Requirements Verification and Validation Leading Indicators

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Agenda

- Background
- Leading Indicator Discussion
- NDIA DT&E Committee Workshop
- Candidate Metrics
- Conclusion
Designed to

- Gather appropriate stakeholder’s recommendations
- **Initiate the development of measures and metrics** in support of Title 10 U.S.C. Section 139d

Statute dictates that the Director of Developmental Test and Evaluation and the Director of Systems Engineering shall jointly, in coordination with the official designated by the Secretary of Defense, issue guidance on the following:

1. Development and tracking of detailed **measurable performance criteria** as part of the systems engineering master plans and the developmental test and evaluation plans within the test and evaluation master plans of major defense acquisition programs

2. Use of DT&E to **measure the achievement of specific performance objectives** within a systems engineering master plan

3. System for storing and **tracking information** relating to the **achievement of the performance criteria** and objectives specified
Metrics identified for development to measure Test and Evaluation program planning, execution, and performance included:

- Program Requirements Parameter Status
- CONOPS Status
- Strength of Requirements Testability
- Strength and Adequacy of Program Staffing
- Industry/Company Program Planning and Execution Assessment
- TES and TEMP Progress
- Technical Maturity
- Software Maturity
- Government Program Office Performance
- Interdependency Status
INCOSE SE Leading Indicators

Result of a project initiated by the MIT Lean Advancement Initiative (LAI) in cooperation with

- International Council on Systems Engineering (INCOSE)
- Practical Software and Systems Measurement (PSM)
- MIT Systems Engineering Advancement Research Initiative (SEArI)
- Naval Air Systems Command (NAVAIR)
- Department of Defense Systems Engineering Research Center (SERC)
What is a leading indicator?

“A measure for evaluating effectiveness of how a specific activity is applied on a project in a manner that provides information about impacts that are likely to affect the system performance objectives”
What is a leading indicator?

- “A measure for evaluating effectiveness of how a specific activity is applied on a project in a manner that provides information about impacts that are likely to affect the system performance objectives”
- May be an individual measure, or collection of measures & associated analysis that are predictive of future systems engineering performance before the system is fully realized
What is a leading indicator?

- “A measure for evaluating effectiveness of how a specific activity is applied on a project in a manner that provides information about impacts that are likely to affect the system performance objectives”
- May be an individual measure, or collection of measures & associated analysis that are predictive of future systems engineering performance before the system is fully realized
- Aid leadership in delivering value to customers and end users, while assisting in taking interventions and actions to avoid rework and wasted effort
INCOSE SE Leading Indicators

- 18 Leading Indicators Identified
  - Requirements Validation Trends
  - Requirements Verification Trends
NDIA System Development Performance Measurement Working Group

Important Information Needs

<table>
<thead>
<tr>
<th>Highest Priority Information Needs (Addressed by current results)</th>
<th>Other Information Needs (To be considered in the future)</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Requirements</td>
<td>• Reliability</td>
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<tr>
<td>• Interfaces</td>
<td>• Requirements Verification and Validation</td>
</tr>
<tr>
<td>• Architecture</td>
<td>• Defects and Errors</td>
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<td>• Staffing and Skills</td>
<td>• System Assurance</td>
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<td>• Technical Performance</td>
<td>• Process Compliance</td>
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<td>• Technology Maturity</td>
<td>• Work Product Progress</td>
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<td>• Affordability</td>
<td>• Facilities and Equipment</td>
</tr>
<tr>
<td>• Risk Management</td>
<td>• Change Backlog</td>
</tr>
<tr>
<td>• Risk Management</td>
<td>• Review Action Item Closure</td>
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<td>• Manufacturability</td>
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As Determined by the Workshop

Indicator Selection Criteria

- Strongly addresses the information need
- Feasible to produce
- Raw data exists and easily processed
- Already frequently utilized (in common use)
- Provides leading or predictive insight
- Applicable to Technology Development (TD) and Engineering Manufacturing & Development (EMD) phases

Recommended Leading Indicators

<table>
<thead>
<tr>
<th>Information Need</th>
<th>Specific Leading Indicator</th>
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<tbody>
<tr>
<td>Requirements</td>
<td>Requirements Stability</td>
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<tr>
<td>Requirements</td>
<td>Stakeholder Needs Met</td>
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<tr>
<td>Interfaces</td>
<td>Interface Trends</td>
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<tr>
<td>Staffing and Skills</td>
<td>Staffing and Skills Trends</td>
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<td>Risk Management</td>
<td>Risk Burndown</td>
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<tr>
<td>Technical Performance</td>
<td>TPM Trend (specific TPM)</td>
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<tr>
<td>Technical Performance</td>
<td>TPM Summary (all TPMs)</td>
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<tr>
<td>Technical Maturity</td>
<td>Technology Readiness Level</td>
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<tr>
<td>Manufacturability</td>
<td>Manufacturing Readiness Level</td>
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NDIA DT&E Metrics Workshop
Information Needs

**Both Sides of V**
- Requirements defined
- Requirements validated
- Requirements stable
- Verification use cases executed to plan
- Stakeholder needs met
- Technical measurement trends
- Requirement volatility

**Left Side of V**
- Verification requirement maturity
- System requirement maturity
- Requirements validated
- Operational coverage

**Right Side of V**
- Verification methods closed versus planned
- Verification re-plans
- Verification is feasible (cost, schedule, technical)
- Verification infrastructure readiness
- Verification assets available
NDIA DT&E Metrics Workshop
Potential Leading Indicators

1. System Maturity Level
2. Verification Requirement Maturity
3. Technical Measures and Stakeholder Need
System Maturity Level Assessment

Focus: Technology Readiness

- System Test, Launch & Operations
- System/Subsystem Development
- Technology Demonstration
- Technology Development
- Research to Prove Feasibility
- Basic Technology Research

Technology Readiness Levels:
- TRL 1
- TRL 2
- TRL 3
- TRL 4
- TRL 5
- TRL 6
- TRL 7
- TRL 8
- TRL 9

Focus: System Readiness

System Maturity Levels:
- SM 1
- SM 10

Overlap SMLs:
- TRLs 6-9
- "System context"

Mature, Producible Sub-S/System Testing
- Production Rep Sub-S/System Testing
- Sub-S/System Prototype Testing
- Sub-S/System Validation
- Sub-S/System Design Concept
Verification Requirement Maturity

- Aims to ensure verification requirements are correct, complete & executable
- Provides insight into the viability of the verification activity execution

- **Base Measures**
  - What verification methods are defined?
  - Is the success criteria defined and approved?
  - Is the verification environment available with committed resources?
Requirements Validation

- Provides leading insights into
  - TRL of sub-system / system
  - Cost of any present risk
  - Schedule impacts risks may cause

**Questions Answered**
- Is the requirement necessary to satisfy a stakeholder’s need?
- Are changes in the stakeholder’s needs reflected in changed requirements?
- Are requirements feasible for cost, schedule and technical maturity?
Technical Measures and Stakeholder Need

- Base measures providing leading insight to validation progress
  - Cumulative # of activities *planned* vs cumulative # of validation activities *actually conducted*
  - Total # of MOEs and Key Performance Parameters (KPPs) vs # of MOEs/KPPs fully or partially satisfied by Technical Performance Measures (TPMs)

Source: NDIA 2011
Technical Measures and Stakeholder Need

- Additional derived measures
  - Variance of validation activities conducted (plan versus actual) relative to the schedule
  - Percentage of MOEs/KPPs fully satisfied by derived technical measures
Technical Measures and Performance Trends

- Technical measurement & Performance Trends
  - Useful to be able to understand the risk of achieving critical sub-system / system TPMs based on progress and projections
  - Aids in answering the question “will the project achieve the goal for each critical technical measure?”

- Generally each TPM will have
  - A Goal
  - A threshold
  - An achieved value to date
TPM Tracking Example

TPM = Weight
- Planned values graphed with acceptable tolerance bands
- Actual measured values plotted regularly

Timing of collection should be tailored to fit individual programs

Example TPM Performance Profile

Source: INCOSE 2010
Program TPM Tracking Example

- Visual matrix provides quick reference
- Provides opportunity for early detection of issues & opportunity to intervene before it’s too late

### Technical Performance Measures (TPMs)

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<th></th>
<th>Jul</th>
<th>Aug</th>
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Source: SELI  
Time Now

Cumulative Technical Performance Measures Status

Gives program leadership ability to predict areas of risk, cost impacts & the likelihood of realization
Conclusion

- NDIA DT&E Committee goal: identify a set of metrics to be used as leading indicators for validation and verification

- 3 candidate Requirements Verification Leading Indicators
  1. System Maturity Level
  2. Verification Requirement Maturity
  3. Technical Measures & Stakeholder Need

Programs expected to tailor to fit each unique situation to provide meaningful added value
What questions can I address?

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References


# Workshop Attendees

<table>
<thead>
<tr>
<th>Name</th>
<th>Organization</th>
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<tbody>
<tr>
<td>Beth Wilson</td>
<td>Raytheon</td>
</tr>
<tr>
<td>Marty Leek</td>
<td>Raytheon</td>
</tr>
<tr>
<td>Gary Downs</td>
<td>Lockheed Martin</td>
</tr>
<tr>
<td>Ron Carson</td>
<td>Boeing</td>
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<tr>
<td>John R. Palmer</td>
<td>Boeing</td>
</tr>
<tr>
<td>Garry Roedler</td>
<td>Lockheed Martin</td>
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<tr>
<td>Pete McLoone</td>
<td>Lockheed Martin</td>
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<tr>
<td>Ben Mancuso</td>
<td>Pratt &amp; Whitney</td>
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<tr>
<td>Al Brown</td>
<td>Boeing</td>
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<tr>
<td>Geoff Draper</td>
<td>Harris</td>
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<td>Steve Henry</td>
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