# Systems Engineering - How Future Trends in Systems and Software Technology Bode Well for the Rapid Adoption of CMMI

CMMI Technology Conference and User Group
November 12-15, 2007
Investigation, Measures and Lessons Learned about the Relationship between CMMI Process Capability and Project or Program Performance
Hyatt Regency Tech Center- Denver, CO
Systems and Software Technology – Enabling the Global Mission

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

Federally Funded Research and Development Center

Created in 1984

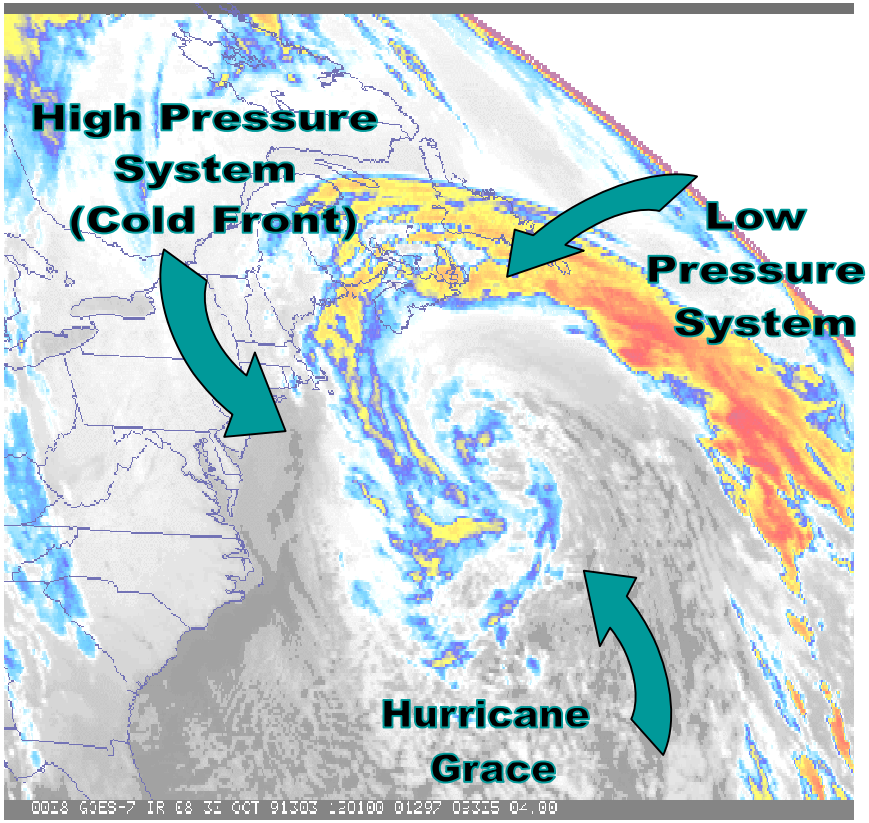
Sponsored by the U.S. Department of Defense

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

Operated by Carnegie Mellon University

# Overview

- Environmental Challenges
  - Development
  - Acquisition
- Storms of Change
  - Human Element
  - Project/Risk Management
  - Communications
- Warning Signs
- Concluding Comments




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

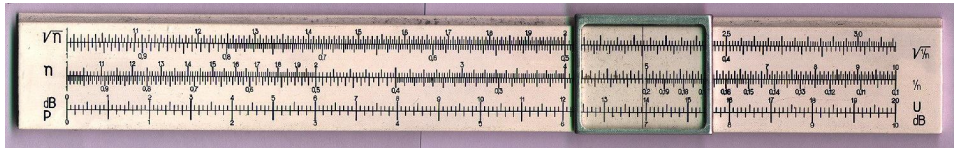
# enges: Software Engineering Trends That gineering*

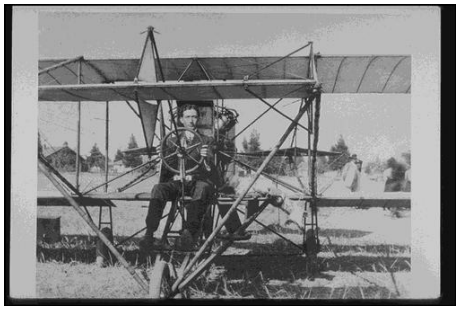
| Traditional | Future |
|---|---|
| Standalone systems | Everything connected-maybe |
| Mostly source code | Mostly COTS components |
| Requirements-driven | Requirements are emergent |
| Focus on software | Focus on systems and software |
| Premium on cost | Premium on value, speed, quality |
| Stable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

ÅTrends provided by Don Reifer, REIFER CONSULTANTS, INC.

# enges: Augustine's Law – Growth of Magnitude Every 10 Years

## *In The Beginning*





| *1960's* | *1970's* | *1980's* | *1990's* | *2000+* |
|---|---|---|---|---|
|  |  |  |  |  |
| *F-4A* | *F-15A* | *F-16C* | *F-22* | *F-35* |
| *1000* | *50,000* | *300K* | *1.7M* | *>6M* |
| *LOC* | *LOC* | *LOC* | *LOC* | *LOC* |
|  |  |  |  |  |

# allenges: Relationship Between Complexity and Acquisition Success Improving But Not Enough!

## Software is Growing in Complexity

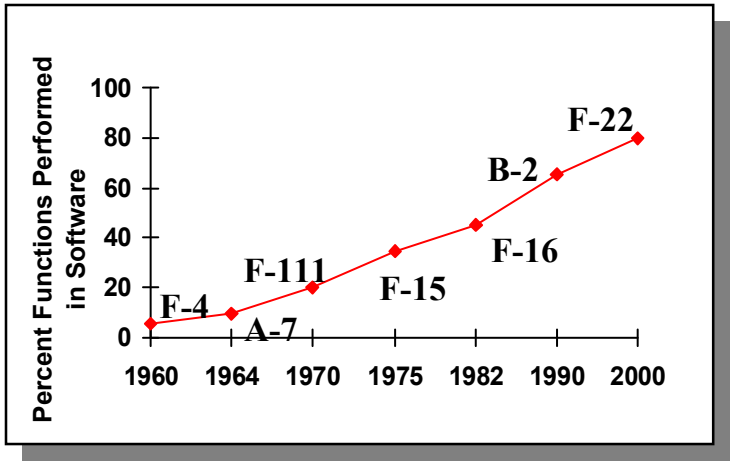
- 80% of some weapon system functionality is dependent upon software[1]
- Consequences of software failure can be catastrophic

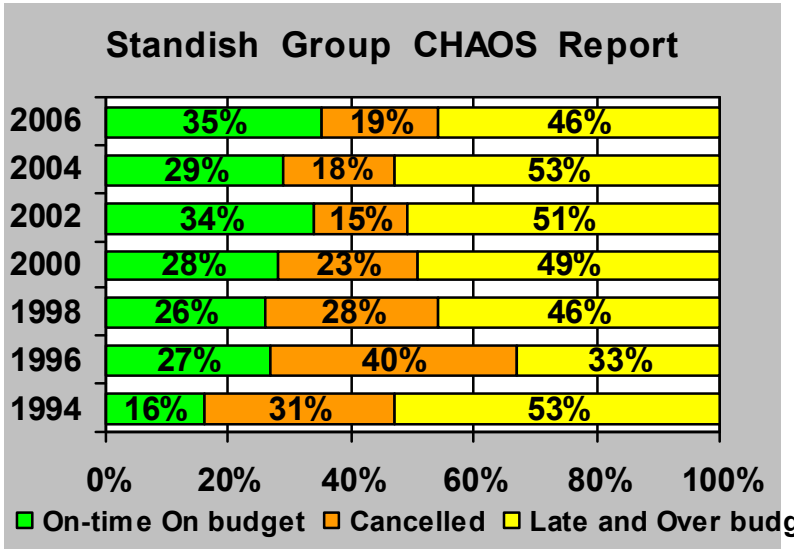
## Software Acquisition is Difficult

- 46% are over-budget (by an average of 47%) or late (by an average of 72%)[2]
- Successful projects have 68% of specified features[2]

## Software is Pervasive

- IT Systems, C4ISR, Weapons, etc



# ges: Some Drivers That Increase the ring Software-Intensive Systems

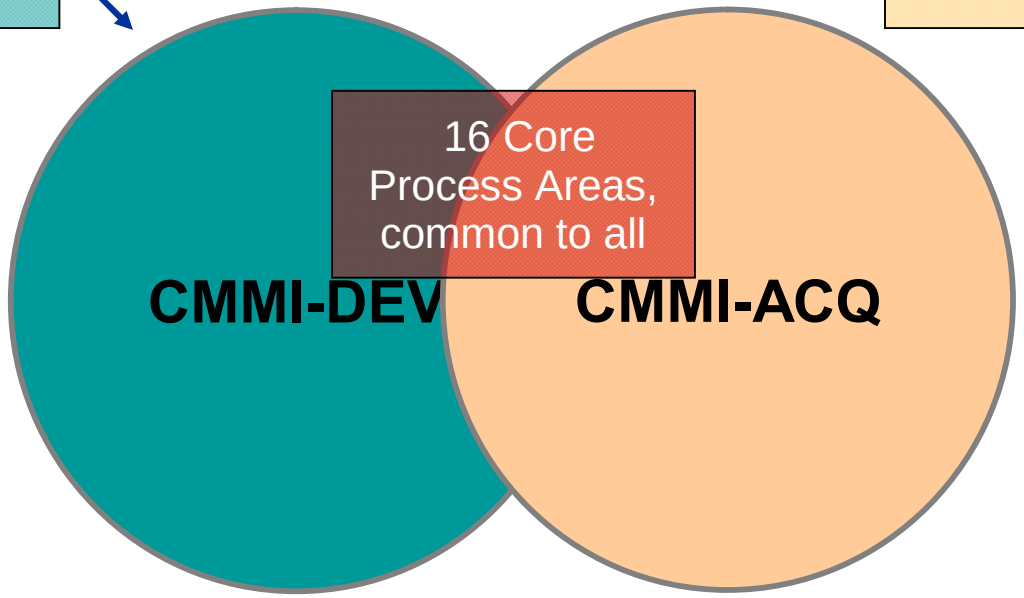
| | | |
|---|---|---|
| Platform | *Customer Emphasis* | Enterprise |
| Requirements | *Acquisition Model* | Objectives |
| Dominant Prime | *Program Execution* | Strategic Teaming |
| "Boxes" | *Integration Challenge* | "Layers & Stacks" |
| Proprietary | *Architectures and Standards* | Plug & Play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

***The emerging dynamic is to address both sides, and do so with compressed delivery schedules via improvements in systems/software engineering***

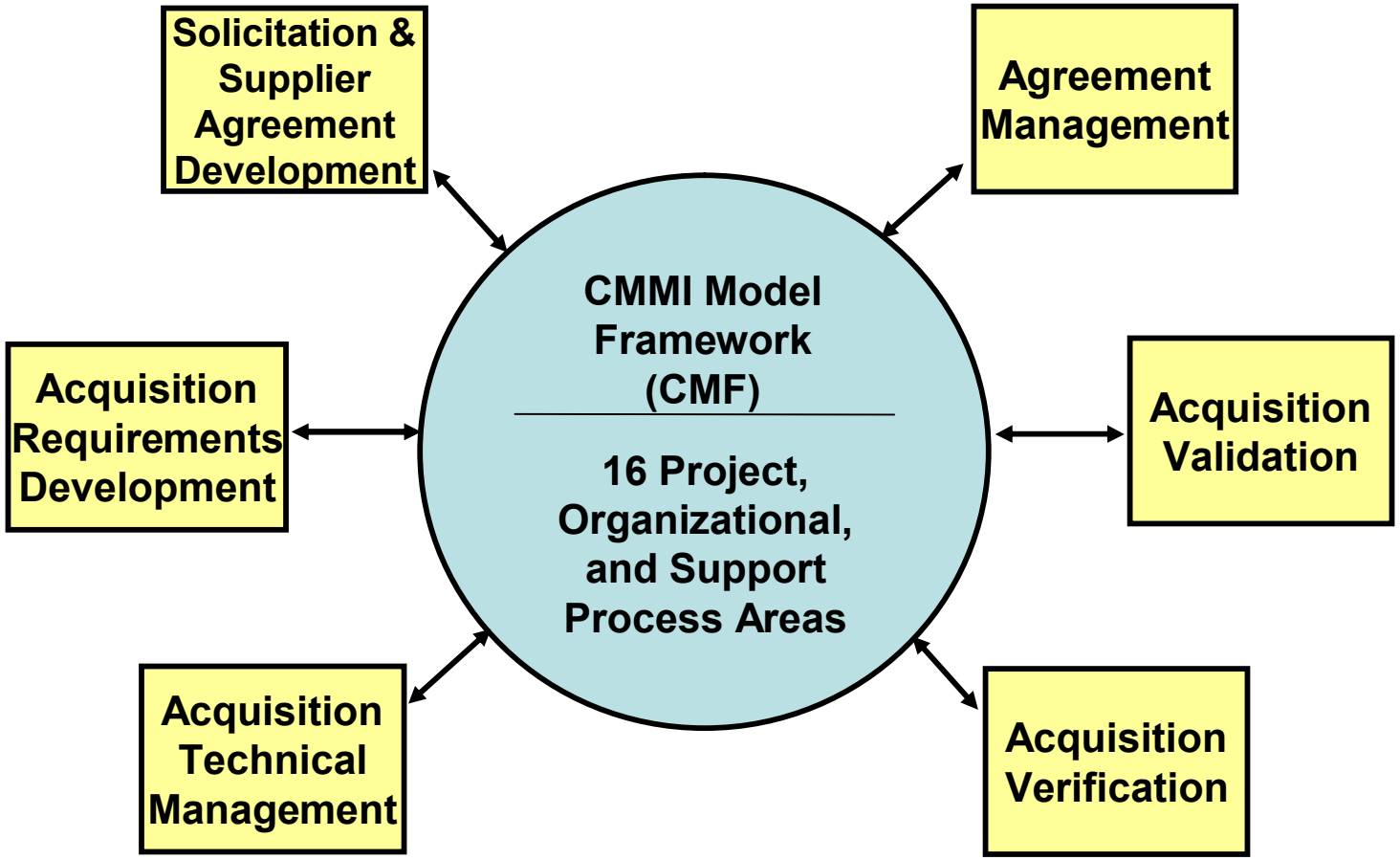
# d Acquisition Challenges: CMMI Constellations

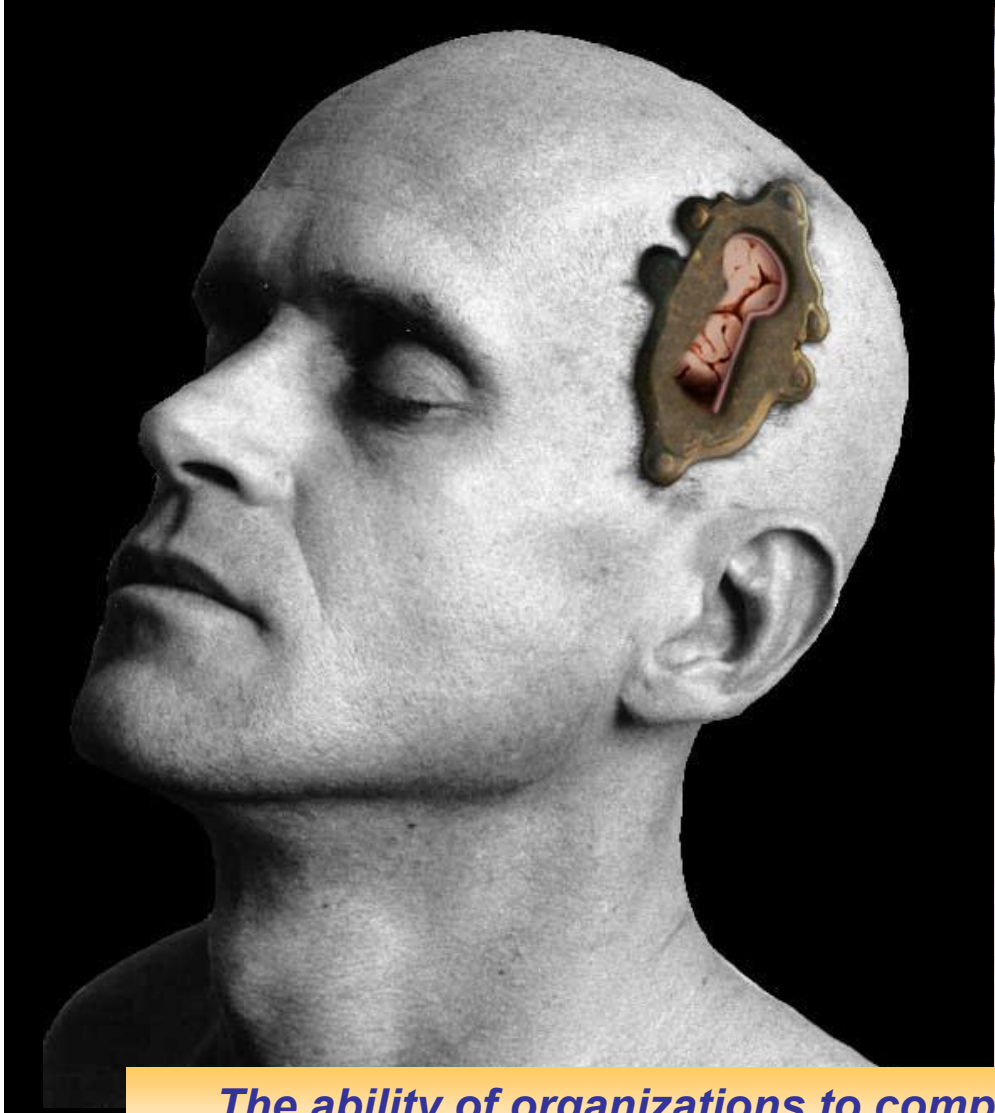
CMMI-Dev provides guidance for measuring, monitoring and managing development processes

CMMI-ACQ provides guidance to enable informed and decisive acquisition leadership



# Acquisition Category Process Areas (Released Nov)





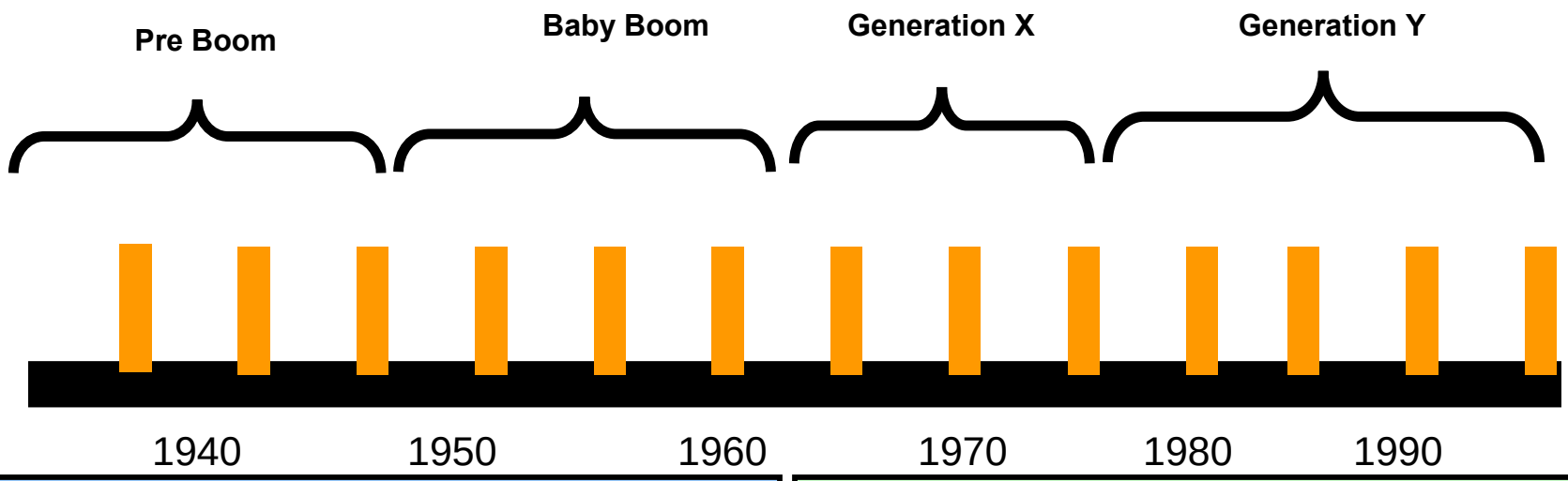
***The ability of organizations to compete will increasing depend on the innovation of the human element***

# he Demographic Context…

- A shrinking pool of experienced workers.
  - **42% decline from 1990 peak *(AIA Employment Database)***
- Consolidation left our industry with a mature workforce.
  - **54% over age 45 *(BAH Study)***
- Engineering enrollment trends are down.
  - **15% decline since 1991 *(National Science Foundation Indicators)***
- Brutal competition for technologists.
  - **Demand for experienced engineers is projected to increase by 97% between 1998 and 2008. *(US Bureau of Labor Statistics)***

***A key challenge is how to transform the workforce to meet demand***

# re Generation Y Workers Will Enter the Workplace




## Generation Y Characteristics

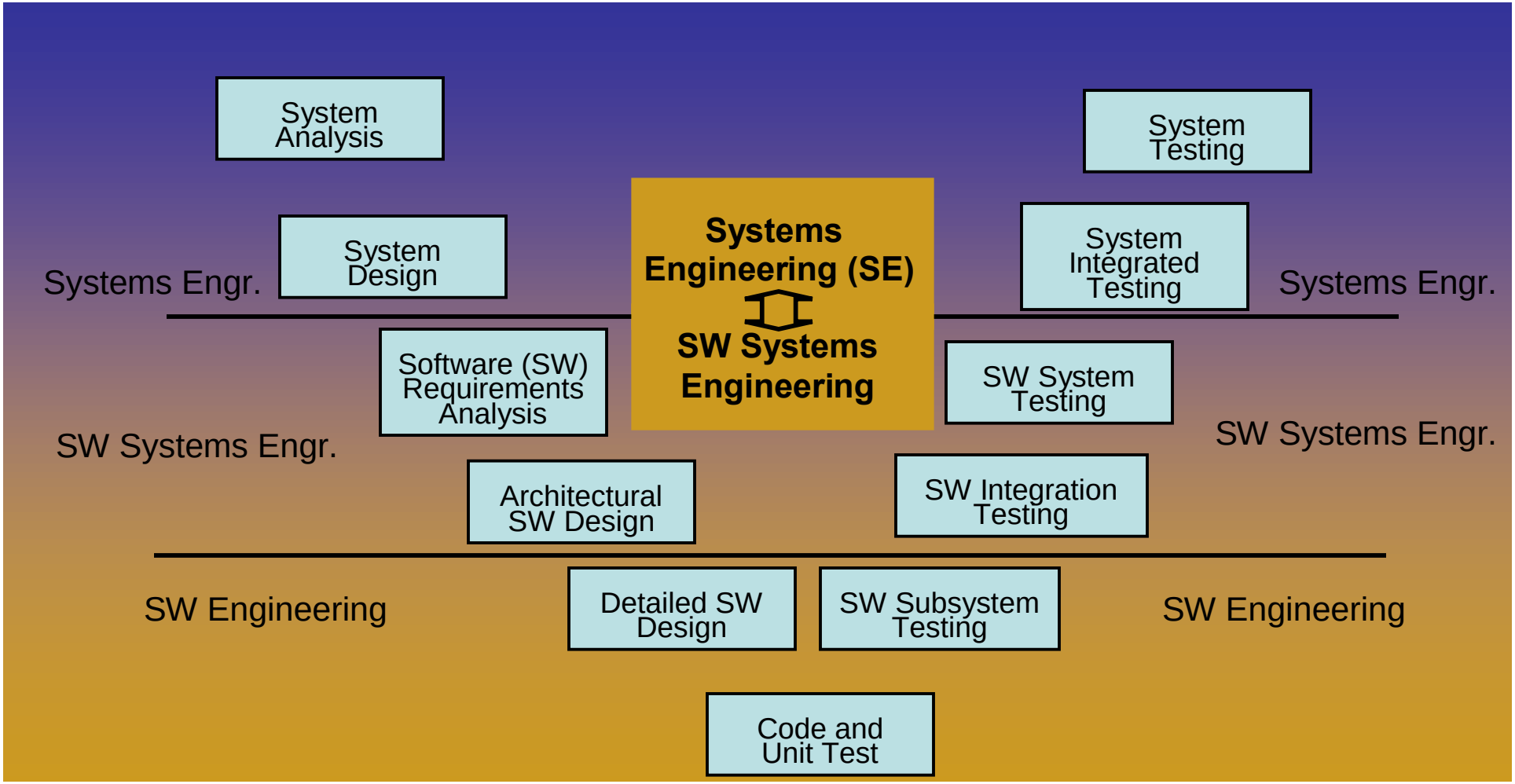
- Born late 1970s to mid-1990s
- Larger than Generation X
- More ethnically diverse
- Technologically savvy

## What Makes Generation Y Tick

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

Source: Cara Spiro, DAU, 2006

# urrent Trends is for Software and Systems ome More Integrated Versus Separated

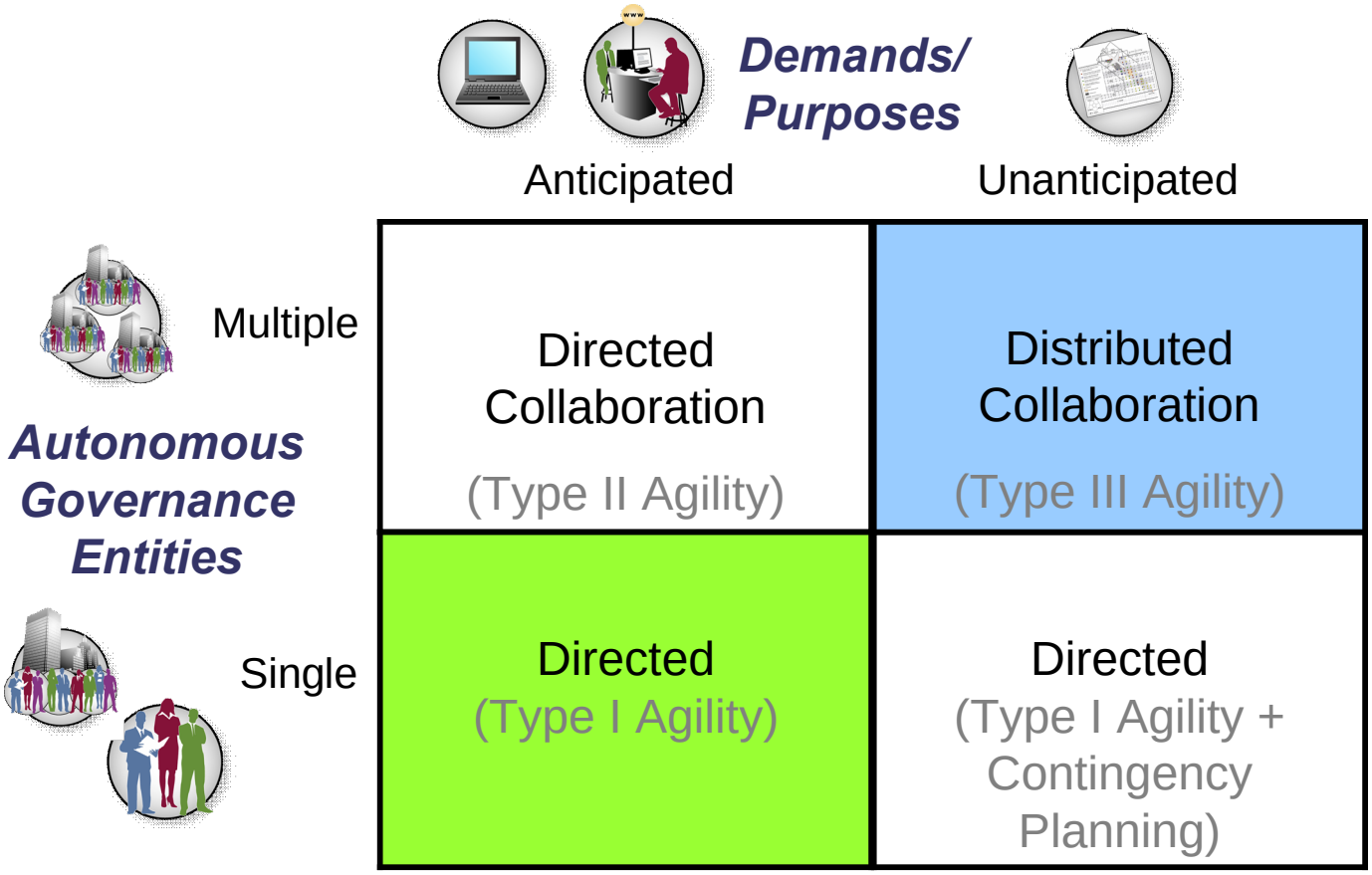



*OSD Initiative: Integrated Software and Systems Engineering Curriculum*

# Software and Systems Engineering Curriculum Project (*iSSEc*)

- **Creating a Reference Curriculum for Graduate Software Engineering Education**
- ***iSSEc* is sponsored by DOD and led by Stevens, involving 4 sets of stakeholders:**
  - The industrial and government workforce who are the customers of SWE graduate education
  - Academics who provide SWE and SE graduate education
  - Professional societies with a vested interest in SWE and SE graduate education
  - Government organizations who fund improvements in SWE graduate education
- ***iSSEc* recognizes that the divide between systems and software engineers in industry, government, and academia works against successfully delivering modern systems in which software is almost always central.**
- ***iSSEc* will integrate SE principles and practices into the SWE curriculum.**

# Performance - Flexible Boundary-Crossing Acquisition Structure



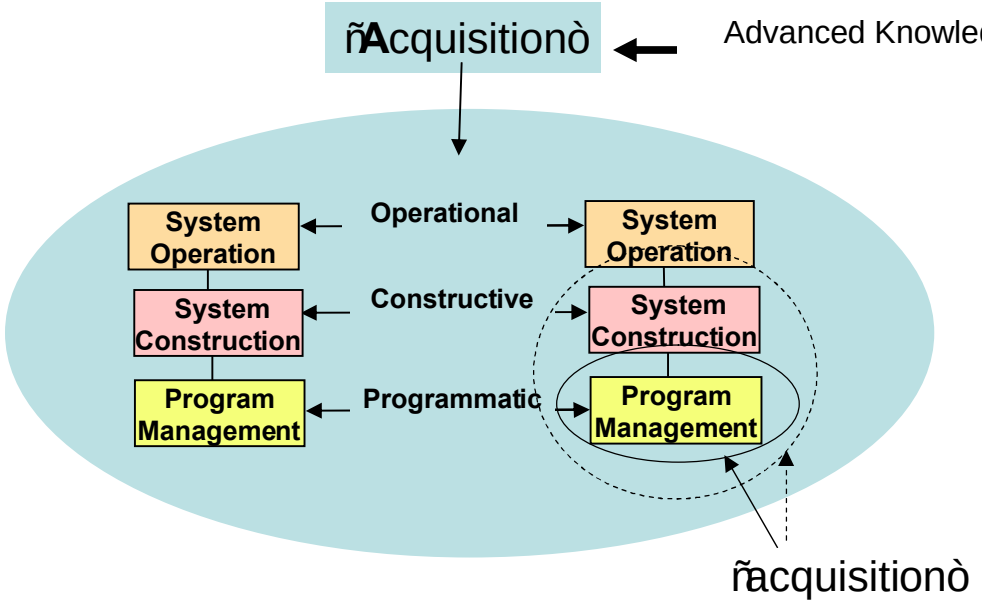

*Forms of Collaboration from "Architecting Principles for Systems of Systems", by Mark W. Maier http://www.infoed.com/open/papers/systems.htm*

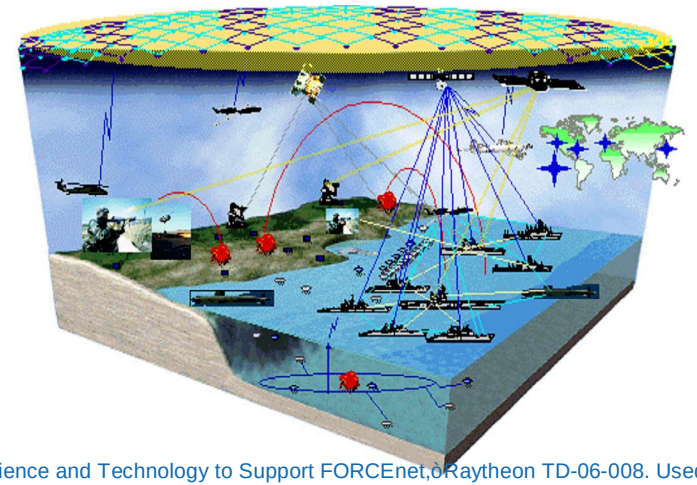
# erformance - Flexible Boundary-Crossing ture

2005 study confirmed*:

- In advanced knowledge-based organizations, managementõs 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 ñScience and Technology to Support FORCEnet,ó Raytheon TD-06-008. Used by permission.

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

# t: Increased Focus on Doing More with Less

Random motion ï lots of energy, not much progress

Directed motion ï every step brings you closer to the goal

No teamwork ï individual effort

Coordinated efforts

Frequent conflict

Cooperation

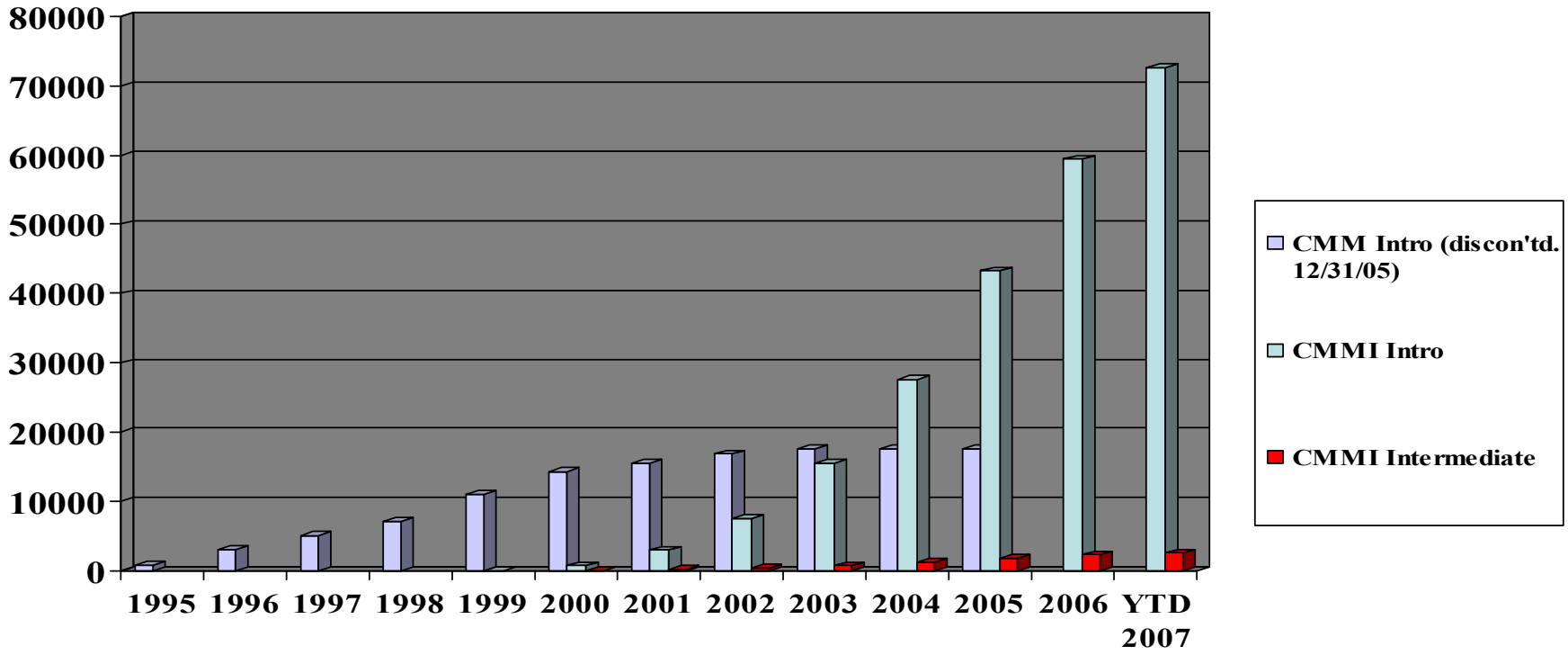
You never know where you'll end up

Predictable results

Processes Can Make the Difference

# MM and CMMI Technology Transfer Trends

## Intro to the CMM and CMMI Attendees (Cumulative)

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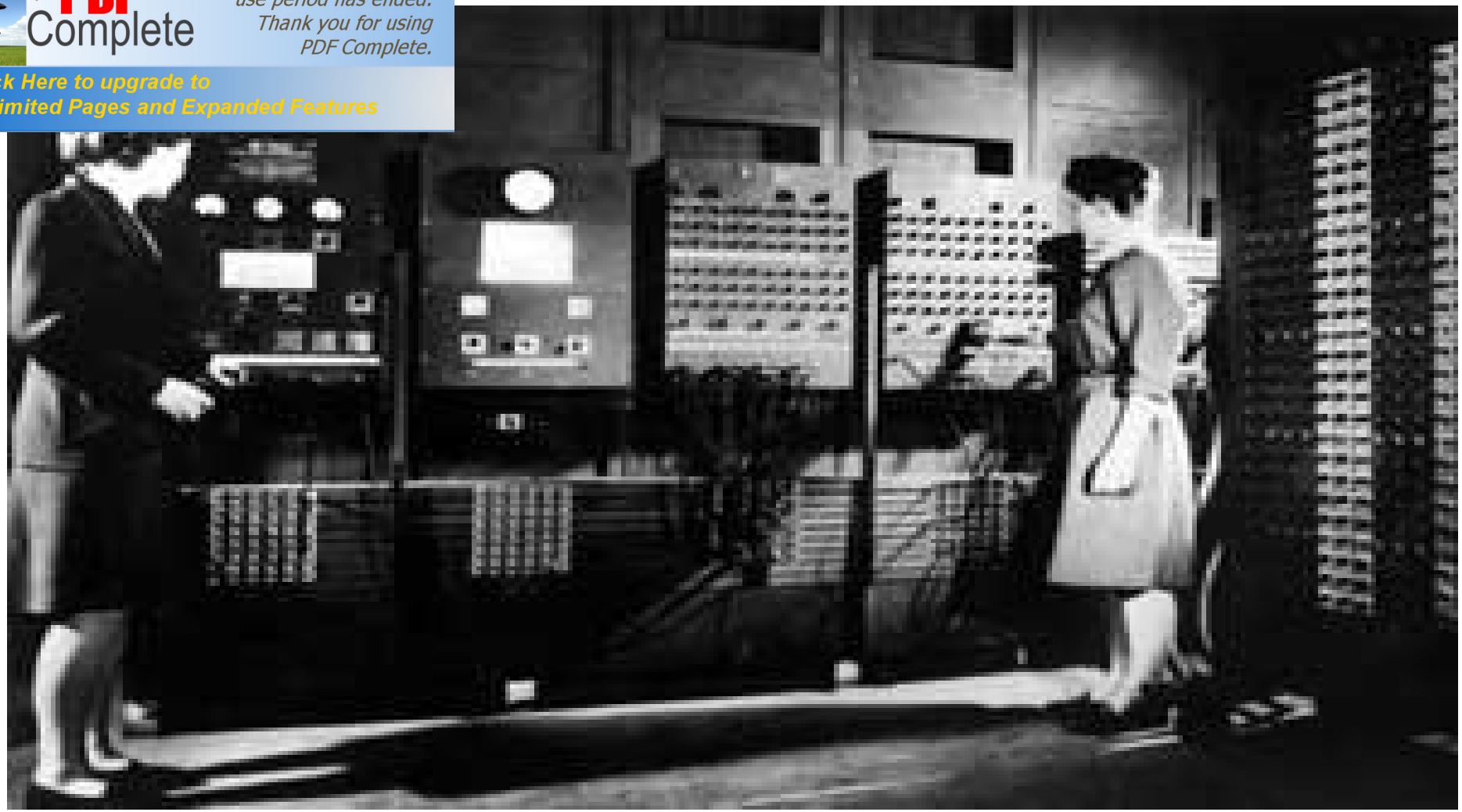
# nent – Effectively Managing Risk

*A key challenge is how to obtain a better alignment of risk among the key stakeholders who often leverage technology*

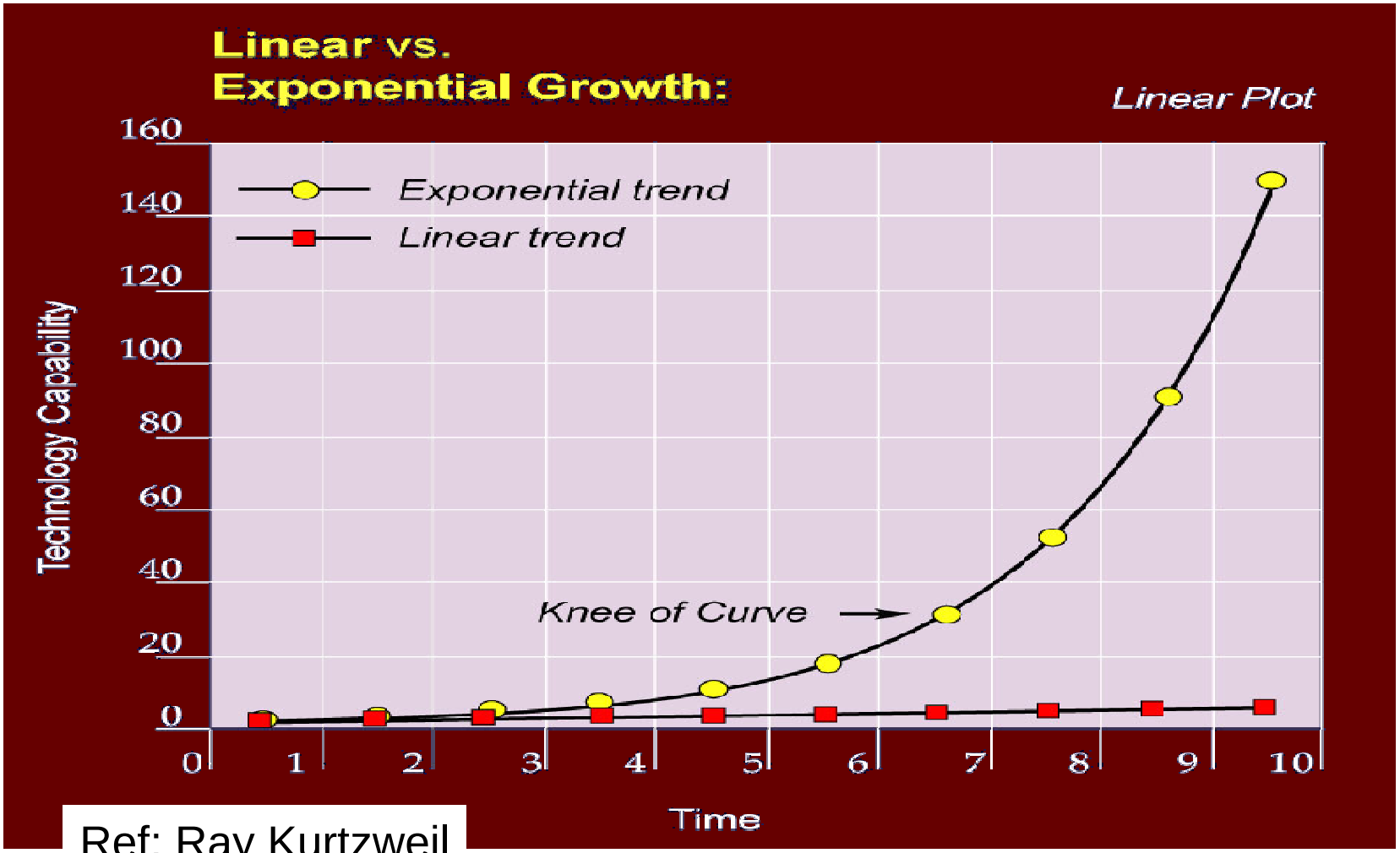


## Greater Demand for Improvements in Project Performance

***What Got us Where We Are***

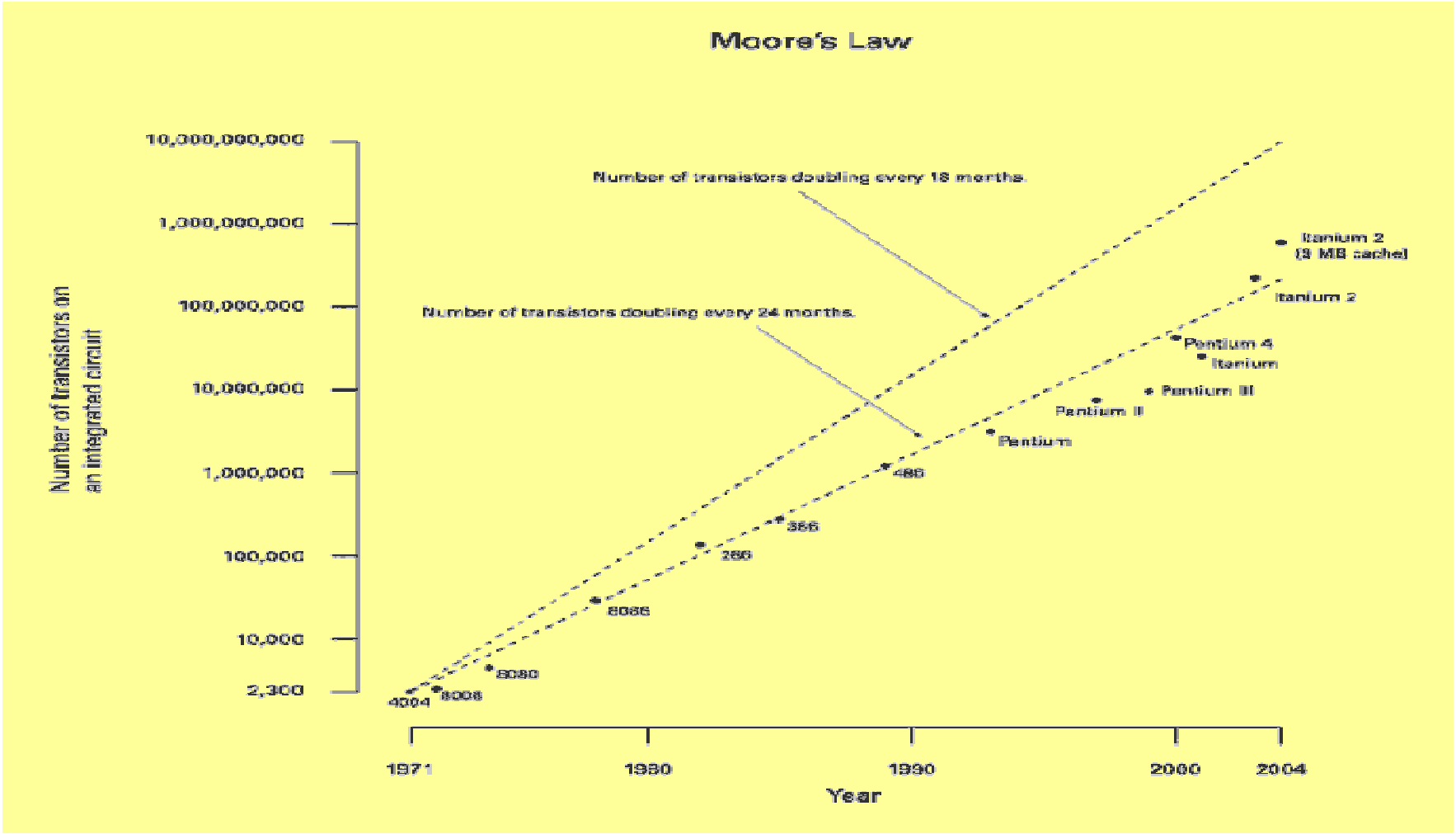
***Won't Necessarily Get us Where We Need to Be!***

# Acceleration of Innovation in the 21st Century - ness and Society

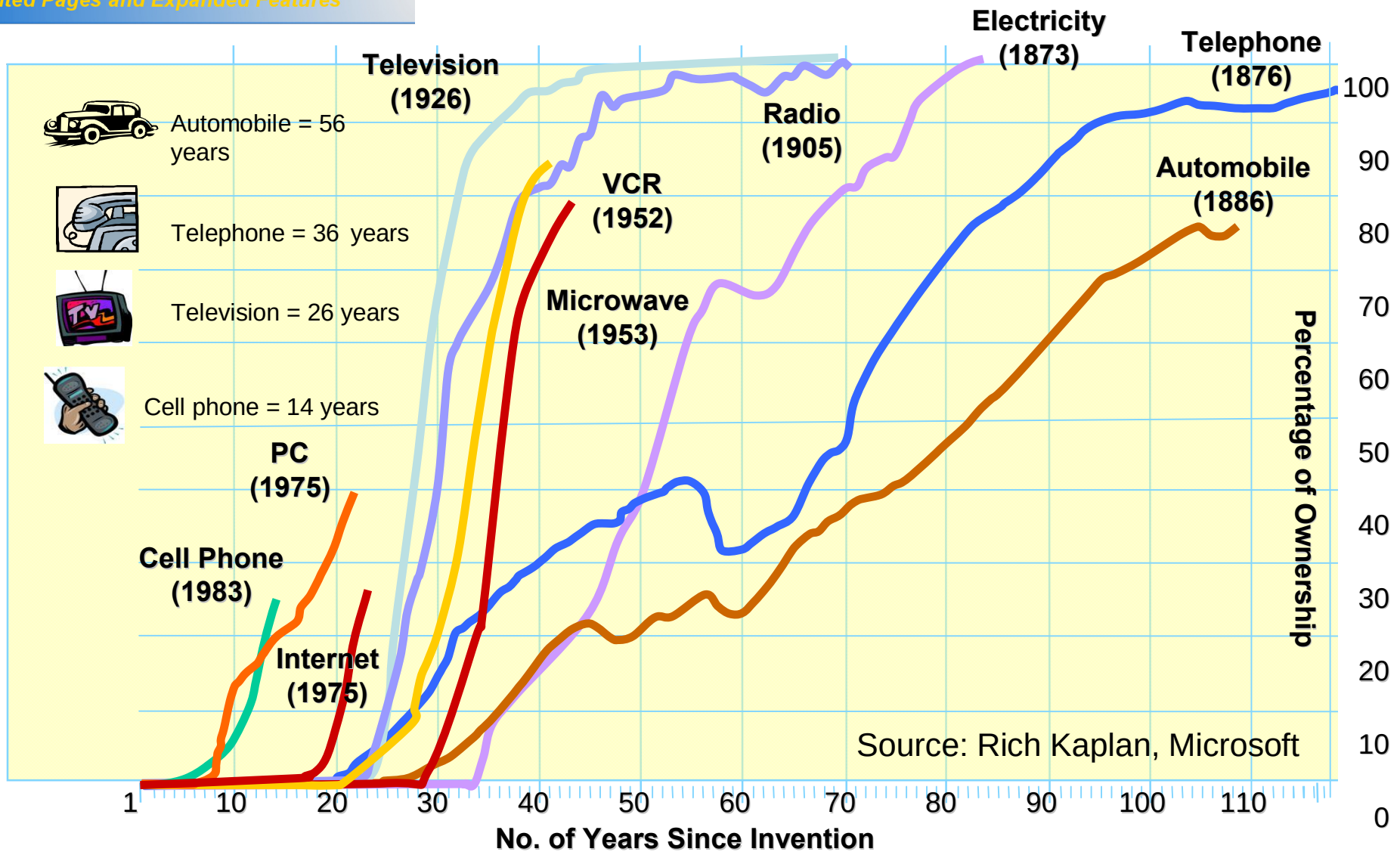



Ref: Ray Kurtzweil

# ration: Moore's Law - The Number of n be Placed on an Integrated Circuit is Doubling Approximately Every Two Years

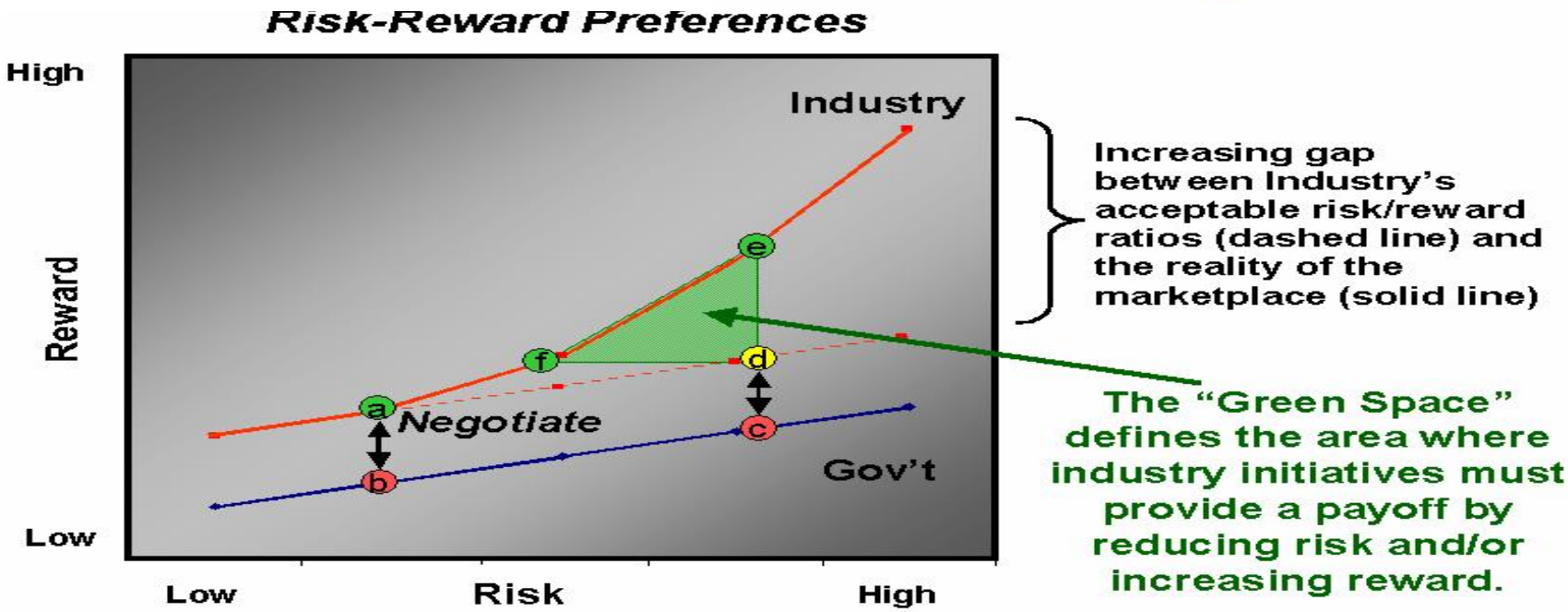


# eration: Increased Technology Rate of



# Project Management (Especially the Acquirer) to tively Navigating the Green/Acquisition Space

## Navigating the "Green Space"




Acquisition changes based on previous legislation have introduced new levels of risk.

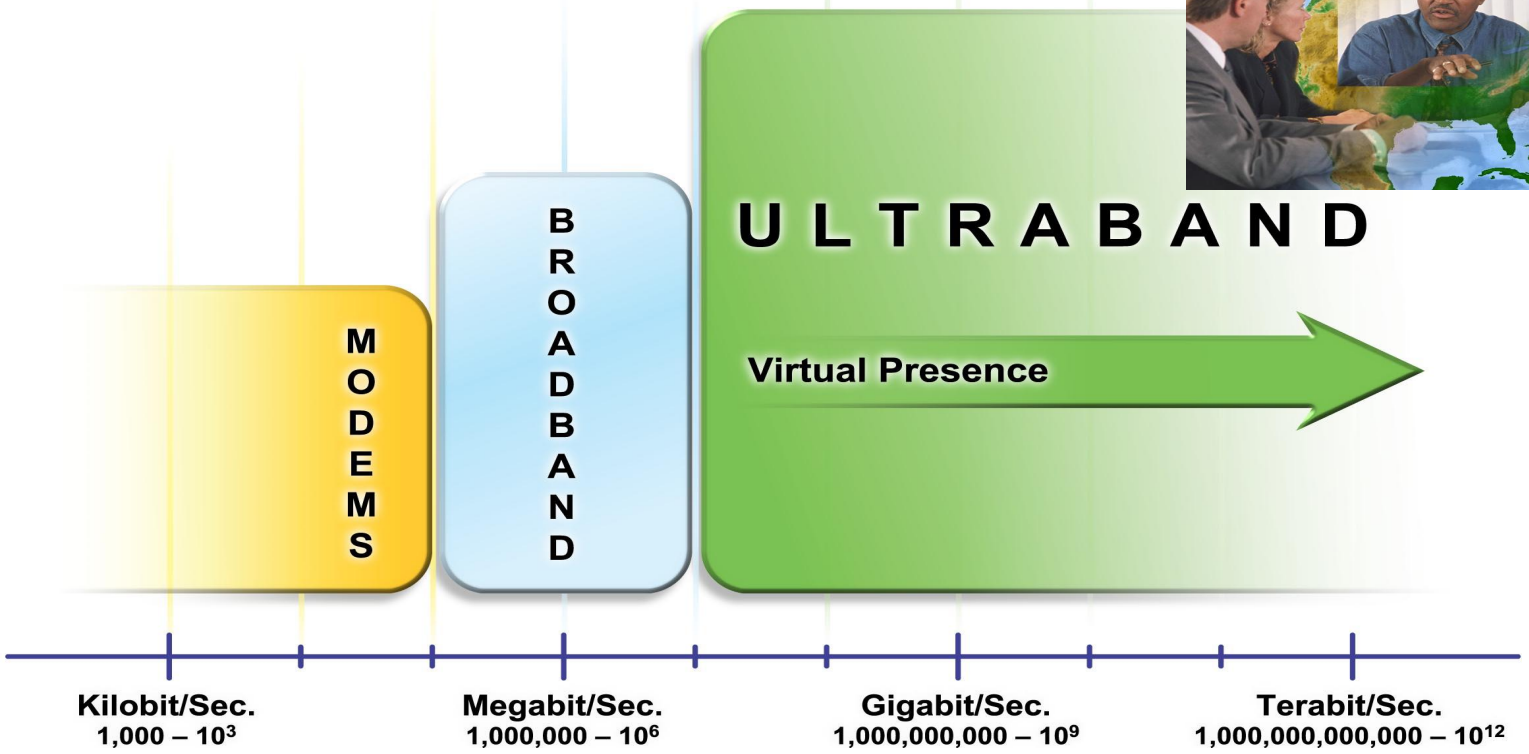


Source: Nidiffer and Dolan, IEEE Software, Sept/Oct 2005

# isals and Maturity Levels
# EI by Country

| Country | Number of Appraisals | Maturity Level 1 Reported | Maturity Level 2 Reported | Maturity Level 3 Reported | Maturity Level 4 Reported | Maturity Level 5 Reported | Country | Number of Appraisals | Maturity Level 1 Reported | Maturity Level 2 Reported | Maturity Level 3 Reported | Maturity Level 4 Reported | Maturity Level 5 Reported |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Argentina | 19 | No | Yes | Yes | Yes | Yes | Korea, Republic Of | 78 | Yes | Yes | Yes | Yes | Yes |
| Australia | 23 | Yes | Yes | Yes | Yes | Yes | Latvia | 10 or fewer | | | | | |
| Austria | 10 or fewer | | | | | | Malaysia | 19 | No | Yes | Yes | No | Yes |
| Bahrain | 10 or fewer | | | | | | Mauritius | 10 or fewer | | | | | |
| Belarus | 10 or fewer | | | | | | Mexico | 15 | No | Yes | Yes | Yes | Yes |
| Belgium | 10 or fewer | | | | | | Morocco | 10 or fewer | | | | | |
| Brazil | 48 | No | Yes | Yes | Yes | Yes | Netherlands | 10 or fewer | | | | | |
| Canada | 26 | No | Yes | Yes | Yes | Yes | New Zealand | 10 or fewer | | | | | |
| Chile | 15 | No | Yes | Yes | No | Yes | Pakistan | 10 or fewer | | | | | |
| China | 240 | Yes | Yes | Yes | Yes | Yes | Peru | 10 or fewer | | | | | |
| Colombia | 10 or fewer | | | | | | Philippines | 16 | No | Yes | Yes | No | Yes |
| Czech Republic | 10 or fewer | | | | | | Portugal | 10 or fewer | | | | | |
| Denmark | 10 or fewer | | | | | | Russia | 10 or fewer | | | | | |
| Dominican Republic | 10 or fewer | | | | | | Singapore | 10 or fewer | | | | | |
| Egypt | 17 | No | Yes | Yes | Yes | Yes | Slovakia | 10 or fewer | | | | | |
| Finland | 10 or fewer | | | | | | South Africa | 10 or fewer | | | | | |
| France | 75 | Yes | Yes | Yes | Yes | Yes | Spain | 31 | No | Yes | Yes | No | Yes |
| Germany | 35 | Yes | Yes | Yes | Yes | Yes | Sweden | 10 or fewer | | | | | |
| Hong Kong | 10 | | | | | | Switzerland | 10 or fewer | | | | | |
| India | 204 | No | Yes | Yes | Yes | Yes | Taiwan | 46 | No | Yes | Yes | No | Yes |
| Indonesia | 10 or fewer | | | | | | Thailand | 10 or fewer | | | | | |
| Ireland | 10 or fewer | | | | | | Turkey | 10 or fewer | | | | | |
| Israel | 10 | | | | | | United Kingdom | 48 | Yes | Yes | Yes | Yes | No |
| Italy | 10 or fewer | | | | | | United States | 718 | Yes | Yes | Yes | Yes | Yes |
| Japan | 172 | Yes | Yes | Yes | Yes | Yes | Viet Nam | 10 or fewer | | | | | |

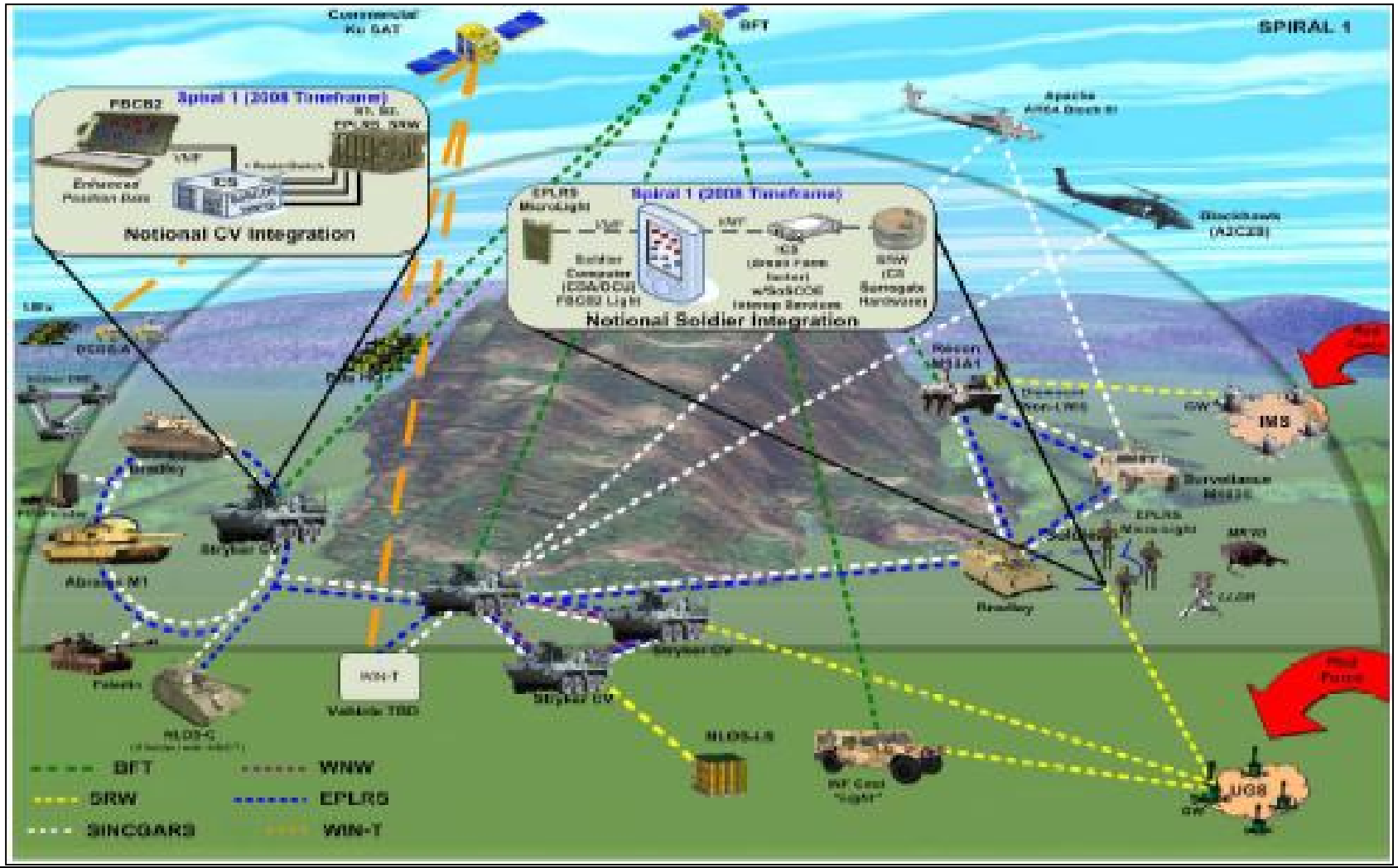
# s in the Digital Spectrum Enables nmunication and Collaboration




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

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

# e Connects Systems…



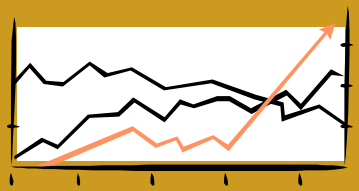
# e of Modeling and Simulation

## n Unveils New Modeling and Simulation Research Center

New Aviation Ship Integration Center, a state-of-the-art research facility established in partnership with the U.S. Navy to conduct modeling, simulation, research, development and in-depth analysis for CVN 21-class aircraft carriers and other aviation-capable ships.

# 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

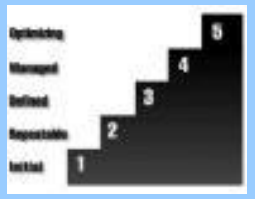
Identify and prioritize improvement opportunities

- Causal analysis of data

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

- Design for Six Sigma

## *Model-Driven (e.g., CMMI)*




Determine the industry best practice

- Benchmarking, models

Compare your current practices to the model

- Appraisal, education

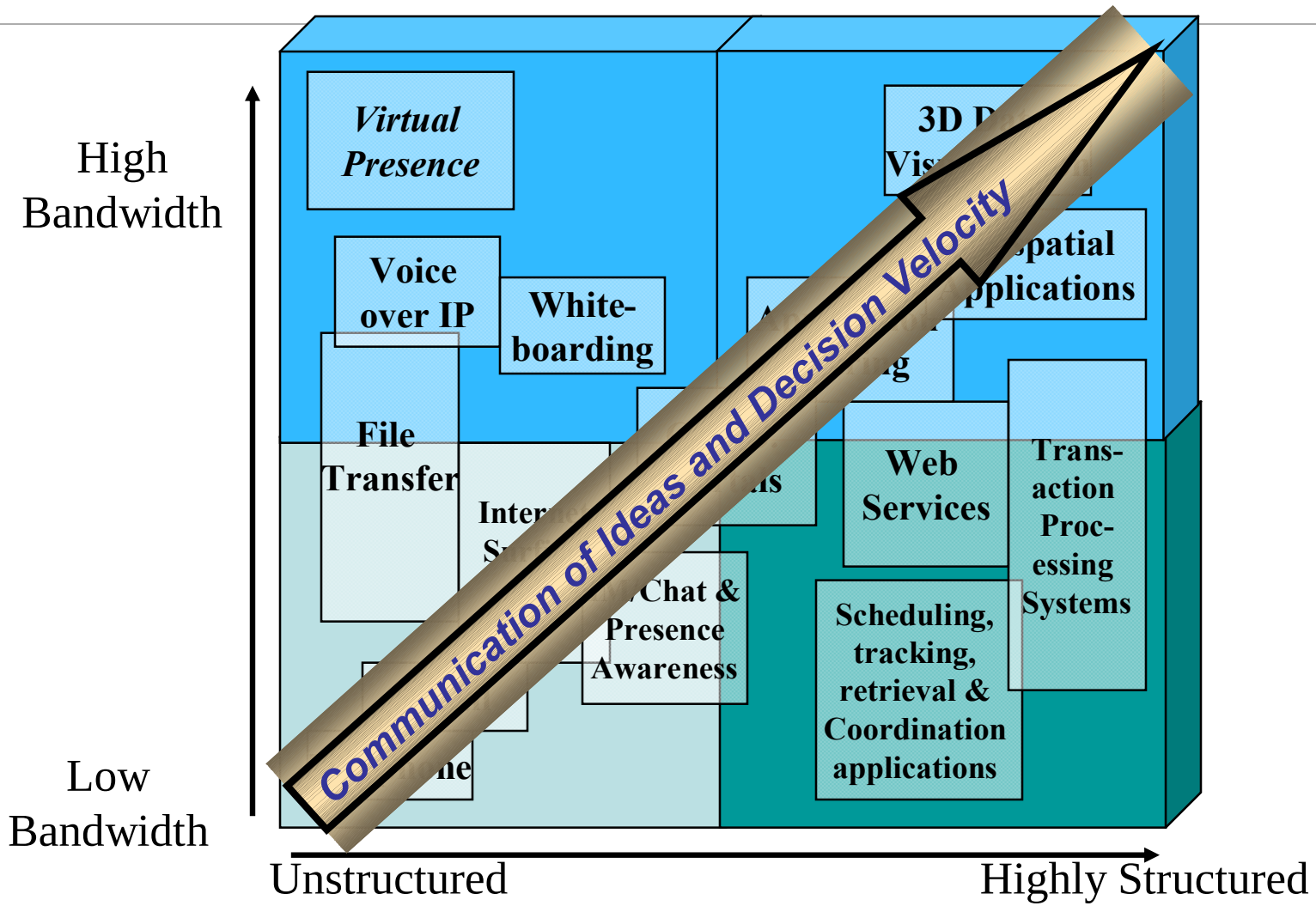
Identify and prioritize improvement opportunities

- Implementation
- Institutionalization

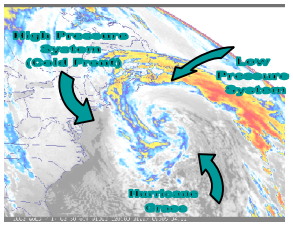
Look for ways to optimize the processes

Ref. Dr. Rick Hefner, Northrop Grumman

# vements in Collaboration Mechanisms ystem Engineering Success

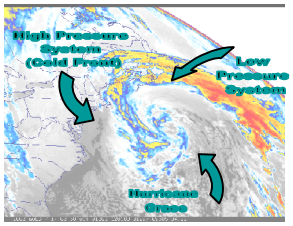


# Well for the Rapid Adoption of CMMI



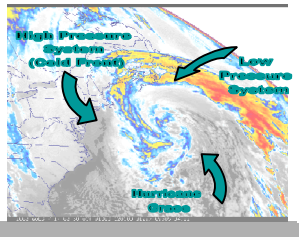

- *Greater demands on systems and software engineers will stimulate growth in the field – nationally and internationally*
- *Industry/Gov't will increasingly focus on attracting, training and retaining systems and software engineering talent – short and long run – with emphasis on providing a Generation 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"*

# re Engineering Trends That Bode doption of CMMI




- *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*
    - *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 the networks*
- *Process improvement will continue to be important*

# eadings

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