SE Program Metrics Panel

NDIA SE Conference

26 October 2011

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Note: This presentation is being given from the perspective of the industry association roles held by the presenter.

Objectives

Review Industry Collaboration in System Engineering (SE) Measurement

Provide an Overview of the Systems Engineering Leading Indicators Guide

Provide an Overview of the System Development Performance Measurement Report

A Top Systems Engineering Issue

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.

Significant work has been performed to develop the guidance, training, and tools to address this issue.

Consistent implementation is needed!

Growing Industry Collaboration

Measurement
Goals, Objectives, Needs

PSM
Practical Software & Systems Measurement

- PSM Guidance
- PSM Training
- Technical Guides/Papers
- Collaborative Work

INCOSE

- SE Meas. Primer
- SE Handbook
- Measurement Papers
- Measurement Tools DB
- Collaborative Work

Others

- SERC – SE Effectiveness Measurement
- DAU – Online training
- SEI – CMMI M&A PA, SEMA
- …

Complementary And Supplementary

ISO/IEC IEEE-CS

- ISO/IEC/IEEE 15939
- Coordinated development

NDIA SED

- SDPM
- Collaborative Work

SEBoK SWEBoK

- SE Body of Knowledge
- SW Body of Knowledge

Vocabularies

- SE & SW Processes SEVOCAB

Influence other key SE & SW resources

Other Standards

- ISO/IEC/IEEE 15288
- ISO/IEC/IEEE 12207

Key Collaborative Measurement Guidance

Technical Measurement Guide (V1.0 – 2005)

- Comprehensive Guide on selecting and using MOEs, MOPs, and TPMs
- Collaborators: INCOSE, PSM, Industry
- URL: http://www.incose.org; http://www.psmsc.com

Systems Engineering Leading Indicators Guide (V2.0 – 2010)

- Tailorable guidance for selecting and using leading indicators to address key SE issues
- Collaborators: INCOSE, PSM, LAI, MIT SEARI, DoD, Industry
- URL: http://www.psmsc.com; http://www.incose.org; http://www.mit.edu

PSM-based Measurement Continuous Learning Module (V1.0 – 2010)

- Introductory level online, self-paced learning module
- Collaborators: Defense Acquisition University (DAU), PSM
- URL: https://learn.dau.mil/html/clc/Clc.jsp

SE Effectiveness Measurement (V1.0 – 2009)

- Risk based approach to understand the effectiveness of SE on programs based on 51 success criteria; includes a risk tool and leverages SE Leading Indicators Guide
- Collaborators: SERC, INCOSE, PSM, …
- URL: http://www.serc.org

System Development Performance Measurement Report (Final draft)

- Small set of leading indicators focused on the most significant issues during system development for DoD programs
- Collaborators: NDIA, PSM
- URL: http://www.ndia.org; http://www/psmsc.com

Other Key Measurement Guidance

INCOSE
- SE Measurement Primer V2.0
- Measurement Tools DB
- Measurement Papers
- URL: http://www.incose.org

Practical Software and Systems Measurement (PSM)
- Guidebook V4.0b
- Technical Guides/Papers (Safety Measurement, Security Measurement, SW Assurance, …)
- PSM Training
- URL: http://www.psmsc.com

ISO/IEC/IEEE Standards
- ISO/IEC/IEEE 15939, Measurement Process
  - Standard is consistent with PSM and INCOSE products
  - ISO/IEC/IEEE 15288, System Life Cycle uses summary level info
- URL: http://www.iso.org or http://www.ieee.org

Software Engineering Institute (SEI)
- CMMI™ Measurement & Analysis Process Area
  - Drew from measurement concepts in PSM and ISO/IEC/IEEE Standard
- Measurement Guides
- URL: http://www.sei.cmu.edu

Systems Engineering Leading Indicators Guidance

Systems Engineering Leading Indicators

Objective: Develop a set of SE Leading Indicators to assess if program is performing SE effectively, and to enhance proactive decision making

Thirteen leading indicators defined by SE measurement experts

Beta guide released December 2005 for validation

- Pilot programs conducted
- Workshops conducted
- Survey conducted
  - 106 responses
  - Query of utility of each indicator
  - No obvious candidates for deletion

Version 1.0 released in June 2007

Version 2.0 released in Feb 2010

- Enhancements and lessons learned
- 5 additional leading indicators

SYSTEMS ENGINEERING LEADING INDICATORS GUIDE

Version 2.0

January 29, 2010

Supersedes Initial Release, June 2007

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Developed and Published by Members of

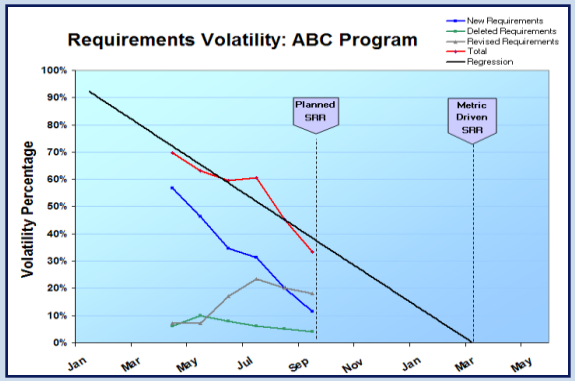
LAI MIT LEAN ADVANCEMENT INITIATIVE

SEA RI Systems Engineering Advancement Research Initiative

INCOSE International Council on Systems Engineering

PSM

INCOSE Technical Product Number: INCOSE-TP-2005-001-03



List of Indicators (Original Set)

Requirements Trends (growth; correct and complete)

System Definition Change Backlog Trends (cycle time, growth)

Interface Trends (growth; correct and complete)

Requirements Validation Rate Trends (at each level of development)

Requirements Verification Trends (at each level of development)

Work Product Approval Trends

- Internal Approval (approval by program review authority)
- External Approval (approval by the customer review authority)

Review Action Closure Trends (plan vs actual for closure of actions over time)

Technology Maturity Trends (planned vs actual over time)

- New Technology (program applicability)
- Older Technology (obsolesence)

Risk Exposure Trends (planned vs, actual over time)

Risk Handling Trends (plan vs, actual for closure of actions over time)

SE Staffing and Skills Trends: # of SE staff per staffing plan (level or skill - planned vs. actual)

Process Compliance Trends

Technical Measurement Trends: MOEs (or KPPs), MOPs, TPMs, and margins

Original set had 13 Leading Indicators

List of Indicators (added in Version 2.0)

Facility and Equipment Availability (availability of non-personnel resources needed throughout the project lifecycle)

Defect and Error Trends (defect discovery profile over time)

System Affordability Trends (cost/effort/schedule/performance distributions)

Architecture Trends (architecture process maturity, system definition maturity, architecture skills)

Schedule and Cost Pressure (impact of schedule and cost challenges)

Version 2 Added 5 Leading Indicators

Guide Contents

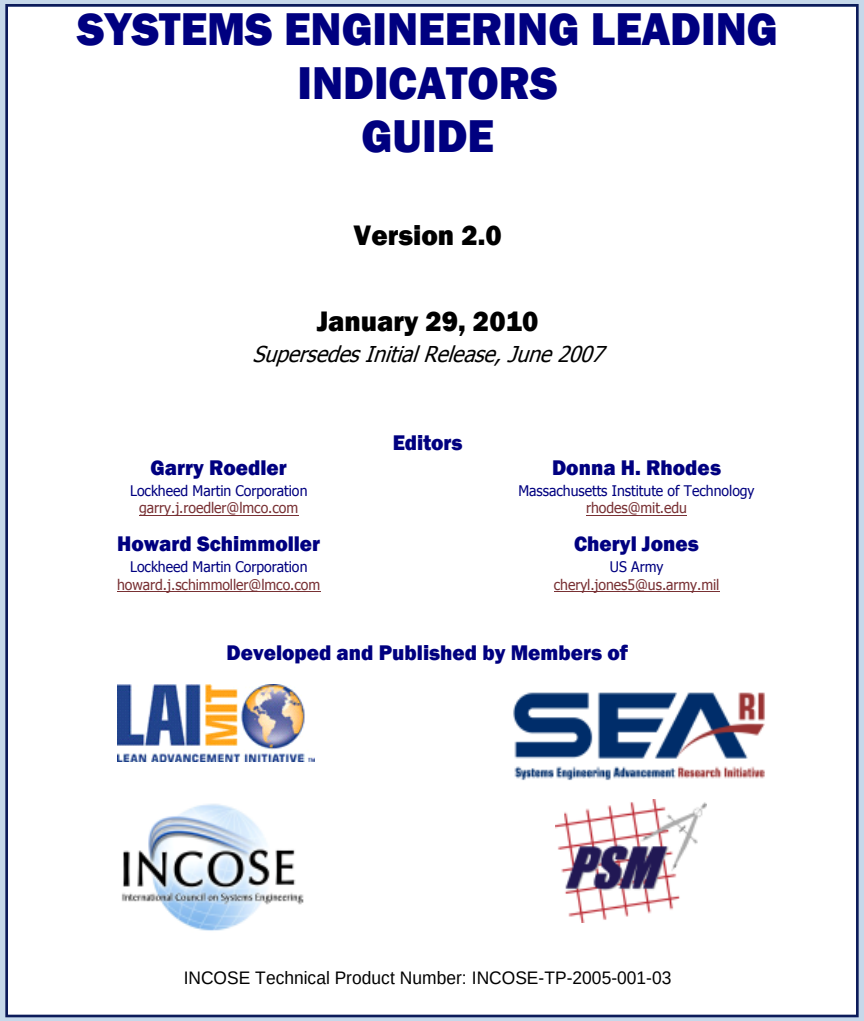
1. About This Document
2. Executive Summary
   - Includes mapping of indicators to life cycle phases/stages
3. Leading Indicators Descriptions
   - Description of each indicator, example graphics, and detailed definitions with all fields of information
4. Implementation Considerations
   - Includes Cost-Benefit, Leading Indicator Performance, Composite Indicators, Mapping to SE Activities
5. References

Appendices

NAVAIR Applied Leading Indicator Implementation

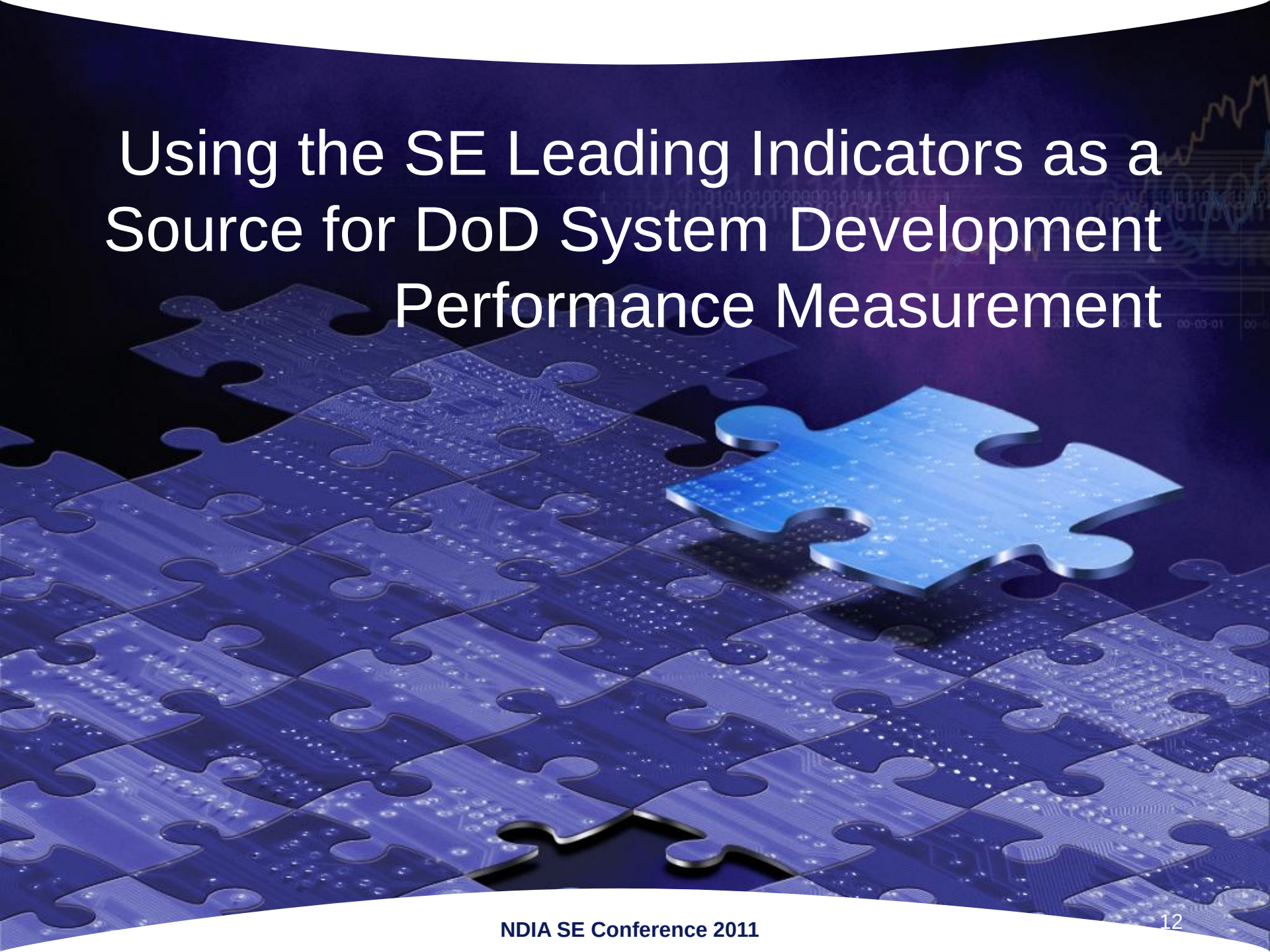
Human Systems Integration Considerations

Early Identification of SE-Related Program Risks (SERC SE Effectiveness)

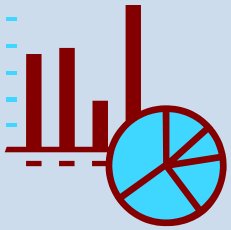


- http://www.incose.org/ProductsPubs/products/seleadingIndicators.aspx
- http://www.psmsc.com

Using the SE Leading Indicators as a Source for DoD System Development Performance Measurement



Working Group Goal



Identify potential high value

- measures,
- indicators, and
- methods

for managing programs, particularly in support of

- making better technical decisions and
- providing better insight into technical risk

at key program milestones during

- Technology Development and
- Engineering and Manufacturing Development

for both the acquirer and supplier

Working Group Process

Top SE Issues (2010)

Guidance and Findings

OSD/Industry Directives, Policy, Guidance, and Initiatives

Identify and Prioritize Information Needs

- Background
- Brainstorming
- Analysis of Key Industry Measurement Resources (Appendix B)
- Group discussion

Prioritized Information Needs

Select and Specify Leading Indicators and Measure sources

- Detailed concepts and questions
- Insight into effects and root causes
- Consensus on candidate indicators

Candidate Indicators

Refine Workshop Results

Document Results

- Measures
- Supporting Information per template
- Recommendations

Task report

Core Team

Workshop

Post Workshop Core Team with Working Group Review

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

No recommendations at this time for Affordability and Architecture

Final Report – Table of Contents

Back-up Charts

SE Leading Indicator Definition

A measure for evaluating the effectiveness of a how a specific SE activity is applied on a program in a manner that provides information about impacts that are likely to affect the system performance objectives

- An individual measure or collection of measures that are *predictive of future system performance*
  - Predictive information (e.g., a trend) is provided before the performance is adversely impacted
- Measures factors that *may impact the system engineering performance*, not just measure the system performance itself
- Aids leadership by providing insight to take actions regarding:
  - Assessment of process effectiveness and impacts
  - Necessary interventions and actions to avoid rework and wasted effort
  - Delivering value to customers and end users

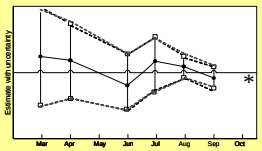
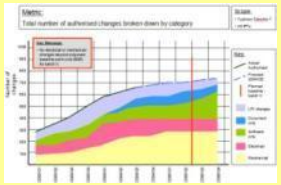
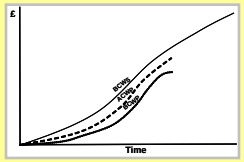
Leading Indicators

Sources of ignition

Smoke detectors

Fire alarms

Fires

Engineering Capability	Engineering Performance	Engineering Status	Financial Indicators
			

Causes ← *Consequences*

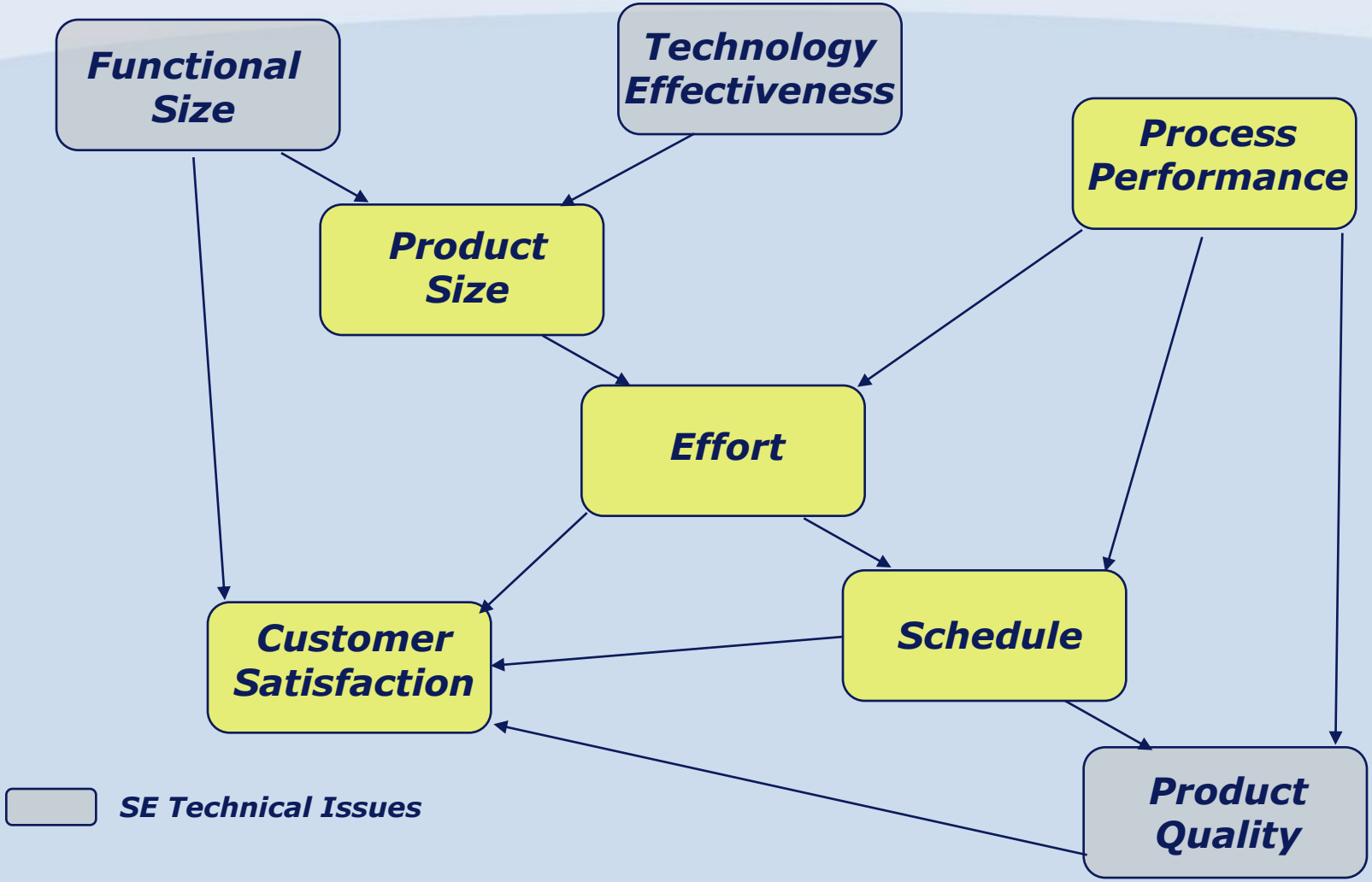
Need to monitor drivers and triggers

Performance not meeting plans

Product not maturing fast enough

Behind schedule, unpredictable

Interactions Among Factors



Adapted from J. McGarry, D.Card, et al., *Practical Software Measurement*, Addison Wesley, 2002

Criteria of Leading Indicators

- Early in activity flow
- In-process data collection
- In time to make decisions
  - Actionable
  - Key decisions
- Objective
- Insight into goals / obstacles
- Able to provide regular feedback
- Can support defined checkpoints
  - Technical reviews, etc.
- Confidence
  - Quantitative (Statistical)
  - Qualitative
- Can clearly/objectively define decision criteria for interpretation
  - Thresholds
- Tailorable or universal

Used criteria to prioritize candidates for inclusion in guide

Fields of Information Collected for Each Indicator

- Information Need/Category
- Measurable Concept
- Leading Information Description
- Base Measures Specification
  - Base Measures Description
  - Measurement Methods
  - Units of Measure
- Entities and Attributes
  - Relevant Entities (being measured)
  - Attributes (of the entities)
- Derived Measures Specification
  - Derived Measures Description
  - Measurement Function
- Indicator Specification
  - Indicator Description and Sample
  - Thresholds and Outliers
  - Decision Criteria
  - Indicator Interpretation
- Additional Information
  - Related SE Processes
  - Assumptions
  - Additional Analysis Guidance
  - Implementation Considerations
  - User of the Information
  - Data Collection Procedure
  - Data Analysis Procedure

Derived from measurement guidance of PSM and ISO/IEC 15939, Measurement Process

SERC SE Effectiveness Measurement Project

SE Leading Indicators Guide is pointed to from SERC SE Effectiveness Measurement (EM) project for quantitative measurement perspective

SERC EM contribution:

- Short-term:
  - Mapping of SE Effectiveness Measurement Framework to SE Leading Indicators (SELI)
    - 51 Criteria => Critical Success Factors => Questions => SELI
      - » Critical Success Factors serve as Information Needs
      - » Questions serve as Measurable Concepts
  - Mapping of 51 Criteria to SELI
  - Review to ensure consistency of concepts and terminology
  - SERC EM Risk Tool provides insight into risk areas that need more measurement focus
- Longer-term:
  - Work with OSD to get infrastructure in place to support data collection and analysis

Important Information Needs

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

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

Relating the Guidance to Technical Measurement (MOEs, MOPs, TPMs)

Technical Measurement Guide

What is Technical Measurement?

- Set of measurement activities and measures used to provide insight into the technical solution
  - Requirements (performance, quality, etc.)
  - Risks
  - Progress
- Tracked across the life cycle
  - Established early in the life cycle
  - Increasing levels of fidelity as technical solution is developed

Provides comprehensive guidance for:

- Types of technical measures and their use
- Planning, performing, and evaluating technical measurement

Collective Usage of Guidance

SEP Requirements for TPMs

INCOSE

INCOSE Systems Engineering Measurement Primer v2.0
Document No.: INCOSE-TP-2010-005-02
5 November 2010

Systems Engineering Measurement Primer

A Basic Introduction to Measurement Concepts and Use for Systems Engineering

Document No.: INCOSE-TP-2010-005-02
Version/Revision: 2.0
Date: 5 November 2010
File: INCOSE Measurement Primer 2010-1105 FINAL.docx

Prepared by:
Measurement Working Group
International Council on Systems Engineering (INCOSE)
7670 Opportunity Rd, Suite 220
San Diego, CA 92111-2222

General Measure Foundation (INCOSE Primer, PSM, …)

Technical Measurement INCOSE-TP-2003-020-01

Technical Measurement

A Collaborative Project of PSM, INCOSE, and Industry

Technical Report Prepared by
Garry J. Roedler, Lockheed Martin
Cheryl Jones, US Army

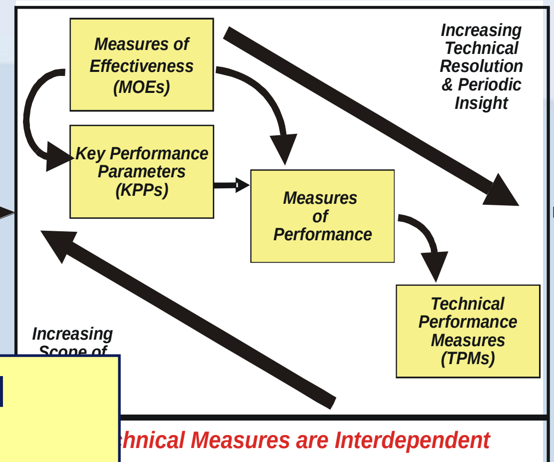
27 December 2005
Version 1.0
INCOSE-TP-2003-020-01

PSM Practical Software and Systems Measurement

INCOSE

27 December 2005

Principles and Application of Technical Meas. (Tech Meas Guide)



NDIA National Defense Industrial Association Systems Engineering Division

PSM Practical Software and Systems Measurement

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January 29, 2010
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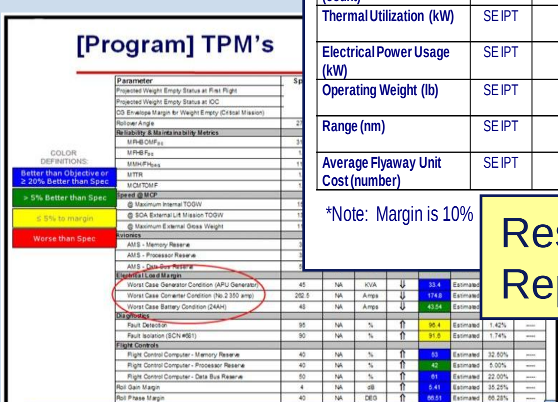
Developed and Published by Members of
LAI MIT, SEAri, INCOSE, PSM

INCOSE Technical Product Number: INCOSE-TP-2005-001-03

Specific Guidance for Use in Predictive Manner – Apply for DoD

Name	Responsible Position /IPT	KPP or KSA	Performance Spec.	PDR Status Actual	MS B Status Actual	CDR Status Actual	MS C Status Planned	FRP Status Planned
Aerodynamic Drag (count)	SE IPT		<222	225	223	220	187	187
Thermal Utilization (kW)	SE IPT		<60	56	59	55	51	50
Electrical Power Usage (kW)	SE IPT		<201	150	185	123	123	123
Operating Weight (lb)	SE IPT		<99,000	97,001	101,001	97,001	85,540	85,650
Range (nm)	SE IPT		>1,000	1,111	1,101	1,111	1,122	1,130
Average Flyaway Unit Cost (number)	SE IPT		<1.5	1.3	1.58	1.37	1.35	1.32

*Note: Margin is 10%



Resulting TPM Reporting