Analysis of LSI Activity Areas and Decision Making Processes

Jo Ann Lane
jolane@usc.edu
University of Southern California
Center for Software Engineering

Outline

• Goal of Research
• Background
  – What is a System-of-Systems?
  – What is a Lead System Integrator?
  – Scope of Proposed SoS Cost Model
• Analysis Findings
  – Key LSI activities and issues at the SoS level
  – Impact of key activities and issues on traditional system and software development processes
  – Observations on how system and software development processes are adapting to the SoS environment
  – How these activities differ from more traditional EIA 632 system engineering activities
• Summary and Future Plans
Goal of Research

• Develop a cost model to
  – Support the estimation of effort for System-of-System (SoS) Lead System Integrators (LSIs)
  – Complement the other USC CSE cost models for software development, system engineering (SE), and Commercial-Off-the-Shelf (COTS) integration, leading toward a more comprehensive and unified cost model to support the much broader system of interest life cycle

What is a “System-of-Systems”?

• Very-large systems developed by creating a framework or architecture to integrate
  – Existing systems
  – Systems currently under development
  – New systems to be developed
• SoS system components independently developed and managed
• Business Domain: enterprise-wide integration and sharing of core business information across functional and geographical areas
• Military Domain: dynamic communications infrastructure to support operations in a constantly changing, sometimes adversarial, environment
• SoS activities often planned and coordinated by a Lead System Integrator (LSI)
What is a “Lead System Integrator”?

- Organization (or set of organizations) selected to oversee the definition, development and integration of an SoS
- Typical activities
  - Lead concurrent engineering of requirements, architecture, and plans
  - Identify and evaluate technologies to be integrated
  - Conduct source selection
  - Coordinate supplier activities and validate SoS architecture feasibility
  - Integrate and test SoS-level capabilities
  - Manage changes at the SoS level and across the SoS-related IPTs
- Typically do not develop system components to be integrated (possible exception: SoS infrastructure)

Scope of Proposed SoS Cost Model

- Characteristics of SoSs supported by cost model
  - Strategically-oriented stakeholders interested in tradeoffs and costs
  - Long-range architectural vision for SoS
  - Developed and integrated by an LSI
  - System component independence
- Size drivers and scale factors
  - Based on product characteristics, processes that impact LSI effort, and LSI personnel experience and capabilities
Key SoS Activities and Issues

- **LSI Activities**
  - Concurrent SoS scoping, planning, requirements, architecting
  - Source selection
  - Teambuilding, re-architecting, feasibility assurance with selected suppliers
  - Incremental acquisition management
    - Development
    - Integration and test
  - Continuous change, risk, and opportunity management

- **Issues**
  - Number of stakeholders
  - Number of development organizations
  - Number of parallel, independent (or not so independent) developments
  - Impacts of non-SoS related system component changes
  - Length of decision chains
  - Cross-cutting risks vs. system component level risks

Impact of Key Activities and Issues on Traditional Processes

- **Key LSI activities in the CMMI® Project Management process category**
  - Project Planning
  - Project Monitoring and Control
  - Supplier Agreement Management
  - Integrated Project Management
  - Risk Management
  - Integrated Teaming
  - Quantitative Project Management

- **Potential Impacts**
  - Traditional planning and scheduling
    - May lead to unacceptably long schedules
    - Must integrate inputs from different organization processes
  - Traditional oversight spreads key personnel too thin
  - Need more emphasis on contracting
    - Incentives
    - Participatory change management
  - Standardization of all processes may be overwhelming
  - Decision making process
    - Involves considerably more organizations
    - Much more complex and time-consuming—may have significant impacts on overall schedule
  - Risk management for cross-cutting risks needs to cross organizational boundaries
Impact of Key Activities and Issues on Traditional Processes (continued)

- Key LSI activities in the CMMI® Engineering process category
  - Requirements Development
  - Requirements Management
  - Technical Solution
  - Product Integration
  - Verification
  - Validation

- Change in traditional engineering focus
  - Requirements: primarily at the SoS level and only address the system components with respect to their integration into the SoS framework
  - Requirements changes: continual renegotiation across users and suppliers
  - Know when not to system engineer
  - SoS technical solution, product integration, verification, and validation focuses primarily on the communications between the system components
  - Other system component technical solutions, integration, verification, and validation activities are the responsibility of the system component “owner”
  - LSI may or may not be responsible for actual development of system components for the SoS

Observations on How Processes Are Adapting to the SoS Environment

- Traditional planning and scheduling
  - Plan activities as independent projects
    - Requires that up-front SoS architecting be performed in sufficient detail to allow sub-projects to be somewhat independent of each other
    - Requires that risk-driven processes be used to identify and manage risks early at SoS and sub-project levels
  - Blend traditional processes with more agile processes
    - Plan for stabilized evolutionary increments
    - Concurrently have agile change/risk/opportunity team
      - Performs acquisition intelligence/surveillance/reconnaissance functions
      - Rebaselines future increment solutions
    - Competing priorities: use stakeholders to negotiate priorities with other on-going system component enhancements and maintenance
Observations on How Processes Are Adapting to the SoS Environment (continued)

- Project monitoring and control
  - Minimize impacts on key personnel
  - Prioritize oversight areas
- Integrated project management
  - Identify key cross-cutting processes for standardization
  - Allow flexibility in other areas
    - Let organizations to use their own proven processes
    - Supplier organizations have been selected by the independent system component “owner” for their technical expertise and ability to produce
- Decision making process
  - Need to reduce to the extent possible
    - Length of decision chain: number of required SoS-level decisions
    - Number of clearances required for each decision
  - Studies indicate that the probability of success decreases as the number of required decision clearances increases

Observations on How Processes Are Adapting to the SoS Environment (continued)

- Risk management
  - Cross-cutting risks need to be managed and balanced across system and organizational boundaries
  - Each risk needs a responsible “owner” and committed suppliers
  - Risk portfolios and “owners” to manage cross-cutting risks
- Integrated product teams typically play a much larger role and have more responsibilities
- The people processes are at least as important as the technical processes
  - Personal, organizational, and political motivations and priorities can impact the success of the project
Summary of EIA/ANSI 632 Analysis

- EIA/ANSI 632 process areas
  - Acquisition and supply
  - Technical management
  - System design
  - Product realization
  - Technical evaluation

Summary of EIA/ANSI 632 Analysis (continued)

- Summary of findings
  - In general, all EIA/ANSI 632 tasks are applicable to LSI efforts
  - Some process areas/tasks are similar to SE focus
  - Some process areas/tasks have narrower focus than more traditional SE activities
  - Some tasks are a much larger percentage of the overall LSI effort than the more traditional SE task
  - Some activities are distributed between the LSI and the system component supplier organizations
Summary

• Initial analysis of LSI activities shows
  – LSI focus is more on SoS
    • Architecture
    • Management
    • Technical oversight
  – LSI effort is often more than corresponding SE effort
due to cross-organizational interactions
  – More traditional SE activities will often not achieve the
desired goals in the desired timeframe for larger SoSs

Summary (continued)

• Initial analysis of LSI activities shows *(continued)*
  – EIA/ANSI 632 tasks do not adequately reflect the scope and
    importance of
    • People processes
      – Multi-supplier coordination
      – Potentially conflicting goals and priorities between LSI stakeholders and
        system component stakeholders
      – Complex decision making process
      – Organizations working as a team instead of competitors
    • Standards development for current and future components
    • Continuous and timely change, risk, and opportunity management
  – Data collection and analysis to better quantify findings still
    in early stages
Future Plans

- Workshop this week
  - Complete Delphi survey to better determine the differences between LSI activities and more traditional SE activities
  - Discuss factors that cause more/less work to complete LSI activities
- Use information to determine
  - Is an LSI cost estimation model really different than COSYSMO that estimates system engineering effort?
  - If so, how are the drivers and scale factors different?

Backup Slides
### EIA/ANSI 632 Analysis

**EIA/ANSI 632 Task** | **SoS LSI Focus**
--- | ---
1. Product Supply | Similar to SE focus
2. Product Acquisition | Similar to SE focus
3. Supplier Performance | Major activity for LSI
4. Process Implementation Strategy | Major LSI responsibility
5. Technical Effort Definition | Major LSI responsibility
6. Schedule and Organization | Similar to SE focus at SoS level
7. Technical Plans | System component “owners” and suppliers have primary responsibility at the SoS component level
8. Work Directives | Similar to SE focus at the SoS level
9. Progress Against Plans and Schedules | System component “owners” and suppliers have primary responsibility at the SoS component level

### EIA/ANSI 632 Analysis (continued)

**EIA/ANSI 632 Task** | **SoS LSI Focus**
--- | ---
10. Progress Against Requirements | Performed at the SoS level
11. Technical Reviews | Performed at the SoS level
12. Outcomes Management | Key reviews defined for suppliers, other supplier reviews managed at the supplier level
13. Information Dissemination | Performed at the SoS level
14. Acquirer Requirements | Performed at the SoS level
15. Other Stakeholder Requirements | Performed at the SoS level
16. System Technical Requirements | Responsibility of the supplier to integrate with other requirements from other system component stakeholders
17. Logical Solution Representations | Key activity at the SoS level
18. Physical Solution Representations | Responsibility of the supplier to integrate with other system component requirements
<table>
<thead>
<tr>
<th>EIA/ANSI 632 Task</th>
<th>SoS LSI Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>19. Specified Requirements</td>
<td>LSI responsible at the SoS framework level</td>
</tr>
<tr>
<td>20. Implementation</td>
<td>System component suppliers responsible at the system component level</td>
</tr>
<tr>
<td>21. Transition to Use</td>
<td>LSI responsible at the SoS framework level</td>
</tr>
<tr>
<td>22. Effectiveness Analysis</td>
<td>System component suppliers responsible at the system component level</td>
</tr>
<tr>
<td>23. Tradeoff Analysis</td>
<td>LSI responsible at the SoS framework level</td>
</tr>
<tr>
<td>24. Risk Analysis</td>
<td>System component suppliers responsible at the system component level</td>
</tr>
<tr>
<td>25. Requirements Statements Validation</td>
<td>Possible LSI responsibility</td>
</tr>
<tr>
<td>26. Acquirer Requirements Validation</td>
<td>Major LSI activity in development of SoS architecture and in system component/ supplier selection</td>
</tr>
</tbody>
</table>

SoS LSI Activities
© USC CSE 2005

<table>
<thead>
<tr>
<th>EIA/ANSI 632 Task</th>
<th>SoS LSI Focus</th>
</tr>
</thead>
<tbody>
<tr>
<td>27. Other Stakeholder Requirements Validation</td>
<td>Similar to SE focus at SoS level</td>
</tr>
<tr>
<td>28. System Technical Requirements Validation</td>
<td>Similar to SE focus at SoS level</td>
</tr>
<tr>
<td>29. Logical Solution Representations Validation</td>
<td>Similar to SE focus at SoS level</td>
</tr>
<tr>
<td>30. Design Solution Verification</td>
<td>Similar to SE focus at SoS level</td>
</tr>
<tr>
<td>31. End Product Verification</td>
<td>Similar to SE focus at SoS level</td>
</tr>
<tr>
<td>32. Enabling Product Readiness</td>
<td>Similar to SE focus at SoS level</td>
</tr>
<tr>
<td>33. End Products Validation</td>
<td>Similar to SE focus at SoS level</td>
</tr>
</tbody>
</table>