Adjusting Software Life-Cycle Anchorpoints
Lessons Learned in a System of Systems Context

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Case 09-9041. 11 March 2009.
Agenda

• Overview/Introduction

• Concept of the SoS LCA

• Establishing Focus Area Priority

• Results of Data Analysis

• Conclusions

• Epilogue
Introduction

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Introduction – Software Review Basics

• Schedule and/or Event driven reviews are key to any major software development project

• Different reviews provide different benefits
  – Producibility
  – Capability
  – Integration and Test
  – Schedule
What is Future Combat Systems (FCS)?

• FCS is the Army’s modernization approach

• Utilizes a unique organizational structure utilizing the concept of a Lead System Integrator (LSI) to manage a collection of “best of industry” defense contractors

• Currently finishing a round of platform and network Preliminary Design Reviews (PDRs) and preparing for a System of Systems PDR (SoS PDR)

• Developing cutting-edge software and network functionality to provide increased capability to the Soldier
FCS Review Structure

• FCS Software is developed via several incremental builds

• Each build with its own set of software review events with specific foci:
  – Evaluation of functionality to be developed in software build against cost and schedule resources
  – Development of delivery, integration, and test timelines and criteria
  – Review of requirements and interface maturity
  – Horizontal and vertical integration of capabilities and requirements

• Each review is limited in scope to only apply to the current software build

• There was a need for the program to provide an overall assessment of the software development effort

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Existing Software Review Events

• Two main levels of events are utilized for each FCS software build, one set for individual software packages and another for integrated software builds

• Individual software package reviews
  – Life Cycle Objective
  – Life Cycle Architecture

• Integrated software build reviews
  – Build Definition Checkpoint
  – Build Planning Checkpoint
  – Build Readiness Checkpoint
  – Build Assessment Checkpoint

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# Software Package Review Event Overviews

<table>
<thead>
<tr>
<th>Event Name</th>
<th>Level of Review</th>
<th>Purpose of Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build Definition Checkpoint</td>
<td>Integrated software build</td>
<td>Present, discuss and agree on SoS level build plan and capabilities to be developed in this build.</td>
</tr>
<tr>
<td>Life Cycle Objective</td>
<td>Individual software package</td>
<td>Developers demonstrate understanding of the requirements and capabilities they need to provide in this build. Show understanding of the architecture and the ability to provide software within budget and schedule constraints.</td>
</tr>
<tr>
<td>Build Planning Checkpoint</td>
<td>Integrated software build</td>
<td>Roll-up of all artifacts presented at individual LCOs. Emphasis on horizontal integration of individual software package development.</td>
</tr>
<tr>
<td>Life Cycle Architecture</td>
<td>Individual software package</td>
<td>Focuses on design and prototype activities as well as analysis of the ability of software design to meet KPPs.</td>
</tr>
<tr>
<td>Build Readiness Checkpoint</td>
<td>Integrated software build</td>
<td>Considered the most important of checkpoint reviews. Serves as commitment based on available evidence and data that capabilities for this build can be developed, tested, and delivered within existing budget and schedule limitations.</td>
</tr>
<tr>
<td>Build Assessment Checkpoint</td>
<td>Integrated software build</td>
<td>Focused on reviewing integration and test results and establishing lessons learned.</td>
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Need for an SoS LCA

• Existing events provide quality insight into the development plans and results of individual software builds

• Focus on evaluating design, architecture and requirements to develop a solution that should meet program needs

• However, very little emphasis on integrated quantitative modeling, simulation and test evidence reviews and evaluations to determine if the resultant software is going to meet program needs

• None of the events provide a review of the entire FCS software effort, but rather reviews of focused pieces of that effort

• There existed a need for an over-arching review of the results of the software development effort to date
Concept of the SoS LCA
Concept of the SoS LCA

• SoS LCA attempts to focus on test data and results (as well as a software producibility analysis) to evaluate current capability of the FCS software effort and project ability to meet program software capability needs

• This evaluation and forward projection of capability development ability of the FCS program will be a key feeder to the program SoS PDR event as well as Milestone C evaluation

• Event differs from existing FCS software reviews in that the SoS LCA focus is almost entirely on existing data and results, rather than plans

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SoS LCA Areas of Review

• Due to the size and scope of the FCS software development effort, narrowing down areas of review for the SoS LCA was a challenge in itself.

• Tried to select areas (called “Focus Areas” by the review team) that would have impacts to the widest range of FCS IPT development efforts.

• Focus areas selected were not necessarily risk areas, but just crucial to the successful development of the FCS software package.

• Evaluation of each focus area wasn’t just on the status of that area, but the impact of that status on the entirety of the FCS software development effort.

• Goal was to have a true System of Systems software evaluation.

• If result of evaluation was less than current program plan, the analysis was to be accompanied by recommendations to resolve or mitigate any issues going forward, to provide the most capability possible to FCS.
## SoS LCA Focus Areas

<table>
<thead>
<tr>
<th>Focus Area</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Producibility</td>
<td>Analysis of FCS software against cost and schedule models with acknowledgement that the scope and size of the FCS software effort is larger and more complex than most other projects.</td>
</tr>
<tr>
<td>End-State Design</td>
<td>Determination of whether the End State design will meet Operational needs with a focus on FCS KPPs.</td>
</tr>
<tr>
<td>Software Performance</td>
<td>Analysis of the processes for developing and testing software products, their effectiveness in testing requirements, and of the performance efficiency of the software.</td>
</tr>
<tr>
<td>Information Assurance and Security</td>
<td>Review of the status of efforts to develop and test FCS IA components, and a determination of the attainment of necessary functional capabilities</td>
</tr>
<tr>
<td>Distributed Information Management</td>
<td>Effectiveness of data communications between platforms and systems over the FCS network, analysis of data reliability, latency, etc.</td>
</tr>
<tr>
<td>Distributed Fusion Management</td>
<td>Analyze effectiveness of utilizing several sources to gather and distribute fusion data, includes network usage, data reliability, latency, accuracy, etc.</td>
</tr>
<tr>
<td>Network Management</td>
<td>Review of current status of development of the Network Management system, as well as analysis of the current state of general network management issues.</td>
</tr>
<tr>
<td>Modeling &amp; Simulation</td>
<td>Analysis of the process used to develop modeling and simulation test environments and supplemental functionality.</td>
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De Facto Review of Program Needs

- Due to SoS LCA review team resources, list of focus areas to be reviewed had to be narrowed down

- As a result of this, top-level analysis of the impacts to the FCS program of candidate focus areas were reviewed

- Result was a review of major software issues facing the program and an assessment of the level of impact they had on the software development effort

- Querying of all program IPTs for key software related issues provided not just focus areas for the SoS LCA, but an overall assessment and review of all program software review efforts

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Resultant Lower Level Analysis

- While not chosen, these areas were reviewed in the process of selecting the SoS LCA focus areas and were part of the final review event analysis.

<table>
<thead>
<tr>
<th>General Review Area</th>
<th>Comment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Software Interfaces</td>
<td>Via review of IA, security, and software performance, amongst others, necessitated a review of software interfaces. This included interface requirements and capabilities, as well as interface definition sessions and their effectiveness within the FCS software development effort.</td>
</tr>
<tr>
<td>Hardware Availability and Performance</td>
<td>While focus of the event was on software development, any software review on FCS must come with an accompanying understanding of hardware capability and delivery schedules. Tested and available hardware are necessary for any FCS operational software test.</td>
</tr>
<tr>
<td>Lessons Learned</td>
<td>Review of already completed test events provided ability to examine after-action reports and lessons learned from each event, providing additional insight on issues the SoS LCA could address</td>
</tr>
<tr>
<td>Integration Efforts</td>
<td>Through research to find available FCS test data came a review of how well FCS integration efforts were operating. This included having proper personnel and equipment as well as properly defined plans, processes and adequate time.</td>
</tr>
</tbody>
</table>
Establishing Focus Area Priority
Laying Foundation for Analysis

• In order to prepare for the analysis and presentation of eventual results, it was necessary to establish a hierarchy of focus area priority

• Result was that all focus area analyses would be rolled up as part, but not the entirety, of the Software Producibility and End-State Design focus areas

• The Producibility and End-State areas would provide the overarching FCS software review from a budget and production standpoint and a technical standpoint respectively
Software Producibility Concept

• Unlike hardware, the software producibility costs for later increments tend to increase due to previous increment breakage as well as increased integration and test costs.

• Using hardware-like estimates for future software increment producibility projections would lead to severe underestimation.

• To calibrate software estimates involves measurement of producibility data from early increment software deliveries.

• The complexity and size of a program such as FCS further compounds the problem.
End-State Design Concept

• Perhaps the most ambitious of the focus areas, as the depth of what this area attempted to address was unprecedented on the program.

• Attempting to determine if the end state of FCS software at completion truly supports operational needs based upon currently available data, documentation and plans.

• Decision was to base analysis around ability to realize all FCS KPPs.

• Analysis was conducted through the use of Software Engineering Institute (SEI) assurance case methodology.
Assurance Case Example

C: Dependable System
System X meets its
dependability
requirements

S: Dependability
Types
Argue over the relevant
dependability attributes

Cttx: Dependability
Requirements
Top level dependability
requirements are specified in
document X. Derived
requirements are specified in
document Y, version n.

C: Reliability
The relevant reliability
requirements are satisfied

C: Availability
The relevant availability
requirements are satisfied

C: Security
The relevant security
requirements are satisfied

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Courtesy of SEI: <http://www.sei.cmu.edu/pcs/acprep.html>
Results of Data Analysis

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Preliminary Assessment

• Initial analysis of producibility and end-state focus areas (including the roll ups of other areas) indicated several areas of the FCS software development areas where key changes should be made

• Gaps in design, architecture and requirements coverage were identified

• A path to reach necessary capability in time for a Milestone C decision was identified

• Existing software reviews had specific artifacts and criteria to review, by being able to define appropriate and relevant criteria the SoS LCA gave the freedom to independently assess areas critical to FCS success

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Conclusions

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Value of the SoS LCA

• Both the depth and breadth of analysis of this software review event far exceeded other software-specific review events on the program

• The broad, multi-build SoS view, in conjunction with the individual system or individual build software reviews provide an excellent assessment of the current state of the FCS software development effort

• New areas of analysis provided insight into areas of the software development program that had never had an in-depth review

• Overall, the SoS LCA was a success both as a new piece to the FCS software review puzzle, but more importantly in providing a solid functional baseline for FCS software leading into SoS PDR

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Epilogue
The Payoff

• Recommended changes to program processes and evaluations were proposed and are being developed

• Analyses not only helped discover problem areas, but also recognized software packages that were meeting or exceeding expectations
  – This latter category provided guidelines for recommended paths forward for other software packages

• Rather than mere action items to be tracked to answer specific questions, the SoS LCA provides new direction for certain program areas; more details and greater program benefit
References


Backup

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FCS Integrated Network

- Networked Sensors
- Commonality

FCS(BCT) Network

GLOBAL INFORMATION GRID

LANDWARNET

Sensors

- Battle Command and Control, Intelligence, Surveillance, and Reconnaissance (B2ISR), Embarked Training, and Decision

APPLICATIONS

- Common Warfighter Interface Display in FCS
- Provides relevant and timely battlefield info
- Provides combined arms presentation
- Reduces training demands

NETWORK OPERATIONS

- Platform integration
- Tactical Network Integration
- Strategic Network Integration
- Battle Command Integration

TRANSPORT (Transported Services)

- Provides secure, reliable access
- Infrastructure enables dynamic networking to enable mobile formations
- Open infrastructure
- Connectivity

STANDARDS

- Foundation of the FCS-BCT framework
- Provides framework to enable

INFORMATION MANAGEMENT

- Information assurance, interoperability, etc.

SERVICE

- Vehicle

SOSTEO

- Role Based Access
- Information Assurance
- Interoperability

JTRS GMR

- Network-enabled Battle Command on the Move
- Timeliness of Information To Squad Level in Seconds
- Units “Self-synchronize” as They Re-establish Network Connectivity

JTRS HMS

WIN-T JCIS

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FCS Brigade Combat Team...

Manned Ground Vehicles (MGV)

- Mounted Combat System (MCS) XM1202
- Infantry Combat Vehicle (ICV) XM1206
- Command and Control Vehicle (C2V) XM1209

Unmanned Aircraft Systems (UAS)

- Class I Unmanned Air Vehicle (UAV) XM 156
- Class IV Unmanned Air Vehicle (UAV) XM 157

Unattended Systems

- Centralized Controller

Unmanned Ground Vehicles (UGV)

- Non-Line of Sight Cannon (NLOS-C) XM1203
- Non-Line of Sight Mortar (NLOS-M) XM1204
- Field Recovery and Maintenance Vehicle (FRMV) XM1205
- Medical Vehicle Treatment (MV-T) XM1208
- Medical Vehicle Evacuation (MV-E) XM1210
- Armed Robotic Vehicle – Assault Light (ARV-AL) XM1219
- Multifunctional Utility/Logistics and Equipment Countermine and Transport (MULE-C) XM1218
- Small UGV (SUGV) XM1216
- MULE-T XM1217

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Acronyms

- BAC – Build Assessment Checkpoint
- BCT – Brigade Combat Team
- BDC – Build Definition Checkpoint
- BPC – Build Planning Checkpoint
- BRC – Build Readiness Checkpoint
- FCS – Future Combat Systems
- IA – Information Assurance
- IEEE – Institute of Electrical and Electronics Engineers
- IPT – Integrated Product Team
- KPP – Key Performance Parameter
- LCA – Life Cycle Architecture
- LCO – Life Cycle Objective
- LSI – Lead System Integrator
- MGV – Manned Ground Vehicle
- MS C – Milestone C
- PDR – Preliminary Design Review
- PM – Program Manager
- SDP – Software Development Plan
- SEI – Software Engineering Institute
- SoS – System of Systems
- UAV – Unmanned Aerial Vehicle
- UGV – Unmanned Ground Vehicle
- USC – University of Southern California