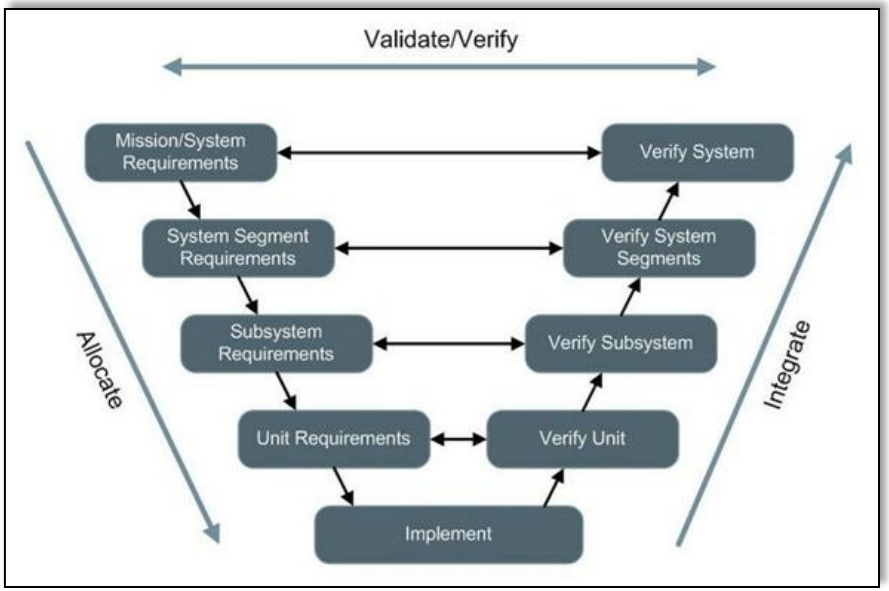
Requirements Verification and Validation Leading Indicators

Cory Lloyd, Raytheon Company

October 30, 2013

Agenda

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



2010 OSD DT&E Measures & Metrics Workshop

- 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

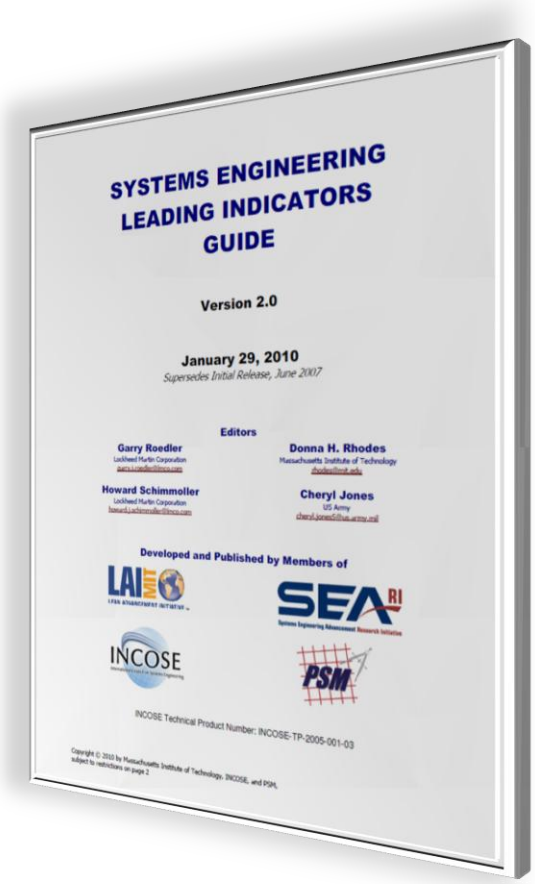
2010 OSD DT&E Candidate Metrics

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)



INCOSE SE Leading Indicators

- 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*"

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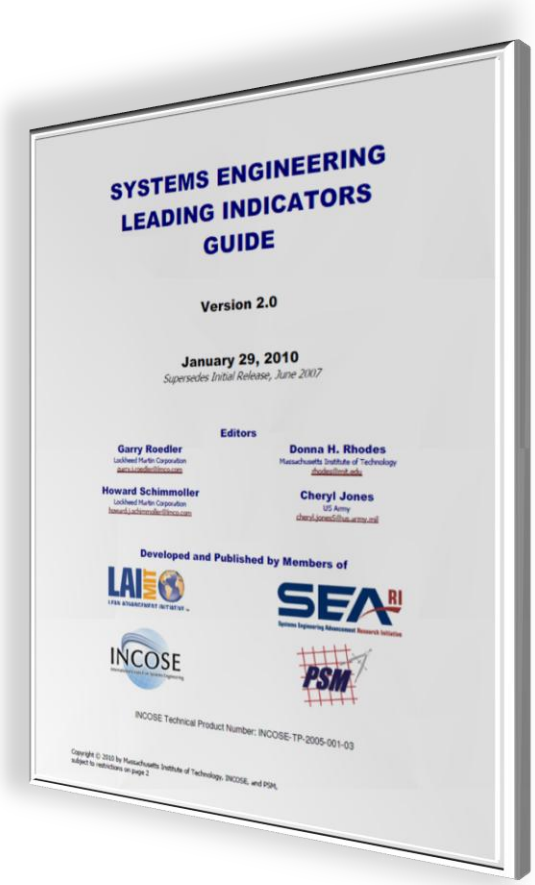
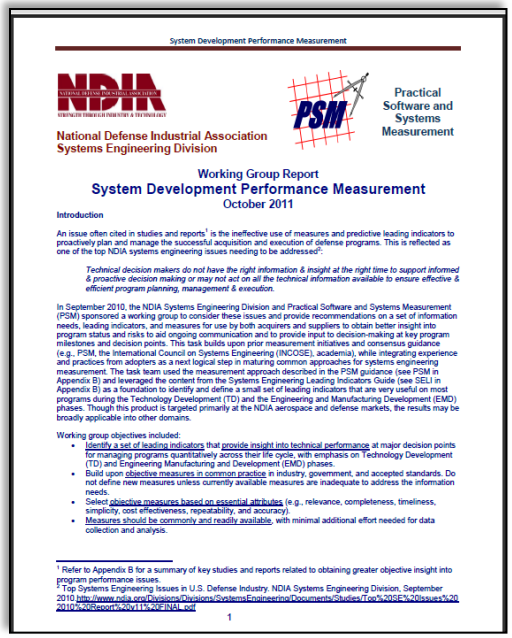
  - May be an individual measure, or collection of measures & associated analysis that are *predictive* of future systems engineering performance *before the system is fully realized*
  - Aid leadership in delivering value to customers and end users, while assisting in taking interventions and actions 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



System Development Performance Measurement

National Defense Industrial Association
Systems Engineering Division

Practical Software and Systems Measurement

Working Group Report
System Development Performance Measurement
October 2011

Introduction

An issue often cited in studies and reports[1] is the ineffective use of measures and predictive leading indicators to proactively plan and manage the successful acquisition and execution of defense programs. This is reflected as one of the top NDIA systems engineering issues needing to be addressed[2]:

Technical decision makers do not have the right information & insight at the right time to support informed & proactive decision making or may not act on all the technical information available to ensure effective & efficient program planning, management & execution.

In September 2010, the NDIA Systems Engineering Division and Practical Software and Systems Measurement (PSM) sponsored a working group to consider these issues and provide recommendations on a set of information needs, leading indicators, and measures for use by both acquirers and suppliers to obtain better insight into program status and risks to aid ongoing communication and to provide input to decision-making at key program milestones and decision points. This task builds upon prior measurement initiatives and consensus guidance (e.g., PSM, the International Council on Systems Engineering (INCOSE), academia), while integrating experience and practices from adopters as a next logical step in maturing common approaches for systems engineering measurement. The task team used the measurement approach described in the PSM guidance (see PSM in Appendix B) and leveraged the content from the Systems Engineering Leading Indicators Guide (see SELI in Appendix B) as a foundation to identify and define a small set of leading indicators that are very useful on most programs during the Technology Development (TD) and the Engineering and Manufacturing Development (EMD) phases. Though this product is targeted primarily at the NDIA aerospace and defense markets, the results may be broadly applicable into other domains.

Working group objectives included:

- Identify a set of leading indicators that provide insight into technical performance at major decision points for managing programs quantitatively across their life cycle, with emphasis on Technology Development (TD) and Engineering Manufacturing and Development (EMD) phases.
- Build upon objective measures in common practice in industry, government, and accepted standards. Do not define new measures unless currently available measures are inadequate to address the information needs.
- Select objective measures based on essential attributes (e.g., relevance, completeness, timeliness, simplicity, cost effectiveness, repeatability, and accuracy).
- Measures should be commonly and readily available, with minimal additional effort needed for data collection and analysis.

[1] Refer to Appendix B for a summary of key studies and reports related to obtaining greater objective insight into program performance issues.
[2] Top Systems Engineering Issues in U.S. Defense Industry. NDIA Systems Engineering Division, September 2010 http://www.ndia.org/Divisions/Divisions/SystemsEngineering/Documents/Studies/Top%20SE%20Issues%202010%20Report%20v11%20FINAL.pdf

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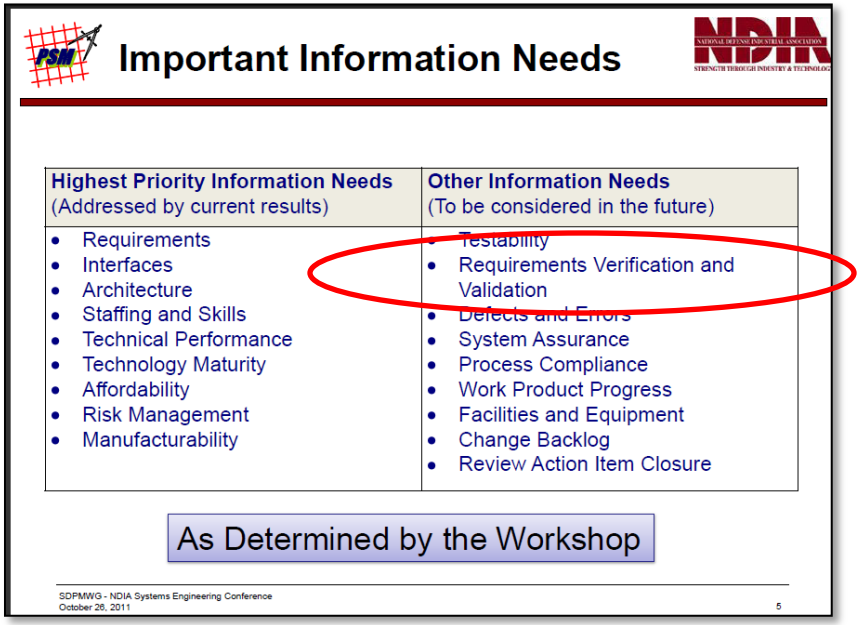

Important Information Needs

Highest Priority Information Needs (Addressed by current results)	Other Information Needs (To be considered in the future)
• Requirements	• Testability
• Interfaces	• Requirements Verification and Validation
• Architecture	• Defects and Errors
• Staffing and Skills	• System Assurance
• Technical Performance	• Process Compliance
• Technology Maturity	• Work Product Progress
• Affordability	• Facilities and Equipment
• Risk Management	• Change Backlog
• Manufacturability	• Review Action Item Closure

As Determined by the Workshop

SDPMWG - NDIA Systems Engineering Conference
October 26, 2011

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Indicator Selection Criteria

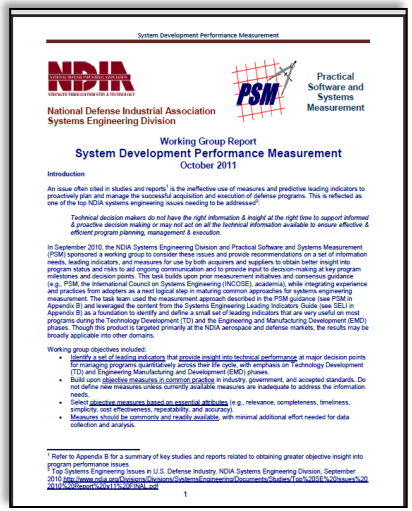
- Strongly addresses the information need
- Feasible to produce
- Raw data exists and easily processed
- Already frequently utilized (in common use)
- Provides leading or predictive insight
- Applicable to Technology Development (TD) and Engineering Manufacturing & Development (EMD) phases

Recommended Leading Indicators

Information Need	Specific Leading Indicator
Requirements	Requirements Stability
Requirements	Stakeholder Needs Met
Interfaces	Interface Trends
Staffing and Skills	Staffing and Skills Trends
Risk Management	Risk Burndown
Technical Performance	TPM Trend (specific TPM)
Technical Performance	TPM Summary (all TPMs)
Technical Maturity	Technology Readiness Level
Manufacturability	Manufacturing Readiness Level

NDIA DT&E Metrics Workshop

October 2012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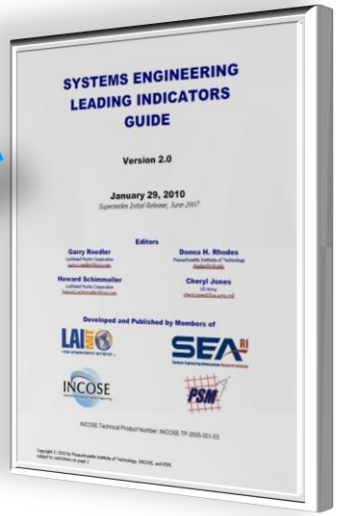
SYSTEMS ENGINEERING LEADING INDICATORS GUIDE

Version 2.0

January 29, 2010

Editors

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Developed and Published by Members of

INCOSE
PSM

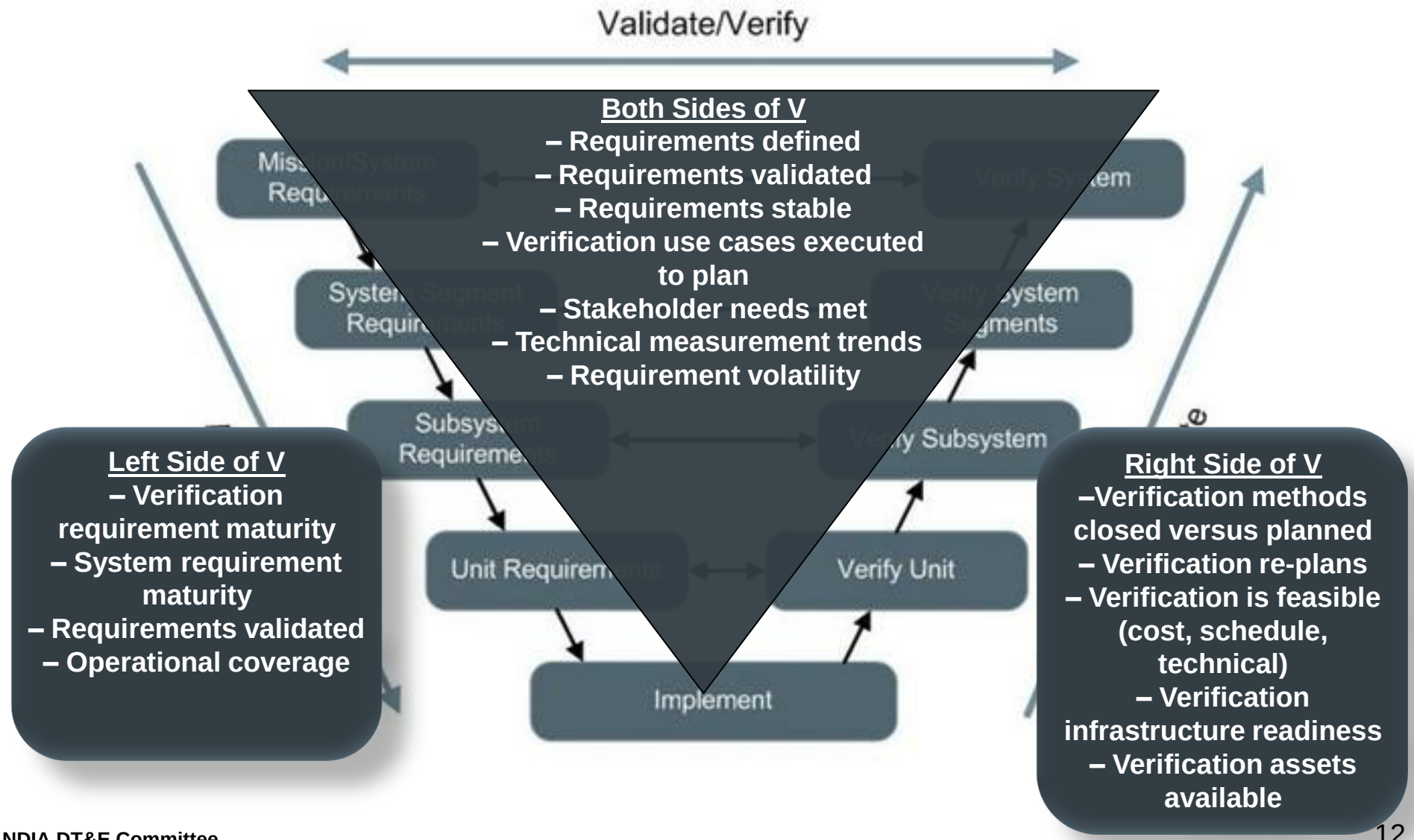
2012 NDIA DT&E Workshop

OSD DT&E

Measures & Metrics Workshop

NDIA DT&E Metrics Workshop

Information Needs

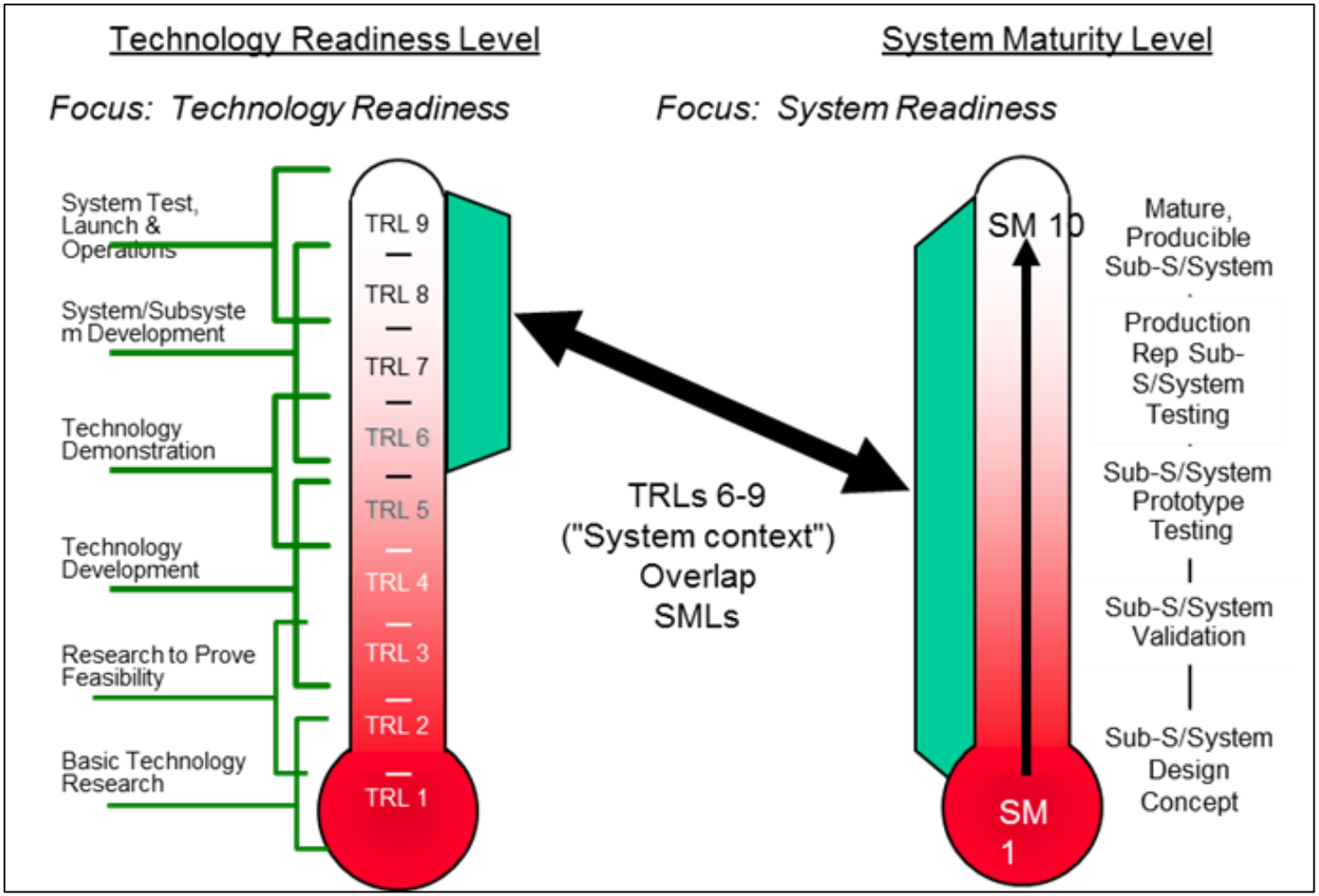


NDIA DT&E Metrics Workshop

Potential Leading Indicators

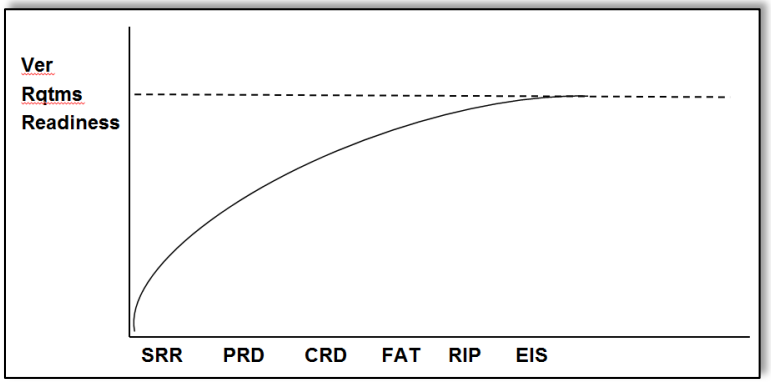
1. System Maturity Level
2. Verification Requirement Maturity
3. Technical Measures and Stakeholder Need

System Maturity Level Assessment



Verification Requirement Maturity

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

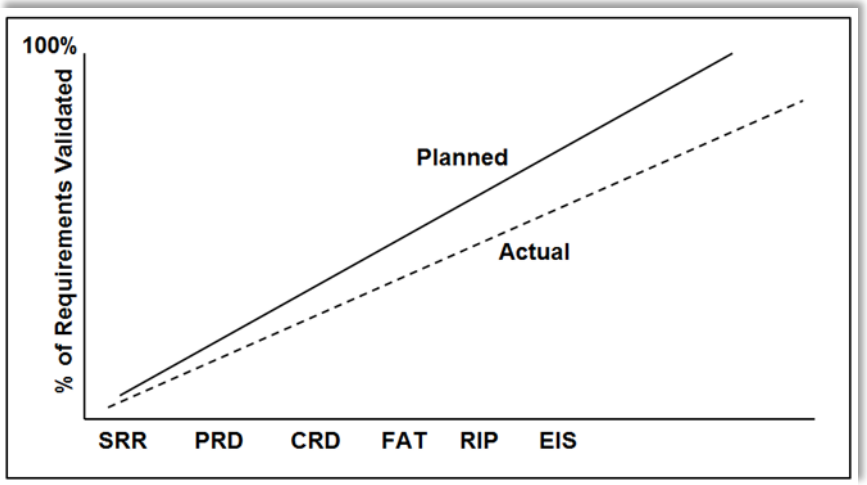


Verification Requirements Readiness Example

- **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

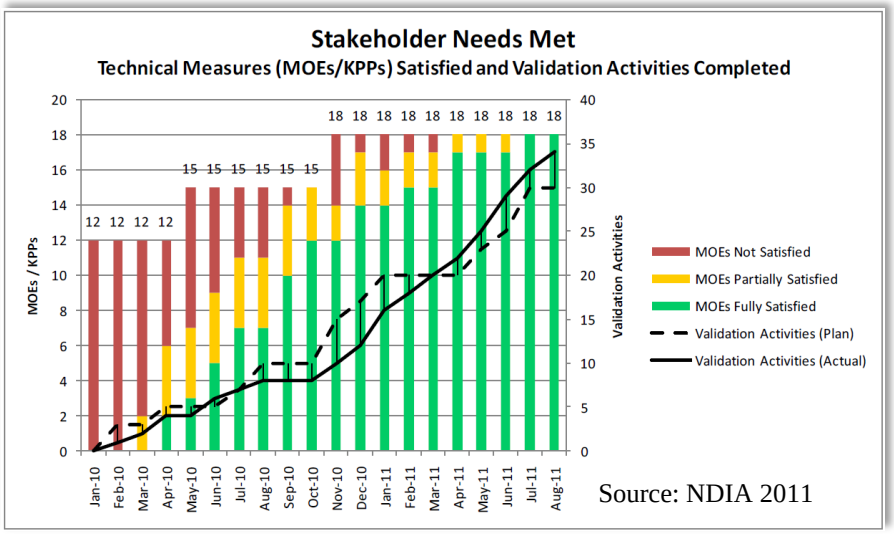


Requirements Validation Status

- **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)



Example of Technical Measures Tracking

Technical Measures and Stakeholder Need

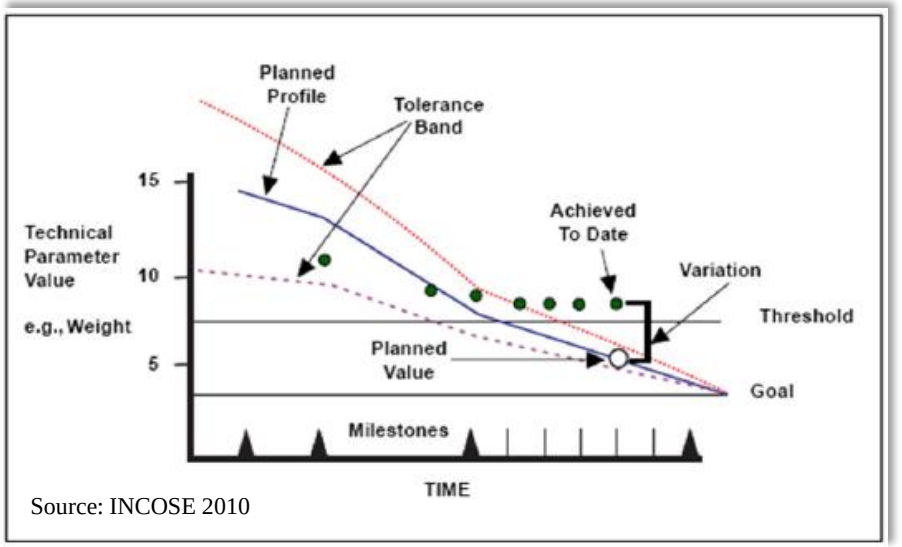
- Additional derived measures
  - Variance of validation activities conducted (plan versus actual) relative to the schedule
  - Percentage of MOEs/KPPs fully satisfied by derived technical measures

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

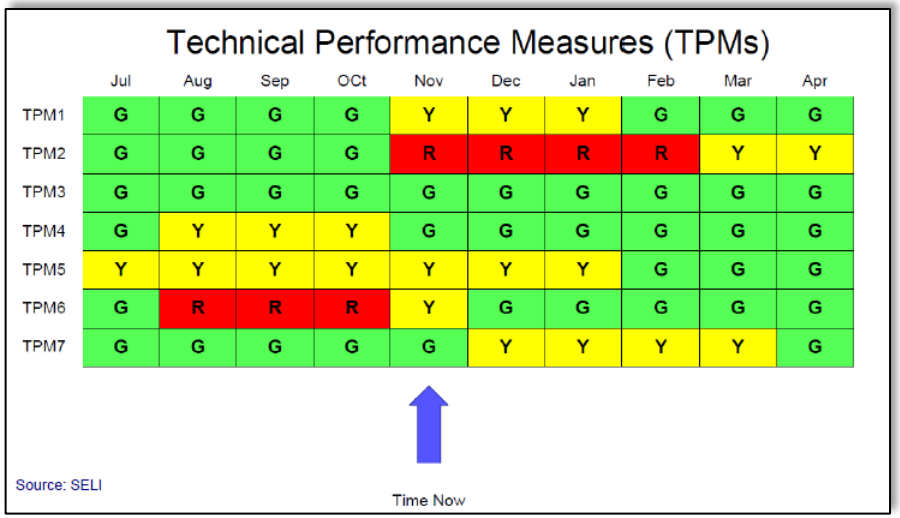


Example TPM Performance Profile

Timing of collection should be tailored to fit individual programs

Program TPM Tracking Example

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



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

- NDIA 2011: National Defense Industrial Association (NDIA) Systems Engineering Division Working Group Report “System Development Performance Measurement,” October 2011
- INCOSE 2007: International Council on Systems Engineering, “Systems Engineering Leading Indicators Guide,” version 1.0, June 15, 2007
- INCOSE 2010: International Council on Systems Engineering, “Systems Engineering Leading Indicators Guide,” version 2.0, January 20, 2010

Workshop Attendees

Name	Organization
Beth Wilson	Raytheon
Marty Leek	Raytheon
Gary Downs	Lockheed Martin
Ron Carson	Boeing
John R. Palmer	Boeing
Garry Roedler	Lockheed Martin
Pete McLoone	Lockheed Martin
Ben Mancuso	Pratt & Whitney
Al Brown	Boeing
Geoff Draper	Harris
Steve Henry	NGC