Systems Engineering Impact of the Rapid Acquisition of IT Systems in Support of Public Law 111

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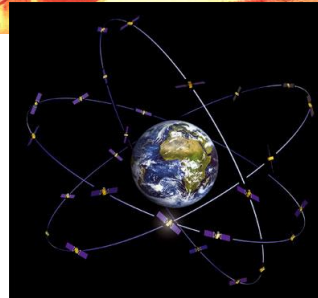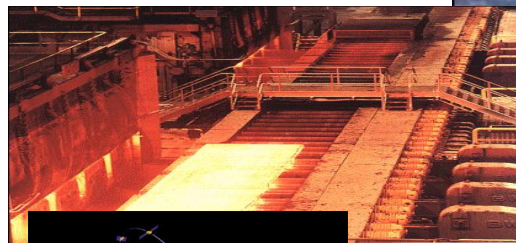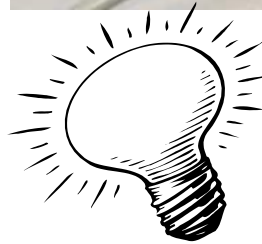**Software Engineering Institute** | **Carnegie Mellon**

Overview

- Background

- Overview of Proposed Changes

- Challenges

- Summary

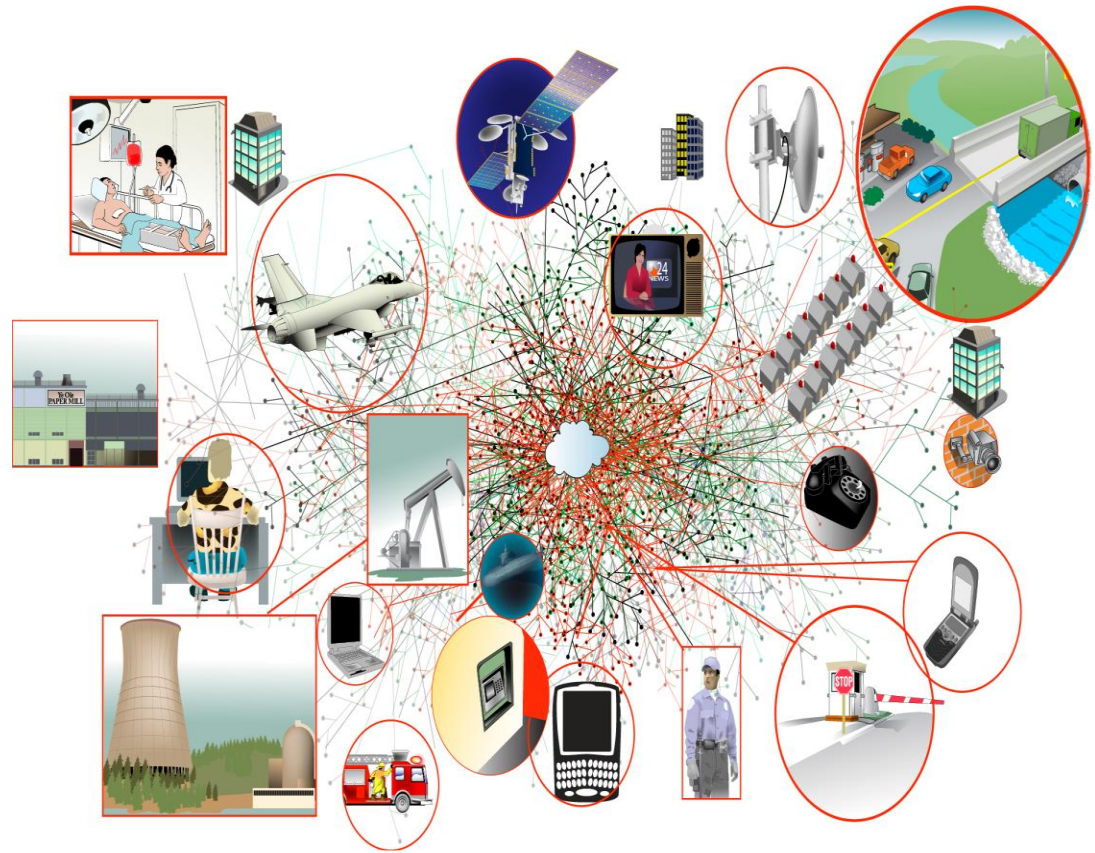**This presentation focuses on the *past, present,* and *future* of IT acquisitions**

What is the Information Technology (IT) Environment?

Includes all

- System of Systems

- Architecture

- Services

- Networked Hardware/ Platforms

- People who digitally connect to cyberspace

Source: SEI
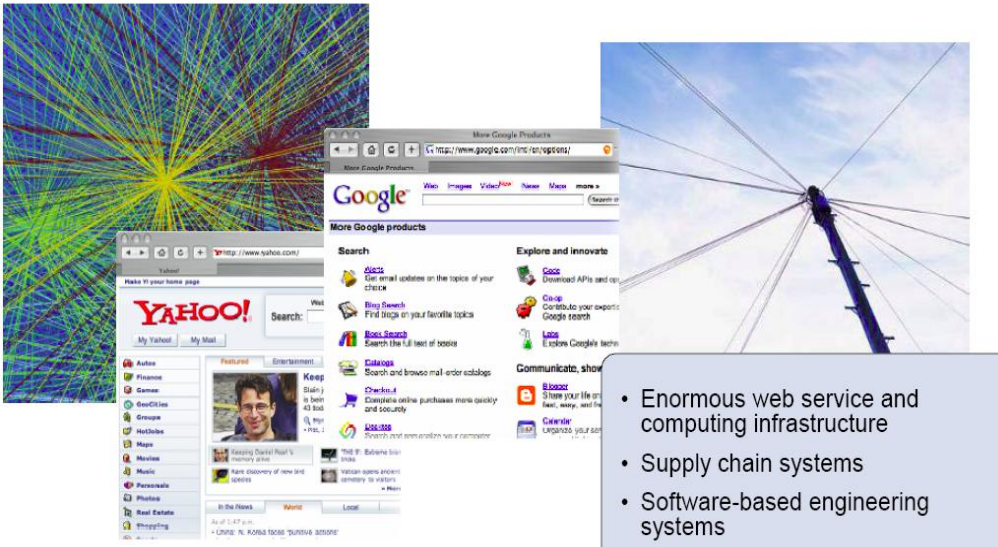

Often difficult to distinguish IT systems from other types of systems because they are networked systems!
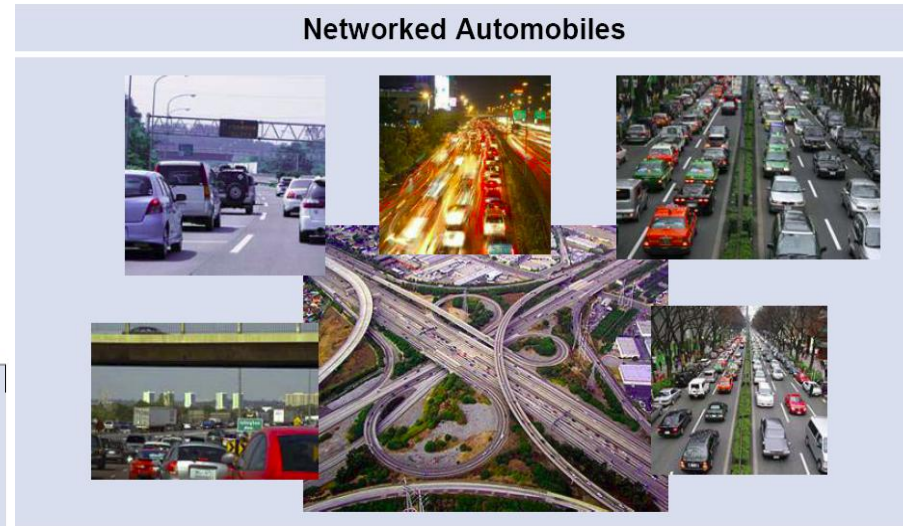
Examples of Emerging Ultra-Large IT Systems

- Enormous web service and computing infrastructure
- Supply chain systems
- Software-based engineering systems
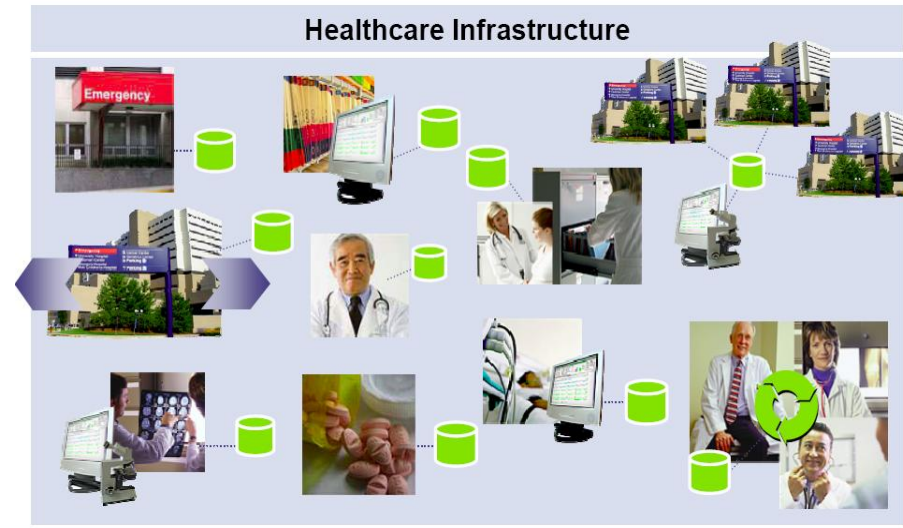
Networked Automobiles

Homeland Security

Healthcare Infrastructure

Source: www.sei.cmu.edu/uls

Optimizing Information Technology*

- Adaptable IT Infrastructure Center on
  - Cloud Computing
  - Common Services
  - Network/Desktop Consolidation
- Streamlined IT Acquisition Processes ⬅
- Robust Cyber Security Implementation
- Information Sharing Approaches
- Information Assurance
- Renewed Focus on Using Facilities on Reducing Overall Environment Consumption (e.g., power, space, cooling)

Sources: Department of Defense (DoD) Chief Information Officer (CIO) Campaign Plan Baseline (Oct, 2011) and SEI Discussions with CIOs (2010)

* Partial List

Acquisition: IT Systems are Different from a Weapon System — and Critical to Enable a more Resilient Cyber Environment

Weapon Systems

- Weapon platform centric
- Military unique requirements
- Development of military-unique, breakthrough technologies
- Development cycle of decade or more
- Production decisions for unique HW
- Service lives extending into decades

IT Systems

- Enterprise network centric
- Adapt commercial capabilities for military needs
- Leverage commercial technologies
- Technology cycle 12-18 months
- Procure commodity HW
- Periodic technology refresh to avoid obsolescence

Demand Different Acquisition Life Cycles and Processes

Sources: IT Acquisition Reform Task Force/MITRE Corporation

DoD IT Acquisition Cycle Time - 32 MAIS

Milestone B

Initial Operational Capability

Planning Phase   **Build Phase**

43   **48**

MS C

Analysis of Alternatives   **Economic Analysis**   **Development**   **Test**

40   **5**

91
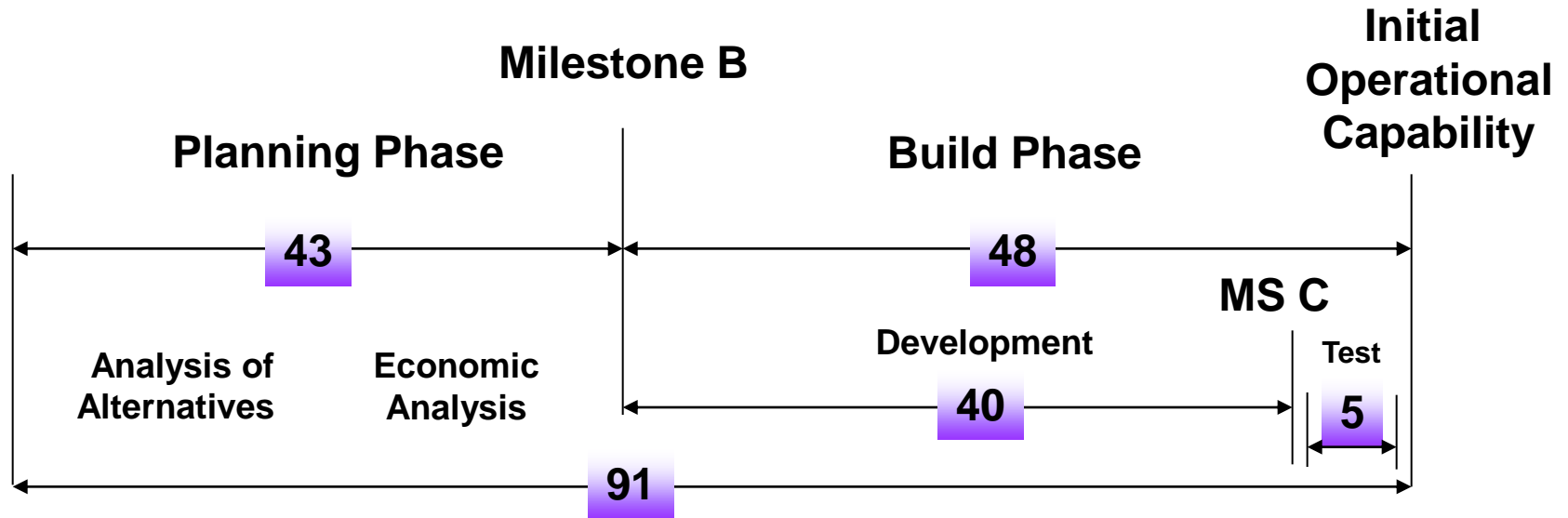
Cycle Time Driven by Processes Developed to Counter a Cold War Adversary In Industrial Age Society

Source: Defense Science Board Report, March 2009

The Opportunities

MAIS Program Avg = 91 Months

Adaptability

Speed

Agility

Previous DEPSECDEF Bill Lynn established a new goal: 18 months

Source: A New Approach for Delivering IT Capabilities in DoD, Report to Congress, November 2010

IT Acquisition Reform Imperative

Congress
- **Develop and Implement a new process for Acquiring IT (FY10 NDAA* Section 804)**
- HASC** Panel on Defense Acquisition Reform Finding and Recommendations (23 March 2010)

Widely documented Problems with DoD IT Acquisitions

- Defense Science Board
  - Jan 09 – Integrating COTS
  - Mar '09 – IT Acquisition
  - Apr '09 – Fix the Acq process
  - Jul '09 – Rapid Acquisition
- Industry Associations
  - AFEI, TechAmerica,
- National Academies - Achieving Effective Acq of IT in DoD 2010
- Business Leads – Aug '08 Joint DISA IT Review

Improve DoD IT Acquisition

Federal CIO

25-Pt Implementation Plan to Reform Federal IT Management

Vivek Kundra, U.S. CIO, December 9, 2010

DoD Senior Leadership Vision

"First step [for DoD to succeed in delivery of IT] is to acknowledge that simply tailoring the existing processes in not sufficient" (National Research Council, DEC 2009)

NDAA: National Defense Authorization Act ; HASC: House Armed Services Committee;
AFEI: Association for Enterprise Information; DISA: Defense Information Systems Agency

Defense Science Board Report & Public Law 111 (Section 804) 2010 National Defense Authorization Act

• NEW ACQUISITION PROCESS REQUIRED -The Secretary of Defense shall develop and implement a new acquisition process for information technology systems

• To the extent determined by the Secretary, be based on the recommendations in Chapter 6 of the March 2009 report of the DSB Task Force on DoD and Procedures for the Acquisition of Information Technology

A New Acquisition Process for Information Technology
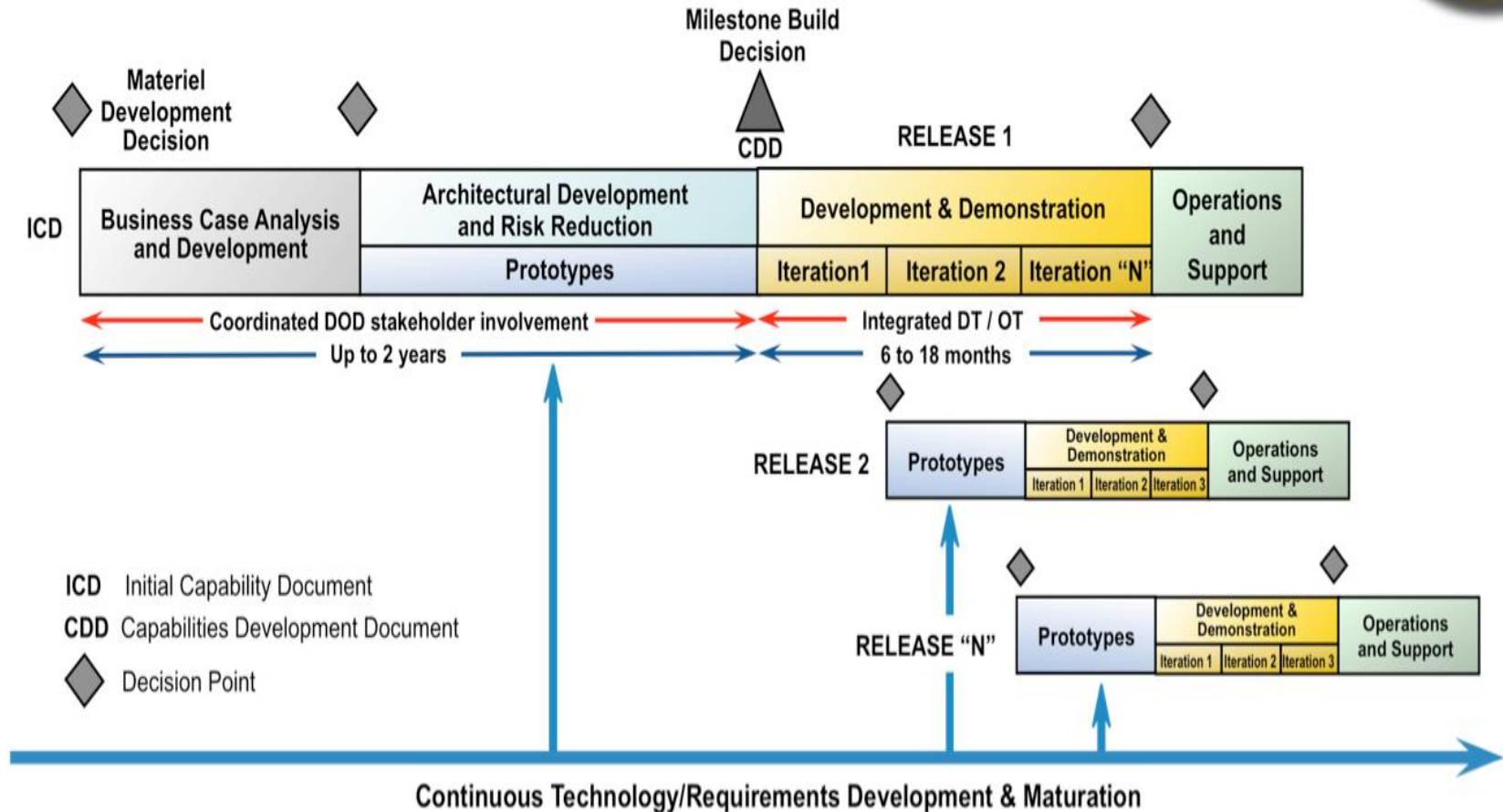
Source: Defense Science Board Report, March 2009

Guiding Principles

1. Deliver Early and Often

2. Incremental and Iterative Development and Testing

3. Rationalized Requirements

4. Flexible/Tailored Processes

5. Knowledgeable and Experienced IT Workforce

Sources: Defense Science Board Report, March 2009 and A New Approach for Delivering IT
Capabilities in DoD, Report to Congress, November 2010

DOD Software Acquisition Process Improvement Programs, DoD Major Events, and Leadership Rotation

Cohen
01-24-1997 to 01-20-2001

Rumsfeld
01-20-2001 to 12-17-2006

Gates
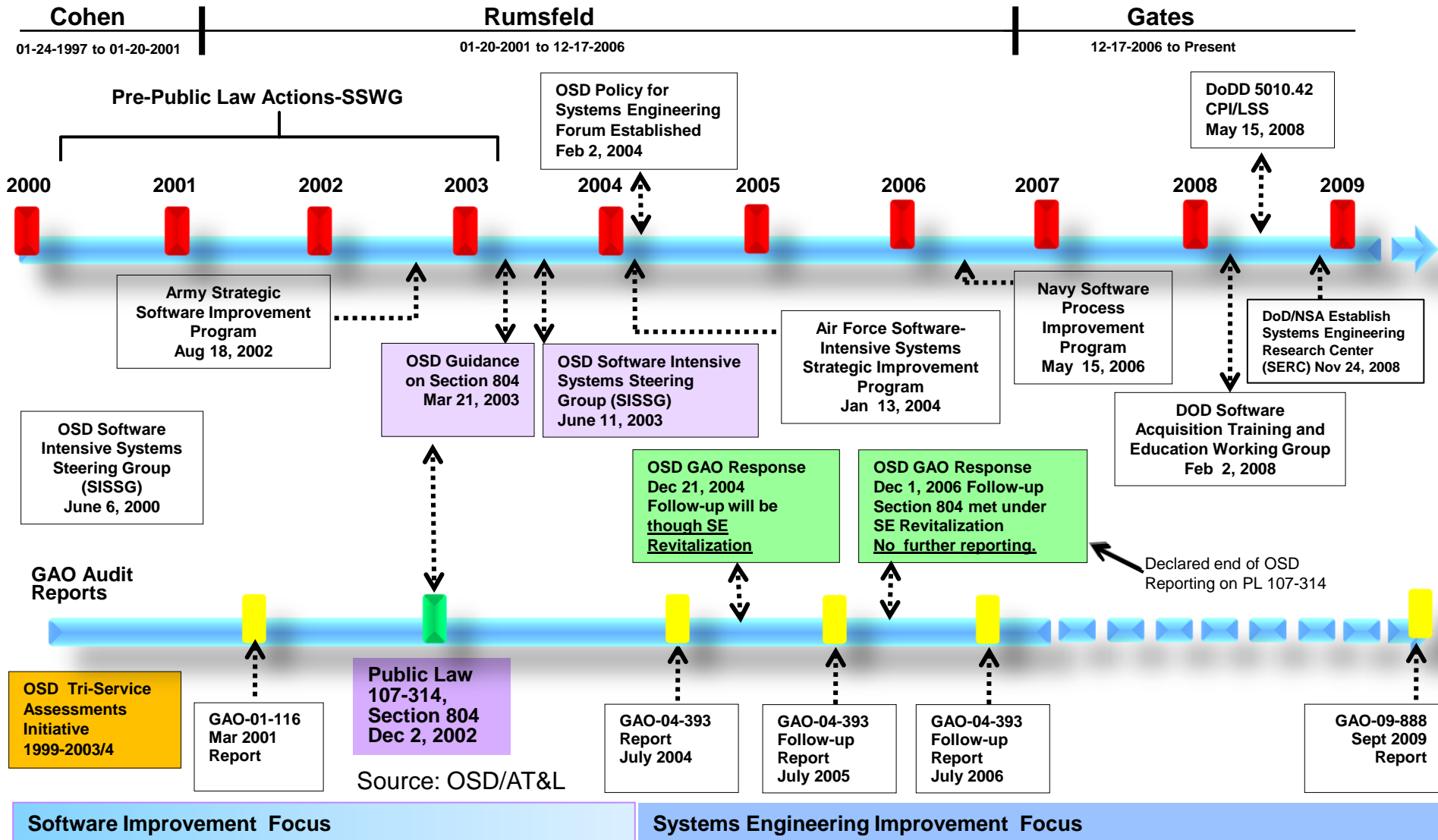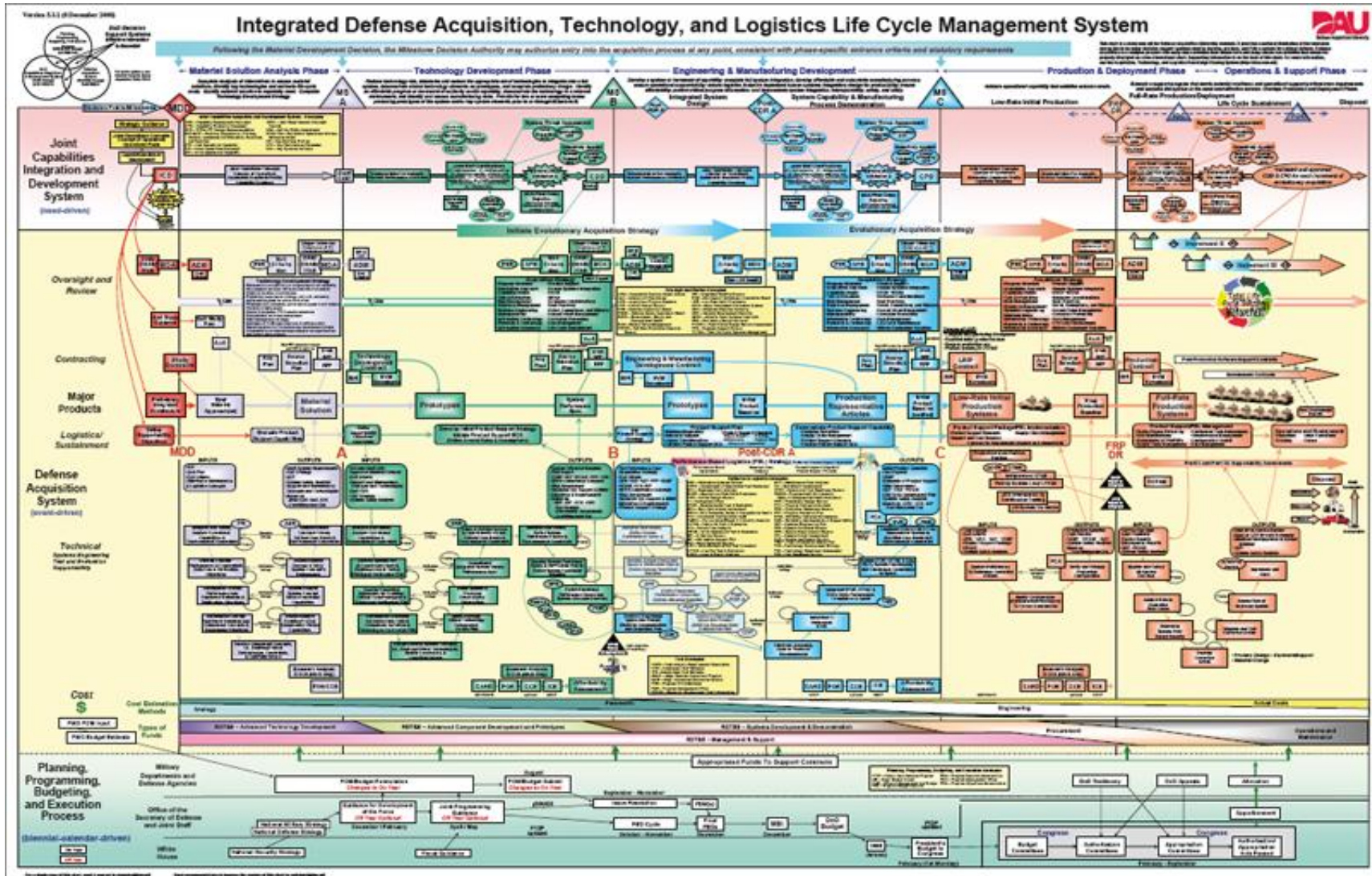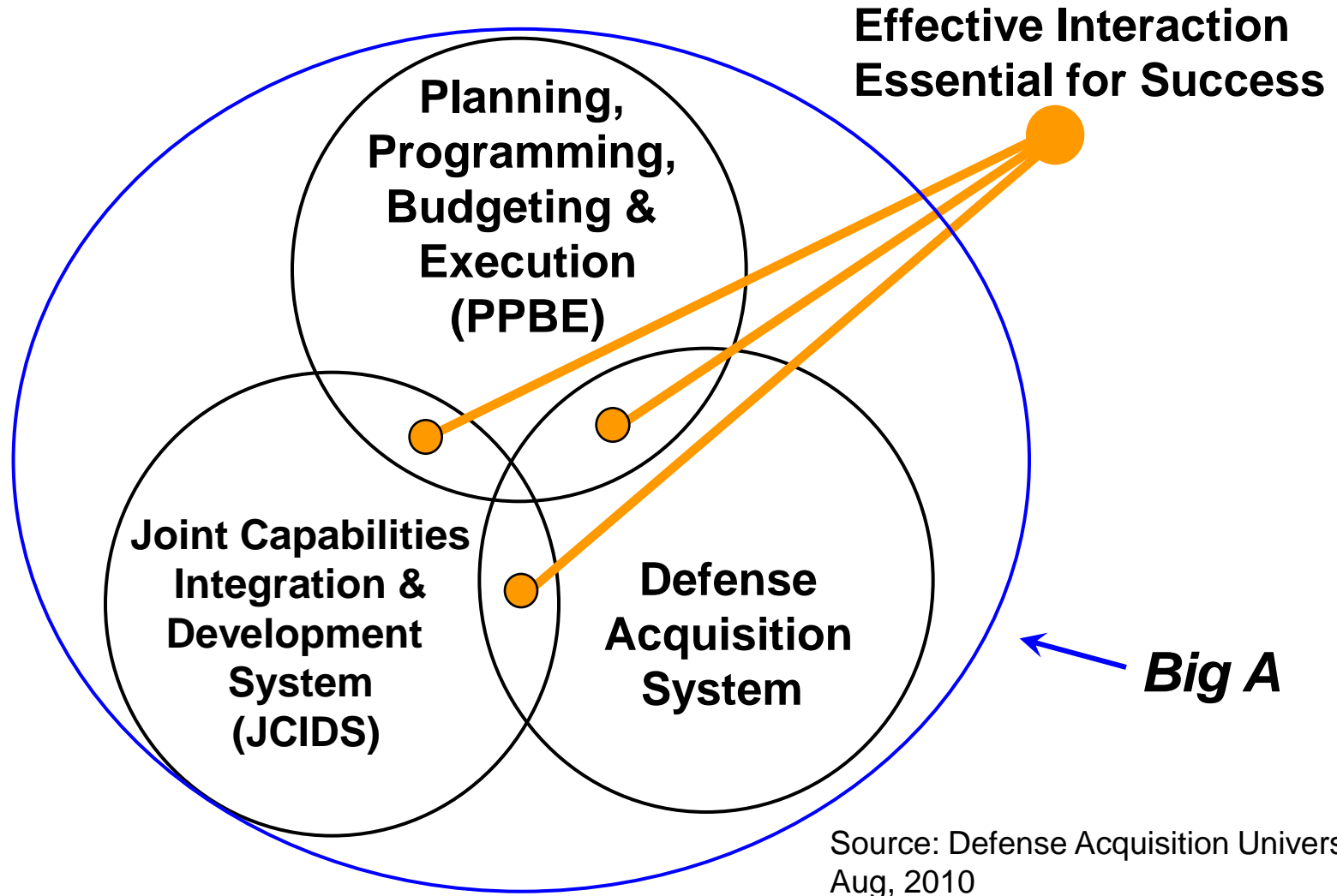12-17-2006 to Present

Pre-Public Law Actions-SSWG

OSD Policy for Systems Engineering Forum Established Feb 2, 2004

DoDD 5010.42 CPI/LSS May 15, 2008

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

Army Strategic Software Improvement Program Aug 18, 2002

Navy Software Process Improvement Program May 15, 2006

DoD/NSA Establish Systems Engineering Research Center (SERC) Nov 24, 2008

OSD Guidance on Section 804 Mar 21, 2003

OSD Software Intensive Systems Steering Group (SISSG) June 11, 2003

Air Force Software-Intensive Systems Strategic Improvement Program Jan 13, 2004

OSD Software Intensive Systems Steering Group (SISSG) June 6, 2000

DOD Software Acquisition Training and Education Working Group Feb 2, 2008

OSD GAO Response Dec 21, 2004 Follow-up will be though SE Revitalization

OSD GAO Response Dec 1, 2006 Follow-up Section 804 met under SE Revitalization No further reporting.

Declared end of OSD Reporting on PL 107-314

GAO Audit Reports

OSD Tri-Service Assessments Initiative 1999-2003/4

GAO-01-116 Mar 2001 Report

Public Law 107-314, Section 804 Dec 2, 2002

GAO-04-393 Report July 2004

GAO-04-393 Follow-up Report July 2005

GAO-04-393 Follow-up Report July 2006

GAO-09-888 Sept 2009 Report

Source: OSD/AT&L

Software Improvement Focus

Systems Engineering Improvement Focus

An Effective Process for Major Defense Systems - but not very agile for IT Systems

Integrated Defense Acquisition, Technology, and Logistics Life Cycle Management System

Better Alignment: Three Major DoD Decision Support Systems

Effective Interaction Essential for Success

Planning, Programming, Budgeting & Execution (PPBE)

Joint Capabilities Integration & Development System (JCIDS)

Defense Acquisition System

Big A

Source: Defense Acquisition University Aug, 2010

Challenges: Information Technology (IT) Environment

Source: www.sei.cmu.edu/uls

Information Dominance ~~Opportunity~~ Dilemma

Source: Terry Simpson, PEO-C4I

- ✓ *We are in early stages of Wave 3 information technology*
- ✓ *Mainframe and Client-Server waves remain in place*
- ✓ *Waves represent many co-dependent technologies, matured over time*
- ✓ *Adding functional capability has become easier with each new wave*
- ✓ *__But__ enterprise infrastructure __gaps & vulnerabilities__ have become more critical*

Information Driven Capability

3. Internet - Cloud
- • **Virtualized compute; global network enabled**
- • **Software decoupled from hardware**
- • **Work from anywhere**

2. Networked - Decentralized
- • **PC enabled and network**
- • **Software distributed in both server and client computers**
- • **Work from the user location**

1. Centralized - Mainframe
- • **Central computer center**
- • **Software in computer center only**
- • **Work brought to the computer center**

1950   1960   1970   1980   1990   2000   2010   2020
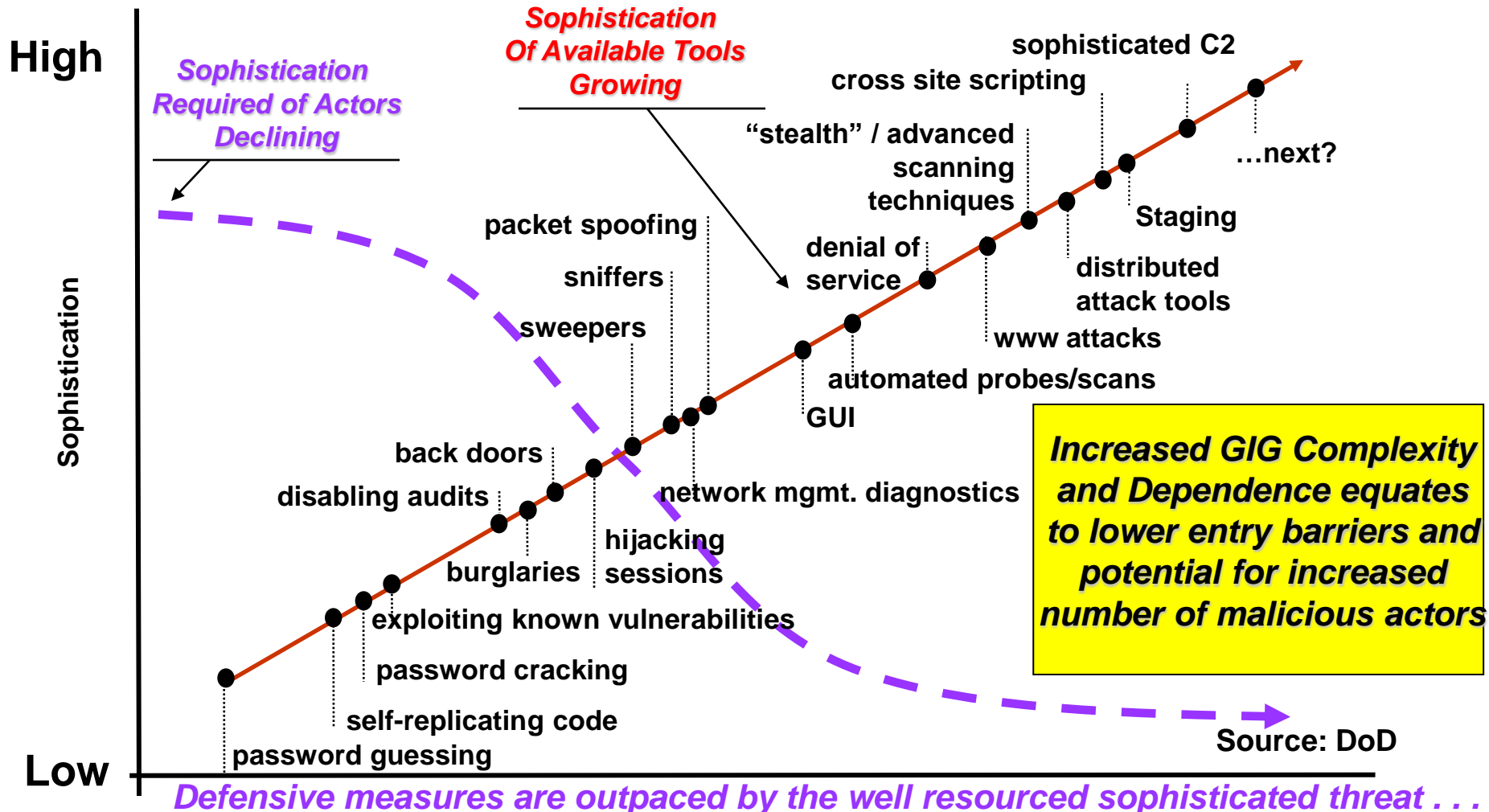
Information Technology Evolution

IC/DoD is using Wave 1& 2 acquisition & budget processes; but requires Wave 3 capability

Rate of Adoption
The Cyber Domain is Hotly Contested

High

Sophistication Required of Actors Declining

Sophistication Of Available Tools Growing

sophisticated C2

cross site scripting

"stealth" / advanced scanning techniques

…next?

packet spoofing

denial of service

Staging

sniffers

distributed attack tools

sweepers

www attacks

automated probes/scans

Sophistication

GUI

back doors

network mgmt. diagnostics

Increased GIG Complexity and Dependence equates to lower entry barriers and potential for increased number of malicious actors

disabling audits

hijacking sessions

burglaries

exploiting known vulnerabilities

password cracking

self-replicating code

password guessing

Source: DoD

Low

Defensive measures are outpaced by the well resourced sophisticated threat . . .

Software Engineering Institute | Carnegie Mellon

Cyber Compared with Other Sciences

	PHYSICAL SCIENCE	BIOSCIENCE	COMPUTER/SOFTWARE/CYBER SCIENCE
Origins/History	Begun in antiquity	Begun in antiquity	Mid-20th Century
Enduring Laws	Laws are foundational to furthering exploration in the science	Laws are foundational to furthering exploration in the science	Only mathematical laws have proven foundational to computation
Framework of Scientific Study	Four main areas: astronomy, physics, chemistry, and earth sciences	Science of dealing with health maintenance and disease prevention/treatment	• Several areas of study: computer science, software/ systems engineering, IT, HCI, social dynamics, AI • All nodes attached to/relying on netted system
R&D and Launch Cycle	10-20 years	10-20 years	Significantly **compressed**; solution time to market needs to happen very quickly

Source: SEI

HCI: Human Computer Interaction; AI: Artificial intelligence

Opportunity - 21st Century Acquisition Workforce

- Acquisition Guidance, and Training Programs Need to Be Updated to Support the 21st Century Acquisition Workforce

Silent Generation 1928-1945	Baby Boomers 1946-1964	Generation X 1965-1980	Generation Y/Millenials 1981-2000
Hard worker	Workaholic	Technically advanced	Technically savvy
Respects authority	Questions authority	Prefers informality	Embraces diversity
Work is obligation	Works efficiently	Needs structure and direction	Requires supervision
Formal communicator	Competitive	Direct/immediate communicator	Indirect/virtual communicator
Work/family separation	Little work/life balance	Seeks work/life balance	Demands work/life balance

Why are Software Intensive IT Projects Difficult?

According to Fred Brooks software projects are difficult because of accidental and essential difficulties

- Accidental difficulties are caused by the current state of our understanding
  - of methods, tools, and techniques
  - of the underlying technology base
- Essential difficulties are caused by the inherent nature of software
  - invisibility - lack of physical properties
  - conformity
  - changeability
  - complexity

Source: *The Mythical Man-Month* by Fred Brooks, Addison Wesley, 1995

Realities of Software Quality

The flowchart might correspond to a 100 LOC module with a single loop that may be executed no more than 20 times.

There are approximately 10^{14} possible paths that may be executed!

For any but the smallest programs, complete path coverage for defect detection is impractical.

Loop ≤ 20 times
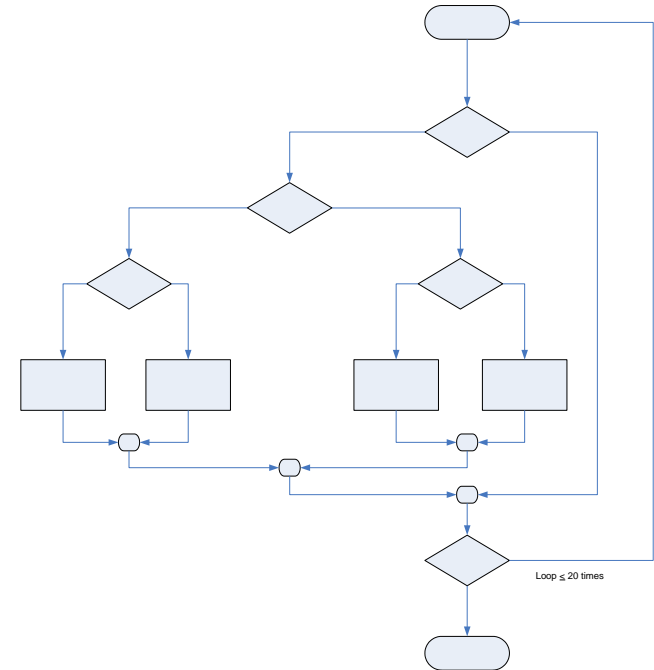
Lehman Laws:
1. The Law of Continuing Change – programs must change to be useful
2. The Law of Increasing Complexity – programs that change become more complex

Source: Adapted from Pressman, R.S., *Software Engineering: A Practitioner's Approach, Third Edition*, McGraw Hill, 1992

Software Evolution and Maintenance Cost Is Increasing

Year	Proportion of software maintenance costs	Definition	Reference
2000	>90%	Software cost devoted to system maintenance & evolution / total software costs	Erlikh (2000)
1993	75%	Software maintenance / information system budget (in Fortune 1000 companies)	Eastwood (1993)
1990	>90%	Software cost devoted to system maintenance & evolution / total software costs	Moad (1990)
1990	60-70%	Software maintenance / total management information systems (MIS) operating budgets	Huff (1990)
1988	60-70%	Software maintenance / total management information systems (MIS) operating budgets	Port (1988)
1984	65-75%	Effort spent on software maintenance / total available software engineering effort.	McKee (1984)
1981	>50%	Staff time spent on maintenance / total time (in 487 organizations)	Lientz & Swanson (1981)
1979	67%	Maintenance costs / total software costs	Zelkowitz *et al.* (1979)

Source: Jussi Koskinen, Department of Computer Science and Information Systems, University of Jyväskylä
P.O. Box 35, 40014 Jyväskylä, Finland

Federal IT Market Growth

"In the next five years, IT contractors will see the federal market for their services increase by a compound annual growth rate of 5.4 percent to a total of $111.9 billion by 2015."

-- Ben Bain
   Federal Computer Week
   April 8, 2010

Proposed Changes: Think and Perform Differently
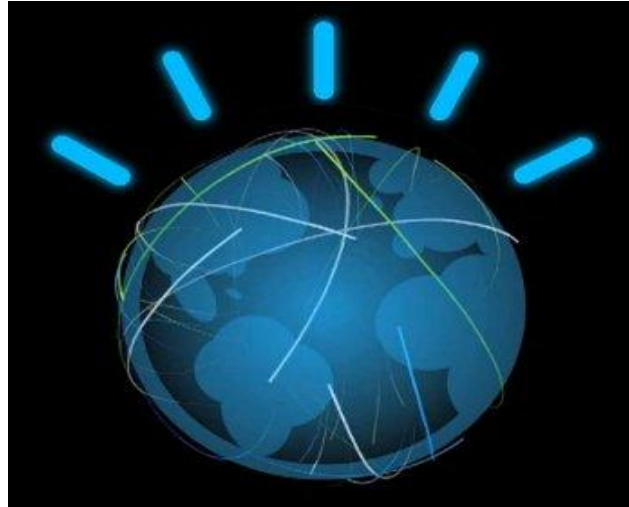
Watson's Avatar, Inspired by the IBM "Smarter Planet" Logo

**Systems Engineering is the Foundational Engineering Discipline
for IT Net-Centric Software Intensive Systems**

Source: Wikipedia - IBM Watson: The Face of Watson on You Tube

Summary

- The IT Acquisition Task Force Initiative concepts may have to be quite radical to meet the IT Acquisition Reform Guiding Principles (Section 804)
    - Deliver Early and Often – *Be responsive to the users needs*
    - Incremental and Iterative Development and Testing
    - Rationalized Requirements – *Balance user needs with constraints*
    - Flexible/Tailored Processes – *Customize to IT category*
    - Knowledgeable and Experience IT Workforce – *Understands IT uniqueness*
- Systems Engineering is the Foundational Engineering Discipline for IT Net-Centric Software Intensive Systems
- General acknowledgement that we can and must do better!

Source: A New Approach for Delivering IT Capabilities in the DoD, Report to Congress, November 2010

Wrap Up
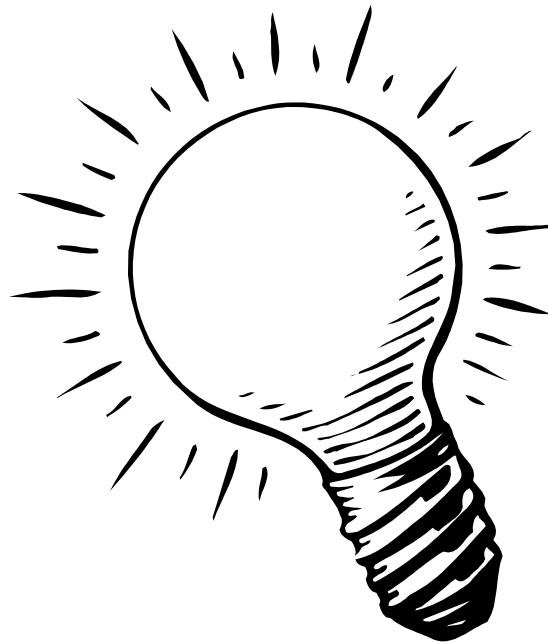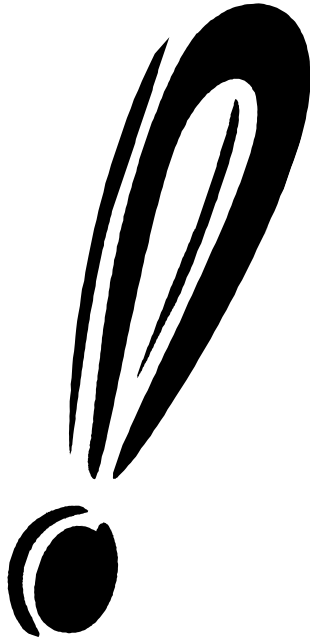
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