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Analysis of LSI Activity Areas and Decision Making Processes

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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
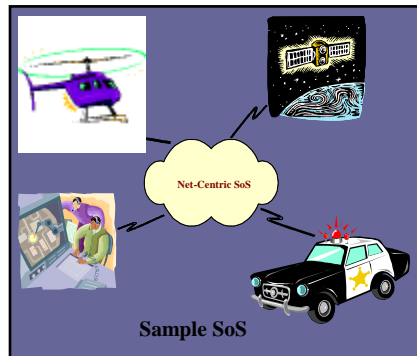- Summary and Future Plans

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

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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)

Net-Centric SoS

Sample SoS

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

Size Drivers → **COSOSIMO** → SoS Definition and Integration Effort

Scale Factors →

Calibration

- 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

SoS LSI Activities
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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

SoS LSI Activities
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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

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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

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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

EIA/ANSI 632 Analysis *(continued)*

EIA/ANSI 632 Task	SoS LSI Focus
19. Specified Requirements	LSI responsible at the SoS framework level
20. Implementation	System component suppliers responsible at the system component level
21. Transition to Use	LSI responsible at the SoS framework level
22. Effectiveness Analysis	System component suppliers responsible at the system component level
23. Tradeoff Analysis	LSI responsible at the SoS framework level
24. Risk Analysis	System component suppliers responsible at the system component level
25. Requirements Statements Validation	Possible LSI responsibility
26. Acquirer Requirements Validation	Major LSI activity in development of SoS architecture and in system component/ supplier selection

EIA/ANSI 632 Analysis *(continued)*

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

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