



Progress Report

LAI INITIATIVE on SYSTEMS ENGINEERING LEADING INDICATORS

Follow-on Initiative from the Air Force/LAI Workshop on Systems Engineering for Robustness

This progress report contains the information generated during a working meeting of the "Systems Engineering Leading Indicators Action Team" with preliminary recommendations and action plan.

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1 LEADING INDICATORS INITIATIVE

The June 2004 Air Force/LAI Workshop on Systems Engineering for Robustness established the groundwork for six initiatives in support of Systems Engineering Revitalization efforts. One of these initiatives is focused on **leading indicators for evaluating the goodness of systems engineering on a program**. The initiative is described in Table 1 (excerpted from the full workshop report).

TABLE ONE	
Leading Indicators for Evaluating Goodness of Systems Engineering on a Program	
<p>Program leaders evaluating whether their programs are doing good systems engineering need to have access to a set of leading indicators. Today, we have many good leading indicators for the programmatic aspects of engineering, but lack good leading indicators of the more engineering aspects of a program.</p>	
<p>2004 Action Plan</p> <p>A “Leading Indicators Action Team” has been formed, comprised of experts on engineering metrics and measurement processes. Some leading indicators are included in the AF Guide on Engineering for Robustness; this team will develop and propose an expanded set of leading indicators for systems engineering. The leading indicators should be piloted and validated through several studies before broad use.</p>	<p>Deliverable</p> <p>Recommendations for Leading Indicators for Systems Engineering, Version 1.0</p> <ul style="list-style-type: none"> • Oct 30, 2004
<p>Additional Recommendations: Using the action team’s recommendations, the Air Force should establish pilot programs for these leading indicators to validate and assess usefulness to leadership in government and industry. Based on results of pilot programs, the leading indicators need to be adjusted as required and recommendations developed regarding which leading indicators are most effective for particular types of programs.</p>	
Perspectives of the Workshop Participants	
<p>What do we do well today?</p> <p>We have good leading indicators for the more programmatic aspects of engineering such as cost and schedule performance. Sound technical performance measures exist for most programs and we have approaches to track and manage these. The current AF Guide on Engineering for Robustness includes some useful measures and the new leading indicators can be published in this guide.</p>	<p>What are we not doing well today?</p> <p>We do not have leading indicators for the goodness of systems engineering effort or the desired aspects of the systems being developed. For example, we have no leading indicators for robustness, flexibility, architectural integrity, etc. And, we lack systems engineering measurements that are useful and reasonably immune to distortion.</p>
<p>What are the inhibitors or barriers?</p> <p>Leading indicators for systems engineering are difficult to define. There is some perception today that there is an the intrusion of excessive metrics, and we need to avoid any new initiative being viewed in such a way. There is also a risk of galvanizing prematurely on immature metrics strategies, contract language, etc., if validation of the leading indicators is not properly done.</p>	<p>What are the improvement opportunities?</p> <p>There is a rich opportunity to define a new set of leading indicators that is targeted at SoS and complex enterprises. There is great potential for effective progress if we the various groups thinking about this subject (PSM, INCOSE, LAI, SPC, etc.) to integrate current leading indicators/metrics research and practices.</p>

1.1 Action Team

Subsequent to the workshop an action team was formed; the group is co-chaired by Garry Roedler, Lockheed Martin and Donna Rhodes, MIT/LAI. Participants on the action team include representatives from Air Force and selected participants who have led working groups and councils with initiatives on systems engineering measurement practices/metrics in corporations, consortiums, and industry associations. The team intends to involve additional participants in consultation and review, and also intends to collaborate with NDIA and INCOSE to ensure convergence of related ongoing efforts. A first meeting was held August 26-27 in Bethesda, MD, with attendees listed in Table 2. The objectives for the meeting were:

1. Gain common understanding of DoD needs/drivers of the SE Leading Indicators Initiative
2. Identify information needs underlying the application of SE effectiveness
 - a. Address SE effectiveness and key systems attributes for systems, SoS, and complex enterprises, such as robustness, flexibility, and architectural integrity
3. Identify set of leading indicators for systems engineering effectiveness
4. Define and document measurable constructs for highest priority indicators
 - a. Includes base and derived measures needed to support each indicator, attributes, and interpretation guidance
5. Identify challenges for implementation of each indicator and recommendations for managing implementation
6. Initiate the effort to establish recommendations for piloting and validating the new indicators before broad use

Table 2. Action Team Participants in Aug 26-27 Meeting.

NAME	ORGANIZATION	EMAIL
Abbott, Danny	Air Force/ACE	Danny.Abbott@pentagon.af.mil
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1.2 Review of PSM Measurement Concepts

At the Aug 26-27 meeting, Garry Roedler reviewed with the action team some of the important measurement concepts from the Practical Systems and Software Measurement (PSM) guide. **Click on the icon** to view the PowerPoint presentation presented to the group:

PSM Concepts
Presentation

1.3 Action Team Perspectives on Evaluating Goodness of Systems Engineering

The action team agreed that evaluation of the goodness of systems engineering on a program requires both **criteria** and **leading indicators**, and that these may be both quantitative and qualitative. The approach should be to build on the existing work, including the measurement/leading indicators work of Practical Systems and Software Measurement (PSM); INCOSE; and COSYSMO. Leading indicators are needed that focus on the effectiveness of systems engineering to deliver system capabilities within cost and schedule, as well as providing robust system solutions. The outcomes of the “goodness of SE on a program” initiatives are expected to be (1) a small set of high-value leading indicators applicable to broad range of projects; and (2) a set of checklists that address key criteria for good SE on a program. The action team agreed that CMMI provides the criteria for capability of an organization to perform good SE. Another LAI action team is looking into criteria for evaluation of goodness of SE on a program.

1.4 Additional Observations of Meeting Participants

The meeting resulted in a number of key ideas; next steps are to further define the meeting outputs (concepts for leading indicators) and to work to establish an initiative to pilot and validate outputs, analyze results, and refine the indicators. Participants agreed that we need to develop a consistent definition of the scope of work of SE in order to have consistent interpretation of the leading indicators. Some felt that using MIL-STD 881, para. 40.2.5.1 as the basis for scope definition might work well. Participants also agreed that there are some measures in use today that if applied consistently, could help address the need for leading indicators.

1.5 Relationship of Performance Goals and Processes

The action team explored the relationship of performance goals to the management and technical processes of SE, in a session led by David Card, SPC. This session underscored the need to further define the scope for the leading indicators and to further the team’s thinking on what processes may be most important in the definition of and use of leading indicators. **Click icon** to view.

Worksheet
Performance/Process

1.6 Progress on Leading Indicators

The action team worked to develop the preliminary concepts for a set of leading indicators. This was explored by looking at goals in relationship to the systems engineering processes. Indicators were identified along with base measures and concepts for derived measures, and considerations for application. This preliminary work will be further elaborated by the team, and specific recommendations will be developed. The results of the team will be incorporated into the *AF Guide for Engineering for Robustness* and other systems engineering guidebooks as applicable.

Categories for leading indicators need to be defined, with a preliminary set defined as: (1) Effort; (2) Correctness, Completeness, and Convergence; (3) Technical Measures (MOPs, TPMs); (4) Risk/Threat; (5) Technology Insertion/Opportunity; and (6) Process Compliance.

The work in progress is captured in an Excel spreadsheet (**click icon below**).



Preliminary - SE
Leading Indicator Wc

2 RECOMMENDATIONS

Specific recommendations for leading indicators and their use are under development by the action team. The preliminary recommendations and action plan of the group are:

Recommendation	Action Plan	Who/When
<p>1. LEADING INDICATOR GUIDANCE. The concept of leading indicators is often not well understood and these are often confused with progress measures. The development of additional guidance is recommended for informing program managers and systems engineers to on the clear differentiation of leading indicators (and their use) versus metrics used for other purposes (historical data, progress tracking, etc.).</p>	<p>Develop some additional descriptive material and possibly training material to help provide better guidance to PM/SE on purpose of leading indicators, use, examples, etc. Determine where guidance needs to be documented and update materials. Communicate to organizations who have interest in such guidance.</p>	<p>Roedler, Rhodes, Sheard, Wilson Dec 2004/2005 Include tbd OSD participant.</p>
<p>2. REVIEW CURRENT BODY of KNOWLEDGE. PSM (Practical Software & Systems Measurement Guide), INCOSE Metrics Guidebook , SPC guidance, etc should be reviewed for concepts/candidate leading indicators.</p>	<p>Review and gather applicable information from current body of knowledge on metrics and measurements.</p>	<p>Roedler, Rhodes, Sheard Nov 30 2004</p>
<p>3. SCOPE for SE LEADING INDICATORS. The action team recommends additional effort to effectively define the scope of SE for leading indicators including activities and deliverables.</p>	<p>Define scope of SE sufficient for measurement purposes; Start with MIL-STD 881, para. 40.2.5.1</p>	<p>Robitaille, Wilson, Rhodes, Nov 2004</p>
<p>4. REFINE SE LEADING INDICATOR WORKSHEET. The action team needs to elaborate the preliminary worksheet developed at the August meeting (see Excel spreadsheet in this report).</p>	<p>Refine indicators/measures identified in August workshop. Include review of PSM and other measures in-use for potential addition to worksheet information.</p>	<p>Garry Roedler, Dave Card, John Rieff; Next version by Nov 30</p>
<p>5. REQUEST ADDITIONAL SUPPORT. Request selected industry association working groups and corporate councils to investigate leading indicators in area of influence. Note that the NDIA SE Committee has also undertaken an effort to solicit member inputs on systems engineering leading indicators</p>	<ol style="list-style-type: none"> 1. Request to INCOSE working groups for Reqs, Architecture, Measurement 2. Request to LAI member organizations. 	<p>Rhodes and Robitaille; request submitted in Oct for INCOSE working group discussions at INCOSE International Workshop (Jan 05). Rhodes; request submitted via LAI consortium.</p>

Recommendation	Action Plan	Who/When
<p>6. INVESTIGATE SE ROBUSTNESS INDEX. Investigate feasibility of a overall SE robustness index or assessment method for use as leading indicator of the evolving robustness of a system.</p>	<p>Use Best Practices document (NAVSO P-6071) - Willoughby templates as input; explore the feasibility of such a leading indicator and how to test the idea in practice.</p>	<p>Paul Robitaille, Garry Roedler, Donna Rhodes, Bill Miller, Dave Jacques ; Dec 2004</p>
<p>7. TECHNOLOGY OPPORTUNITY INDEX. Investigate feasibility of a opportunity index (and assessment method) drawing from risk management practices to provide a leading indicator for opportunity for new technology insertion during development program.</p>	<p>Elaborate on preliminary ideas for opportunity index and develop a technical paper including example.</p>	<p>Winter and Rhodes; Dec 2004; target publication at SE conference or in SE journal.</p>
<p>8. VALIDATION STRATEGY. The action team recommends that any new leading indicators be piloted on targeted program (s) to validate prior to recommending these for broad implementation.</p>	<p>For any recommended leading indicators, the action team will also develop a validation strategy and will seek support from LAI and NDIA member organizations to implement pilot efforts.</p>	<p>Roedler, Card, Rhodes, general validation strategy (2004) Roedler, Rhodes, Wilson, Abbott, Loren - specific validation strategies (2005)</p>
<p>9. EVALUATE POTENTIAL to TRANSFORM METRICS to LEADING INDICATORS. Assess the metrics used by programs today to see if these may be transformed (to be used individually or in combination) as leading indicators. Include qualitative as well as quantitative leading indicator approaches.</p>	<p>Based on results of refining leading indicator worksheet and information gathered from LAI organizations, NDIA efforts, INCOSE efforts, etc. evaluate the potential for transforming metrics in use to leading indicators.</p>	<p>Action Team (in follow-on meeting); Jan 2005</p>
<p>10. LINK LEADING INDICATORS to CRITERIA. Another LAI action team is working on the criteria for assessing the goodness of SE on a program. As leading indicators are defined and validated these need to be associated with the applicable evaluation criteria.</p>	<p>Ensure collaboration between the two action teams. Incorporate the leading indicators (with the criteria) into the common framework for assessing goodness of SE on a program.</p>	<p>Rhodes, action teams, 2005</p>