Better Requirements Decomposition Guidelines Can Improve Cost Estimation of Systems Engineering and Human Systems Integration

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8th Annual Conference on Systems Engineering Research
March 17-19, 2010 | Hoboken, New Jersey

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Motivation-SE Performance

NDIA Survey of SE Effectiveness

Project Performance vs. Systems Engineering Capability

- Projects with Lower SE Capability: 39% (15% Higher, 46% Moderate, 31% Lower)
- Projects with Moderate SE Capability: 29% (12% Higher, 59% Moderate, 13% Lower)
- Projects with Higher SE Capability: 56% (13% Higher, 59% Moderate, 29% Lower)

SE is not the answer alone
Motivation-Cost Model

Size Drivers

- # Requirements
- # Interfaces
- # Scenarios
- # Algorithms
  + 3 Volatility Factors

Effort Multipliers

- Application factors
  - 8 factors
- Team factors
  - 6 factors
- Schedule driver

COSYSMO

Calibration

SE Effort
Motivation-Cost Model

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Motivation: Early Cost Estimation

Inputs:
- # of Requirements

Outputs:
1. Cost estimate
2. Requirements analysis

Diagram:
- Capabilities Based Assessment
- Material Development Decision
- Material Solution Analysis
- Technology Development
- Engineering and Manufacturing Development

Refinements:
- Design Readiness Review

CO SYS MO
CONSTRUCTIVE SYSTEM ENGINEERING COST MODEL
Workshop-Task

Cautions and Warnings. Method for displaying system warnings, cautions, and alarms must be appropriate given the importance of the situation (Threshold).
Workshop-Background

![Bar chart showing participants according to Systems Engineering Requirements Man./Eng. Requirements Decomposition: None, Some, Extensive. The chart indicates the number of participants in each category.]

Presented to the Conference on Systems Engineering Research 2010
Workshop-Background

![Bar Chart]

- First exposure: 1
- Heard of it: 3
- Used briefly: 2
- Used extensively: 1
- Helped to develop: 6

COSYSMO
Workshop-Phase 1

Is the Requirement at the Right Level?

<table>
<thead>
<tr>
<th>requirement #</th>
<th>Too Low</th>
<th>Sea Level</th>
<th>Too High</th>
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</tr>
<tr>
<td>8</td>
<td>0</td>
<td>2</td>
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</tr>
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</table>

which one?
Workshop-Phase 1

Is the Requirement at the Right Level?

Agreement

Disagreement

which one?
Workshop-Phase 2

Can the Requirement be Tested, Designed, or Verified?

- **No**
- **Unsure**
- **Yes**

<table>
<thead>
<tr>
<th>Requirement #</th>
<th>No</th>
<th>Unsure</th>
<th>Yes</th>
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</table>
Workshop-Phase 3

How many requirements does this decompose to?

- None
- One Requirement
- Many Requirements

# of responses

<table>
<thead>
<tr>
<th>requirement #</th>
<th>None</th>
<th>One Requirement</th>
<th>Many Requirements</th>
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## Workshop-Impact

<table>
<thead>
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<th>Step</th>
<th>Description</th>
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<tbody>
<tr>
<td>1</td>
<td>Determine the system-of-interest&lt;br&gt;Is the requirement at the correct level?</td>
</tr>
<tr>
<td>2</td>
<td>Can it be tested, <strong>verified</strong> or designed?&lt;br&gt;Can it be tested or designed?</td>
</tr>
<tr>
<td>3</td>
<td><strong>Assess System of Interest</strong>&lt;br&gt;Relationship with Rest of the System&lt;br&gt;How do nonfunctional requirements affect the System-of-interest?</td>
</tr>
<tr>
<td>4</td>
<td>Count Requirements&lt;br&gt;Count Requirements</td>
</tr>
<tr>
<td>5</td>
<td>Assess Complexity&lt;br&gt;(Difficulty)&lt;br&gt;Assess Complexity&lt;br&gt;(Difficulty)</td>
</tr>
</tbody>
</table>
Takeaways

**Bad requirements** frustrate experienced and inexperienced alike.

Decomposition guidelines are important - for everyone
Takeaways

Bad requirements are easy to identify

Decomposition guidelines highlight what needs to be improved
Takeaways

Nonfunctional requirements cost money.

“Human factors. Human factors engineering principles such as specified in MIL-STD-1472 shall be employed in each GCS system solution (Threshold = Objective).”
Takeaways

Nonfunctional requirements cost money.

"Human factors engineering principles such as specified in MIL-STD-1472 shall be employed in each GCS system solution (Threshold = Objective)."

[Diagrame showing the number of requirements that decompose to different categories]
Next Steps

1. Is the requirement at the correct level?
2. Can it be tested or designed?
3. How do nonfunctional requirements affect the System-of-interest?
4. Count Requirements
5. Assess Complexity (Difficulty)