Leveraging Capability Maturity Model Integration for Acquisition (CMMI®-ACQ) Processes to Improve Organizational Workforce and System Acquisition Performance

Dr. Kenneth E. Nidiffer & Rick Barbour
Software Engineering Institute
Carnegie Mellon University
Pittsburgh, PA 15213
703-908-1117
Overview

• Is your organization working towards achieving acquisition excellence?
  – The application of systems-engineering to improve the workforce may be part of the answer!
• What are the rate-limiting variables/drivers that limit success?
• How can the CMMI®-ACQ model be used?
An Effective Process for Major Defense Systems – but not very agile
DOD Software Acquisition Process Improvement Programs
DoD Major Events and Leadership Rotation

Pre-Public Law Actions-SSWG

2000 2001 2002 2003 2004 2005 2006 2007 2008 2009

Army Strategic Software Improvement Program
Aug 18, 2002

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

OSD Guidance on Section 804
Mar 21, 2003

OSD Policy for Systems Engineering Forum
Established Feb 2, 2004

Air Force Software-Intensive Systems
Strategic Improvement Program
May 15, 2006

Navy Software Process Improvement Program
Jan 13, 2004

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

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

DoDD 5010.42 CPI/LSS
May 15, 2008

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

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

OSD Tri-Service Assessments Initiative
1999-2003/4

GAO Audit Reports

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

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

GAO-04-393
Follow-up Report July 2006

Gap Analysis

Software Improvement Focus

Systems Engineering Improvement Focus
DDR&E Imperatives

1. Accelerate delivery of technical capabilities to win the current fight.

2. Prepare for an uncertain future.

3. Reduce the cost, acquisition time and risk of our major defense acquisition programs.

4. Develop world class science, technology, engineering, and mathematics capabilities for the DoD and the Nation.

Source: The Honorable Zachary J. Lemnios
Director, Defense Research and Engineering
External Forces: Defense Acquisition Approach

Systems Engineering is key discipline

Source: The Honorable Zachary J. Lemnios
Director, Defense Research and Engineering

- Technology “push” investment
- Technology maturation
- Phenomenology measurements

70-75% of Cost Decisions Made Prior to Milestone A
Impact 72% of Total Life Cycle Costs

Software Engineering Institute
23 Principal Actions to Improve Efficiency within 5 Major Areas (14 September 2010)

1. Target Affordability and Control Cost Growth
2. Incentivize Productivity and Innovation in Industry
3. Promote Real Competition
4. Improve Tradecraft in Services Acquisition
5. Reduce Non-Productive Processes and Bureaucracy
DOD acquisition process is too long and too cumbersome to fit the needs of the many IT systems that require continuous changes and upgrades.

The National Defense Authorization Act for Fiscal Year 2010 ("the Act") Public Law 111 includes a significant set of legislative provisions that modify Department of Defense (DoD) procurement policies and practices.

Task Force on Department of Defense Policies and Procedures for the Acquisition of Information Technology March 2009

The National Defense Authorization Act for Fiscal Year 2010 ("the Act") Public Law 111 (Section 804)
External Forces

AT&L Civilians – Risk of Losing

Bimodal Demographics (Space Industry)

Professional Growth vs. Time

Source: DAU

54% of the S&T Workforce is
Over 45 and 33% will be retirement
eligible in 5 years

Source: LMSC

Level 1 - Acquisition Engineer
(Entry)
(minimum 1 year of experience)

Level 2 - Acquisition Engineer
(Journeyman)
(minimum 2 years of experience)

Level 3 - Systems Engineer (Expert)
(minimum 6 years of SE experience)

Level 4 - Program Systems Engineer (Master)
(minimum 10 years of SE experience)

Source: DAU

SPRDE/Systems Engineering Career Field

Source: DAU
Procurement Budget vs. DoD Acquisition Workforce

Increasing # of Procurements & Complex Systems Coupled With Huge Decrease In Acquisition Workforce
Recapture Acquisition Excellence: Revitalize The Acquisition Workforce

Problem

- Acquisition capability has slowly atrophied
- Organic Workforce reductions - 23% since 1999
  - Force shaping, reduced training, retirements of critical cost estimators, price analysts, experienced system engineers, contracting officers

Initiatives

- Recapitalize the Acquisition Corps/Training
- OSD Funding Increased Numbers and Training of Organic Acquisition Personnel

It May Not Be All About the Acquisition Workforce – But Viable Solutions Must Consider the Human Element!
Project Purpose

Use a systems engineering approach to assess acquisition training and organizational training processes for improving acquisition excellence

Experience

Workforce Attributes – Training Easiest to Manage

Training Ability
Business Motivation

Internal

• Improve organization’s performance efficiencies by putting in place trained workforce that can leverage suppliers’ capabilities to deliver quality solutions rapidly, at lower costs, and with appropriate technology

External

• President Barack Obama – Mar/May 2009
  “The government will assist agencies in assessing the capacity and ability of the Federal acquisition workforce to develop, manage, and oversee acquisitions” and Weapon Systems Acquisition Reform Act of 2009, Public Law 111-23, 22 May 2009
Summary of Systems Engineering Drivers

External Forces

• Increasing size of untrained defense acquisition workforce
• Retiring of experienced and capable workforce

Technological

• Accelerating technological changes makes systems specific acquisition training difficult at best
• Identifying future competencies to ensure most relevant training content

Human Capital

• Changing workforce demographics requiring newer methods of training and management

Client Business Environment

• Achieving acquisition excellence in a fiscally constrained environment
What Is the Cyber Environment?

Includes all

- System of Systems
- Architecture
- Services
- Netted Hardware/Platforms
- People who digitally connect to cyberspace

**Cyberspace is where our daily work and our priority missions are conducted**
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
Increasing Software Lines of Code & Complexity

Aircraft IOC, Year

KSLOC

• JSF
• UAVs
• NCW
• Inter-System Operability

UAVs
UCAV

F-35

F/A-18E/F
17101K

F/A-18C/D SMUG/
RUG 14268K

F/A-18C/D XN-8
6629K

AV-8B Radar 3748K

F-14B 2866K

EA-6B ICAP2
BLK 89 2203K

AH-1 NTS 1000K

F-14B 364K

AV-8B Night
Attack 1780K

AH-1 764K

F/A-18 Night
Attack 3054k

AV-8B 764K

F/A-18C/D 2130K

F-14D 416K

F-14B 395K

A-6E 64K

F-14 80K

E-A6B ICAP1
48K

A-7E 16K

F-14 80K

A-4 (ARBS) 16K

F-14 80K

A-6E 64K

F-14 80K

A-7E 16K
Technological: Acceleration of Innovation in the 21st Century - Facilitating Our Ability to Build Move Complex Systems

The Amount of New Technological Innovation is Doubling Every Two Years - Requires More Upfront SE/SW Engineering to Leverage Trends

**Linear vs. Exponential Growth:**

- **Exponential trend**
- **Linear trend**

*Knee of Curve*
Technological: Moore's Law Holding - The Number of Transistors That Can be Placed on an Integrated Circuit is Doubling Approximately Every Two Years
Technological: Augustine’s Law Holding - Growth of Software is an Order of Magnitude Every 10 Years

In The Beginning

F-4A 1000 LOC F-15A 50,000 LOC F-16C 300K LOC F-22 1.7M LOC F-35 >6M LOC
Technological: Increasing Rate of Adoption

Automobile = 56 years
Telephone = 36 years
Television = 26 years
Cell phone = 14 years
PC (1975)
Internet (1975)

Source: Rich Kaplan, Microsoft

Percentage of Ownership

No. of Years Since Invention

Source: Rich Kaplan, Microsoft

Technological: Increasing Rate of Adoption

Automobile (1926)
Telephone (1876)
Television (1926)
Radio (1905)
VCR (1952)
Microwave (1953)
Cell phone (1983)
PC (1975)
Internet (1975)

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Human Capital: Refocusing University Curriculums - Alignment of Software Systems Engineering

OSD Initiatives: Graduate Software Engineering Reference Curriculum (GSwERC) & Body of Knowledge and Curriculum to Advance Systems Engineering (BKCASE)

SW = Software
Human Capital: Changing Demographics

Demographics of workforce are changing and different views may emerge with four generations to consider.

Generation Y professionals entering workforce will likely necessitate non-traditional training techniques, such as virtual approaches.
## Client Business Environment: Increasingly Complex

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Commercial Software Products</th>
<th>Information Technology &amp; Internet Financial Services</th>
<th>Government Aerospace Systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Market</td>
<td>Commercial</td>
<td>Information technology &amp; internet</td>
<td>Government</td>
</tr>
<tr>
<td>Industry</td>
<td>Software</td>
<td>Financial</td>
<td>Aerospace</td>
</tr>
<tr>
<td>Packaging</td>
<td>Products</td>
<td>Services</td>
<td>Systems</td>
</tr>
<tr>
<td>Primary Output</td>
<td>Software</td>
<td>Integrated system engr &amp; HW &amp; SW &amp; network</td>
<td>Integrated system engr &amp; HW &amp; SW &amp; network</td>
</tr>
<tr>
<td>Purpose</td>
<td>User empowerment:</td>
<td>Organization/business operations</td>
<td>Mission/science capabilities</td>
</tr>
<tr>
<td></td>
<td>effectiveness, efficiency,</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>creativity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Project Duration</td>
<td>1-36 months</td>
<td>1-18 months</td>
<td>6 months - 10 years</td>
</tr>
<tr>
<td>Team Size</td>
<td>1-1000’s</td>
<td>1-1000’s</td>
<td>10’s-1000’s</td>
</tr>
<tr>
<td>Ratio of Custom to COTS/Reuse</td>
<td>Software: Low-high</td>
<td>Business logic: High Others: Low</td>
<td>All: High</td>
</tr>
<tr>
<td>Agreement</td>
<td>License</td>
<td>Service level agreement</td>
<td>Contract</td>
</tr>
<tr>
<td>Customer</td>
<td>External</td>
<td>Internal and external</td>
<td>External</td>
</tr>
<tr>
<td># Customers</td>
<td>100’s-1,000,000’s</td>
<td>1-1,000,000’s</td>
<td>1</td>
</tr>
<tr>
<td>Focus</td>
<td>Features, Time-to-market,</td>
<td>User experience, Workflow cycletime, Uptime</td>
<td>Reliability, Milestones,</td>
</tr>
<tr>
<td></td>
<td>Ship it</td>
<td></td>
<td>Interdependencies</td>
</tr>
</tbody>
</table>

Source – Northrop Grumman
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

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

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

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Systems Engineering Approach

Selected based on
- amount/type of data to be reviewed
- availability of a reference model
- requirements, logical and physical loops
- iteration and recursion activities
- access to key stakeholders

Phase 1: Identify/Collect Data
- Identify Training Courses
- Identify/Select Reference Model
- Identify Org. Training Process
- Identify Stakeholders
- Review Legacy/Current Efforts

Phase 2: Perform Gap Analysis
- Identify/Select Reference Model
- Training Class Coverage Gaps
- Organizational Process Gaps
- Framework Space Gaps

Phase 3: Formulate/Codify Findings
- Findings, Impacts, Recommendations
- Write Draft Report

Phase 4: Develop/Deliver Results
- Write Final Report
- Communicate Results and Collect Feedback

Selected based on
- amount/type of data to be reviewed
- availability of a reference model
- requirements, logical and physical loops
- iteration and recursion activities
- access to key stakeholders
Project Objectives

During assessment Phase 1 project objectives were formulated in terms of five questions:

• Do coverage gaps exist in the training of acquisition best practices?
• Do gaps exist in acquisition training on the unique aspects of the client’s system acquisitions?
• Do gaps exist in the training of the client’s acquisition lifecycle framework and processes?
• Do best-practice gaps exist in the client’s organizational training processes?
• Do gaps exist in identifying training requirements for satisfying the acquisition workforce core competencies?
Assessment Framework: CMMI®-ACQ

Operational Need

Focus on Acquisition Best Practices (Acquirer)

Development (Developer)

Plan | Design | Develop | Integrate and Test | Deliver

Operational Capabilities
# CMMI® -ACQ categories and process areas

<table>
<thead>
<tr>
<th>Category</th>
<th>Process Area</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition</td>
<td>Agreement Management (AM)</td>
</tr>
<tr>
<td></td>
<td>Acquisition Requirements Development (ARD)</td>
</tr>
<tr>
<td></td>
<td>Acquisition Technical Management (ATM)</td>
</tr>
<tr>
<td></td>
<td>Acquisition Validation (AVAL)</td>
</tr>
<tr>
<td></td>
<td>Acquisition Verification (AVER)</td>
</tr>
<tr>
<td></td>
<td>Solicitation and Supplier Agreement Development (SSAD)</td>
</tr>
<tr>
<td>Process Management</td>
<td>Organizational Innovation and Deployment (OID)</td>
</tr>
<tr>
<td></td>
<td>Organizational Process Definition (OPD)</td>
</tr>
<tr>
<td></td>
<td>Organizational Process Focus (OPF)</td>
</tr>
<tr>
<td></td>
<td>Organizational Process Performance (OPP)</td>
</tr>
<tr>
<td></td>
<td>Organizational Training (OT)</td>
</tr>
<tr>
<td>Project Management</td>
<td>Integrated Project Management (IPM)</td>
</tr>
<tr>
<td></td>
<td>Project Monitoring and Control (PMC)</td>
</tr>
<tr>
<td></td>
<td>Project Planning (PP)</td>
</tr>
<tr>
<td></td>
<td>Quantitative Project Management (QPM)</td>
</tr>
<tr>
<td></td>
<td>Requirements Management (REQM)</td>
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<tr>
<td></td>
<td>Risk Management (RSKM)</td>
</tr>
<tr>
<td>Support</td>
<td>Causal Analysis and Resolution (CAR)</td>
</tr>
<tr>
<td></td>
<td>Configuration Management (CM)</td>
</tr>
<tr>
<td></td>
<td>Decision Analysis and Resolution (DAR)</td>
</tr>
<tr>
<td></td>
<td>Measurement and Analysis (MA)</td>
</tr>
<tr>
<td></td>
<td>Process and Product Quality Assurance (PPQA)</td>
</tr>
</tbody>
</table>

CMMI® -ACQ model was developed to codify best practices to help organizations improve acquisition processes.

CMMI® reference models have gained significant traction across commercial and defense community and are widely used throughout world [CMMI Product Team 07]
Summary of Results

- Strengths
- Areas for Improvement
- Lessons Learned
Results – General Overall Strengths

• Excellent coverage in the training of acquisition best practices
• Adequate number and variety of course offerings
• Simple but adequate training facilities
• Consistency of course material & presentation layout & style
• Variety of media used for announcing upcoming courses
• Scope and breath of Earned Value programs
• Knowledgeable SME* teach classes
• Talented instructor workforce
• Intelligent student population
• Professionalism of the training staff
• Desire to improve

*SME = Subject Matter Expert
# Representative Results: Question 1

## Question 1: Do Coverage Gaps Exist in the Training of Acquisition Best Practices?

### Findings

- Detailed findings awaiting client approval

### Impacts

- Missing opportunities to
  - attract more students
  - provide training on the most relevant issues
  - effectively plan
  - save resources
  - provide a richer variety of courses
  - continuously improve training processes

### Recommendations and Considerations

- Conducting a review to assess use of web-based and non-traditional acquisition training
  - **Consider:** Leveraging of efforts by DAU, commercial industry and academia

- Conducting a review of best practices for training among different types of acquisitions
  - **Consider:** Developing and teaching approaches that focus on agile and SOA acquisition approaches

- Making a better use of repository information
  - **Consider:** Using DAU’s Acquisition Best Practices

- Putting a systematic process improvement program in place
  - **Consider:** Using CMMI-ACQ and IDEAL

- Developing a strategic plan
  - **Consider:** Socializing plan among relevant stakeholders
## Results

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Findings</td>
<td>25</td>
</tr>
<tr>
<td>Impacts</td>
<td>20</td>
</tr>
<tr>
<td>Recommendations</td>
<td>23</td>
</tr>
<tr>
<td>Considerations/ Potential Solutions - ways to address some of the recommendations</td>
<td>40</td>
</tr>
</tbody>
</table>

*Systematic Improvement in Client’s Organizational Training Processes Needed*
Lessons Learned

• Tsunami-like impacts on new acquisition training requirements
  • Rapid, large-scale disturbance of current training needs envisioned
  • Forces will include technological, human capital, external and government needs
• Training departments have incorporated best acquisition practices into their training courses; however
  • Mapping of core competencies to training courses needs to be done
  • Training architectures needed
• Developers of organizational training processes could benefit from the application of systems engineering

Images of the Ocean Floor

Tsunami
Wrap Up
Contact Information

Dr. Kenneth E. Nidiffer, Director of Strategic Plans for Government Programs

Software Engineering Institute, Carnegie Mellon University
Office: +1 703-908-1117
Fax: +1 703-908-9317
Email: nidiffer@sei.cmu.edu
Systems Engineering Drivers for Improving Acquisition Excellence

- External Forces
- Technological
- Human Capital
- Client Unique
External Forces

Notional DoD Systems Engineering Workforce Strategy

Workforce Size

Develop / Train and Retain

Recruit: Interns
Recruit: Journeymen
Recruit: Retired Military
Recruit: SE FFRDCs
Recruit: Highly Qualified Experts
Develop / Train: Mentors

Workforce Age

Source: OSD (DDR&E)
Reference Model

Evaluated client’s acquisition training program components using Capability Maturity Model Integration® for Acquisition (CMMI® -ACQ) as reference model
Human Capital: Using Core Competencies

Accurate identification of required competencies are important to support the curriculum review and development effort needed to ensure the best and most relevant training.

<table>
<thead>
<tr>
<th>Competency Family</th>
<th>Software Engineering</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge</td>
<td>Application domain, Procedural design, Cobol &amp; Assembler, Numerical analysis</td>
</tr>
<tr>
<td>Skills</td>
<td>Requirements analysis, System design, Project management, Debugging</td>
</tr>
<tr>
<td>Process Abilities</td>
<td>Integrated team design, Fagan inspections, Test procedures, Change control</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Competency</th>
<th>Staffing by Capacity Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>Current Staffing Level Needed</td>
<td></td>
</tr>
<tr>
<td>Software Engineer</td>
<td>I</td>
</tr>
<tr>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td>User Training</td>
<td>2</td>
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<table>
<thead>
<tr>
<th>Competency</th>
<th>2010 Staffing Level Needed</th>
</tr>
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<tbody>
<tr>
<td>Software Engineer</td>
<td>I</td>
</tr>
<tr>
<td>31</td>
<td>35</td>
</tr>
<tr>
<td>User Training</td>
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