

Future Tends in Systems & Software Engineering

- How Future Trends Bode Well for Systems Engineering's Partnership in the Transformation

Second Annual Systems Engineering Conference
4 June 2008
National Reconnaissance Office
Chantilly, Virginia
Theme: Systems Engineering: A Partner in Transformation

Dr. Kenneth E. Nidiffer
Director of Strategic Plans for
Government Programs
nidiffer@nro.mil
nidiffer@sei.cmu.edu



Software Engineering Institute

CarnegieMellon

© 2008 Carnegie Mellon University

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 04 JUN 2008		2. REPORT TYPE		3. DATES COVERED 00-00-2008 to 00-00-2008	
4. TITLE AND SUBTITLE Future Tends in Systems & Software Engineering -How Future Trends Bode Well for Systems Engineering's Partnership in the Transformation				5a. CONTRACT NUMBER	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S)				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) Carnegie Mellon University ,Software Engineering Institute (SEI),Pittsburgh,PA,15213				8. PERFORMING ORGANIZATION REPORT NUMBER	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)				10. SPONSOR/MONITOR'S ACRONYM(S)	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release; distribution unlimited					
13. SUPPLEMENTARY NOTES					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT Same as Report (SAR)	18. NUMBER OF PAGES 28	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

The Software Engineering Institute - Improving the State of Practice of Engineering: Create, Apply and Amplify

Federally Funded Research and Development Center

Created in 1984

Sponsored by the U.S. Department of Defense

Locations in Pittsburgh, PA; Washington, DC;
Frankfurt, Germany

Operated by Carnegie Mellon University



Software Engineering Institute

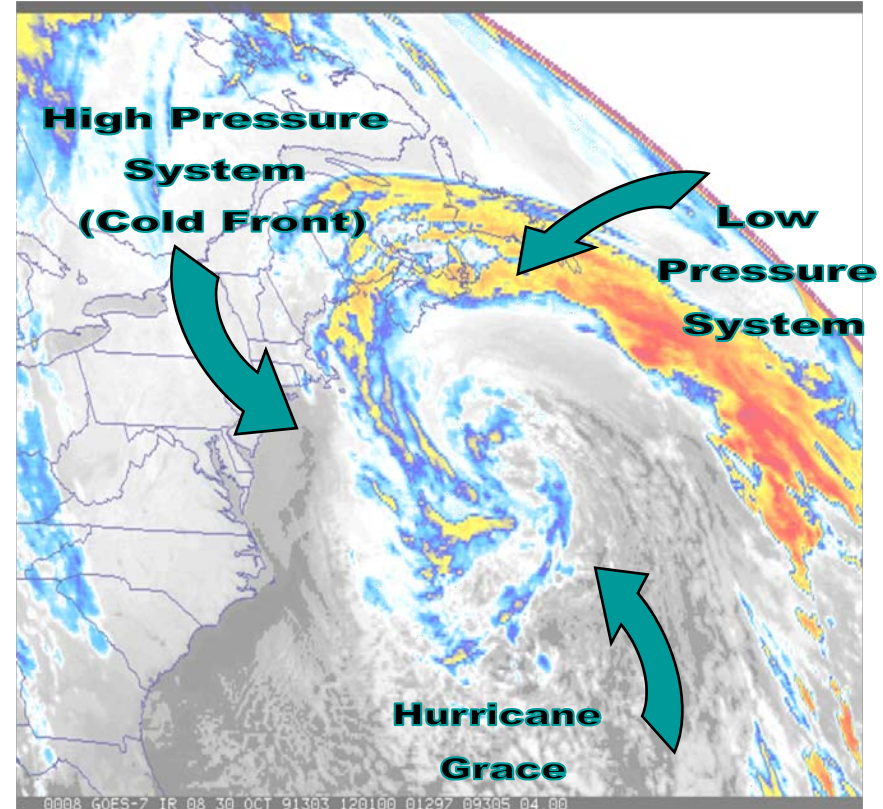
Carnegie Mellon

Dr. Kenneth E. Nidiffer
Future Trends in Systems & Software Engineering
How Future Trends in Systems and Software Technology
Bode Well for Transformation
© 2008 Carnegie Mellon University

Overview



- Transformational Trends in Systems and Software Engineering
 - Development
 - Innovation
 - Integration
 - Human Element
 - Communications
 - Process
- Ten Trends
- Wrap-up



“Perfect Storm” Event, October 1991
National Oceanic & Atmospheric Administration



Development Challenges: 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



Systems Engineering – A Partner in Developing More Responsive Space Systems



Software Engineering Development Trends That Impact Systems Engineering



Traditional

- Standalone systems
- Mostly source code
- Requirements-driven
- Control over evolution
- Focus on software
- Stable requirements
- Premium on cost
- Staffing workable

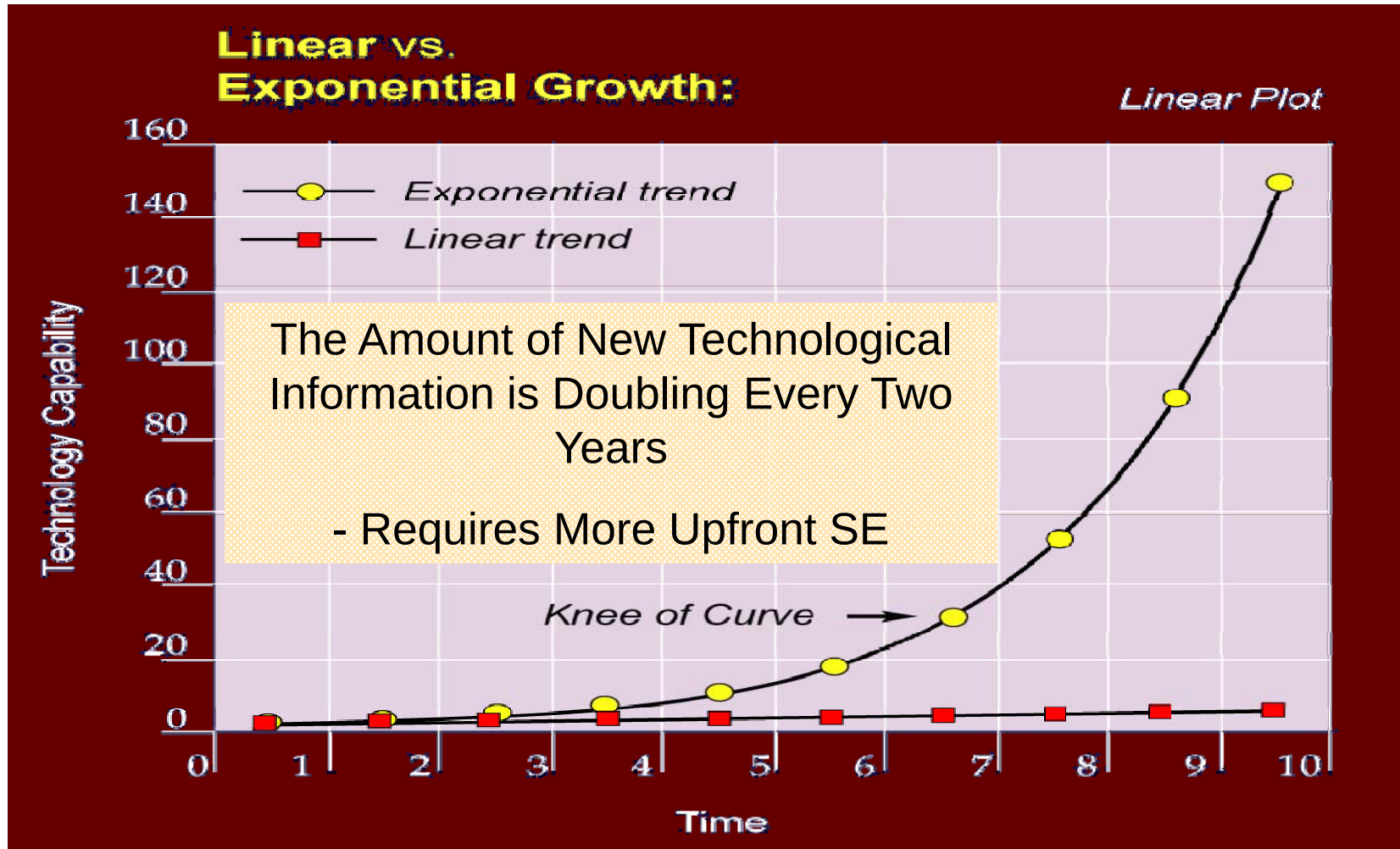
Future

- Everything connected-maybe
- Mostly COTS components
- Requirements are emergent
- Limited control over COTS evolution
- Focus on systems and software
- Rapid change
- Premium on value, speed, quality
- Scarcity of critical talent

Emerging Dynamics of Bringing Systems and Software Engineering in Continued Partnership

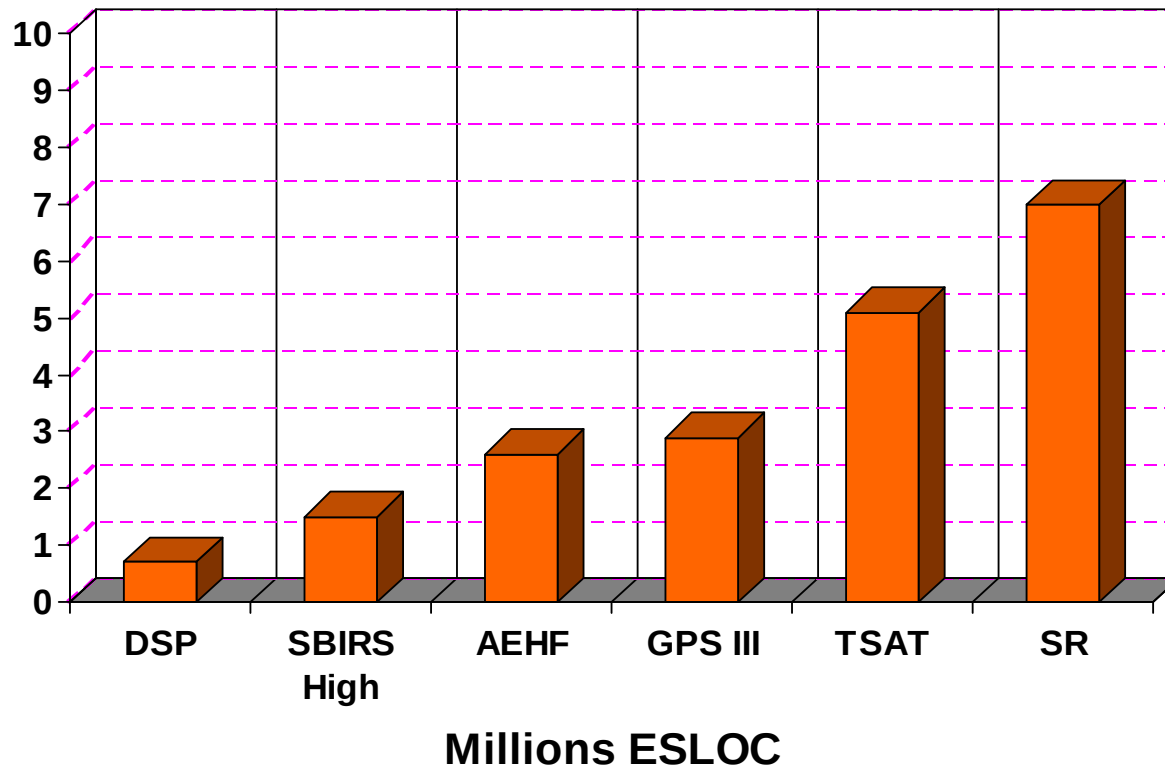


The Acceleration of Innovation in the 21st Century: Impact Systems Engineering Transformational Activities



Growth Trend in Space System Software

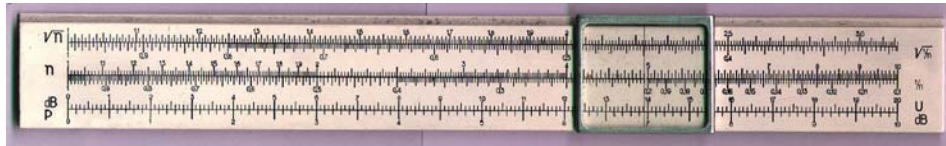
(Onboard and Ground Software)



System/Software Engineering I/F Challenges: 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**



Software Engineering Institute

Carnegie Mellon

Dr. Kenneth E. Nidiffer
Future Trends in Systems & Software Engineering
How Future Trends in Systems and Software Technology
Bode Well for Transformation
© 2008 Carnegie Mellon University

System/Software I/F Challenges: Relationship Between Complexity and Acquisition Success Improving But Not Enough!



Software is Growing in Complexity

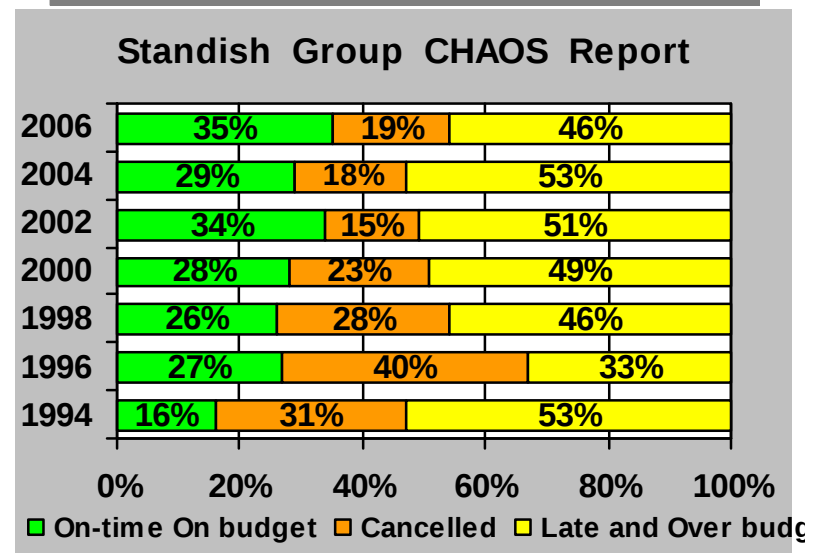
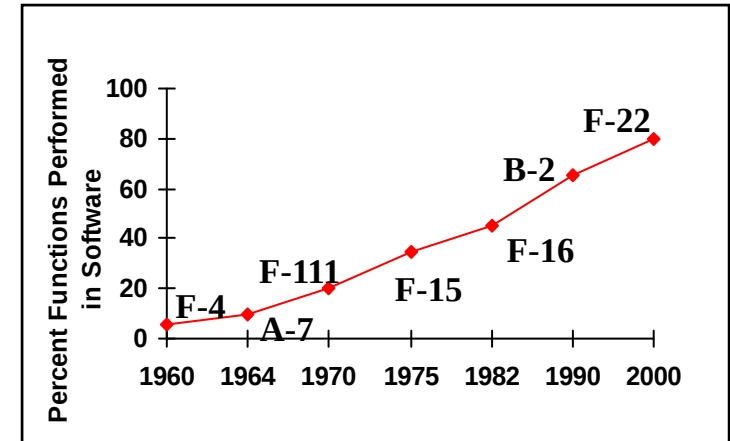
- 80% of some weapon system functionality is dependent upon software¹
- Consequences of software failure can be catastrophic

Software Acquisition is Difficult

- 46% are over-budget (by an average of 47%) or late (by an average of 72%)²
- “Successful projects” have 68% of specified features²

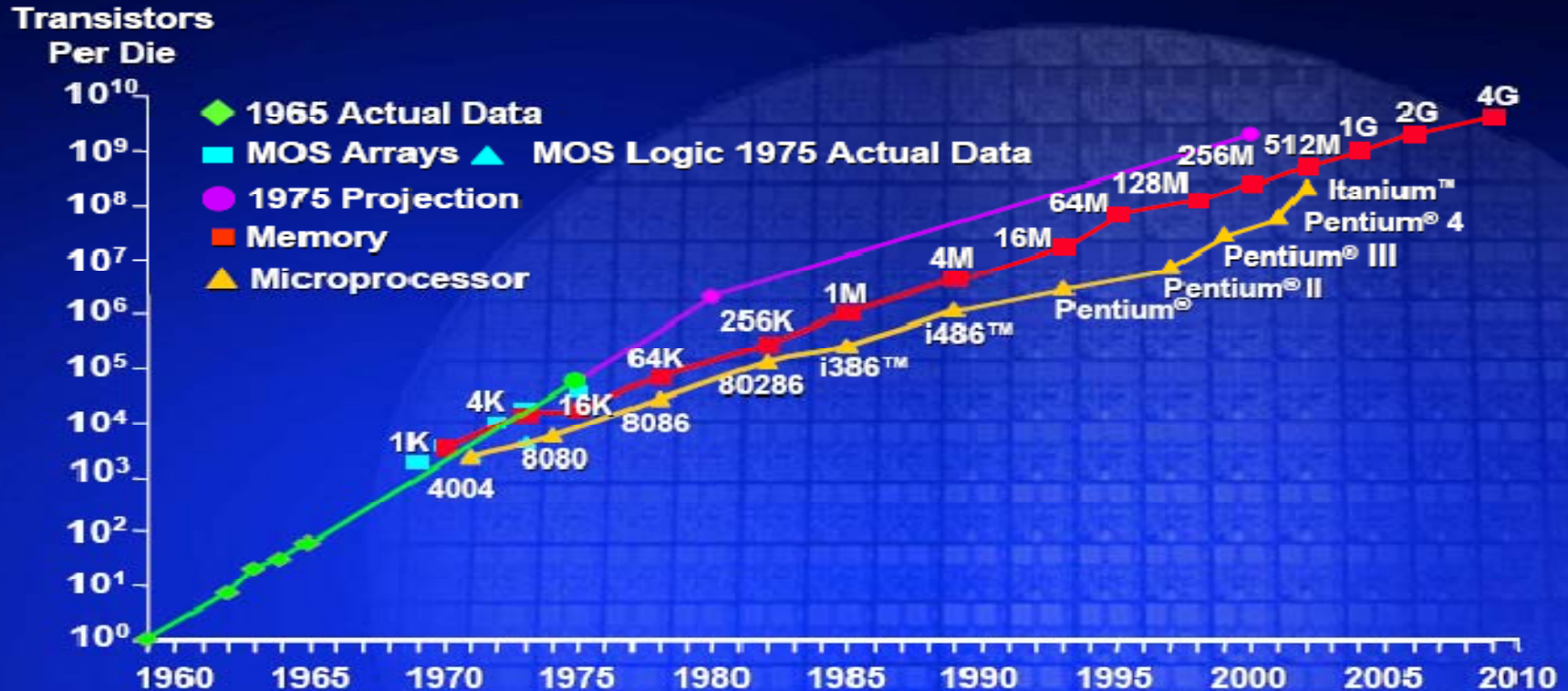
Software is Pervasive

- Space, IT Systems, C4ISR, Weapons, etc



System/Hardware Engineering I/F Challenges - Moore's Law: The Number of Transistors That Can be Placed on an Integrated Circuit is Doubling Approximately Every Two Years

Integrated Circuit Complexity



Systems Engineering Integration Challenges: Some Drivers That Increase the Complexity of Acquiring Systems



Platform → **Enterprise**
Customer Emphasis

Requirements → **Capabilities**
Acquisition Model

Dominant Customer → **Collaboration**
Program Execution

“Boxes” → **“Layers & Stacks”**
Integration Challenge

Proprietary → **Plug & Play**
Architectures and Standards

Transformation will require addressing both sides, and do so with compressed delivery schedules via improvements in systems/software engineering

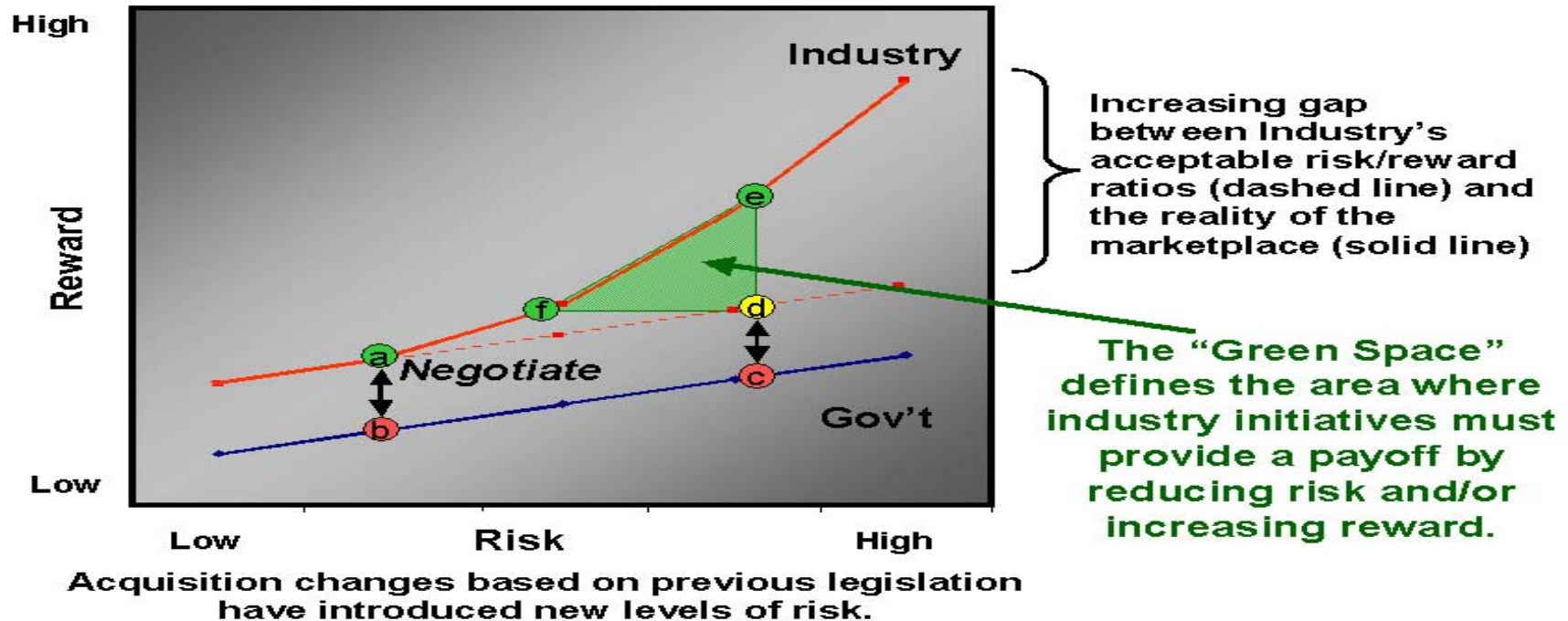


Increased Reliance on Acquirer/Developer to Reduce Integration Risk by Effectively Navigating the Green/Acquisition Space



Navigating the “Green Space”

Risk-Reward Preferences

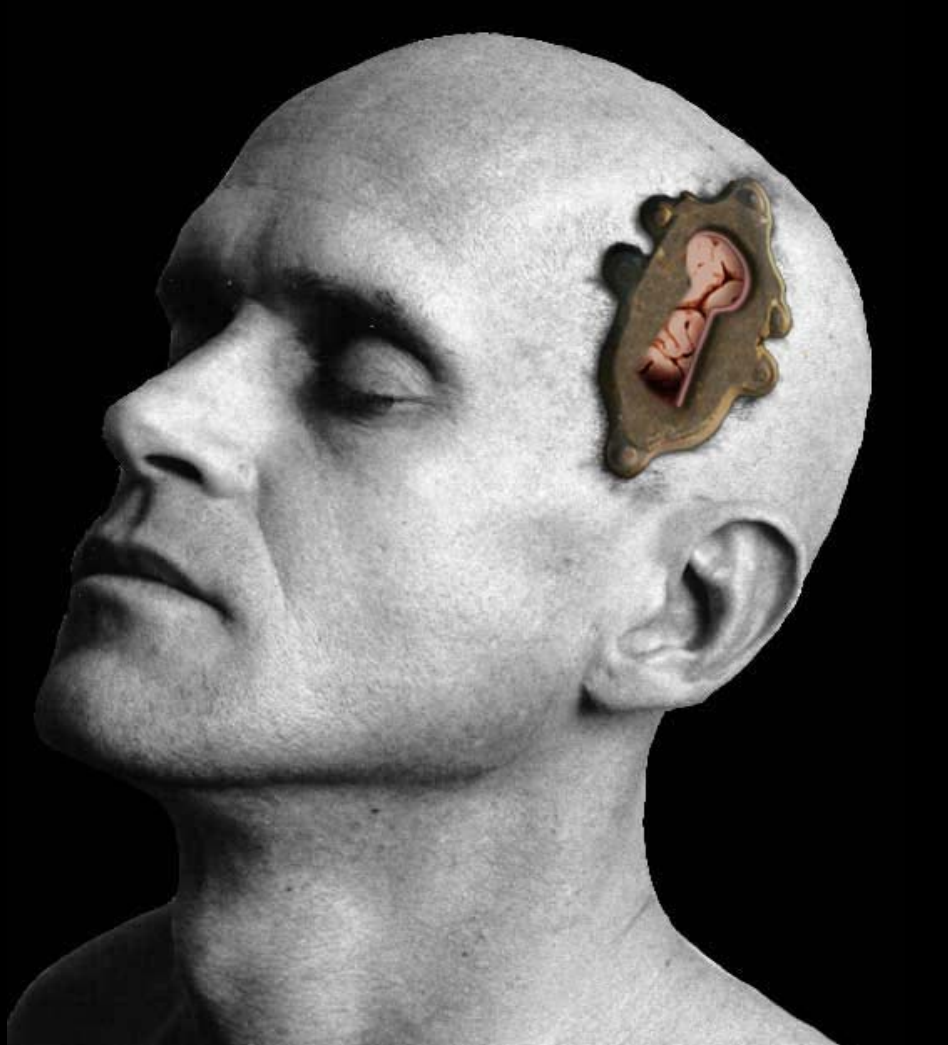


©2005 Systems and Software Consortium, Inc.

Source: Nidiffer and Dolan, IEEE Software, Sept/Oct 2005



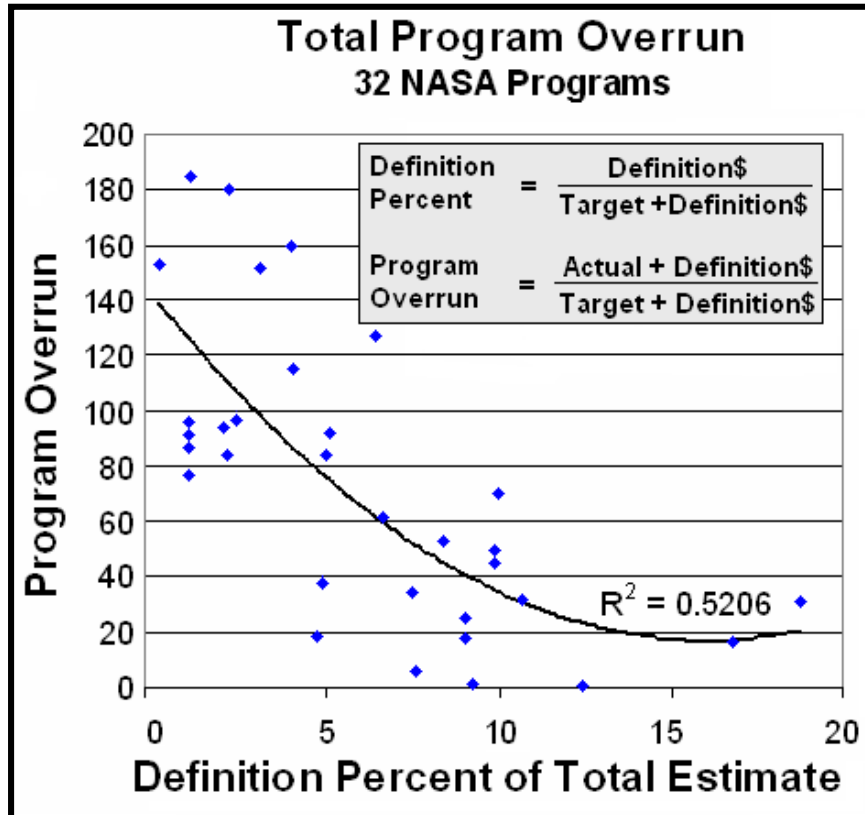
Human Element – Perhaps the Longest Pole in the Tent Is Rebuilding the Workforce – Gen Thomas S. Moorman Jr. (Ret) March 2008



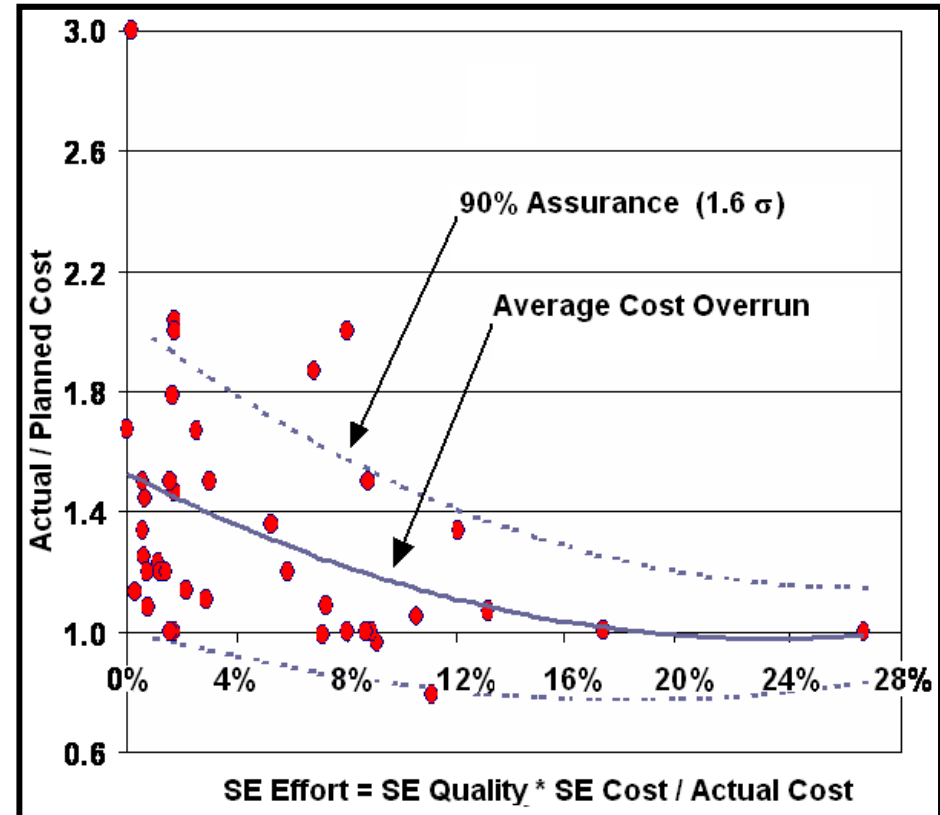
The ability of organizations to compete will increasingly depend on the innovation of the human element



The Challenge - Supporting Evidence



Gruhl, Werner (1992), Lessons Learned:
Cost/Schedule Assessment, Internal Presentation,
NASA Comptroller's Office



Honour, Eric (2004), *Understanding the Value of Systems Engineering*, Proceedings of the 14th Annual INCOSE International Symposium



Systems Engineering Effectiveness Survey (2004-2007)



Hypothesis: The effective performance of SE best practices on a development program yields quantifiable improvements in the program execution (e.g., improved cost performance, schedule performance, technical performance).

Objectives:

- Characterize effective SE practices
- Correlate SE practices with measures of program performance

Approach:

- Distribute survey to NDIA companies
- SEI analysis and correlation of responses

Survey Areas:

Process definition

Project planning

Risk management

Requirements development

Requirements management

Trade studies

Interfaces

Product structure

Product integration

Test and verification

The Effectiveness of Systems Engineering: A Survey - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Reload Home Search Favorites

Address https://seir.sei.cmu.edu/feedback/SystemsEngineering_Demo.htm

Google

Carnegie Mellon Software Engineering Institute

NDIA

The Effectiveness of Systems Engineering: A Survey

The Effectiveness of Systems Engineering: A Survey - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Forward Stop Reload Home Search Favorites

Address https://seir.sei.cmu.edu/feedback/SystemsEngineering_Demo.htm

Google

14. Approximately what percentage of non-recurring engineering (NRE) does systems engin approximate percentage -- without the percentage sign)

%

Is the NRE percentage estimated, or is it a measured value? (Please select one)

☐ Estimated

☐ Measured

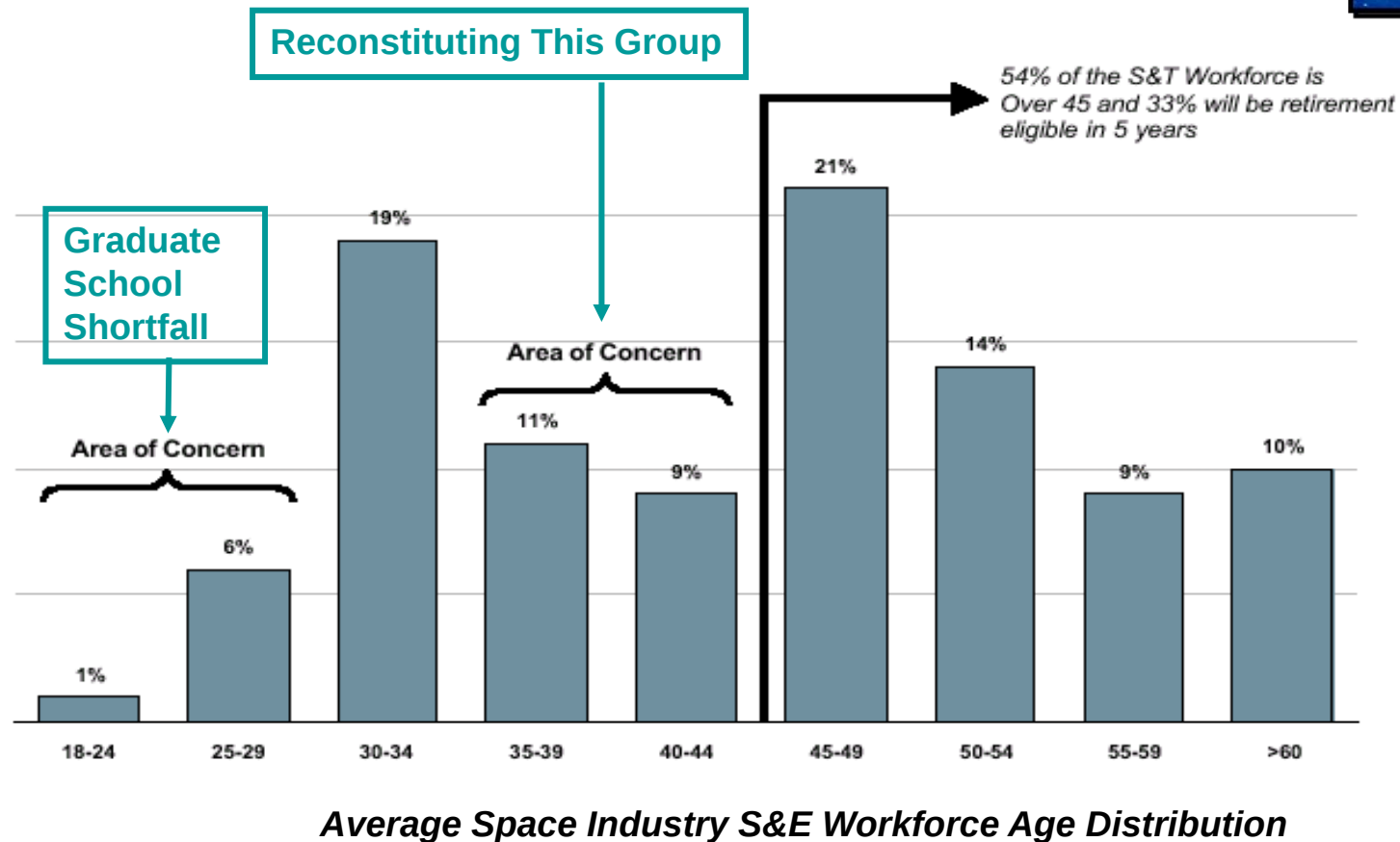
Done Internet

Configuration mgmt

Metrics



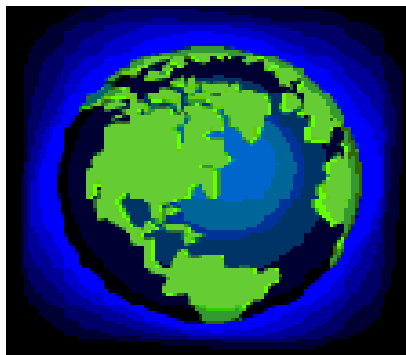
Society Drivers: Bimodal Demographics (Space Industry)



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



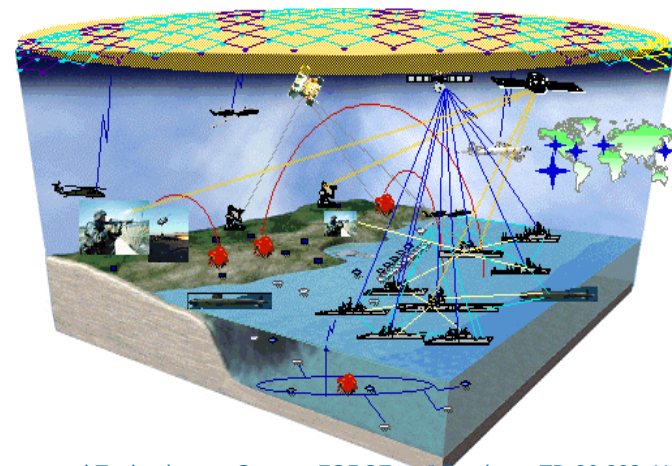
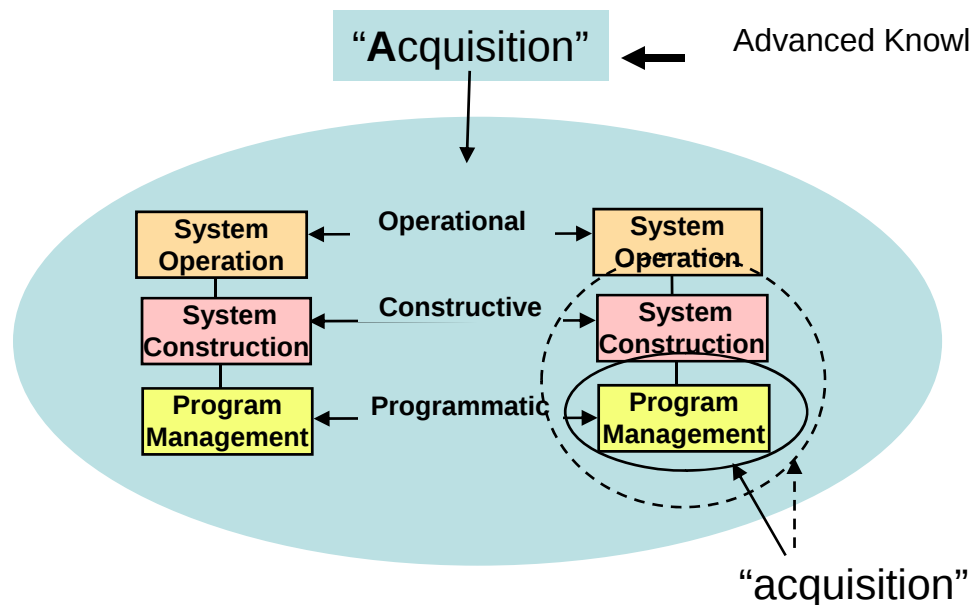
Organizational Performance - Flexible Boundary-Crossing Acquisition Structure



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

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



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

Ref: Jim Smith, (703) 908-8221, jds@sei.cmu.edu



Human Element Challenge: Bumpy Road at the Systems Engineering/Software Engineering Intersection

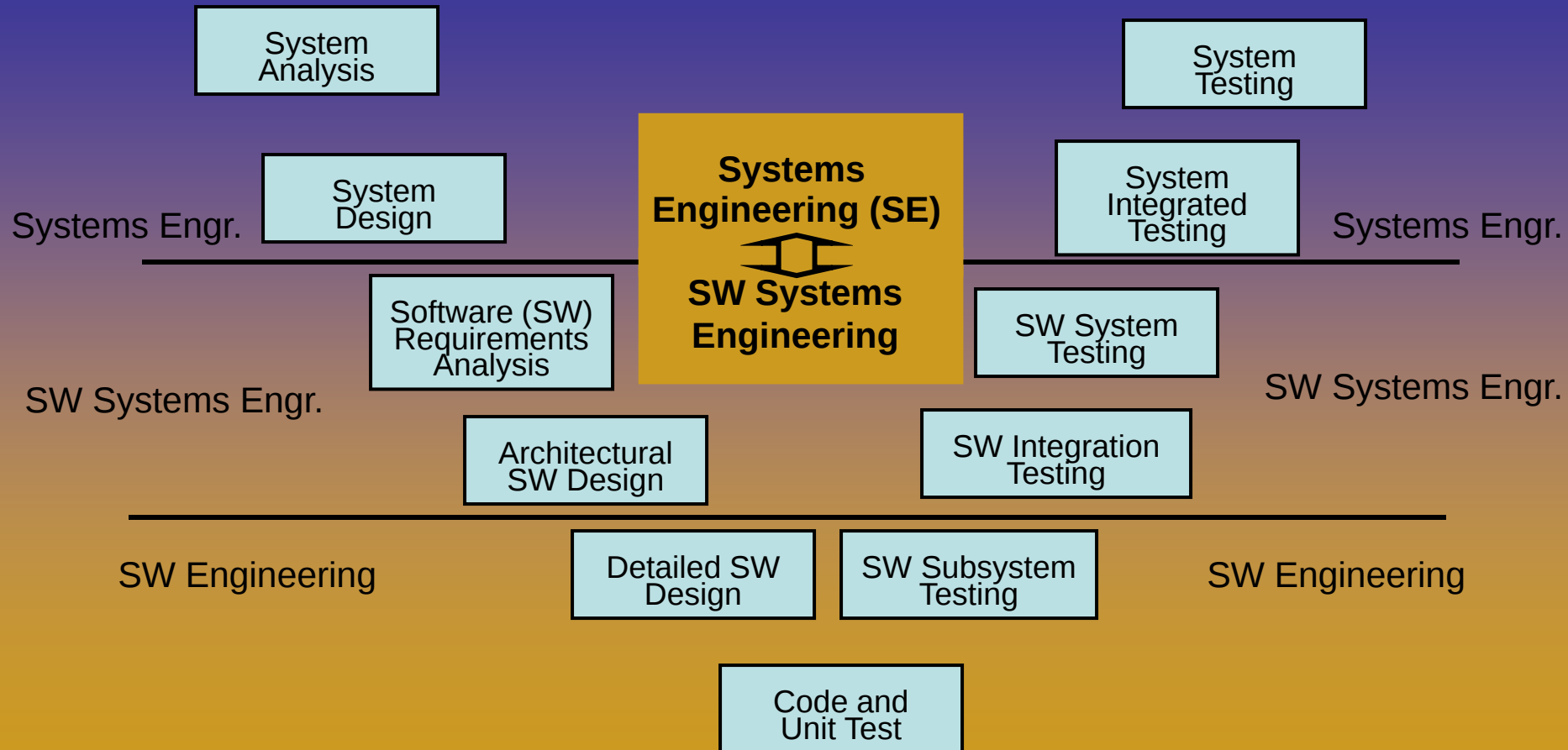


The Integration of Systems and Software Engineering will take SE Leadership Commitment

Source: Kurstedt, Harold, Newport Group, 2008



Human Element: Current Objective is for Software and Systems Engineering to Become More Integrated Versus Separated



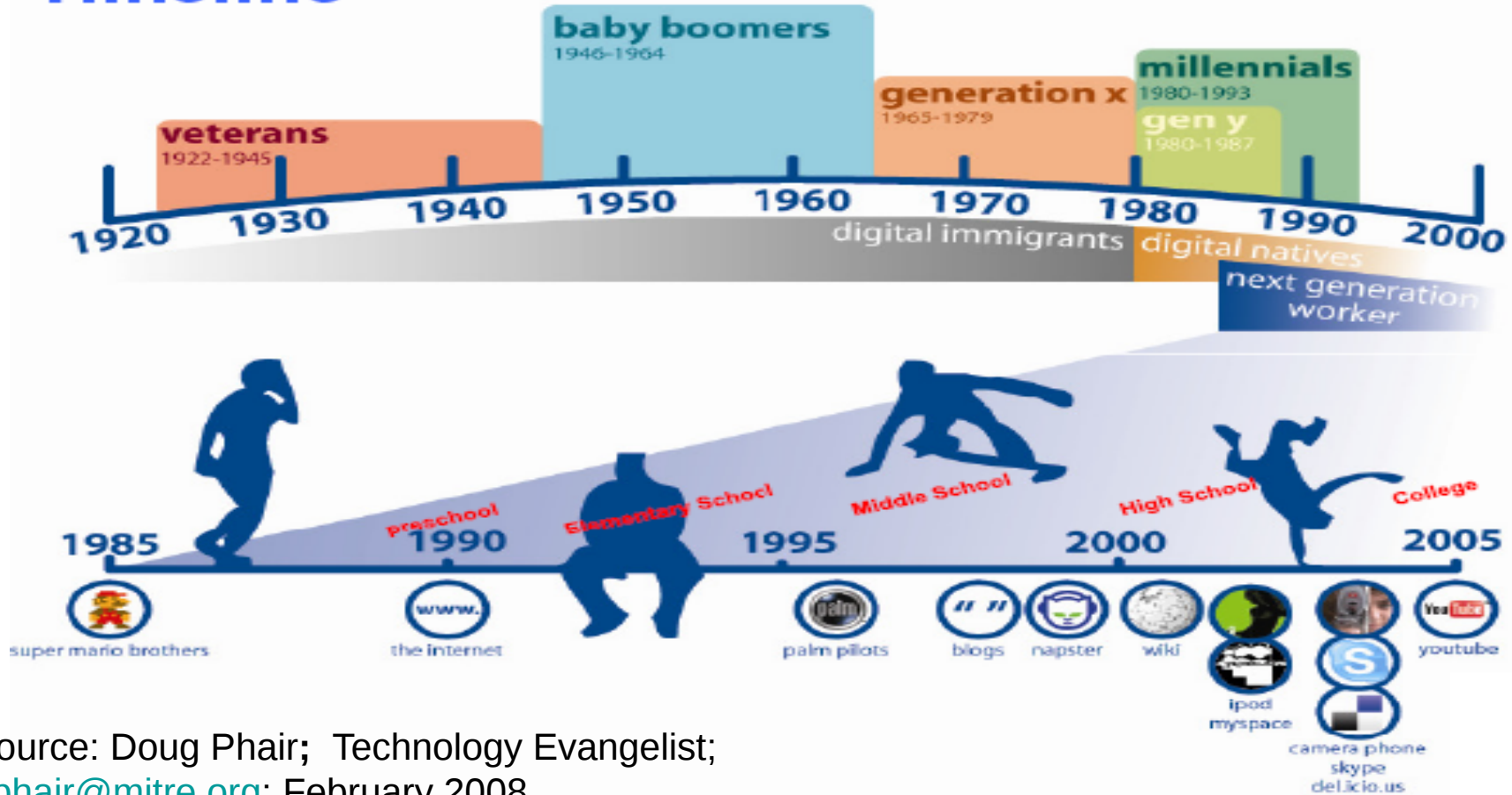
OSD Initiative: Integrated Software and Systems Engineering Curriculum



Human Element in the Work-Space Environment



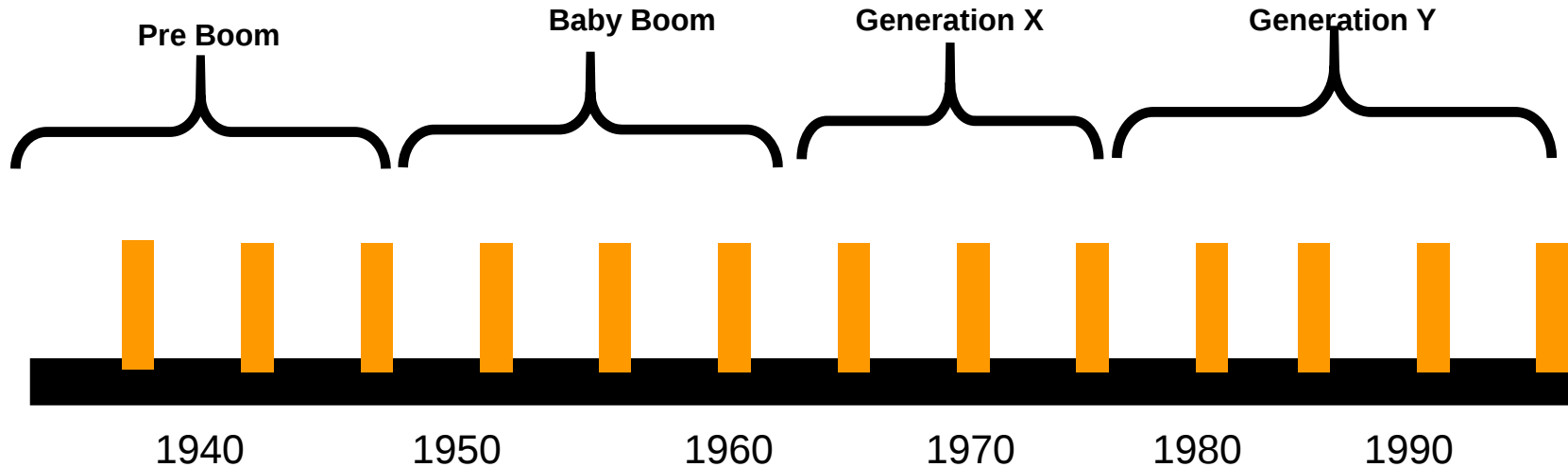
Timeline



Source: Doug Phair; Technology Evangelist;
dphair@mitre.org; February 2008



Human Element: More Generation Y Workers Will Enter the Workplace



Generation Y Characteristics

- Born late 1970s to mid-1990s
- Larger than Generation X
- More ethnically diverse
- Technologically savvy

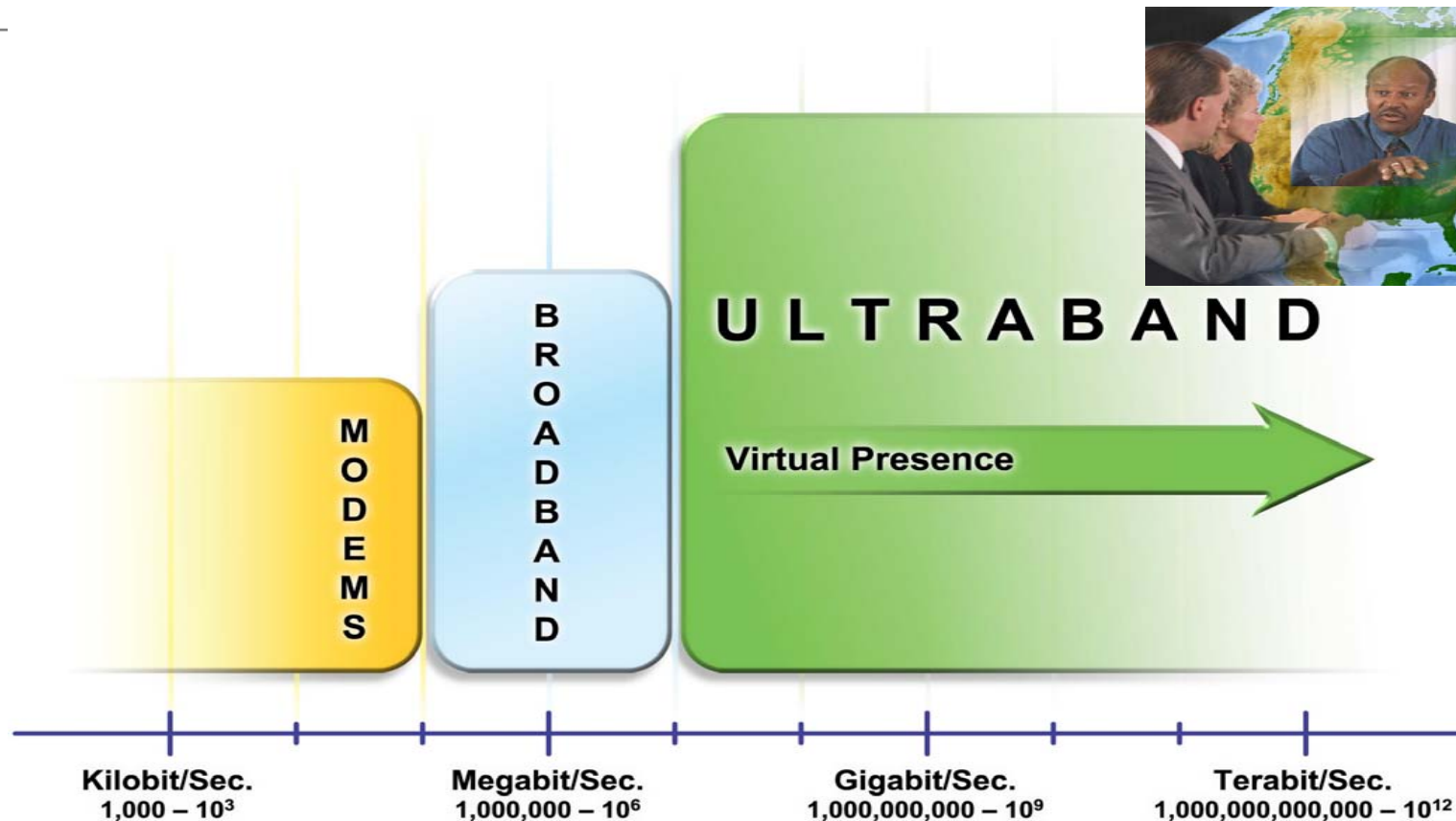
What Makes Generation Y Tick

- High Expectation of Employers
- Goals, Goals, Goals
- Desire for Immediate Responsibility
- Balance and Flexibility

Source: Cara Spiro, DAU, 2006



Increased Capabilities in the Digital Spectrum Enables SE Improvements in Communication and Collaboration

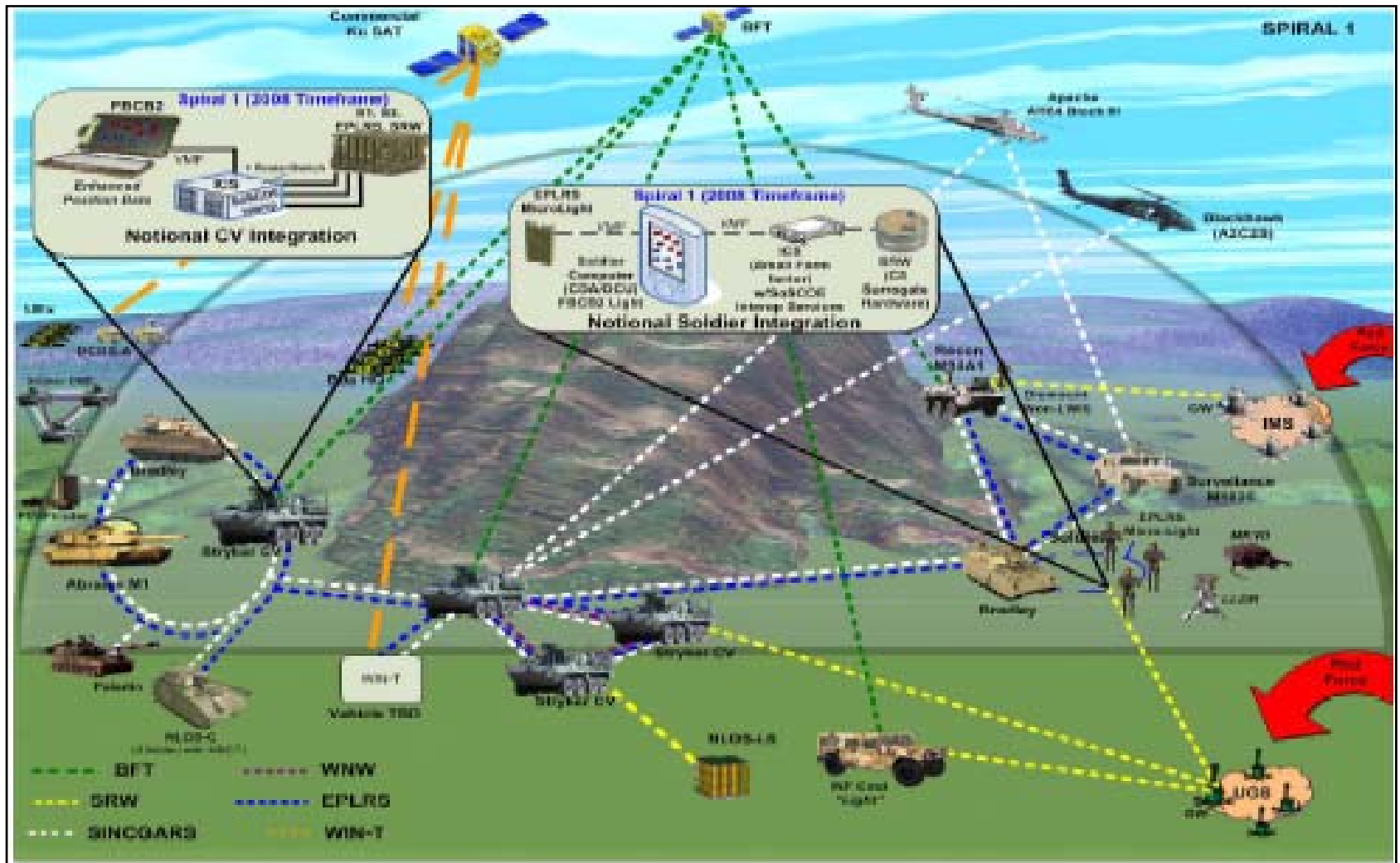


Rule #4: The best companies are the best collaborators*

* Friedman, Thomas L. *"The World Is Flat"*, Farrar, Straus and Giroux, 2005



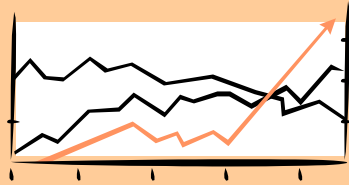
Communications Among Systems – Fostering a Growing Interdependence and Integration



SE is a Partner in Addressing Both Approaches to Process Improvement



Data-Driven (e.g., Six Sigma, Lean)



Clarify what your customer wants
(Voice of Customer)

- Critical to Quality (CTQs)

Determine what your processes can
do (Voice of Process)

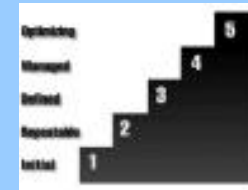
- Statistical Process Control

Identify and prioritize improvement
opportunities

- Causal analysis of data

Determine where your
customers/competitors are going
(Voice of Business)

Model-Driven (e.g., CMM, CMMI)



Determine the industry best practice

- Benchmarking, models

Compare your current practices to
the model

- Appraisal, education

Identify and prioritize improvement
opportunities

- Implementation
- Institutionalization

Look for ways to optimize the
processes





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 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 way 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*
- *Increased customer requests for system and software engineering support will occur earlier in life cycle*
- *Shift of systems and software engineering focus from the platform to the networks and ground systems*
- *Process improvement will continue to be important*





Recommended Readings



- Buckman, Robert H. *Building a Knowledge-Driven Organization*. McGraw-Hill, New York, NY, 2004.
- GAO Report: 08-467SP, Defense Acquisitions – Assessment of Selected Weapon Systems, March 2008
- Chesbrough, Henry William. *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Harvard Business School Publishing Corporation, Boston, MA 2003.
- Drucker, Peter. *Managing in the Next Society*. Truman Talley Books, New York, NY, 2003.
- Friedman, Thomas L. “*The World Is Flat*”, Farrar, Straus and Giroux, 2005
- Gates, William H. III “*Business @ The Speed of Thought – Using a Digital Nervous System*”, Time Warner Books, 1999
- Kurstedt, Harold and Pamela. *Systems and Software Engineering Interfaces, Dealing with the Bumpy Roads, Participant Guide*, March 2008
- Malone, Thomas. *The Future of Work: How the New Order of Business Will Shape Your Organization, Your Management Style and Your Life*. Harvard Business School Publishing, Boston, MA, 2004. See <http://ccs.mit.edu/futureofwork/>
- Nidiffer, Kenneth E. and Doland, Diana “Evolving Distributed Project Management”, special issue *IEEE Software*, Sept/Oct 2005
- Northrop, Linda. *Ultra-Large-Scale Systems – The Software Challenge of the Future*, Software Engineering Institute, June 2006
- Rouse, William B. et al, *Understanding R&D Value Creation with Organizational Simulation*, Tennenbaum Institute, H. Milton Stewart School of Industrial & Systems Engineering, Georgia Institute of Technology, Atlanta, GA 30332-0205, Oct 2006
- Wladawsky-Berger, Irving. “The Future of IT in an On-Demand World.” IBM Server Group, Keynote address at OSBC 2005. Archived at <http://www.itconversations.com/shows/detail495.html>

0008 GOES-7 IR 08 30 OCT 91303 120100 01297 09305 04.00

