenge is How to Obtain a Better Alignment of Risk Among the Relevant Stakeholders
Acquisition Challenges: Some Drivers That Increase the Risk of Acquiring Software-Intensive Systems

- Platform: Customer Emphasis
- Requirements: Acquisition Model
- Dominant Prime: Program Execution
- "Boxes": Integration Challenge
- Proprietary: Architectures and Standards
- Enterprise: Objectives/Capabilities
- Strategic Teaming: "Layers & Stacks"
- Plug & Play: Need Exists to Address Both Sides, and Do So with Compressed Delivery Schedules via Improvements in Systems/Software Engineering

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Acquisition Performance – Flexible Boundary-Crossing Acquisition Structure

2005 study confirmed*:

• In advanced knowledge-based organizations, management’s desire for the flow of knowledge is greater than the desire to control boundaries
• Unlike the matrix organization, there is less impact on the dynamics of formal power and control
• Important to measure the system in terms of user performance

* Using Communities of Practice to Drive Organizational Performance and Innovation, 2005, APQ study

Advanced Knowledge-Based Organizations (Big A)

From “Science and Technology to Support FORCEnet,” Raytheon TD-06-008. Used by permission.

Ref: Jim Smith, (703) 908-8221, jds@sei.cmu.edu
The ability of organizations to compete will increasingly depend on the innovation of the human element.
Society Drivers: Bimodal Demographics (Space Industry)

Reconstituting This Group

Graduate School Shortfall

Area of Concern

Average Space Industry S&E Workforce Age Distribution

Trend: Industry/Gov’t Will Increasingly Focus on Attracting, Training and Retaining Systems Engineering Talent

Source: Lockheed Martin (0004305-001: AIAA SE Workforce Data. Frank Cappuccio VP & GM Skunk Works)

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Objective is for Software and Systems Engineering to Become More Integrated Versus Separated

OSD Initiative: Integrated Software and Systems Engineering Curriculum

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Human Element in the Work-Space Environment

Timeline

Source: Doug Phair; Technology Evangelist; dphair@mitre.org; February 2008
Managing Multiple Generations: Cultural Differences

Traditionalist 1928-1945
- Hard worker
- Respects authority
- Work is an obligation
- Communicates formally & in person
- Organizational loyalty
- Work & family don’t mix

Baby-Boomer 1946 - 1964
- Workaholic
- Questions authority
- Works efficiently
- Competitive
- No news is good news
- Work to live, little balance between work/family

Generation X 1965 - 1980
- Technically savvy
- Prefer informality
- Learns quickly
- Communicates directly & immediately
- Wants structure & direction
- Seek work/life balance

Generation Y 1980 - 2000
- Prefer informality
- Learn quickly
- Embrace diversity
- Requires supervision
- Indirect communication: email & texting
- Seek “demand” work/life balance

Source: Hammill 2005
Trends Affecting the Workforce

From | To
--- | ---
Doers differ from thinkers | Doers must be thinkers
Assets are things | Assets are people
Labor is an expense | People are an investment
Lifetime employment | Lifetime employability
Top down control | Decentralized decisions
Localized work | Networked problems solved
Measure for results | Measure for improvements

Pfeffer (1994)
Communication: Increased Capabilities in the Digital Spectrum Enables Improvements in Communication and Collaboration

Rule #4: The best companies are the best collaborators*

* Friedman, Thomas L. “The World Is Flat”, Farrar, Straus and Giroux, 2005
Communications Among Systems – Fostering a Growing Interdependence and Integration
Implication: Improvements in Collaboration Mechanisms Are Enablers for System and Software Engineering Success

High Presence

Virtual Presence

Voice over IP

Whiteboarding

File Transfer

Internet Surfing

LM/Chat & Presence Awareness

Unstructured

High Bandwidth

Low Bandwidth

Highly Structured

3D Data Visualization

Spatial Applications

Application\n\n\n\n
Web Services

Transaction Processing Systems

Scheduling, tracking, retrieval & Coordination applications

Communication of Ideas and Decision Velocity

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Problem Identification: Ultra-Large-Scale (ULS) Systems – The Software Challenge of the Future

Gather leading experts to study:

• Characteristics of ULS systems
• Challenges and breakthroughs required
• Promising research and approaches

Intended outcomes:

• ULS Systems Research Agenda
• Program proposal
• Collaborative research network

About the Effort
Funded by the Army (ASA ALT)
Staffing: 9 member SEI team; 13 member expert panel

Study lead – Linda Northrop, SEI
Systems and Software Engineering: Ten Trends

• Greater demands on systems and software engineers will stimulate growth in the field – nationally and internationally

• Industry/Gov’t will increasingly focus on attracting, training and retaining systems and software engineering talent – short and long run – with emphasis on providing a Generation Y work environment

• Increased reliance on systems and software engineering processes and technologies to effectively manage the acquisition/”green” space

• The laws of Augustine’s and Moore will continue to hold and will continue to be a forcing function to bring the fields of software and systems engineering closer together

• Improvements in program risk-reduction collaboration mechanisms will be significant enablers for increases in systems and software engineering communication and “decision velocity”
Systems and Software Engineering: Ten Trends

• Increased need for a large number of complex systems and systems of systems will lead to investments in research and technology

• Systems and software engineers will continually find ways to innovative to reduce complexity
  – Increased importance of modeling and simulation
  – Increased reliance on architectures (top-down and bottoms-up)
  – Increased design for continuous evolution and deployment at all levels will occur

  ➢ Understanding users and their context will evolve, e.g. leaner system and software engineering process assets on projects

• Increased customer requests for system and software engineering support earlier in life cycle

• Shift of systems and software engineering focus from the platform to systems of systems

• Process improvement will continue to be important
Recommended Readings


Friedman, Thomas L. “The World Is Flat”, Farrar, Straus and Giroux, 2005


