New Concepts and Trends

- How Future Trends in Systems and Software Technology Bode Well for Enabling Improved Acquisition and Performance in Defense Systems

11th Annual Systems Engineering Conference
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San Diego, CA
Theme: Technology – Tipping the Balance

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Software Engineering Institute | Carnegie Mellon

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

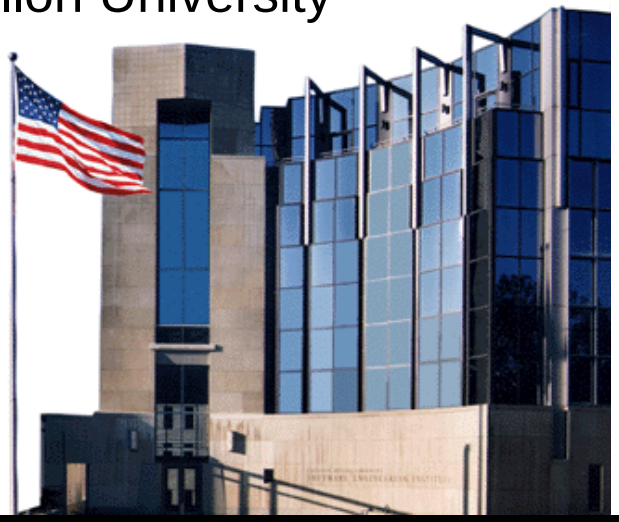
Federally Funded Research and Development Center

Created in 1984

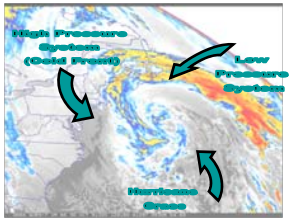
Sponsored by the U.S. Department of Defense

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

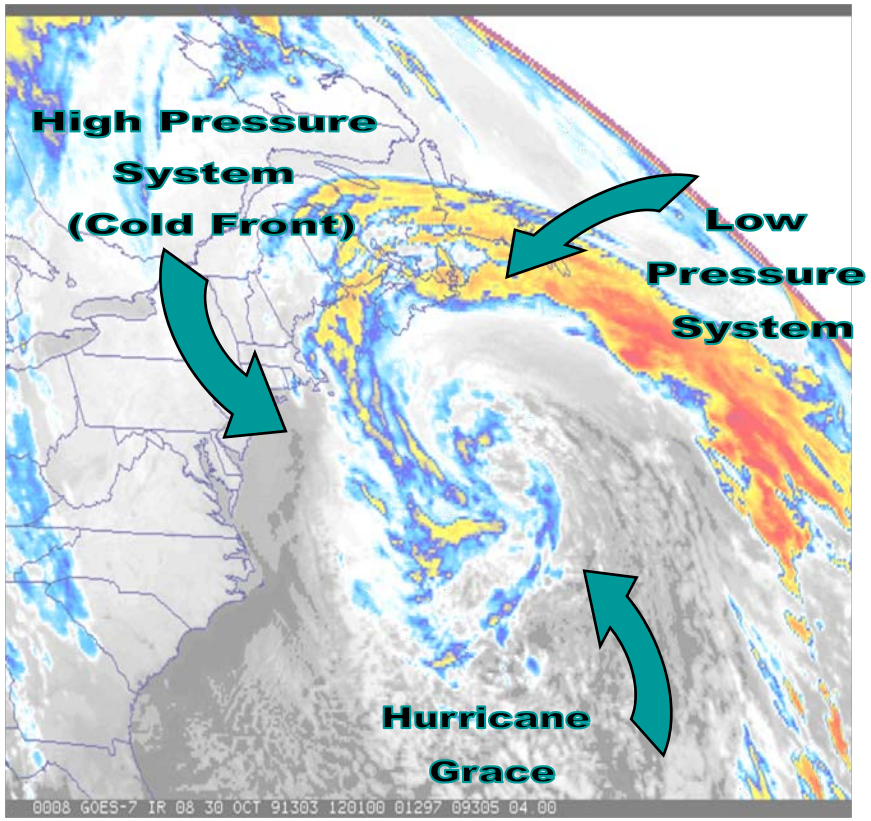
Operated by Carnegie Mellon University



Overview

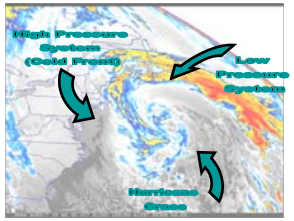


- **Transformational Trends**
  - Development
  - Acquisition
  - Human Element
  - Risk Management
  - Communications
- **Ten Future Trends**
- **Wrap-up**



"Perfect Storm" Event, October 1991
National Oceanic & Atmospheric Administration

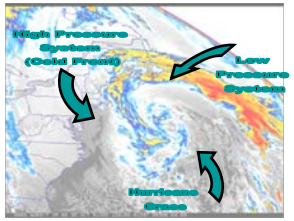
Development: Need for Space, Air, Ground, Water, Underwater Software-Intensive Systems that are Interconnected



- 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

Development Complexity of Software-Intensive Systems is Increasing

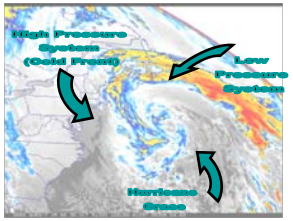
Software Engineering Trends That Impact Systems Engineering



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

Emerging Dynamics of Bringing Systems and Software Engineering in Continued Partnership

The Acceleration of Innovation in the 21st Century: - Impacting Both Defense and Society



Linear vs. Exponential Growth:

Linear Plot

Exponential trend

Linear trend

Technology Capability

160
140
120
100
80
60
40
20
0

0 1 2 3 4 5 6 7 8 9 10

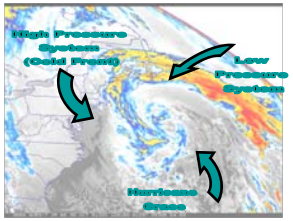
Time

Knee of Curve

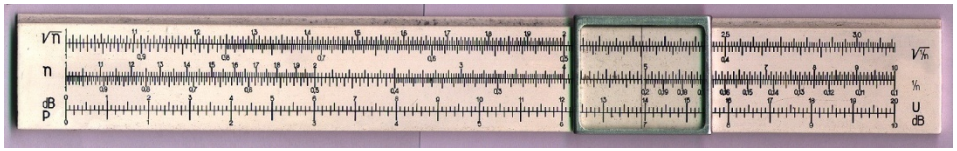
The Amount of New Technological Innovation is Doubling Every Two Years

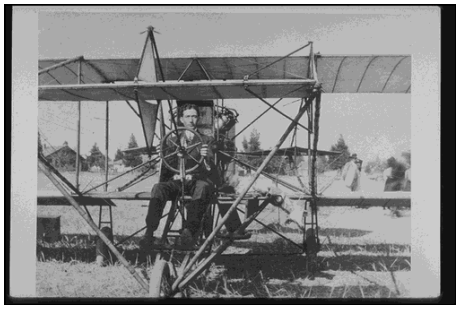
- Requires More Upfront SE/SW Engineering to Leverage Trends

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

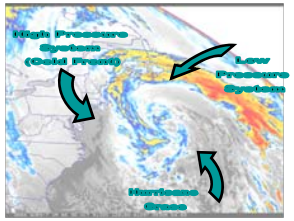
1990's

F-22
1.7M
LOC

2000+

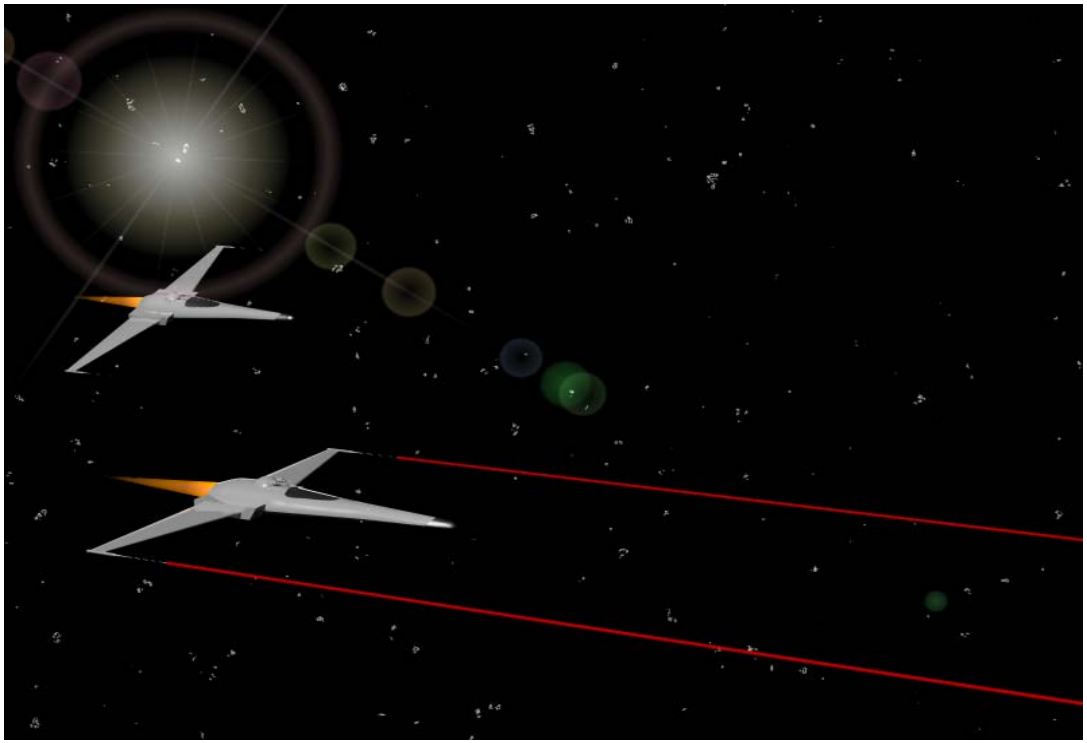
F-35
>6M
LOC

Trend & Implications: Augustine's Law Will Hold



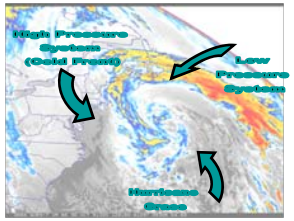
2080?

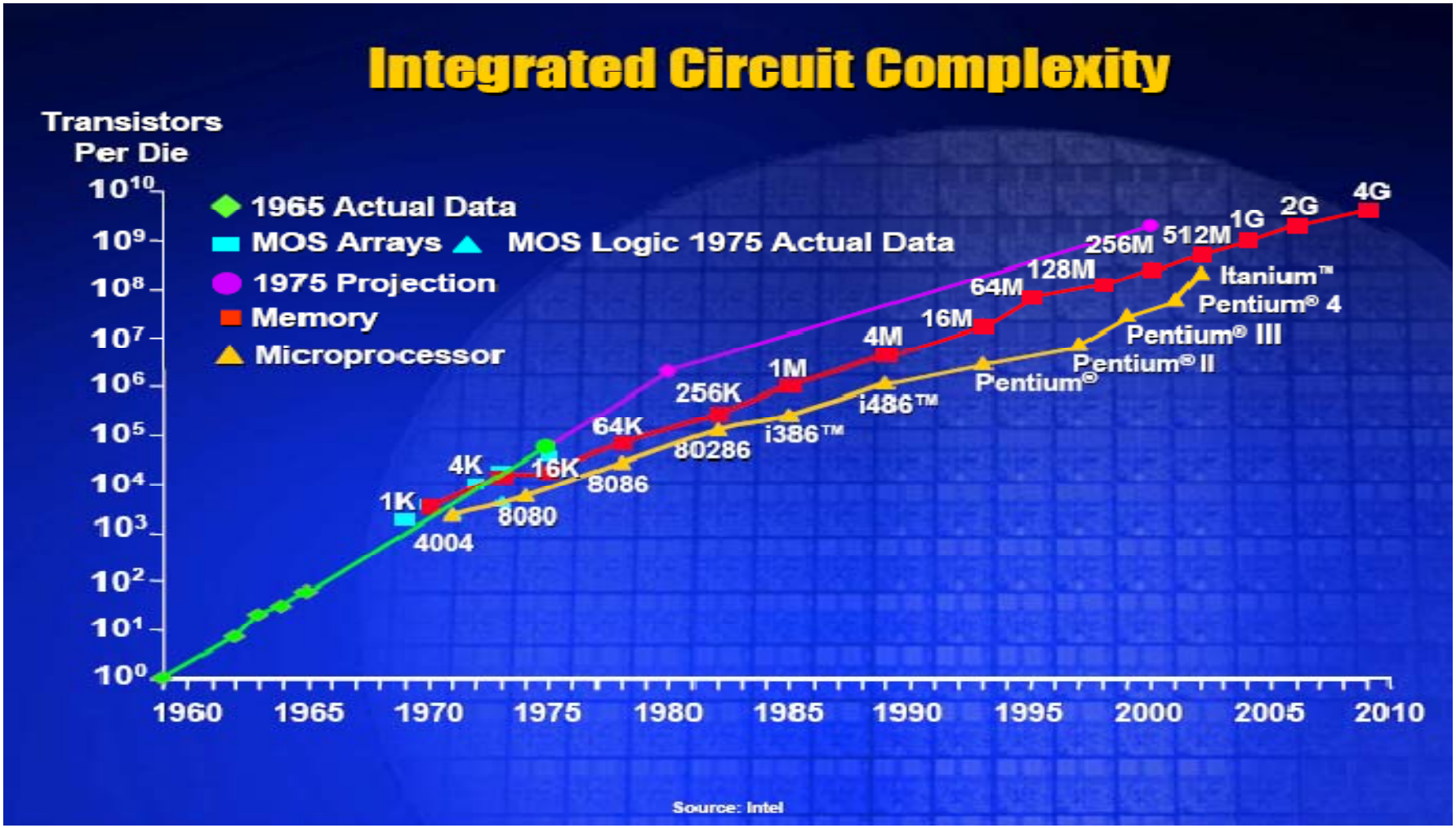
F-50 - 4.7B Lines of Code



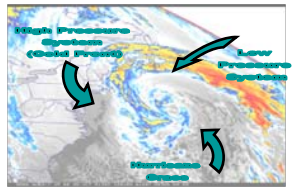
Need for increased functionality will be a forcing function to bring the fields of software and systems engineering closer together

Moore's Law: The Number of Transistors That Can be Placed on an Integrated Circuit is Doubling Approximately Every Two Years





Increased Technological Rate of Adoption



Automobile = 56 years

Telephone = 36 years

Television = 26 years

Cell phone = 14 years

Television (1926)

Electricity (1873)

Telephone (1876)

Radio (1905)

Automobile (1886)

VCR (1952)

Microwave (1953)

PC (1975)

Cell Phone (1983)

Internet (1975)

Source: Rich Kaplan, Microsoft

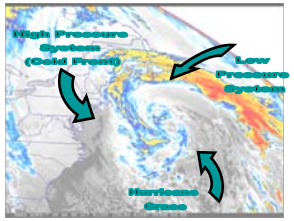
Percentage of Ownership

0 10 20 30 40 50 60 70 80 90 100

1 10 20 30 40 50 60 70 80 90 100 110

No. of Years Since Invention

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

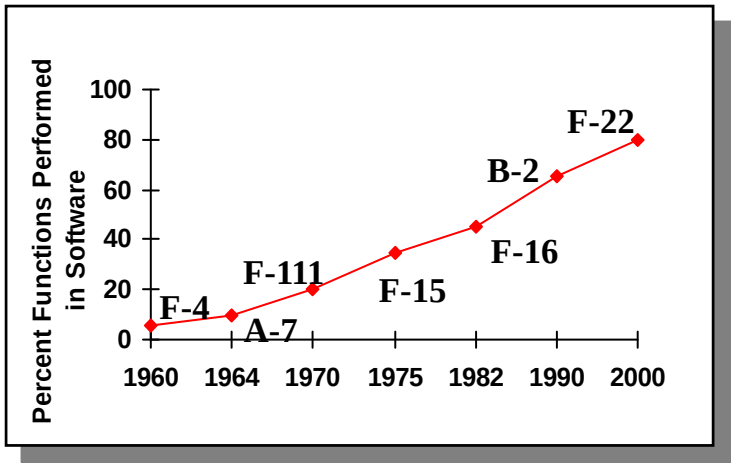
Software Acquisition is Difficult

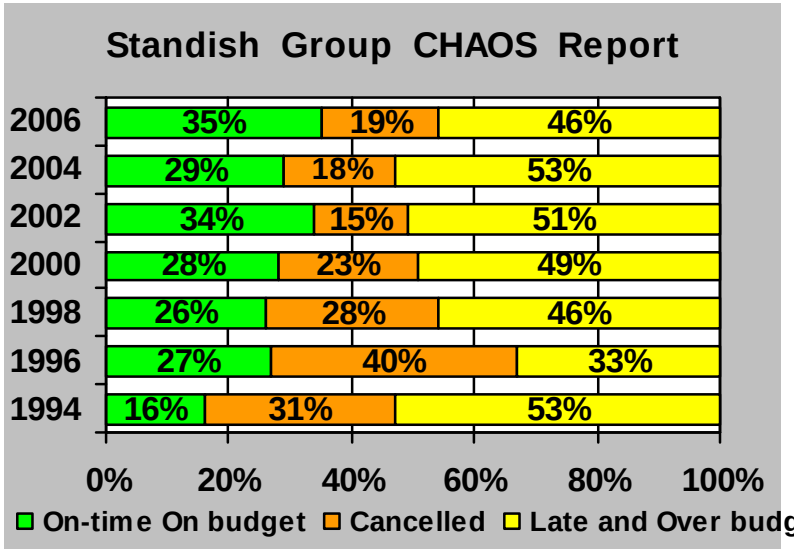
- 46% are over-budget (by an average of 47%) or late (by an average of 72%)
- "Successful projects" have 68% of specified features

Software is Pervasive

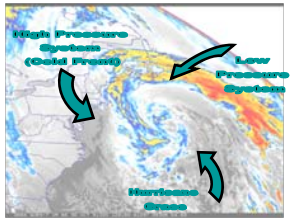
- IT Systems, C4ISR, Weapons, etc

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

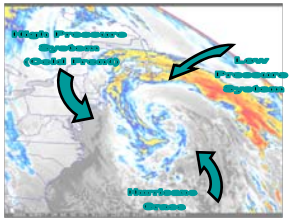


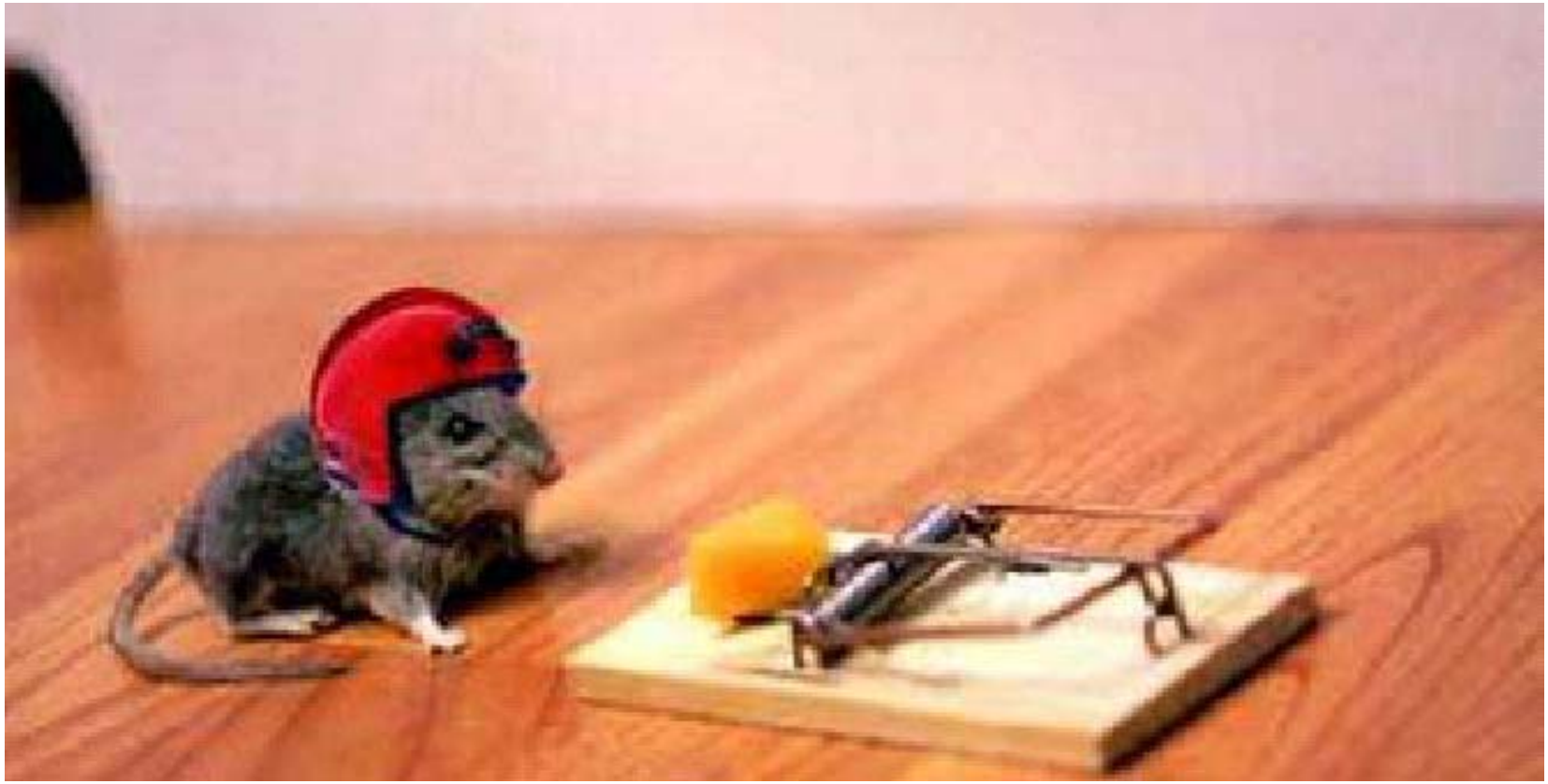


Acquisition: Life of a Program Manager in a System of Systems and/or Net-Centric Operation…



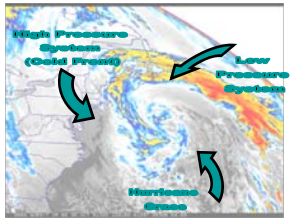
Acquisition: Effectively Managing Risk





A Key Challenge is How to Obtain a Better Alignment of Risk Among the Relevant Stakeholders

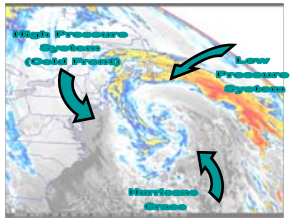
Acquisition Challenges: Some Drivers That Increase the Risk of Acquiring Software-Intensive Systems



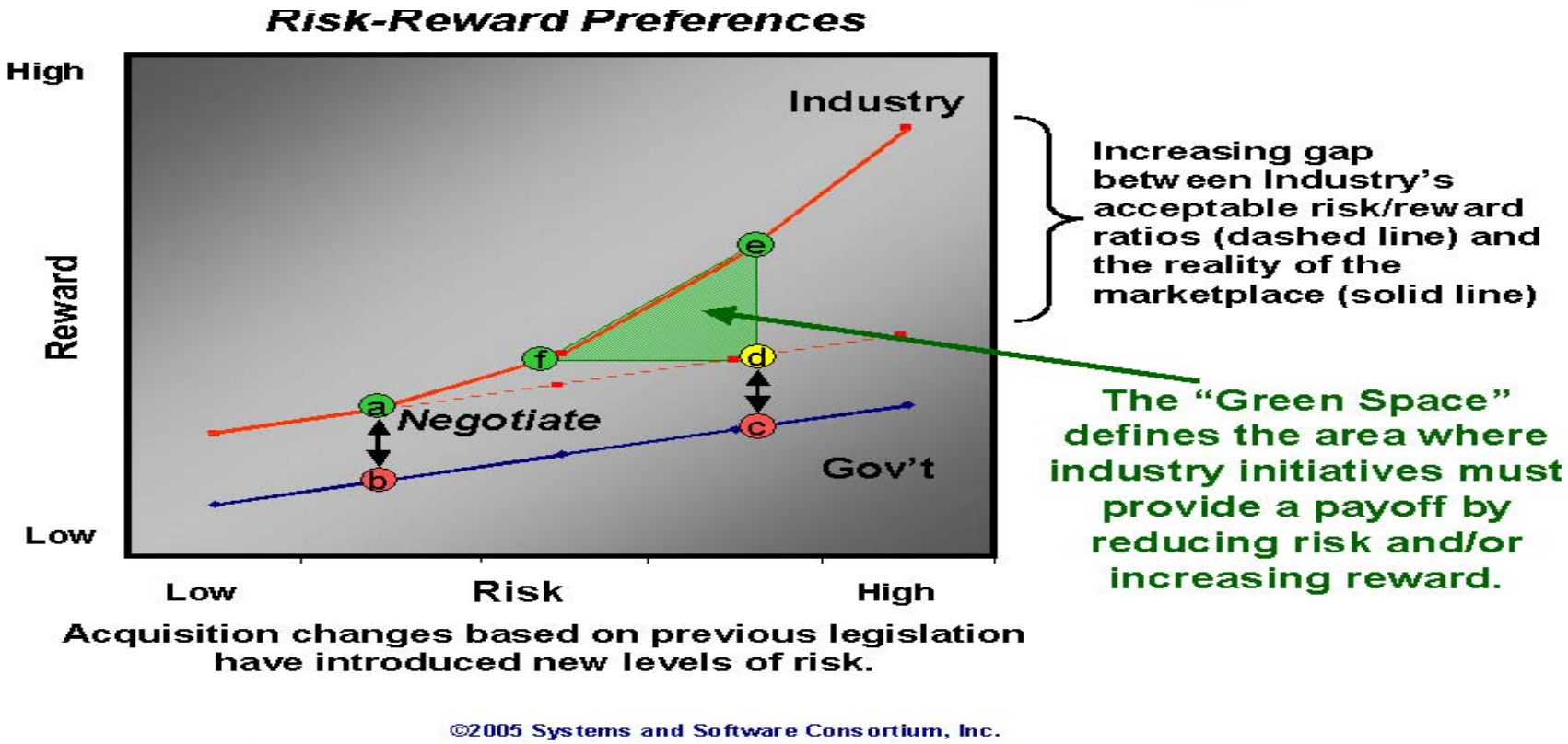
Platform	*Customer Emphasis*	Enterprise
Requirements	*Acquisition Model*	Objectives/ Capabilities
Dominant Prime	*Program Execution*	Strategic Teaming
"Boxes"	*Integration Challenge*	"Layers & Stacks"
Proprietary	*Architectures and Standards*	Plug & Play

Need Exists to Address Both Sides, and Do So with Compressed Delivery Schedules via Improvements in Systems/Software Engineering

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

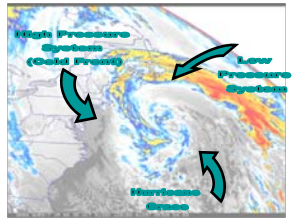


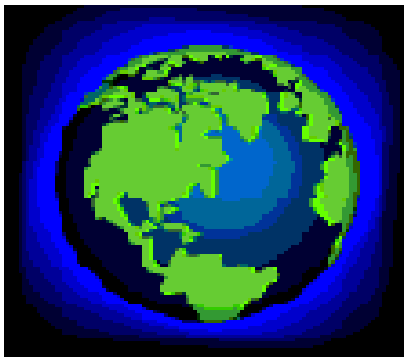
Navigating the "Green Space"



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

Acquisition Performance – Flexible Boundary-Crossing Acquisition Structure

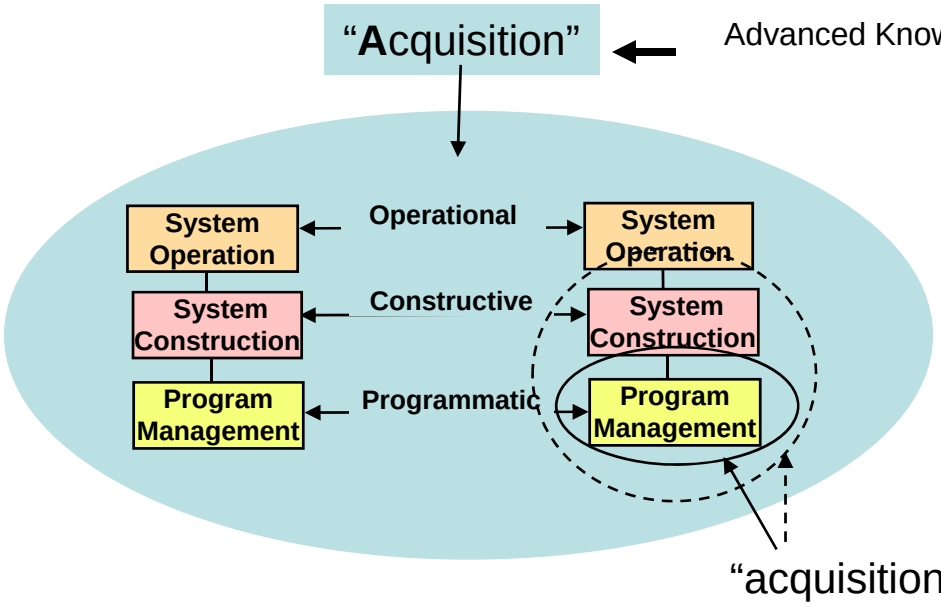


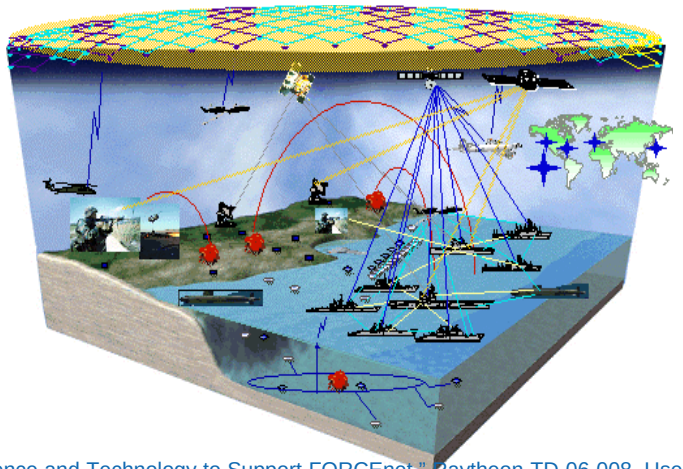


2005 study confirmed*:

- 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

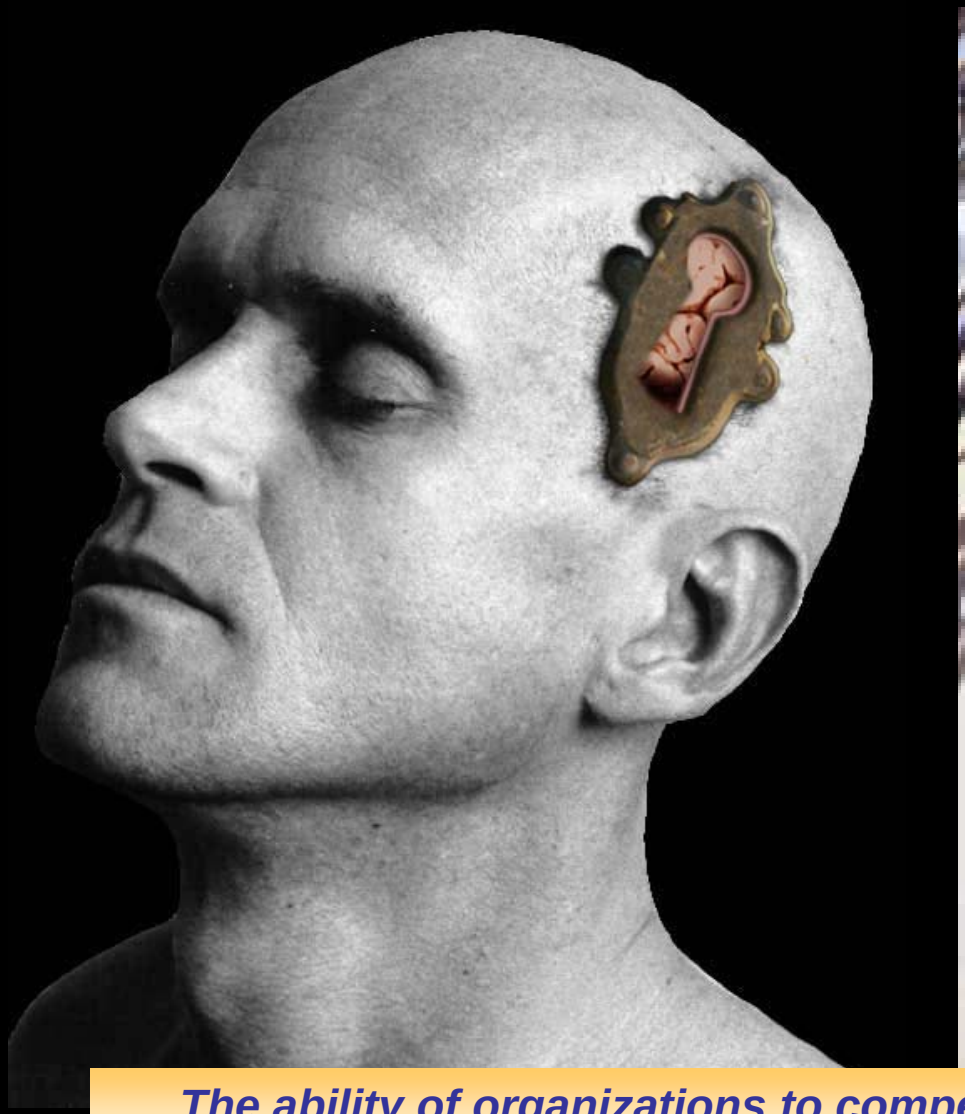




From "Science and Technology to Support FORCEnet," Raytheon TD-06-008. Used by permission.

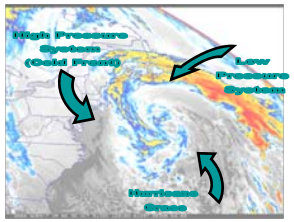
Ref: Jim Smith, (703) 908-8221,jds@sei.cmu.edu

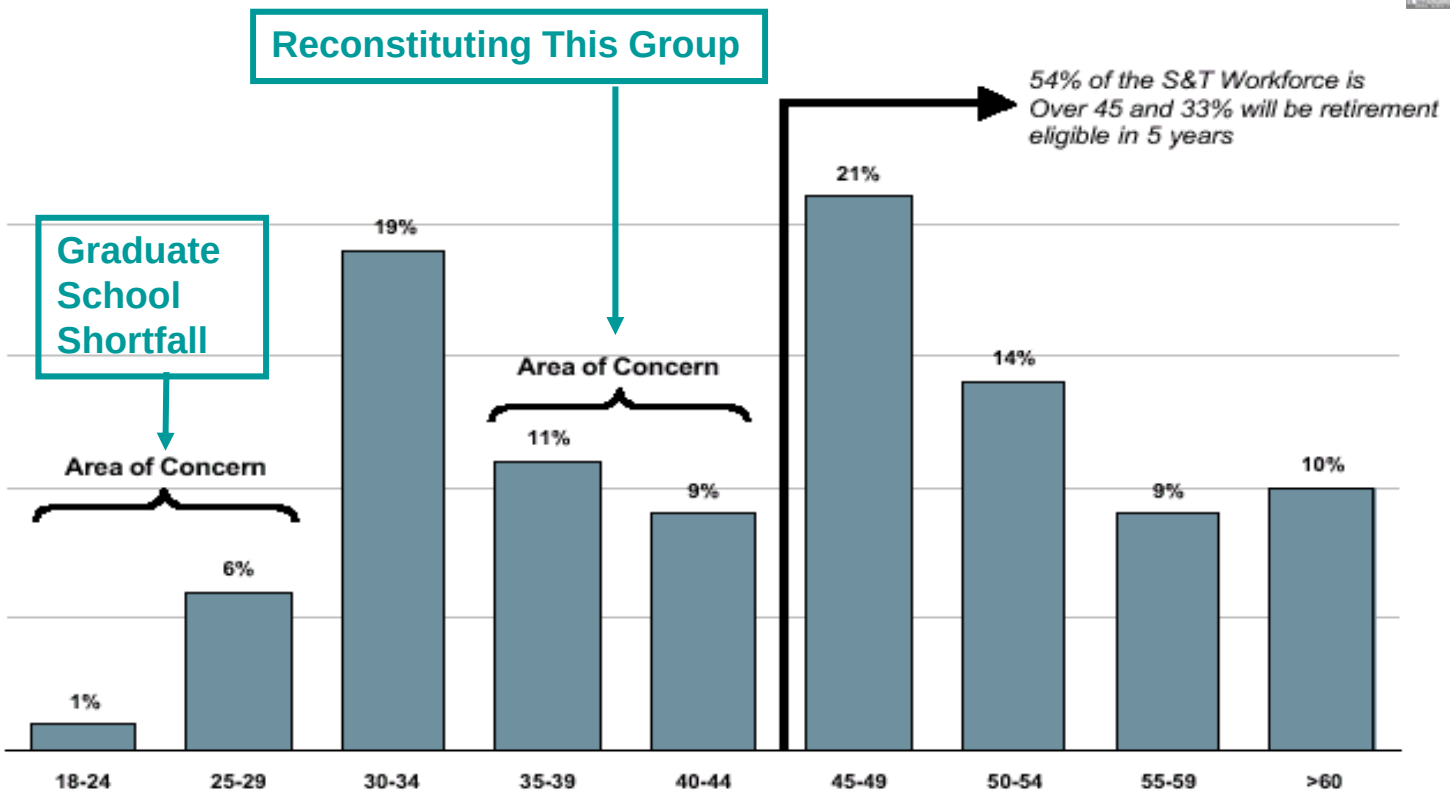
Human Element



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

Society Drivers: Bimodal Demographics (Space Industry)



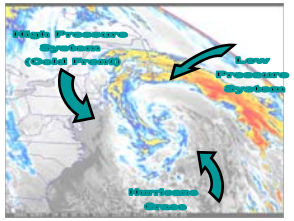


Average Space Industry S&E Workforce Age Distribution

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)

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



Whole System → **Parts of System**

Contradiction in Focus/Optimizing

Long Time → **Rapid**

Contradiction in Cycle Time

Circular Causality → **Linear Causality**

Contradiction in Design Dependency

Systematic → **Art**

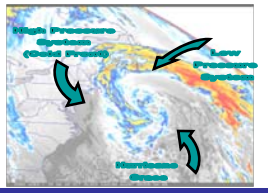
Contradiction in Spirit

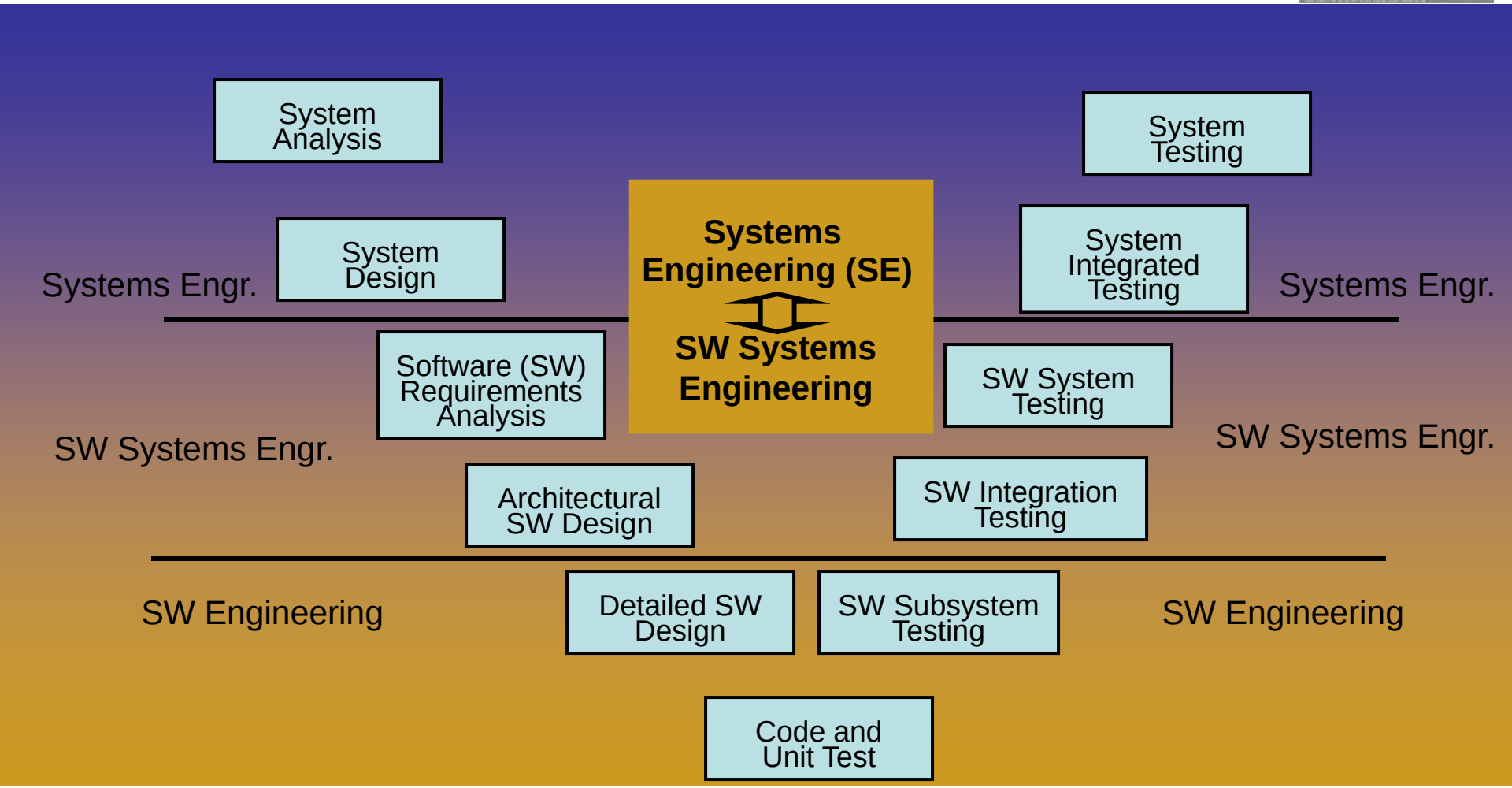
Generalist → **Wants Detail**

Contradiction in Detail

Source: Kurstedt, Harold, Newport Group - 2008

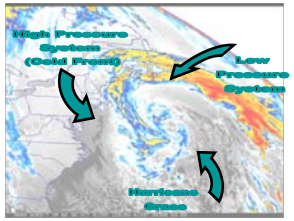
Objective is for Software and Systems Engineering to Become More Integrated Versus Separated

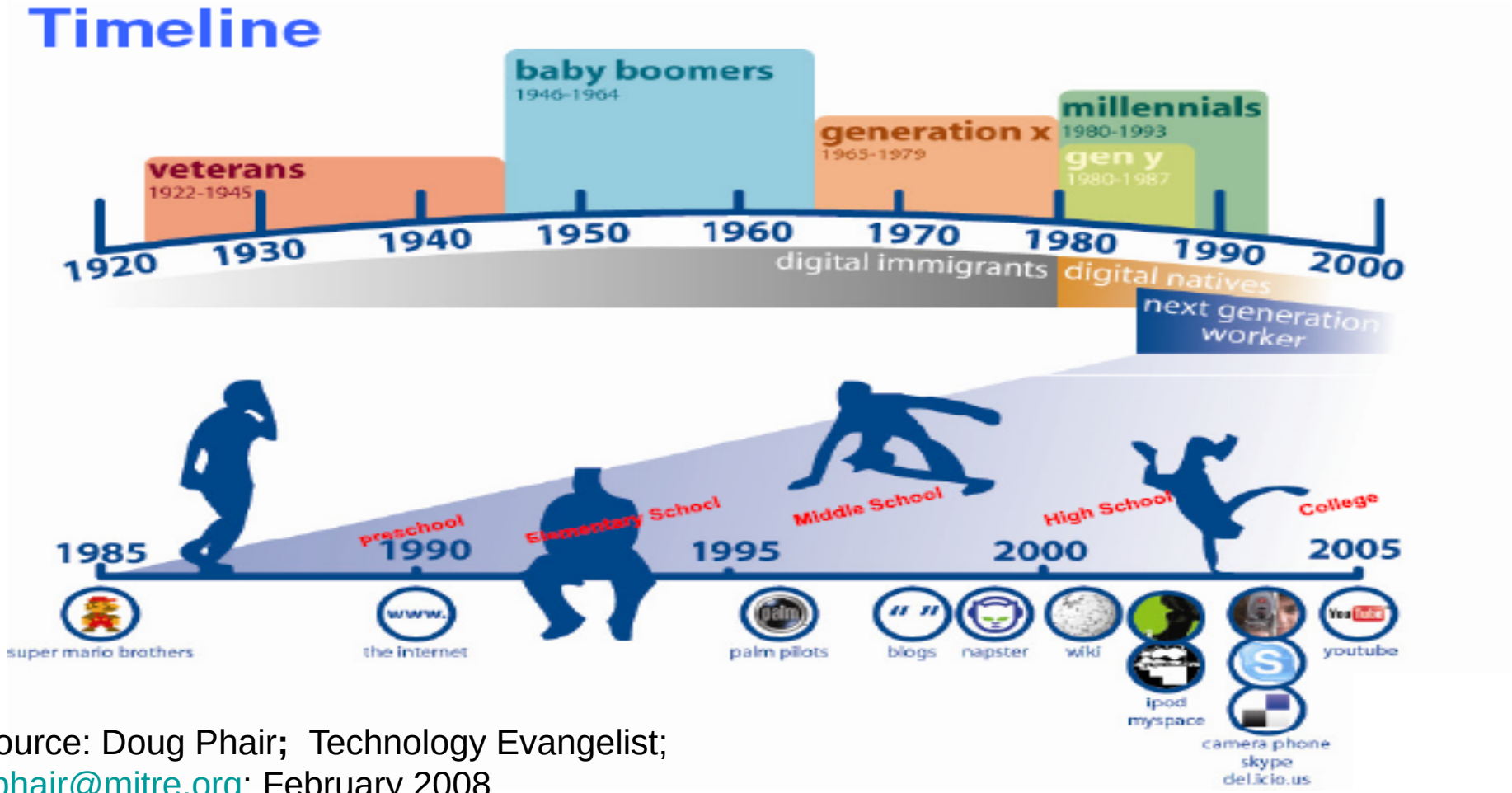




OSD Initiative: Integrated Software and Systems Engineering Curriculum

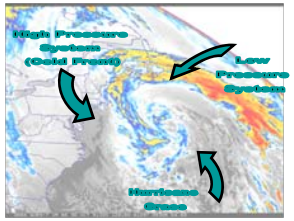
Human Element in the Work-Space Environment

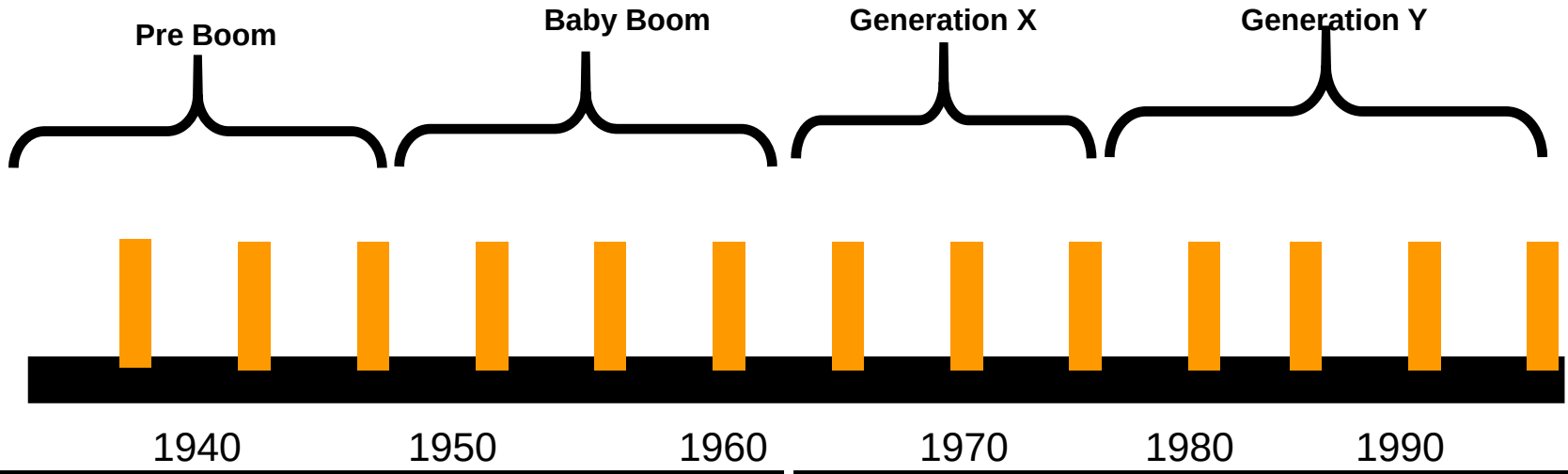




Source: Doug Phair; Technology Evangelist; dphair@mitre.org; February 2008

Human Element: More Generation Y Workers Will Enter the Workplace





Generation Y Characteristics

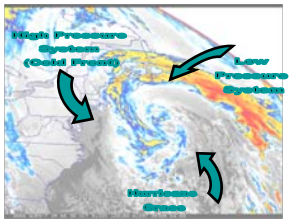
- Born late 1970s to mid-1990s
- Larger than Generation X
- More ethnically diverse
- Technologically savvy

What Makes Generation Y Tick

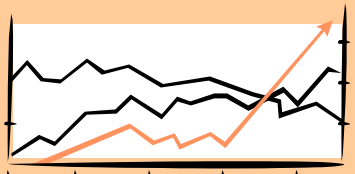
- High Expectation of Employers
- Goals, Goals, Goals
- Desire for Immediate Responsibility
- Balance and Flexibility

Source: Cara Spiro, DAU, 2006

Higher-Maturity Approaches to Process Improvement Are Important and Synergistic Trends



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



Optimizing

Quantitatively Managed

Determine what your processes can do (Voice of Process)

- Statistical Process Control

Clarify what your customer wants (Voice of Customer)

- Critical to Quality (CTQs)

Identify and prioritize improvement opportunities

- Causal analysis of data

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

- Design for Six Sigma

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

Determine the industry best practice

- Benchmarking, models

Compare your current practices to the model

- Appraisal, education

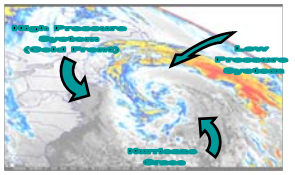
Identify and prioritize improvement opportunities

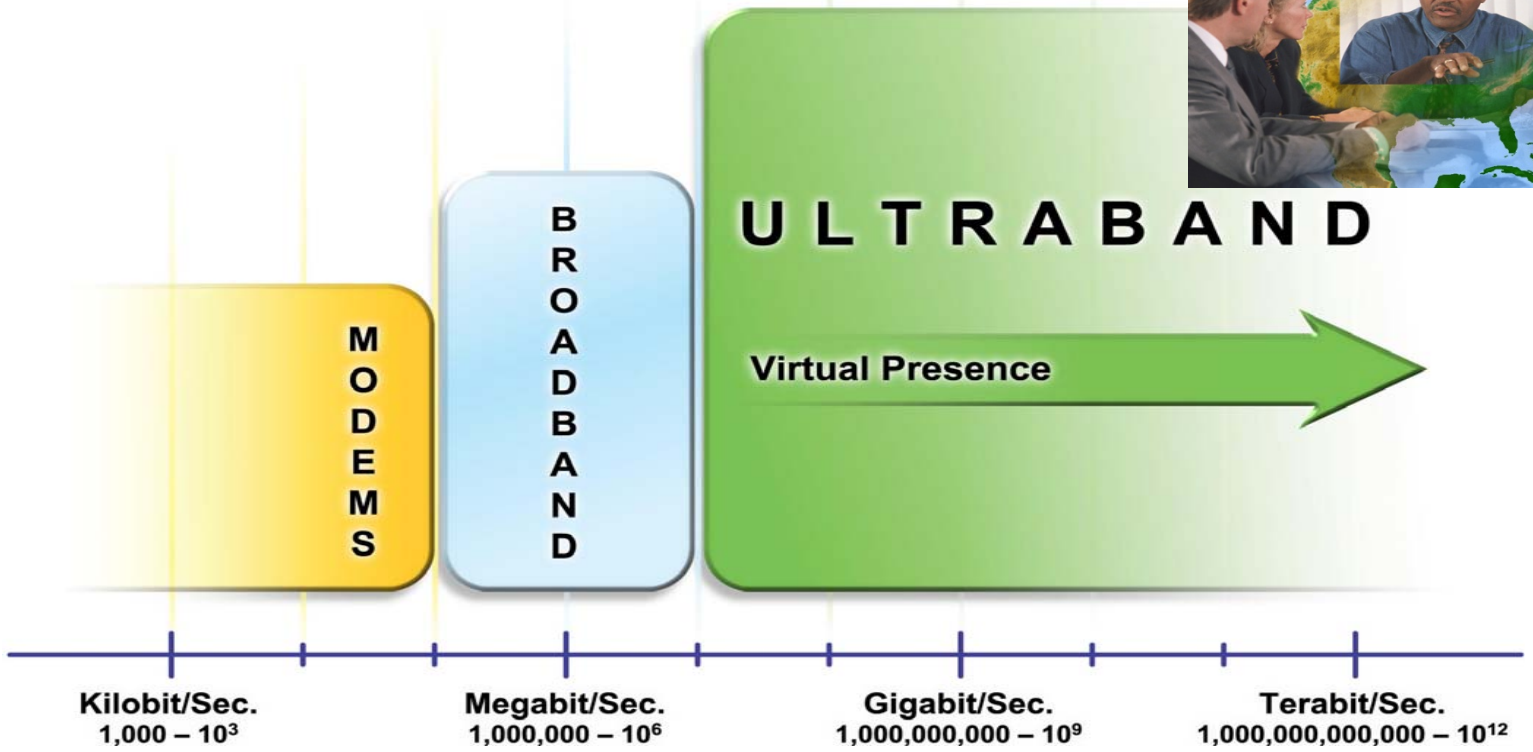
- Implementation
- Institutionalization

Look for ways to optimize the processes

CMMI and Six Sigma,
Siviy, et al, 2007, Addison Wesley

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

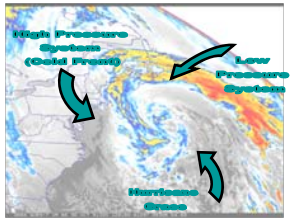




Rule #4: The best companies are the best collaborators*

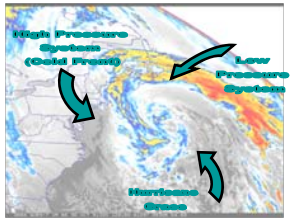
*** Friedman, Thomas L. "*The World Is Flat*", Farrar, Straus and Giroux, 2005**

Systems and Software Engineering: Ten Trends



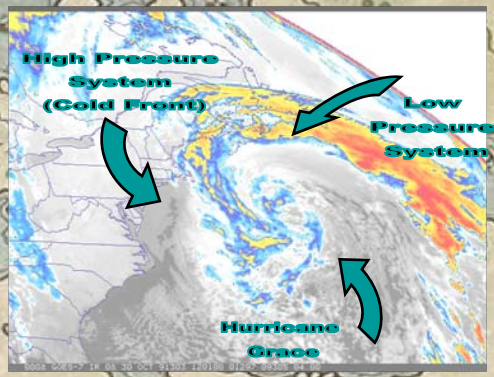
1. *Greater demands on systems and software engineers will stimulate growth in the field – nationally and internationally*
2. *Industry/Gov't will increasingly focus on attracting, training and retaining systems and software engineering talent – short and long run – with emphasis on providing a Generation Y work environment*
3. *Increased reliance on systems and software engineering processes and technologies to effectively manage the acquisition/"green" space*
4. *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*
5. *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



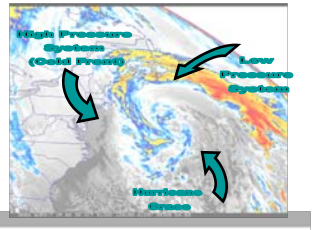
6. *Systems and software engineers will continually find way to innovative to reduce complexity*
7. *Increased importance of modeling and simulation*
8. *Increased customer requests for system and software engineering support will occur earlier in life cycle*
9. *Shift of systems and software engineering focus from the platform to the networks and ground systems*
10. *Process improvement will continue to be important!*

Questions?



THE KNOWN WORLD
Beyond here there be Dragons

Recommended Readings



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