Systems of Systems Evaluations using SCRAM

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SoS Evaluations Overview

• Based on Schedule Compliance Risk Assessment Methodology (SCRAM)
  – Developed by the Australian DMO
• Elaborated to support evaluation of SoS capabilities
• Strives to answer questions such as
  – What is the probability that a given SoS capability will be available by a certain date?
  – What is the most probable date SoS capability will be available?
  – What are the risks associated with this probability?
Evaluate project compliance with current schedule

Conduct root cause analysis using RCASS model

Identify possible remediation activities

Estimate most likely schedule completion date:
  • Monte Carlo schedule risk analysis
  • Parametric estimation to complete

Present results to management for action
SoS Considerations With SCRAM

- Relationships between SoS stakeholders and constituent systems
- Constituent system robustness and flexibility
- Level of SoS architecture maturity
- Asynchronous incremental constituent system evolution
- Tracking SoS capability schedules
- Monte Carlo simulations for SoS
SoS Constituent System Upgrades Over Time

System A upgrade 1
System B and C upgrades
System D upgrade
System A upgrade 2
Evaluating SoS Schedules

- **Requirements** → **Acquisition** → **In-service**
- **Legacy system**
  - In-service
- **Interfacing system 1**
  - In-service
- **Interfacing system 2**
  - Current in-service → Planned upgrade in-service
- **Interfacing system 3**
  - Acquisition → Planned upgrade in-service

**Questions:**
- Do we need to simultaneously support both the legacy system and system of interest here?
- Do we need to support both the current in-service interface as well as the expected future interface in our system of interest?

**Notes:**
- Peer systems in parallel acquisitions need to exchange and agree interface documentation prior to the completion of the acquisition to allow sufficient time for development.
Monte Carlo Simulations for SoS

Monte Carlo Simulation

Single Constituent System

\[ P(\text{SoS}) = P(\text{cs}_1) \times P(\text{cs}_2) \times P(\text{cs}_3) \times \ldots \times P(\text{cs}_n) \]
Common SoS Problems Affecting Schedule

- Lack of attention to CS organizational and technical issues
- Inability to track progress of SoS capability development
- Understanding CS limitations (e.g., CS priorities vs. SoS priorities, interoperability, fragile systems that are difficult to change)
- Immature technology or tech refresh coordination issues, especially those that may impact interoperability between systems
- Lack of planning for data/database conversions required for system upgrades
- Deployments using “all or nothing” approach rather than incremental rollout of capability parts
- Lack of integration and test planning/execution at the SoS level
- Impacts related to any required SoS level safety or security certifications
### Medical First Responder SoS

To provide continuous patient care from point of response to hospital/trauma care center.

#### SCRAM for MedFRS Example

**MedFRS Brownfield Modernization: Increment 1**

<table>
<thead>
<tr>
<th>Exploration</th>
<th>Valuation</th>
<th>Foundations</th>
<th>Development</th>
<th>Operations</th>
</tr>
</thead>
</table>
| **Ambulance:**
  - Cardiac Monitor
  - IV Infusion Pump
  - Camera
  - Laptop |
| **Level 1 Trauma Center:**
  - Emergency workstations (5)
  - Audio communication
  - Video communications
  - Patient information
  - Cardiac monitor information |
| **Device integration:**
  - System of systems |
| **User interface software:**
  - Application Software |
| **Cardiac Monitor:**
  - COTS Device |
| **Wireless IV Infusion Pump:**
  - COTS Device |
| **Ruggedized Laptop:**
  - COTS Device |
| **Device Manufacturer:**
  - Software-intensive device part of Product Line |
| **COTS hardware and custom software integration** |
| **Custom software:**
  - Paramedic laptop
  - Level 1 Trauma Center |
MedFRS SCRAM Analysis

• Desired MedFRS SoS capability
  – Incorporation of an Electronic Health Record (EHR) on MedFRS first responder platform that is compatible with four regional hospitals

• Issues
  – Want new capability within 6 months
  – Interoperability Issues: Four regional hospitals/three different EHR COTS system
  – Power and space issues on the first responder platforms
  – New national healthcare EHR standard may impact existing EHR systems
  – Compatibility with other EHR systems not a high priority for hospitals
  – Assumption that future versions of EHR systems will be interoperable “out of the box”
SCRAM evaluation

- Two options evaluated:
  - One team to implement software required to be interoperable with multiple EHR systems
  - Two teams work in parallel to provide necessary interoperability
- Results of Monte Carlo simulations using 3-point estimates
  - 90% probability that two-team approach will result in desired capability with six months
  - 50% probability that one-team approach will result in desired capability within six months
  - Most probably schedule for one-team approach: 9 months
Conclusions and Future Work

• SoS master scheduling much more challenging compared to single system scheduling
• SCRAM must focus on both single system and SoS-level issues
• Process works well for directed and acknowledged SoS—more work needed for collaborative SoS
• DMO SCRAM program developing materials to better support SoS capability SCRAMs (expected date: late 2015)