

New Concepts and Trends

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

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San Diego, CA
Theme: Technology – Tipping the Balance

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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

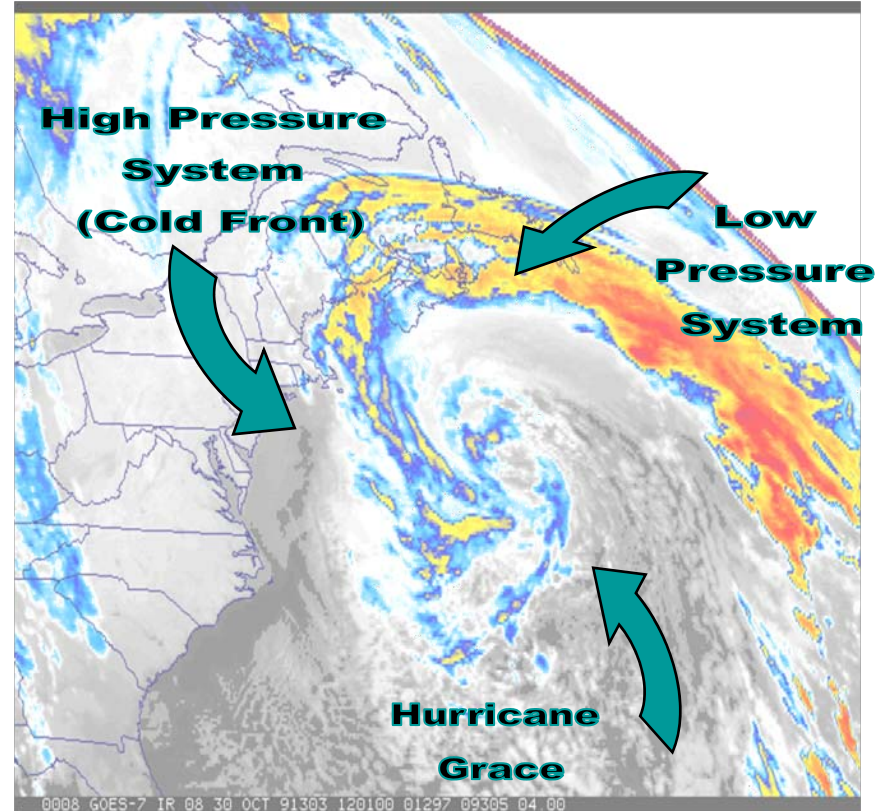
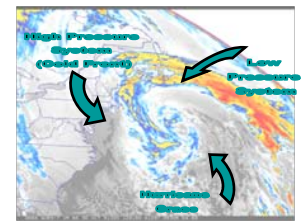
Locations in Pittsburgh, PA; Washington, DC;
Frankfurt, Germany

Operated by Carnegie Mellon University



Overview

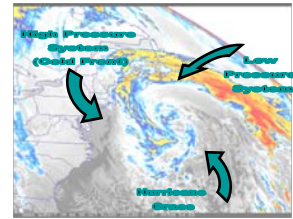
- Transformational Trends
 - Development
 - Acquisition
 - Human Element
 - Risk Management
 - Communications
- Ten Future Trends
- Wrap-up



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



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



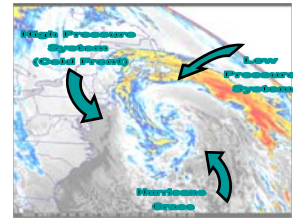
- Several million SLOC programs; “Hybrid” systems combining legacy re-use, COTS, new development
- Multi-contractor teams using different processes; dispersed engineering, development & operational locations
- New technologies create opportunities/challenges; products change/evolve, corporations mutate
- 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

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

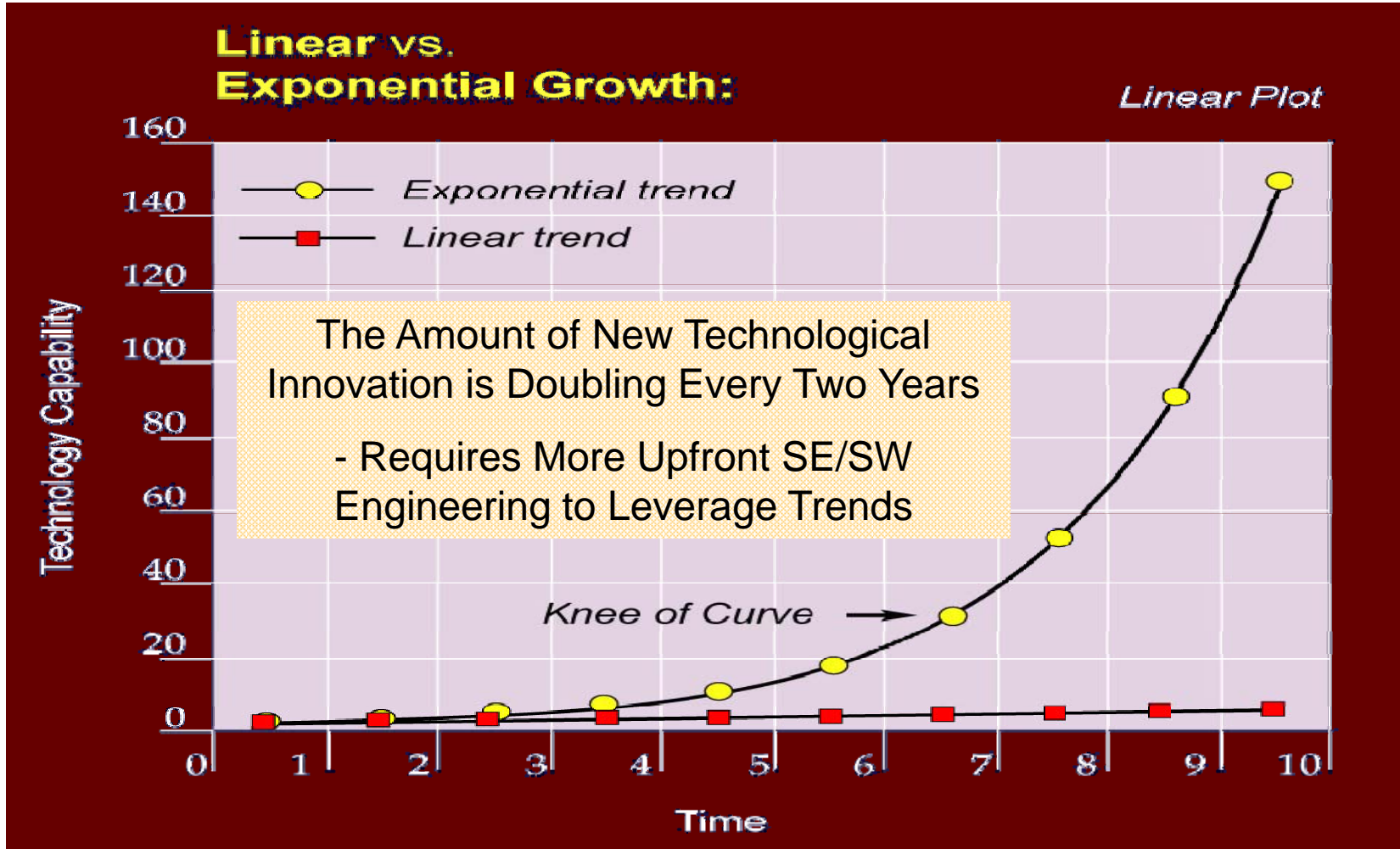
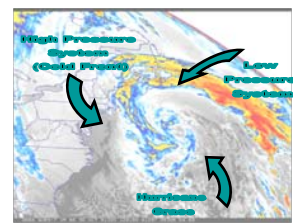
Future

- Everything connected-maybe
- Mostly COTS components
- Requirements are emergent
- No control over COTS evolution
- Focus on systems and software
- Rapid change
- Premium on value, speed, quality
- Scarcity of critical talent

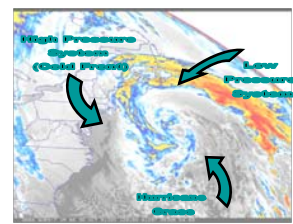
Emerging Dynamics of Bringing Systems and Software Engineering in Continued Partnership



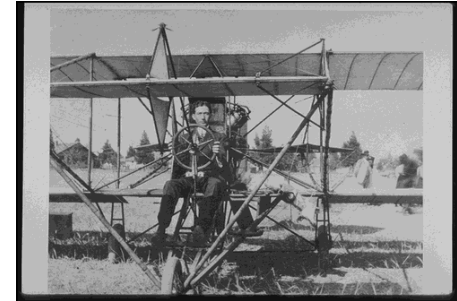
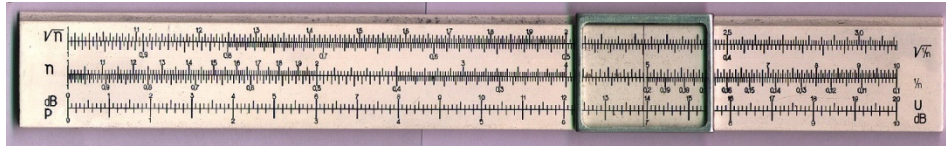
The Acceleration of Innovation in the 21st Century: - Impacting Both Defense and Society



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



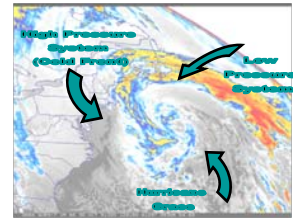
2000+



F-35
>6M
LOC



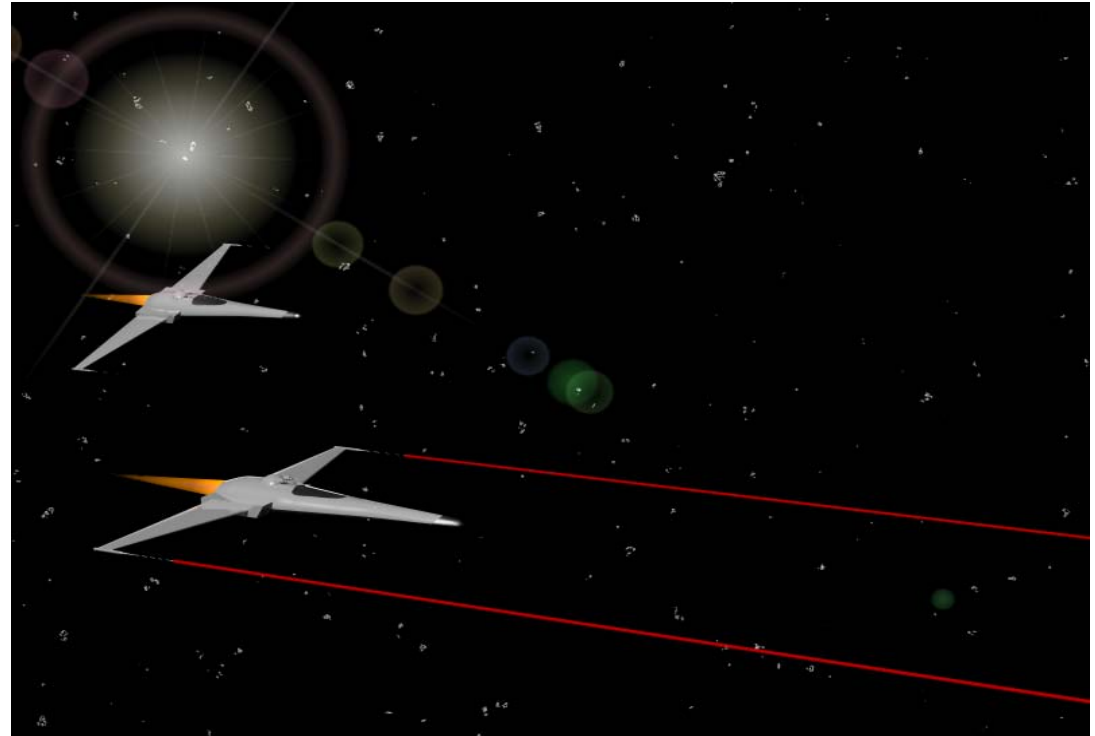
Trend & Implications: Augustine's Law Will Hold



2080?



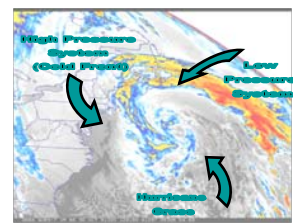
F-50 - 4.7B Lines of Code



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

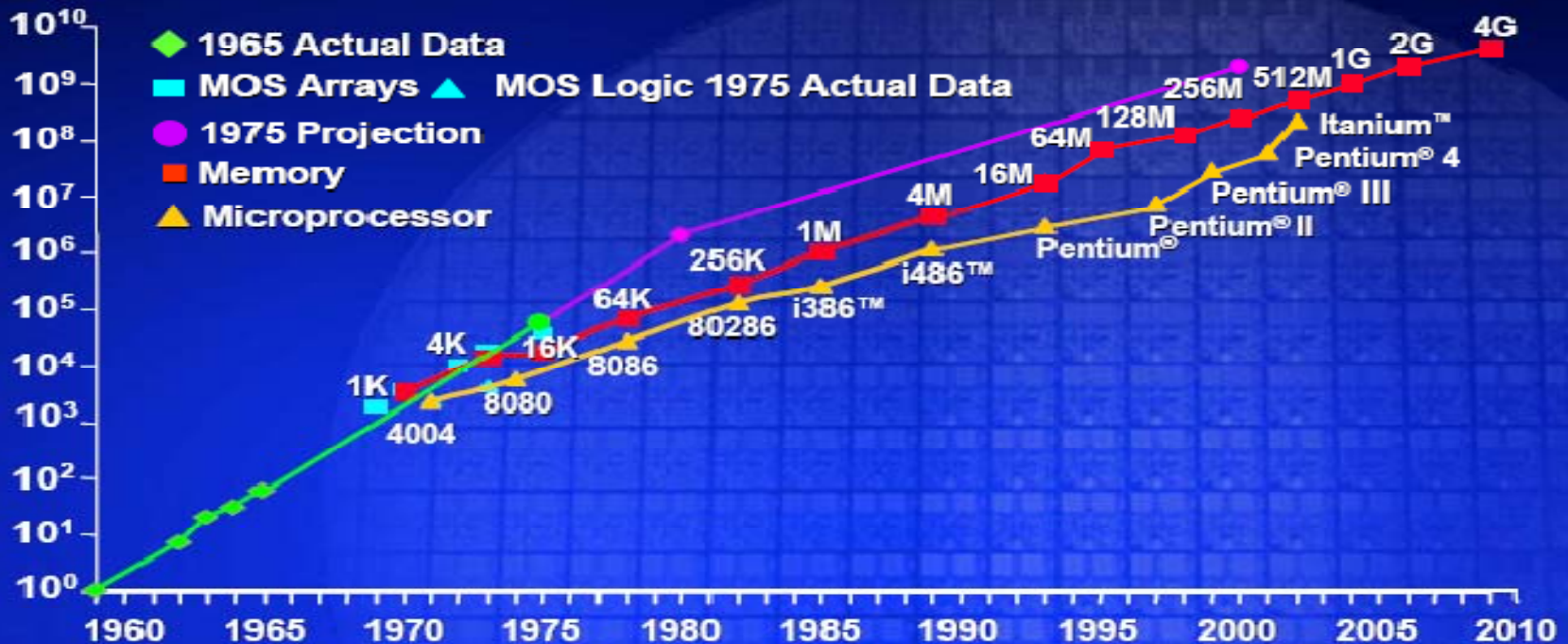


Moore's Law: The Number of Transistors That Can be Placed on an Integrated Circuit is Doubling Approximately Every Two Years



Integrated Circuit Complexity

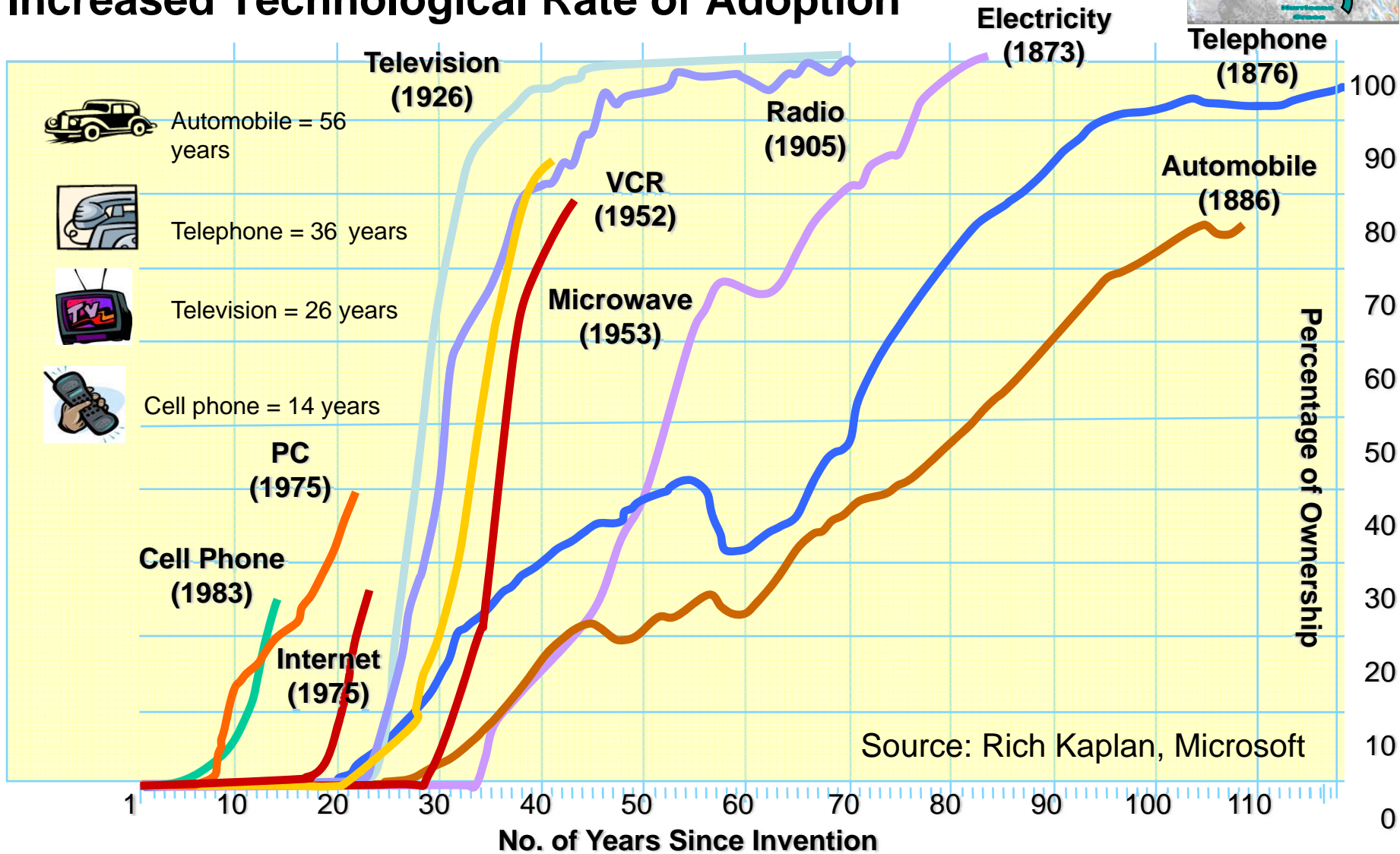
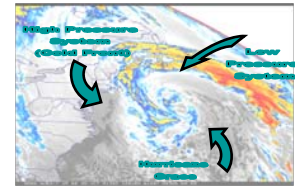
Transistors
Per Die



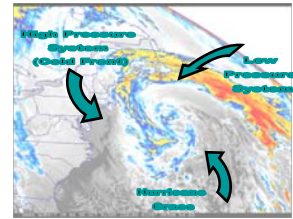
Source: Intel



Increased Technological Rate of Adoption



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



Software is Growing in Complexity

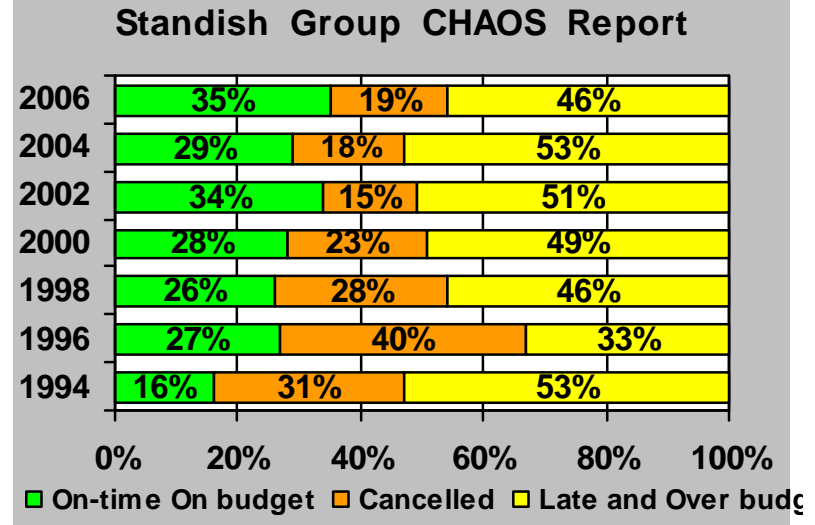
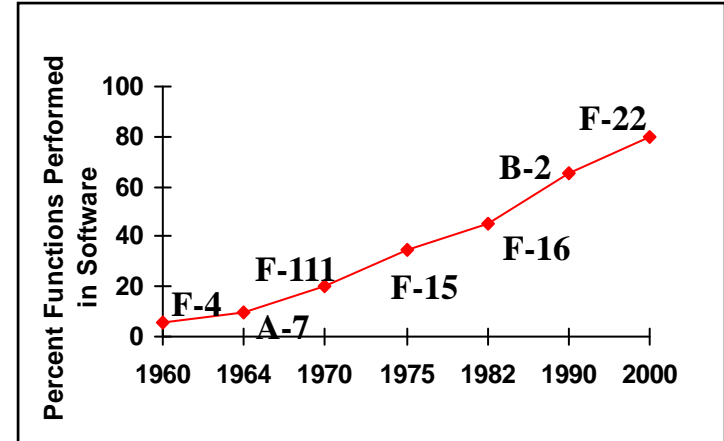
- 80% of some weapon system functionality is dependent upon software
- Consequences of software failure can be catastrophic

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

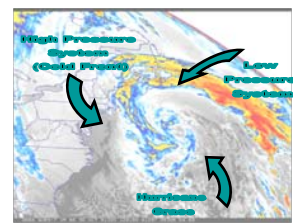
- IT Systems, C4ISR, Weapons, etc



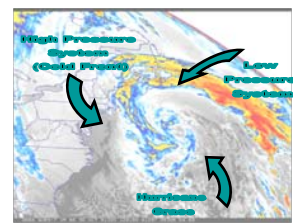
On-going Changes to the Acquisition Process Targeted at Correcting this Issue



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



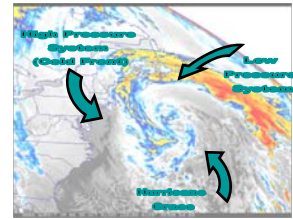
Acquisition: Effectively Managing Risk



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



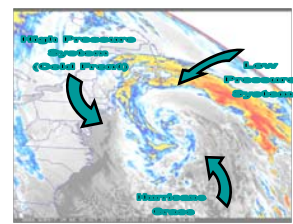
Acquisition Challenges: Some Drivers That Increase the Risk of Acquiring Software-Intensive Systems



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

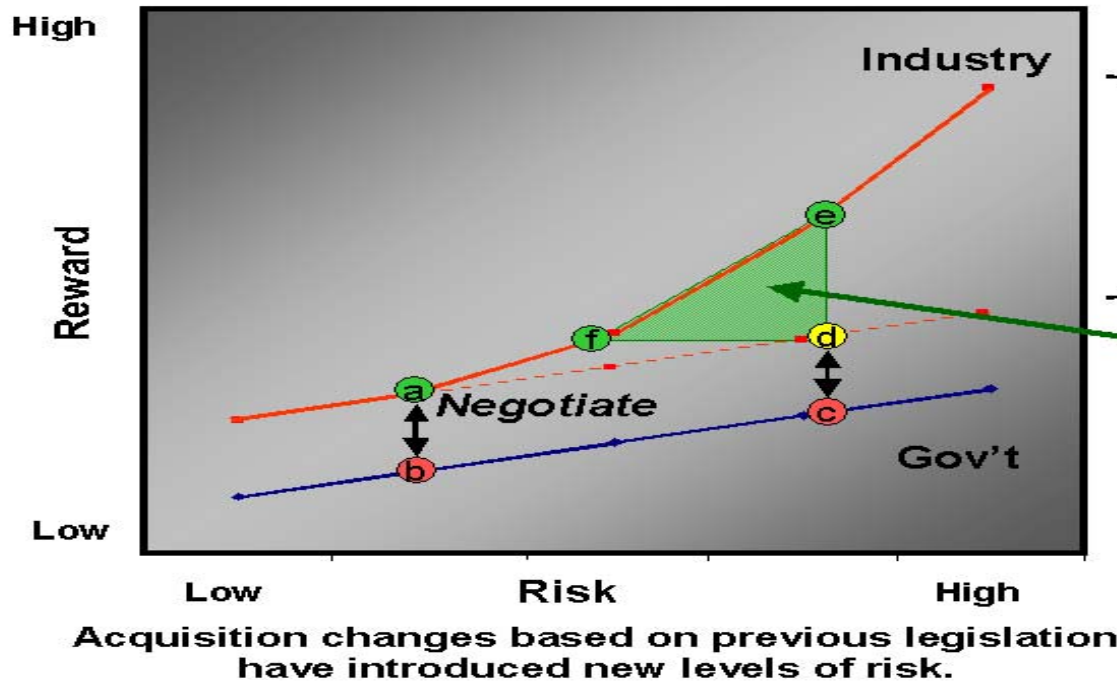


Increased Reliance on Acquirer/Developer to Reduce Risk by Effectively Navigating the Green/Acquisition Space



Navigating the “Green Space”

Risk-Reward Preferences



Increasing gap between Industry's acceptable risk/reward ratios (dashed line) and the reality of the marketplace (solid line)

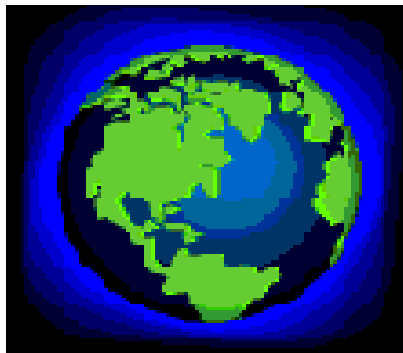
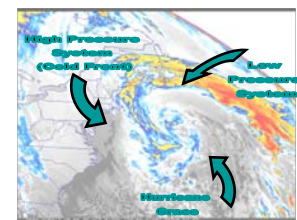
The “Green Space” defines the area where industry initiatives must provide a payoff by reducing risk and/or increasing reward.

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



Acquisition Performance – Flexible Boundary-Crossing Acquisition Structure



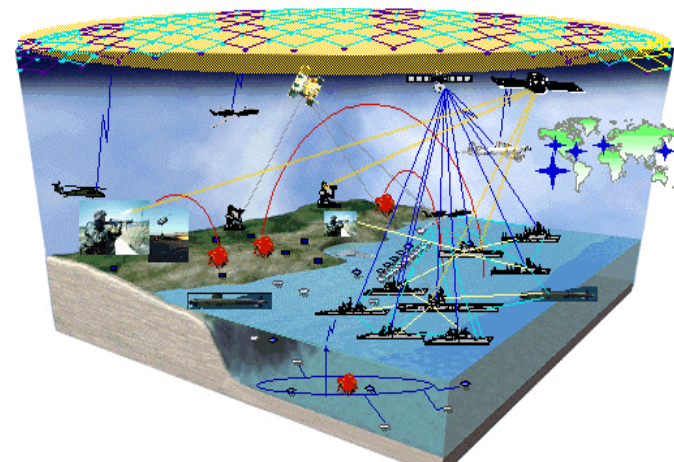
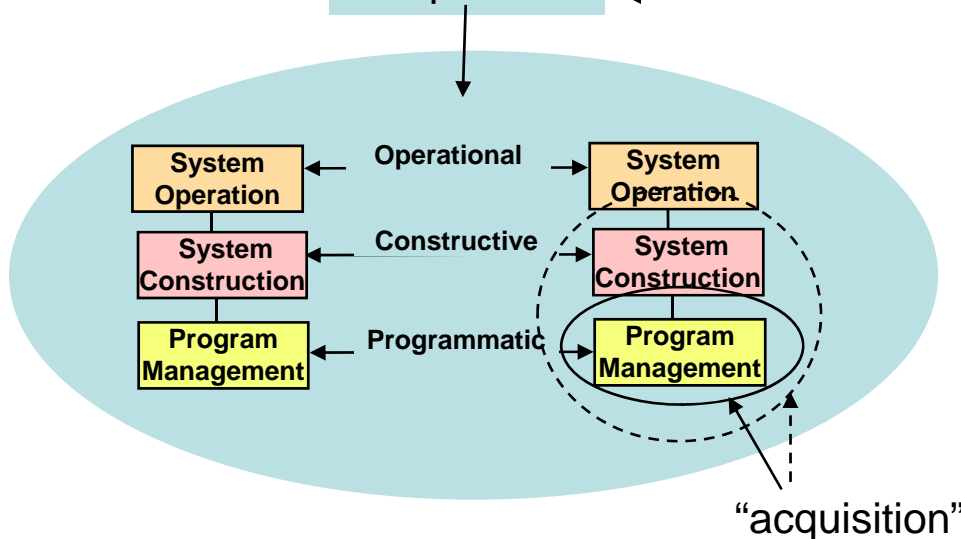
2005 study confirmed*:

- 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

“Acquisition”

Advanced Knowledge-Based Organizations (Big A)

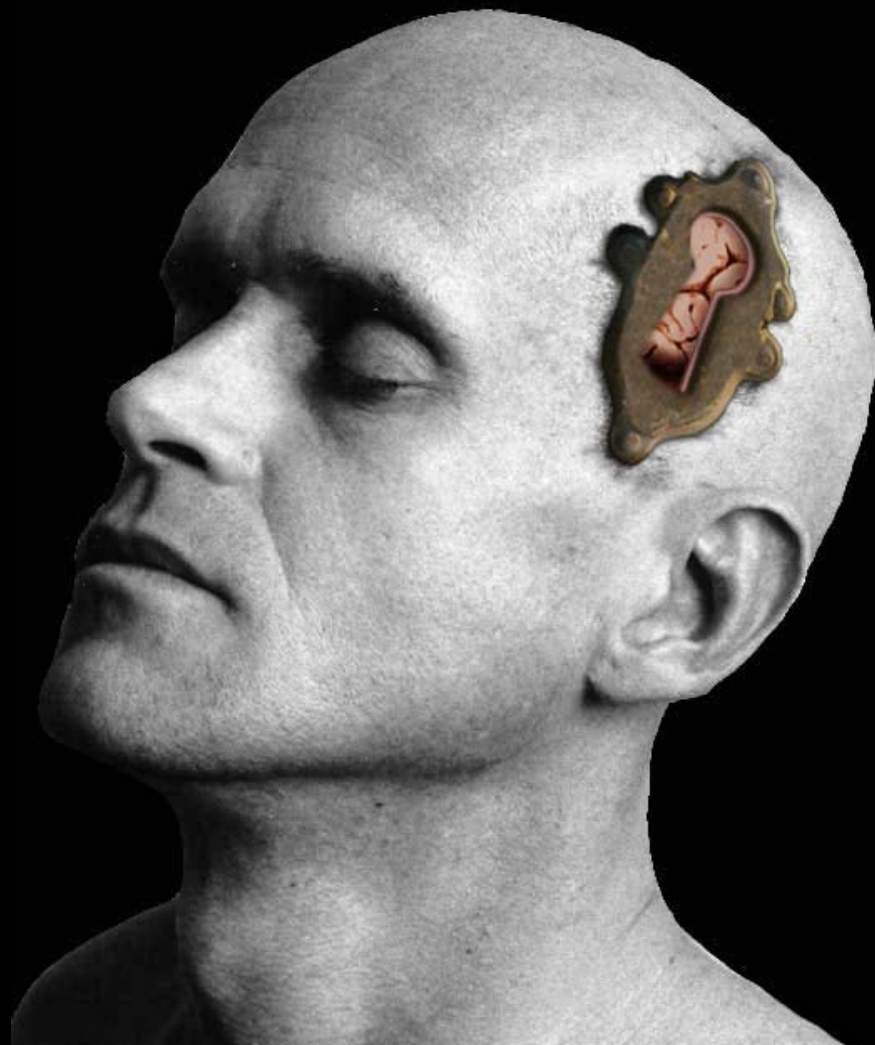


From “Science and Technology to Support FORCEnet,” Raytheon TD-06-008. Used by permission.

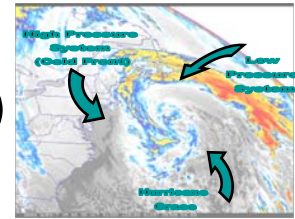
Ref: Jim Smith, (703) 908-8221, jds@sei.cmu.edu



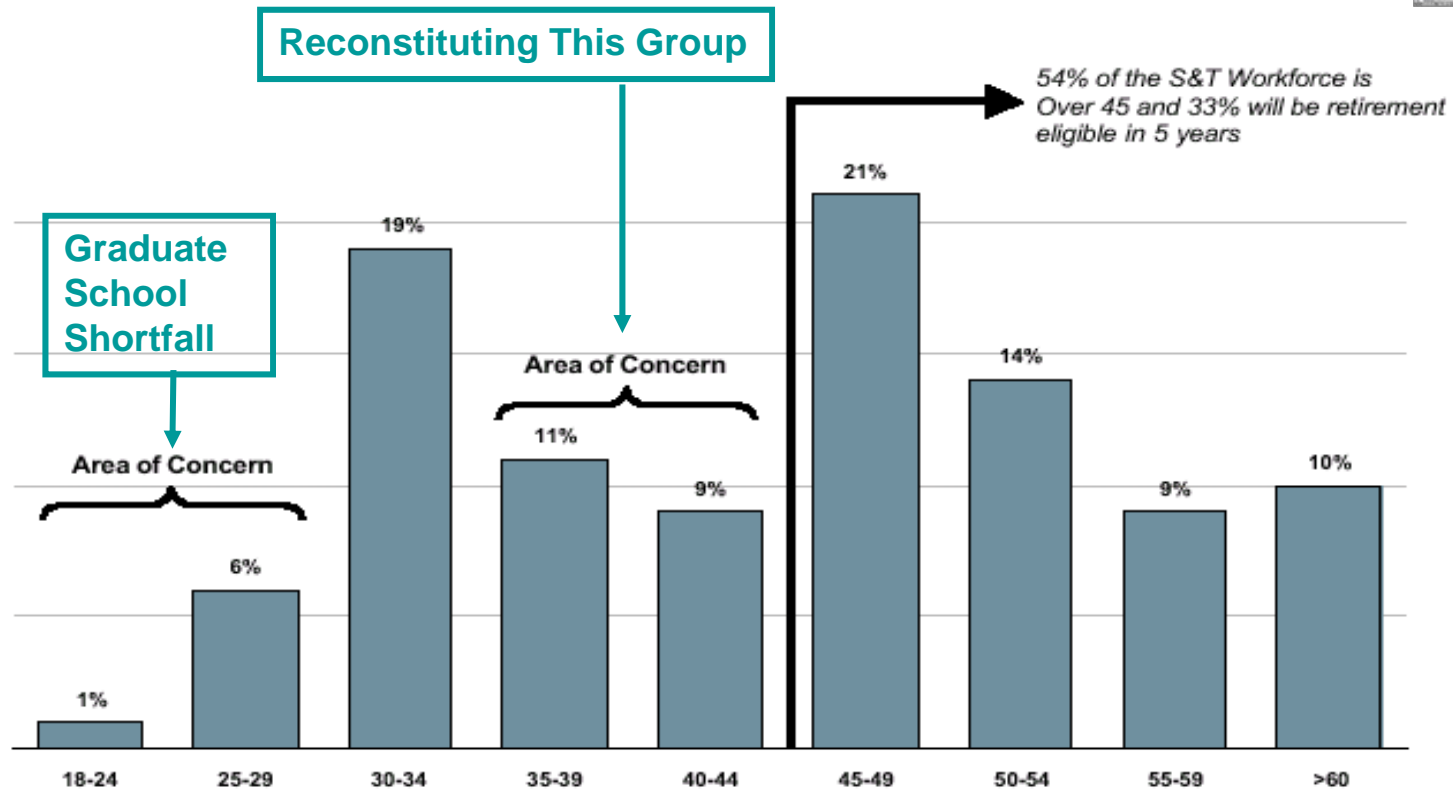
Human Element



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



Society Drivers: Bimodal Demographics (Space Industry)

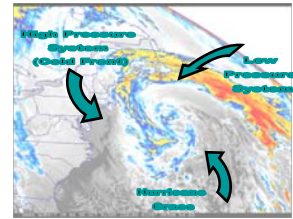


Average Space Industry S&E Workforce Age Distribution

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



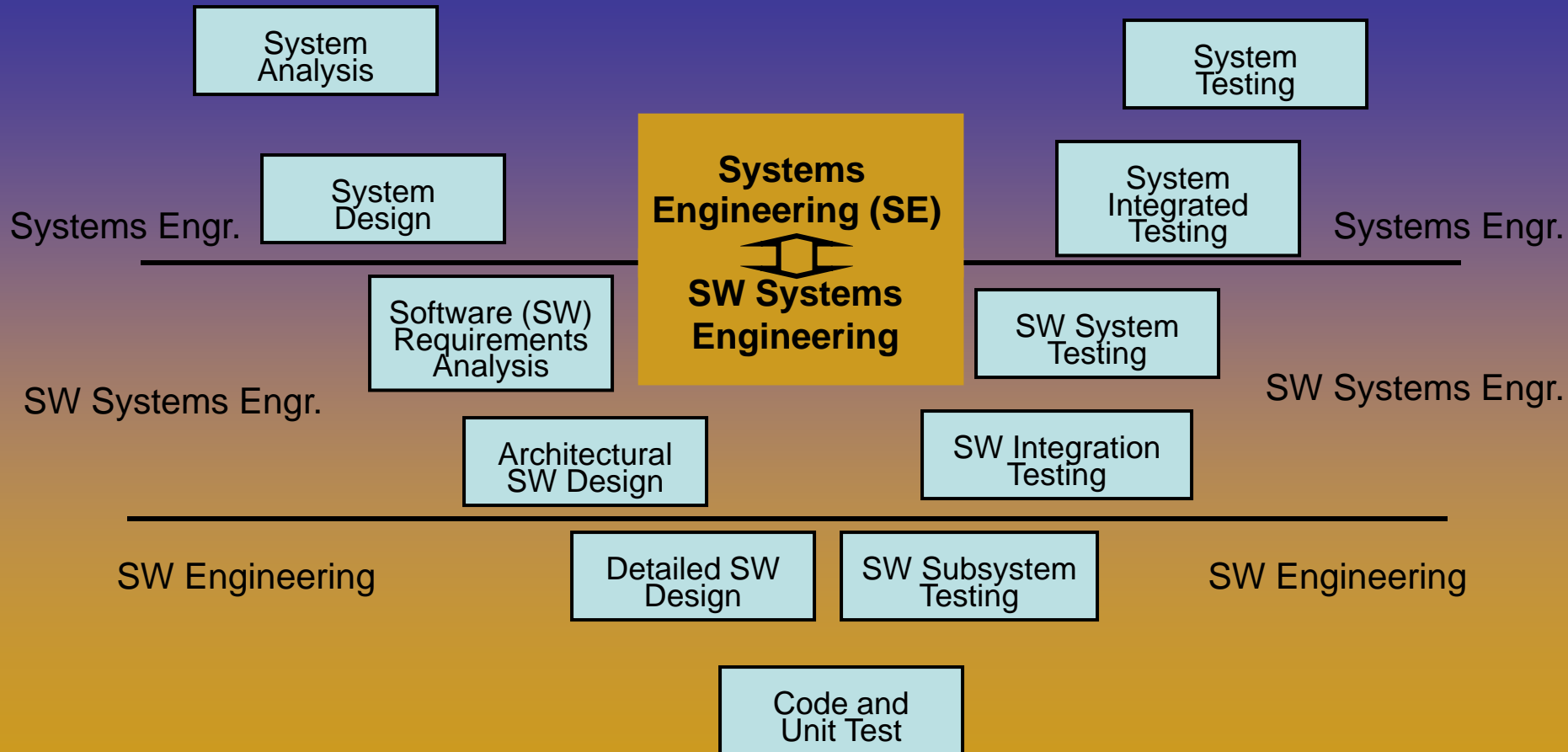
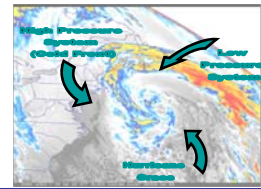
Human Element Challenge: Bumpy Road at the Systems Engineering/Software Engineering Intersection



Source: Kurstedt, Harold, Newport Group - 2008



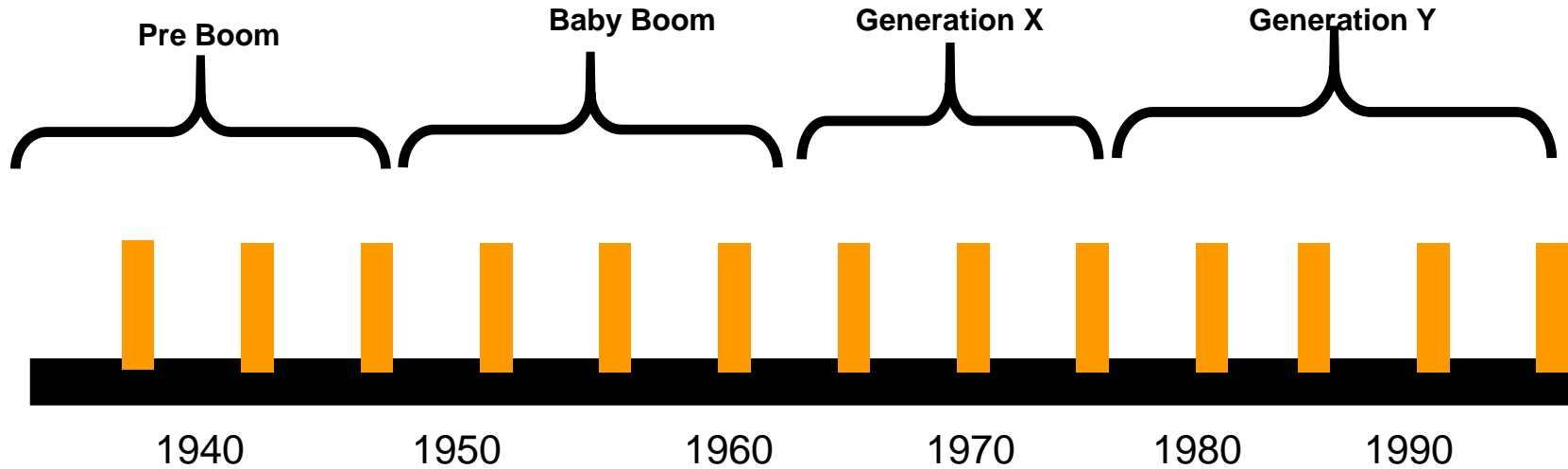
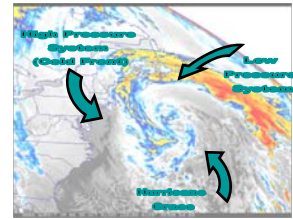
Objective is for Software and Systems Engineering to Become More Integrated Versus Separated



OSD Initiative: Integrated Software and Systems Engineering Curriculum



Human Element: More Generation Y Workers Will Enter the Workplace



Generation Y Characteristics

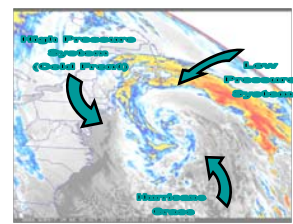
- Born late 1970s to mid-1990s
- Larger than Generation X
- More ethnically diverse
- Technologically savvy

What Makes Generation Y Tick

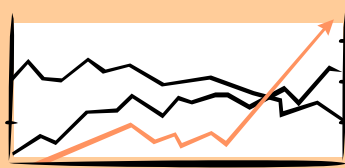
- High Expectation of Employers
- Goals, Goals, Goals
- Desire for Immediate Responsibility
- Balance and Flexibility

Source: Cara Spiro, DAU, 2006

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



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



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

Optimizing

Quantitatively Managed

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

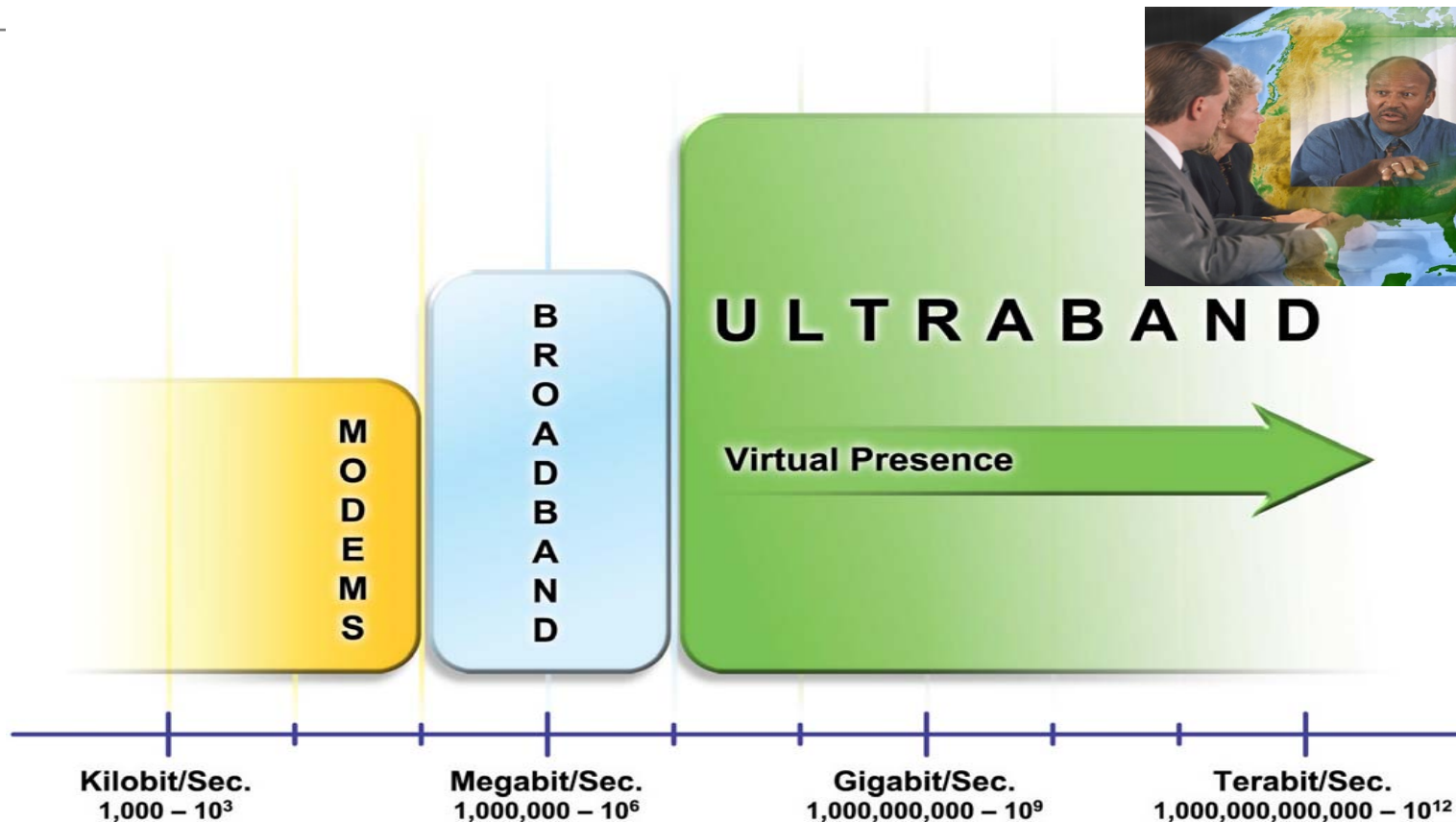
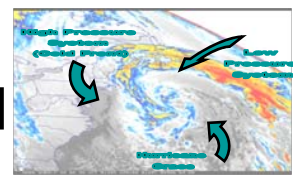
- Implementation
- Institutionalization

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

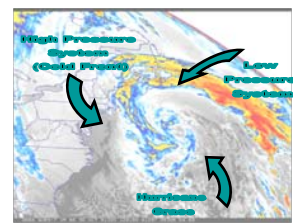


Rule #4: The best companies are the best collaborators*

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



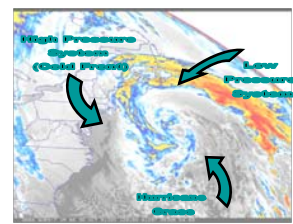
Systems and Software Engineering: Ten Trends



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

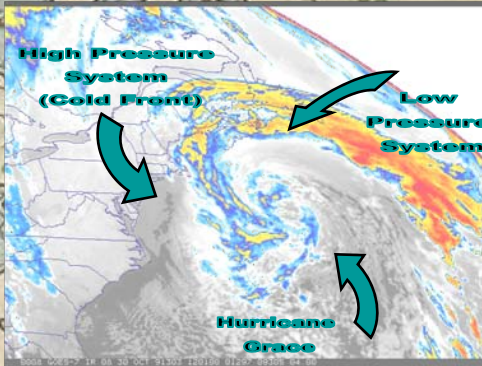


6. *Systems and software engineers will continually find way to innovative to reduce complexity*
7. *Increased importance of modeling and simulation*
8. *Increased customer requests for system and software engineering support will occur earlier in life cycle*
9. *Shift of systems and software engineering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





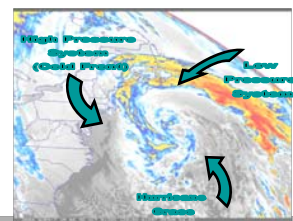
Questions?



THE KNOWN WORLD
Beyond here there be Dragons



Recommended Readings



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>

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