System-of-Systems (SoS) Processes

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

• What is a System-of-Systems?
• Key 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
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)

Future Combat System (FCS) SoS Example
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/architecture
  – 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
      – Life Cycle Objectives (LCO) Reviews
      – Life Cycle Architecture (LCA) reviews
      – Feasibility Rationale (FR) studies
  – **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”
  – 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
Keys for Success

- Plan for
  - Risk-driven spiral processes and organizations
  - Stabilized evolutionary builds
- Rethink supplier management
- Know when not to system engineer
- Streamline SoS-level processes to take advantage of suppliers’ own processes
  - Fewer steps
  - Fewer decisions
- Not too fast—beware of speed problems
- Base program on performance, not promises—tie to LCA simulations and models to reduce risk
- Have appropriate infrastructure in place
  - Services and capabilities required to support development
  - Examples: appropriate labs, development processes, standards and the right technical talents/experts/staff
- New SoS program must fit into arrangements that have been made with other purposes in mind (although this will increase the number of required clearance points)