Process Improvement and CMMI®
- Developing Complex Systems-
Using CCMI® to Achieve Effective Systems and Software Engineering Integration

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November 17-20, 2008
Hyatt Regency Tech Center
Denver, Colorado
Theme: Investigation, Measures, and Lessons Learned About the Relationship Between CMMI® Process Capability and Project or Program Performance.

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**Process Improvement and CMMI: Developing Complex Systems Using CMMI to Achieve Effective Systems and Software Engineering Integration**

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**Approved for public release; distribution unlimited**

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- Report: Unclassified
- Abstract: Unclassified
- This Page: Unclassified

**Limitation of Abstract:** Same as Report (SAR)

**Number of Pages:** 27
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

• Integration Trends
  – Development
  – Mission
  – Technology
  – Engineering
  – Risk

• CMMI Benefits

• Ten Future Trends

• Wrap-up

Development Complexity
Need for Space, Air, Ground, Water, Underwater Software-Intensive Systems to be Integrated

- 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
Need for Mission Integration

Less a Matter of Hitting a Window

And More a Matter of The Right Window - Right Now
### Software Engineering Trends That Impact Systems Engineering

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

**Emerging Dynamics of Bringing Systems and Software Engineering in Continued Partnership**
The Acceleration of Innovation in the 21st Century:

- Facilitating Our Ability to Integrate

- The Amount of New Technological Innovation is Doubling Every Two Years
- Requires More Upfront SE/SW Engineering to Leverage Trends
Facilitating Integration: Augustine’s Law - Growth of Software is an Order of Magnitude Every 10 Years

In The Beginning

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>F-4A</td>
<td>F-15A</td>
<td>F-16C</td>
<td>F-22</td>
<td>F-35</td>
</tr>
<tr>
<td>1000 LOC</td>
<td>50,000 LOC</td>
<td>300K LOC</td>
<td>1.7M LOC</td>
<td>&gt;6M LOC</td>
</tr>
</tbody>
</table>

In The Beginning...
Facilitating Integration: Given Augustine’s Law Holds

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.
Facilitating Integration: Moore's Law - The Number of Transistors That Can be Placed on an Integrated Circuit is Doubling Approximately Every Two Years
Facilitating Integration: Increased Technological Rate of Adoption

- Automobile = 56 years
- Television = 26 years
- Telephone = 36 years
- Cell phone = 14 years
- PC = 20 years
- Internet = 30 years
- VCR = 30 years
- Microwave = 30 years
- Radio = 50 years
- Electricity = 100 years
- Telephone = 100 years

Source: Rich Kaplan, Microsoft
Management Integration: Life of a Program Manager in a System of Systems Operation…
Relationship Between Integration Complexity and Acquisition Success Improving and More Improvements are on the Way But …..

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
Integration Challenges: Some Drivers That Increase the Risk of Engineering Software-Intensive Systems

- **Platform** → **Enterprise**
  - Customer Emphasis

- **Requirements** → **Objectives/Capabilities**
  - Acquisition Model

- **Dominant Prime** → **Strategic Teaming**
  - Program Execution

- **“Boxes”** → **“Layers & Stacks”**
  - Integration Challenge

- **Proprietary** → **Plug & Play**
  - Architectures and Standards

*Need Exists to Address Both Sides, and Do So with Compressed Delivery Schedules via Improvements in Systems/Software Engineering*
CMMI ® Product Integration (PI)

Purpose

Assemble the product from the product components, ensure that the product, as integrated, functions properly, and deliver the product.

Source: SEI CMMI® Training Material
Two Representations – Focus at Higher Maturity May Be Different Depending on Representation

Continuous (More PA Focused)

- for a single process area or a set of process areas

Staged (More Business Focused)

- for a specified set of process areas across an organization

Source: SEI CMMI® Training Material
## Staged Representation: PAs by Maturity Level

<table>
<thead>
<tr>
<th>Level</th>
<th>Focus</th>
<th>Process Areas</th>
</tr>
</thead>
</table>
| 5 Optimizing  | Continuous Process Improvement | Organizational Innovation and Deployment  
                                    Causal Analysis and Resolution  |
| 4 Quantitatively Managed | Quantitative Management               | Organizational Process Performance  
                                    Quantitative Project Management |
| 3 Defined     | Process Standardization | Requirements Development  
                                    Technical Solution  
                                    Product Integration  
                                    Verification  
                                    Validation  
                                    Organizational Process Focus  
                                    Organizational Process Definition +IPPD  
                                    Organizational Training  
                                    Integrated Project Management +IPPD  
                                    Risk Management  
                                    Decision Analysis and Resolution |
| 2 Managed     | Basic Project Management | Requirements Management  
                                    Project Planning  
                                    Project Monitoring and Control  
                                    Supplier Agreement Management  
                                    Measurement and Analysis  
                                    Process and Product Quality Assurance  
                                    Configuration Management |
| 1 Initial     |                        |                                                                              |

Source: SEI CMMI® Training Material
Run Chart - Definitions

- **Upper Control Limit (ULC)**
- **Lower Control Limit (LCL)**
- **Business Objective - Voice of Business**
- **Voice of Process, Common Cause of Variation, Current Voice of Business**
- **Special Cause of Variation**
- **Data**
- **Voice of Customer**
- **Time**
Focus on Business Objectives
CMMI® Provides a Framework for Software and System Engineering to Become More Integrated

System Analysis

System Design

Software (SW) Requirements Analysis

Architectural SW Design

Detailed SW Design

SW Subsystem Testing

Code and Unit Test

SW Systems Engineering (SE)

SW System Testing

SW Integration Testing

SW Systems Engineering

Systems Engineering

Systems Engineering

Software Engineering

SW Systems Engineering

Systems Engineering
Prior to Product Integration – Left Side of Vee Chart
Integration Management By Business Objectives

SYSTEM of SYSTEMS

Enterprise Perspective

Mission
Function
Products
System

Change Management
Configuration Control
Authority
Existing Configuration
Systems Integration Management
User Requirements
Policy & Direction

Enterprise Managers

SYSTEM of SYSTEMS

System A
System B
System N

Operational

Mission
Function
Products
System

Traceability

DoD
Service
Command
Policy & Standards Compliance

Operational

Mission
Function
Products
System

Traceability

DoD
Service
Command
Policy & Standards Compliance
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

Ref: Jim Smith, (703) 908-8221, jds@sei.cmu.edu
Systems and Software Engineering: Ten Trends

• Greater integration 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 more integrated work environment (7 by 24, any shore)

• Increased reliance on systems and software engineering processes and technologies to effectively manage integration issues

• The laws of Augustine’s and Moore will continue to hold and will continue to be a forcing function to facilitate the need for integration
Systems and Software Engineering: Ten Trends

• Improvements risk-reduction collaboration mechanisms will be significant enablers for increases in systems and software engineering communication and “decision velocity”

• Systems and software engineers will continually find way to innovative to reduce integration issues

• Increased importance of modeling and simulation

• Increased business focus for system and software engineering integration

• Shift of systems and software engineering focus from the platform to integrated networks and ground systems

• Use of CMMI-Dev will continue to be important!
Questions?
Recommended Readings


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


Kurstedt, Harold and Pamela, *Systems and Software Engineering Interfaces, Dealing with the Bumpy Roads*,


