A Resource Estimation Framework for System Acquisition using a Hybrid Cost Estimation Approach

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Outline

• Acquisition Challenges
• Problem Statement
• Background
• Approach
• Aquarius Tool
• Next Steps
Acquisition Challenges

• Acquisition environment is rapidly evolving to increase responsiveness to customer needs and create efficiencies of cost, schedule, and effort
  – Emerging technologies and evolving threats dictate responsive system design changes
  – Dynamic processes for engineering changes
  – Constrained resources (e.g., funding, staff) and shorter development cycle times
  – Increased focus on acquiring services and enterprise solutions

• Acquisition challenges require new or non-traditional, acquisition strategies
  – Acquisition strategy and risk posture drive the tailoring of systems engineering (SE) processes and resources to be more responsive and flexible

Implement agile acquisition strategies that maintain the same, or less, risk as traditional acquisitions
Problem Statement

• Develop a repeatable process that can be used to scope and staff the systems engineering effort required to effectively execute a given agile acquisition strategy

• Leverage existing capabilities and best practices from successful agile acquisition programs to develop a tool for estimating and/or optimizing systems engineering resources to support agile acquisitions in a highly responsive manner
  – Expected benefits:
    • Enhance understanding of dependencies between systems engineering/mission assurance tasks and the acquisition strategy
    • Identify characteristics of acquisitions that drive agility and risk
    • Estimate systems engineering effort to aid customers in acquisition planning
    • Develop ratings for agility and feasibility
Background
Level Setting Terminology

**AGILE SYSTEMS ENGINEERING** is the ability to perform responsive, efficient and repeatable systems engineering processes in the face of expected and unexpected changes to dynamic internal and external environments without incurring additional risk.\(^1\)\(^2\)

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Traditional vs. Agile

- **Traditional**: Existing methods adapted to program risk levels
- **Agile**: Methods that improve efficiency for same risk

**Agile: Improve efficiency without accepting greater risk**
**Traditional vs. Agile Acquisitions**

<table>
<thead>
<tr>
<th>Traditional</th>
<th>Agile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Requirements established up front</td>
<td>Requirements emerge as a consequence of development activities</td>
</tr>
<tr>
<td>Work prioritized according to pre-determined milestones/schedule</td>
<td>Work prioritized based on most critical items</td>
</tr>
<tr>
<td>Unpredictable cost and schedule implications for changes to baseline</td>
<td>More predictable costs when successive releases continually adapt to evolving requirements</td>
</tr>
<tr>
<td>Progress assessed by comparison of development progress to requirements/cost/schedule baselines</td>
<td>Progress assessed by delivery of functionality (value) to user (customer)</td>
</tr>
<tr>
<td>Systems Engineering manages document approvals, enforces adherence to development process</td>
<td>Systems Engineering facilitates collaboration and acts as an interpreter between developers and users</td>
</tr>
</tbody>
</table>

*Estimating resources for traditional acquisition strategies does not account for agility*
Background
Techniques for Resource Estimation

- Expert judgment: utilize subject matter expert inputs
- Analogy: rule of thumb based on past, similar systems
- Parametric: mathematical relationships
- Engineering build-up: estimate resources for each task and roll-up total cost
- Extrapolation from actuals: estimate final resource from actual resources used

Resource estimation method changes over the project life cycle depending on available data
Approach

• Conducted literature research on agile systems engineering processes and practices
  – *Developed agile systems engineering definition*

• Identified and interviewed exemplar non-traditional (“agile”) acquisition programs

• Identified characteristics of an agile acquisition strategy
  – *Defined key agile acquisition factors and systems engineering drivers (constraints, acquisition complexity)*
  – *Developed an agility measure based on best practices and lessons learned from existing acquisition programs (software implementation is planned in next phase)*
  – *Implemented a web-based front-end to capture characteristics of the agile acquisition strategy*

• Developed an approach to computing Level of Effort (LOE) for the systems engineering work
  – *Mapping of Agile SE Drivers to COSYSMO Parameters*
  – *Implemented a web-based tool to perform systems engineering level of effort (SE LOE) estimation using COSYSMO 2.0 cost estimator*
The estimation framework computes an initial level of effort to support early acquisition planning; the framework can be used throughout the lifecycle to plan subsequent iterations.
Agile Systems Engineering Estimation Framework

Proposed Method

Systems Engineering drivers (acquisition strategy)

- # requirements
- contract type
- mission class
- requirements stability
- technology readiness
- integration/interoperability
- process and tools capability
- team dynamics
- life cycle phase(s)

Compute initial effort

Compute initial effort

COSYSMO

Parametric cost models

Compute risk

Agility rating

Risk measure

Effort (t = planning phase)

Estimate effort

Update activity list

Activity network models

agility rating = a measure of feasibility for an acquisition to be successful as an agile systems engineering development project (based on acquisition size and execution characteristics)

Risk measure = confidence rating of likelihood of success for executing at an initial estimated LOE

Current status: Developed a software tool to compute initial effort estimation using COSYSMO 2.0 and agility rating from an acquisition strategy
The intent of Aquarius is to provide users access to multiple estimation models and provides a framework for exploring custom estimation models.
User Interface

Sample Inputs

- Preset Value: System 1
- Contract Type: Firm Fixed Price (USD)
- $ (dollar): 90.5
- Mission Class: A
- Requirements Stability: Strong
- Technology Readiness Level: 8

Process Capability and Tools
- What is the CMMI level? 2
- What is the maturity and integration level of software engineering tools? Simple with little integration

Team Dynamics
- What is the degree of compatibility of team? Compatible Objectives
- What is the average subject matter expertise level of the team? Apprentice
- What is the average domain experience level of the team? 5-8 years

SE Start and Stop Dates
- Start: 04/19/2017
- Stop: 08/18/2017

What phases of acquisition life cycle are you covering?
- Conceptualize
- Develop
- Operational Test, and Evaluation
- Transition to Operation

Run
**User Interface**

**Sample Results**

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### Results

**Total Size** 213 Equivalent Nominal Requirements  
**Person months** 62 Person-months

<table>
<thead>
<tr>
<th>Phase/Activity</th>
<th>Conceptualize</th>
<th>Develop</th>
<th>Operation</th>
<th>Test &amp; Evaluation</th>
<th>Transition to Operation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquisition &amp; Supply</td>
<td>1</td>
<td>1.6</td>
<td>1.3</td>
<td></td>
<td>0.7</td>
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<tr>
<td>Technical Management</td>
<td>2.4</td>
<td>3.7</td>
<td>3</td>
<td></td>
<td>1.5</td>
</tr>
<tr>
<td>System Design</td>
<td>4.3</td>
<td>6.5</td>
<td>5.2</td>
<td></td>
<td>2.6</td>
</tr>
<tr>
<td>Product Realization</td>
<td>2.2</td>
<td>3.3</td>
<td>2.6</td>
<td></td>
<td>1.3</td>
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<tr>
<td>Product Evaluation</td>
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<td>6.7</td>
<td>5.4</td>
<td></td>
<td>2.7</td>
</tr>
</tbody>
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**Acquisition Effort Distribution**

- **Conceptualize**: 10  
- **Develop**: 15  
- **Operational test and evaluation**: 10  
- **Transition to operation**: 5

- **acquisition and supply**: 5  
- **technical management**: 5  
- **system design**: 5  
- **product realization**: 5  
- **product evaluation**: 5
Next Steps

• Validate effort estimator and agility index measure by applying to exemplar agile acquisition programs
  – Check assumptions on values assumed for agile acquisition parameters and statistical parameters in cost estimator (i.e., COSYSMO)
  – Verify that results of the resource estimation aligns with characteristics of agile acquisition strategies for prior programs interviewed

• Assess the impact of a selected set of systems engineering tasks on estimated level of effort
  – Leverage task based existing systems engineering process models to determine required and optional systems engineering tasks
  – Include impact of constraints (e.g., allocated budget)

• Improve tool implementation
  – Compute agility index measure and risk factor for decision-making
  – Include support for capturing uncertainty in acquisition strategy parameters and cost estimator statistical parameters

Future planned work expands the tool to allow for tailoring of systems engineering tasks