

# **Practical Systems Measurement (PSysM)**



## **Systems Engineering Measurement Workshop**

*Office of the Under Secretary of Defense  
Acquisition and Technology*

*Joint Logistics Commanders  
Joint Group on Systems Engineering*

*International Council On Systems  
Engineering (INCOSE)*

## **Workshop Objectives**

- ***Provide Background of the Practical Systems Measurement Project***
- ***Review Selection Criteria of Common Issues, Categories, and Measures***
- ***Review Current Candidates for Common Issues, Categories, and Measures***
- ***Achieve Consensus on Terminology***
- ***Review Draft Set of PSysM Measures***
- ***Assess Current Plans for PSysM Guidance and Products***

## **Intended Audience**

- ***System Engineering Project and Technical Managers***
- ***PSM Technical Working Group Members***
- ***INCOSE Measurement Working Group Members***
- ***PSM Users with System Responsibilities***
- ***Other System Level Measurement Analysts***

## **Intended Output**

- ***Agreed upon Terminology***
- ***Refined Set of I-C-Ms***
- ***Initial Reviewed Set of PSystem Measures***
- ***Future Plans***

## **Workshop Agenda**

- **8:30 - 9:15**      *Review Current PSystem Project Background and Goals*
- **9:15 - 10:00**    *I-C-M Criteria and Selection Review*
- **10:00 - 10:30**    *Break*
- **10:30 - 11:00**    *I-C-M Review (cont'd)*
- **11:00 - 11:30**    *Terminology Discussion (Life Cycle)*
- **11:30 - 1:00**      *Lunch*
- **1:00 - 1:30**      *Terminology Discussion (Measures)*
- **1:30 - 2:30**      *Small Group Break-out to Review Measures*
- **2:30 - 3:00**      *Break*
- **3:00 - 3:45**      *Small Group Break-out (cont'd)*
- **3:45 - 4:30**      *Group Reports*
- **4:30 - 5:00**      *Wrap-up*
- **7:00 - 9:00**      *Prepare Summary Briefing (Leads only)*

## **Overview of Background and Goals**

## **Practical Systems Measurement**

- ***Objective - Joint PSM-INCOSE Systems Engineering Measurement Products***
- ***SE Products Based on Existing PSM Approach - Structure***
- ***Foundation - PSM Derived Measurement Process With Specific SE Issues/Measures***
- ***Link Systems and Software Analysis***
- ***Joint Development - Implementation Team***
- ***Phased Development Plan***

## **PSysM Project Objectives**

- ***Help Project Managers Meet Systems Cost, Schedule, and Technical Objectives***
- ***Provide a Basis for Objective Communication and Informed Decision Making***
- ***Establish a Foundation for Executive Level Performance Measurement***
- ***Integrate with the PSM and INCOSE Product Lines***

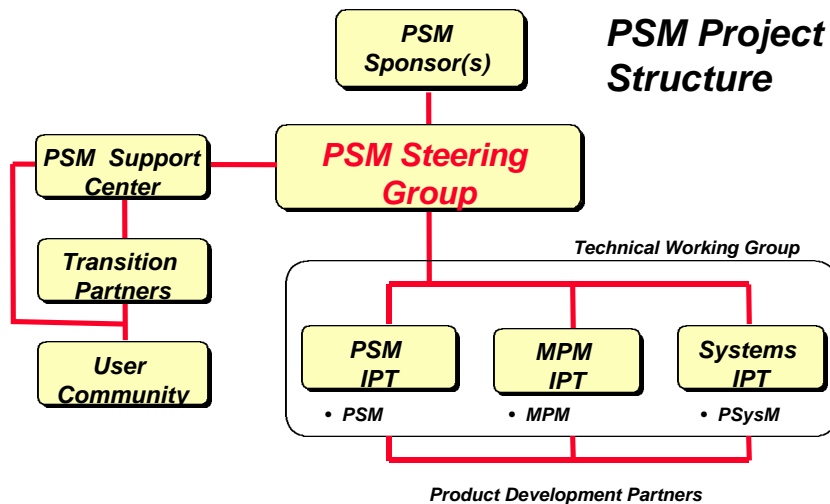
## **PSysM Project Scope**

- **Systems Measurement Needs**
  - *Measurement of Engineering of Systems, not just Systems Engineering*
- **Target Audience is Program Mgrs, Systems Engineers, and Life Cycle Teams\***
- **New and Existing Program Implementations**
- **Life Cycle Application - All Programs, All Systems, All Phases**
- **Single Program/System Analysis**
- **Fundamental Practices - “How To” Guidance**

*\* Life Cycle Teams are the various teams involved in the acquisition, systems engineering, development, maintenance, support, etc. of the system.*

## **Practical Systems Measurement Collaborative Development Approach**

- **Build on Current Products and Experience of PSM, INCOSE, and Development Partners**
- **Documentation**
  - *Use PSM process concepts and documentation directly*
  - *Account for differences between SE and SW*
  - *Use example metrics from current INCOSE guidebook and other sources*
- **Training**
  - *Reuse much of existing training materials*
  - *Training with same constraints as current PSM trainers*



## INCOSE Measurement Working Group (MWG) Charter and Scope

### Charter:

- Promote shared understanding and advancement of systems engineering measures, measurement practices, measurement tools/support, and the overall measurement process.

### Scope:

- **Measurement addressing:**
  - Entire system (software, hardware, people, interfaces)
  - Entire life cycle (concept through disposal)
  - Product, process, and project

## INCOSE MWG Background

- **Represents all SE domains**
- **Large basis of SE expertise**
  - ~3000 members in INCOSE; 50+ in the MWG
  - International membership
- **MWG Products that may serve as references**
  - *Metrics Guidebook for Integrated Systems and Product Development*
  - *SE Measurement Primer*
  - *Metrics Information Systems Tool (MIST)*
- **MWG also developing/maintaining FAQs and Lessons Learned**

## PSysM IPT Membership

### Integrated Product Team

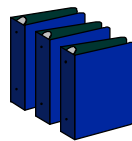
- |                           |                     |
|---------------------------|---------------------|
| • Garry Roedler (Co-lead) | • Bruce Joren       |
| • Bill Farr (Co-lead)     | • Jeanmarie MacLean |
| • Bruce Allgood           | • Dorothy McKinney  |
| • Warren Allmond          | • Chris Miller      |
| • Patrick Antony          | • John Nylund       |
| • Peter Baxter            | • Sharon Rohde      |
| • Florence Beckmann       | • Sarah Sheard      |
| • Dennis Brink            | • Ken Stranc        |
| • John Eget               | • Charles Talley    |
| • Don Gantzer             | • Terry Treadwell   |
| • John Gaffney            | • Al Truesdale      |
| • Wolf Goethert           | • Alan Weinberger   |
| • Ron Kohl                |                     |

## PSysM General Guidance

- **Focus on Technical Consensus**
- **Recommendations based on proven practices and measures**
- **Development and products will be consistent with PSM product line, approach, and philosophy**
  - *Must dovetail with PSM to be an integrated set*
- **Clear and understandable guidance**

### Same Products Are Proposed For PSysM

**PSysM Products**



**Technical Guidance**  
- Guidebook



**Measurement Workstation -**  
Incorporate Systems Measures into Insight



**Training Courses -**  
Adapt Current Course for Systems



## **Logistics**

- **Meeting Frequency**
  - **Approximately every other month**
- **Meeting Location**
  - **Usually based in Reston, VA**
  - **Always provide for Teleconference via “800” dial-in**
- **Means of Communication**
  - **Email distribution**

## **PSysM Background**

- **Kicked Off study group at PSM Users Conference in Vail (July 1997)**
  - **Strong support within workshop for this effort**
  - **PSM process is valid and can be reused extensively**
  - **Systems measurement has broader scope**
  - **Recommendation to proceed with PSysM project accepted and study group formed**
- **Met at INCOSE International Symposium in LA**
  - **Strong agreement with results of workshop**
- **Draft Project Plan completed, reviewed, and revised**
- **First PSysM IPT meeting held at INCOSE Winter Workshop in Dallas (JAN 1998)**
  - **Revised plan & concept outline**
  - **Worked to next level of Issues, Categories, and Measures**

## **PSysM Background (Cont'd)**

- **Held IPT Meeting 31 MAR 1998 at Lockheed Martin site in Reston, VA**
  - *Teleconferenced working session*
  - *Clarified scope*
  - *Refined Issues, Categories, and Measures (ICMs)*
  - *Established Selection Criteria for ICMs*
  - *Actions given for prioritizing ICMs for first release*
- **Coordinated further steps at STC**
- **Held Latest IPT Meeting 4 MAY 1998 at Lockheed Martin site in Reston, VA**
  - *Teleconferenced working session*
  - *Refined Issues, Categories, and Measures (ICMs)*
  - *Actions for draft measure definition*

## **PSysM Status**

- **Draft Project Plan Completed and Revisions Identified**
  - *Incorporation of revisions are waiting for resolution of overall PSM project strategy*
- **Preliminary set of Issues, Categories, and Measures derived and refined**
- **Draft set of Measures Defined for Review at PSM Users Group Conference**
- **Draft Guidebook Outline completed**
  - *Final outline depends on product delivery decisions by government*
  - *Unanimous support by INCOSE MWG and PSM TWG for integrated approach*

## **Issues / Risks**

- *Official Status of the PSystem Project*
- *Funding*
- *Format and Delivery of PSystem Products*

## **Overview of Concepts and Principles**

## **Key Concepts**

- ***Views Measurement as a Process, not a Pre-Defined List of Measures, Graphs, or Reports***
- ***Defines a Systematic Method for Selecting Appropriate Measures that address program/system specific issues***
- ***Defines a Systematic Method for Analyzing Data incorporating the use of analysis independent of the data/analysis provider to Assess Issues/Risks***
- ***Effective Program-Level Measurement is a Prerequisite for Enterprise and Process Measurement***

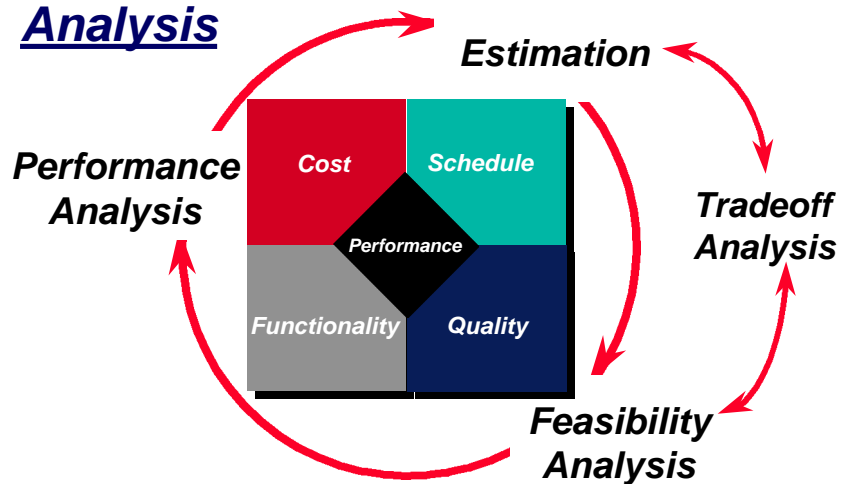
## **Measurement Principles**

- ***System/Program Issues and Objectives Drive the Measurement Requirements***
- ***The Life Cycle Process Defines How the System/Program is Actually Measured***
- ***Collect and Analyze Data at a Level of Detail Sufficient to Identify and Isolate Problems***
- ***Implement an Analysis Capability Independent of the Data/Analysis Provider***
- ***Use a Systematic Analysis Process to Trace the Measures to the Decisions***

## Measurement Principles

- *Interpret the Measurement Results In the Context of Other System/Program Information*
- *Integrate Systems/Program Measurement Into the Entire Life-Cycle Process*
- *Use the Measurement Process as a Basis for Objective Communications*
- *Focus Initially on Single System/Program Analysis*

## Analysis



## **Link Between Software and Systems**

- ***For Issues, Measurement Categories, and Measures regarding software components of the system, reference will be made to the PSM guidebook.***
- ***Further detail or additional links will be defined later.***

## **Review of I-C-Ms**

## **Issues, Categories, and Measures**

- **Initial set of common issues and measurement categories developed at PSM Workshop in 1997**
- **Further work on ICMs conducted at INCOSE Summer Symposium, Winter Workshop, and IPT Meetings**
  - **Refined issues and categories**
  - **Identified Preliminary set of measures**

## **PSysM Issue/Category/Measure Selection Process**

- **Start with the PSM Issues, Categories, and Measures (ICMs)**
  - Complete
- **Remove or modify ICMs not applicable to Engineering a System**
  - Complete
- **Add candidate ICMs that are applicable to Engineering a System**
  - Complete
- **Establish selection criteria for ICMs**
  - Complete
- **Review list of candidate ICMs against established selection criteria and prioritize the list**
  - In-progress
- **Select ICMs for inclusion in guidance**

## PSysM Issue/Category Selection Criteria

- **Uniqueness**
  - Proposed new issue or category has little or no overlap in focus to the existing issues or categories
- **Simplicity**
  - Easy to understand and use
- **Relevance**
  - Relevant to most systems, program managers and systems engineers
  - Addresses the questions most managers and engineers need to answer
- **Lack of Fit Under Other Issues**
  - Scope of other issues and categories cannot be changed to accommodate the proposed issue or category

## PSysM Selection Criteria for Measures/Indicators

- **Past Success**
  - Proposed new measure has been used successfully by multiple users (where success means yielding useful insight into the issues and supporting decision making)
- **Non-proprietary**
  - Available for public use
- **Simplicity**
  - Easy to state, measure, understand, and use
- **Relevance:**
  - Relevant to most systems, program managers and systems engineers
  - Addresses questions most managers and engineers need to answer
- **Data Obtainability**
  - Uses data that are usually readily obtainable
- **Repeatable and Unambiguous**
  - Can be defined in sufficient detail such that collectors, analysts, and users of the data agree on the meaning



## Systems Common Issues

- Schedule and Progress
- Resources and Cost
- Growth, Stability, and Capacity
- Product Quality
- Life Cycle Process
- Technology Effectiveness (and Performance)
- Customer / User Satisfaction \*

\* Not currently in PSM

## PSysM Issues and Measurement Categories

- Schedule and Progress
  - Work Unit Progress
  - Schedule Performance
- Resources and Cost
  - Personnel
  - Financial Performance
  - Other Resources
- Growth, Stability, and Capacity
  - Functional Size and Stability
  - Product Size and Stability (includes capacity)
- Product Quality
  - Defects and Failures
  - Rework, Restore, or Fix
  - Requirements Quality
  - Safety
  - Usability
- Life Cycle Process
  - Process Evaluation
  - Productivity
  - Process Mgt Effectiveness
  - Planning Stability
- Technology Effectiveness
  - Technology Evaluation and Assessment
  - Technical Performance
  - COTS/GOTS/NDI/Reuse Solution Potential
- Customer / User Satisfaction
  - Customer / User Feedback - Satisfaction With Solution
  - Customer / User Feedback - Satisfaction With Engrg Team

## Key Questions Answered By Each Systems Measurement Category

Issue	Measurement Category	Question Addressed
Schedule and Progress	Work Unit Progress	How are specific activities and products progressing?
	Schedule Performance	Is program spending meeting schedule goals?
Resources and Cost	Personnel	Are qualified staff assigned according to plan?
	Financial Performance	Is program spending meeting budget objectives?
	Other Resources	Are necessary facilities and equipment available as planned?
Growth, Stability, and Capacity	Product Size and Stability	Are the product size and capacity changing?
	Functional Size and Stability	Are the functionality and requirements changing?
Product Quality	Defects and Failures	Is the system good enough for delivery to the user?
	Rework, Restore, and Fix	How difficult is the system maintain?
	Requirements Quality	How good are the requirements? Are the requirements verifiable and traceable?
	Safety	Can the system be used without causing harm?
	Usability	How complex is the system to the user?
Life Cycle Process	Process Evaluation	Is there a predictable process that will support meeting cost, schedule and quality goals?
	Productivity	Is the developer efficient enough to meet current commitments?
	Program Mgt Effectiveness	How effective is the management team at planning and executing to plan?
	Planning Stability	Is the program plan changing?
Technology Effectiveness	Technology Eval & Assess	Is the planned impact of the leveraged technology being realized?
	Technical Performance	Is the system achieving the performance targets?
	COTS/GOTS/NDI/Reuse	How much of the functionality and architecture can be satisfied with COTS, GOTS, NDI, or reuse?
Customer/User Satisfaction	Cust. Satisfaction With the Solution	Is the customer and user satisfied with the system or product provided?
	Cust. Satis. With Team	Is the customer and user satisfied with working attributes of the engineering team?

## PSysM Mapping of Issues, Categories, and Measures

ISSUE	CATEGORY	MEASURES / INDICATORS
Schedule and Progress	Work Unit Progress (at each level of the system hierarchy)	Problem Report Status (by attribute) Action Item Status (includes action from audits) TBDs/TBRs Status Issue/Risk Status (includes attributes of identification and mitigation) System Element Status (includes attributes of design, build, integration, test, and delivery) Requirements Status (% Derived, allocated, validated, verified, and delivered) Design Status Integration Status (items include Plans and Procedures) (status includes Defined, Reviewed, and Executed) Test Status (items include Plans, Procedures, and Threads /Scenarios / Use Cases) (status includes Defined, Reviewed / Validated, and Executed Successfully/Unsuccessfully) Reviews/Audits Completed Change Request Status (Baseline Changes Requested, Approved, and Incorporated)
	Schedule Performance (corresponds to Milestone Performance in PSM 3.1)	Milestone Dates Schedule Variance Number of Schedule Dependencies for a Task Amount of Lead/Slack Time Length of Critical Path

**PSysM Mapping of Issues, Categories, and Measures**

<i>ISSUE</i>	<i>CATEGORY</i>	<i>MEASURE</i>
Resources and Cost	Personnel	Effort Profile (per task or product by type)
		Staff Level Profile (includes staff availability)
		Staff Experience
	Financial Performance	Staff Turnover (Attrition Rate)
		Cost Variance
		Actual Cost of Work Performed (ACWP)
		Budgeted Cost of Work Performed (BCWP)
		Budgeted Cost of Work Scheduled (BCWS)
		Cost At Completion
	Other Resources (Corresponds to Environment Availability in PSM 3.1)	Resource Availability Date
		Resource Quantity (by type)

**PSysM Mapping of Issues, Categories, and Measures**

<i>ISSUE</i>	<i>CATEGORY</i>	<i>MEASURES / INDICATORS</i>
Growth, Stability, and Capacity	Functional Size and Stability	Requirements Added, Deleted, or Changed (number and %)
		Number of TBDs/TBRs per Document
		Amount of Reuse / COTS / NDI
		■ Documents
		■ Models / Algorithms
		■ Components (HW, SW, etc.)
		■ Test Cases
		Architecture Elements
		Design Elements
		Object Classes
	Product Size and Stability (includes Capacity and Physical Measures which could be TPMs)	Elements (can include model components, in addition to HW or SW components)
		Subsystems
		Interfaces
		Database Size
	Memory	
	Capacity	
	Weight	
	Dimensions	

**PSysM Mapping of Issues, Categories, and Measures**

<i>ISSUE</i>	<i>CATEGORY</i>	<i>MEASURES / INDICATORS</i>
Product Quality	Defects / Failures	Problem Report Trends (attribution needed; includes opened, closed, and aging)
		Defect Density or Counts (by attribute; e.g., severity)
		Defect Cause Distribution
		Failure Interval or Times
		Failure Trends (by attribute)
Rework / Restore / Fix	Rework / Restore / Fix	Rework / Restore / Fix Time Duration
		Rework / Restore / Fix Time Trends
		Rework / Restore / Fix Effort
		Rework / Fix Size
Requirements Quality (Other than defects)	Requirements Quality (Other than defects)	Requirements Verifiability
		Requirements Traceability (includes traceability specifications, design, test plans, etc.)
		<ul style="list-style-type: none"> <li>■ Top-down (Childless Requirements)</li> <li>■ Bottom-up (Parentless Requirements)</li> </ul>
Safety	Safety	Hazardous Conditions Avoided
Usability (HCI/Human Factors)	Usability (HCI/Human Factors)	Safety Response Time
		Number of Informational Items (on a screen or provided to a user)
		Number of User Interface Devices (such as screens, panels, meters, or gauges)
		Number of Operational Tasks
		Number of Operator Decisions

**PSysM Mapping of Issues, Categories, and Measures**

<i>ISSUE</i>	<i>CATEGORY</i>	<i>MEASURES / INDICATORS</i>	
Life Cycle Process	Process Evaluation	Capability Level for Process Area or Focus Area	
		Processes Defined	
		Compliance To Process	
	Productivity	Productivity	Product Size Per Effort Ratio
			Functional Size Per Effort Ratio
	Process Management Effectiveness	Process Management Effectiveness	Cycle Time
			Planning Estimation Accuracy
			Compliance To Plan
			Risk Management Effectiveness (includes identification and mitigation)
			Disciplines Included in Review
			Review/Inspection Effectiveness
	Planning Stability	Planning Stability	Frequency of Schedule Changes
			Frequency of Resource Changes

***PSysM Mapping of Issues, Categories, and Measures***

<i>ISSUE</i>	<i>CATEGORY</i>	<i>MEASURES / INDICATORS</i>
<b>Technology Effectiveness</b>	<b>Technology Evaluation / Assessment</b> (corresponds to Technology Impacts in PSM 3.1)	Risk/impact of the technology (technical, cost, schedule)
		Relative adequacy for application
		Scalability of the technology
	<b>Technical Performance</b> (of operational system)	Expandability of the technology
		Element Utilization
		Element Throughput
		Operational Capacity
		Operational Throughput
		Turnaround Time
	<b>COTS/GOTS/NDI/Reuse Solution Potential</b>	Response Time
Efficiency		
<b>Customer / User Satisfaction</b>	<b>Customer / User Feedback - Satisfaction With Solution</b>	Functionality Covered by COTS
		Survey Results
	<b>Customer / User Feedback - Satisfaction With Engineering Team</b>	Number of Commendations / Complaints
		Award Fee Amounts and Trends
		Survey Results
		Number of Commendations / Complaints

***System Life Cycle Terminology***

## Current Systems Standards

- **EIA/IS 632 - Systems Engineering**
  - About to be replaced
  - Same as old MIL-STD 499B
- **EIA 632 (version 0.9) - Processes for Engineering a System**
  - Out for Ballot
- **IEEE Std 1220-1994 - Trial Use Std for Application and Mgt of the SE Process**
  - Not widely used

## Development Life Cycle Phases (from EIA 632)

Development Life Cycle Phases				
Conception	Creation			
Pre-System Definition	System Definition	Subsystem Definition	Fabrication, Assembly & Integration	Test & Evaluation
System-Level Design		Subsystem-Level Design		

## **Project & Technical Processes**

- Agreement
- Project Management
- Planning
- System Design
  - Development
  - Production
  - Test
  - Deployment
  - Training
  - Support
  - Disposition
- Control
- System Verification & Validation

## ***Measurement Table Terminology***

## Measurement Tables

**Measure -**  
Measurement Category -  
Issue -

**Definition and Purpose:**

The *Name of Measure Goes Here* measure ....  
This measure provides an indication of ....

**Selection Guidance:**

**Program Application**                      **Usually Applied During**

**Process Integration**                      **Limitations**

**This Measure Answers Questions Such As**

## Measurement Tables

**Specification and Implementation Guidance:**

**Typical Data Items:**

**Typical Attributes:**

**Typical Aggregation Structure**

**Typical Collection Frequency:**

**Typical Collection Level (Typically collected for):**

**Count Actuals Based On:**



## Measurement Tables

**Interpretation Guidance:** (This information is not in the PSM measure specifications, but may be helpful when we try to construct case studies or examples)

Interpretation and Usage Considerations:

Typical Tolerance Ranges (if applicable or known):

Lessons Learned:

---

Additional Information

## Group Breakout Session:

- Breakout into small groups.
- Review Draft Measurement Tables for Category Selected/Assigned (25 minutes per measure)
  - Review against criteria.
  - Adequacy of definition.
  - Ability to use measure as defined.
  - Recommendations for improvement.
- Present results. (10 minutes per group)

## **Group Breakout Session Results:**

## **Proposed Next Steps**

- ***Present Results to INCOSE MWG at Symposium on 27 July 1998***
- ***Complete Definitions of Measures***
- ***Resolve Guidance Format Decision***
- ***Continue to Seek Additional Support***
- ***Develop Relationship Between Measurement and Tradeoff Analysis***
- ***Develop Case Studies***

## Proposed Versions and Content

### **Version 1:**

- *Extend PSM to Systems*
- *Adjust Issues, Measurement Categories, and Measures*
- *Develop for General Audience*
- *Tradeoff Analysis*
- *Risk Analysis for Systems*
- *Link Between Systems and SW Measurement*
- *Case Studies*

### **Future Version(s):**

- *Additional Measures*
- *Decision Support Analysis*
- *Additional Case Studies*
- *Incorporate Lessons Learned*
- *Measures Related to Systems Engineering Capability Model*
- *Measurement Integration*
- *System/Software Interface Measures*
- *Additional Focus on “ilities”*
- *Product Engineering for Systems*

## Proposed Tasks & Schedule

### Development Task

- *Project Plan*
- *Guidebook Outline*
- *Identify Issues, Measurement Categories and Measures*
- *Specify Categories & Measures*
- *Draft Case Studies*
- *First Writers Week*
- *Draft PSystem Guidance*
- *2nd Writers Week*
- *Draft Training*
- *Promotional Briefings /Papers*
- *Release of PSystem Guidance*
- *Training Course Complete*

### Scheduled Completion \*

- *DEC 97 (Done)*
- *FEB 98 (Done)*
- *MAY 98 (Done)*
- *OCT 98 (In-progress)*
- *DEC 98*
- *NOV 98*
- *JAN 99*
- *FEB 99*
- *FEB 99*
- *As required*
- *APR 99*
- *MAY 99*

\* *Dates dependent on full project support by 1 OCT 98*