Practical Software and Systems Measurement

A Foundation for Objective Project Management

Measuring SE Products Workshop

Cumulative Results to July 2001

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In Cooperation With:

Acknowledgement

- ***Primary sources for this information are***
  1. ***Systems Engineering Fundamentals, DSMC***
  2. ***INCOSE Measurement Primer, INCOSE MWG***
  3. ***Practical Software and Systems Measurement version 4.0b***

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SE Product Measures: Definitions and Concepts

SE Product Measures

- ***Measures that are used to track key attributes of the product design***
  - ***Tracks progress in meeting the requirements and ability to fulfill them across the life cycle***
    - ***Performance***
    - ***Suitability***
    - ***Affordability***

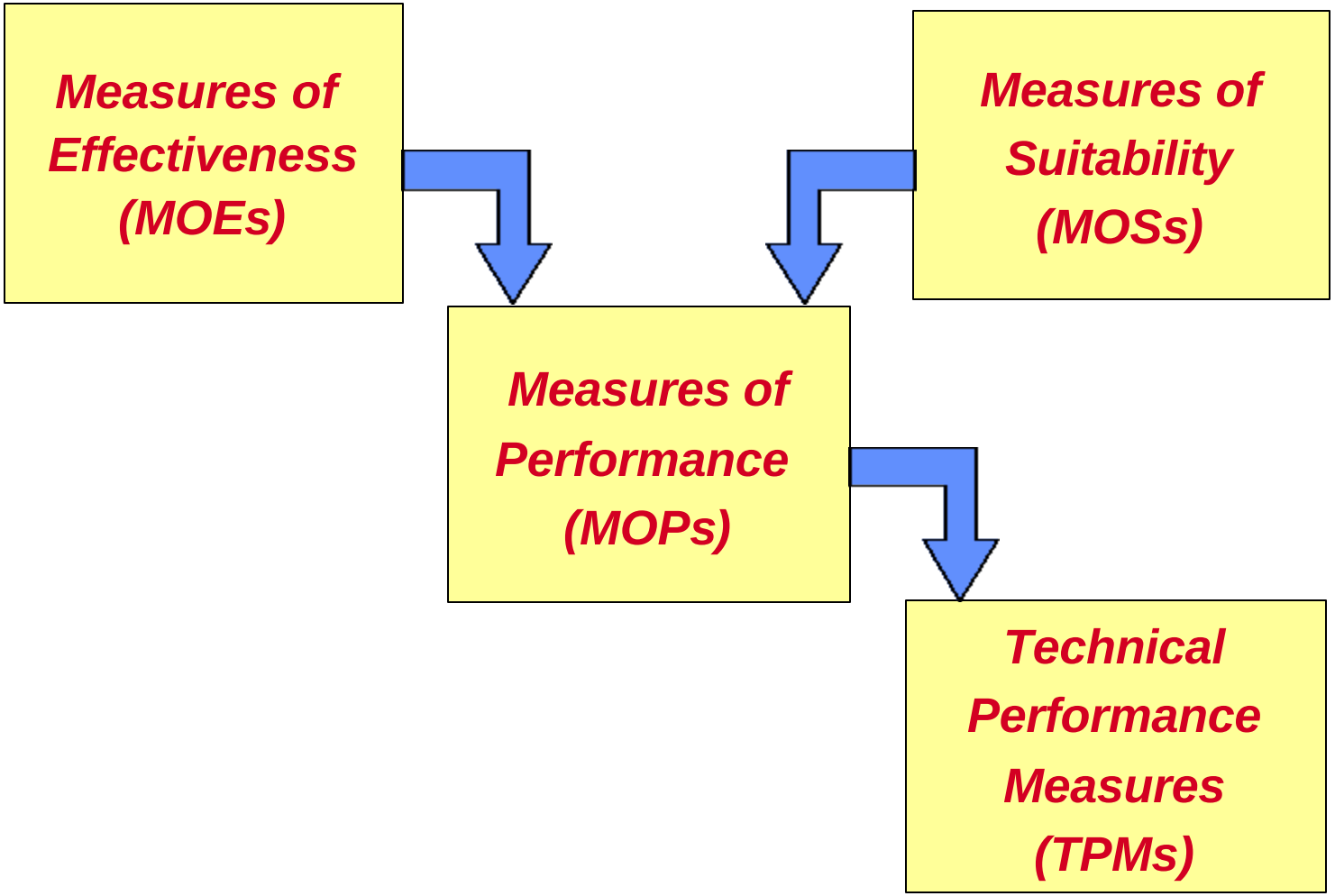
Insight Provided by Measurement

- ***characterize***
  - ***to gain understanding of processes, products, resources and environments***
  - ***to establish baselines for future assessments***
- ***evaluate***
  - ***to determine status with respect to plans***
- ***predict***
  - ***to support planning and trades, BOE/proposal preparation***
- ***improve***
  - ***to help identify roadblocks, root causes, inefficiencies and other opportunities for product and process improvement***

Relationship to PSM

Common Issue Area	Measurement Category	Measures
Product Size and Stability	Physical Size and Stability	Database Size Components Interfaces Lines of Code Physical Dimensions
Product Quality	Functional Correctness	Defects Technical Performance
	Supportability	Time to Restore Maintenance Actions
	Efficiency	Utilization Throughput Timing
	Portability	Standards Compliance
	Usability	Operator Errors
	Dependability	Failures Fault Tolerance

Hierarchy of Product Measures



Measures of Suitability (MOSs)

- ***Measures the extent to which the system integrates into the operational environment***
  - ***Looks at most of the 'ilities***
    - ***Supportability (Maintainability, ILS, Testability, Transportability, etc.)***
    - ***Dependability (Reliability, Availability, Life Expectancy, Safety, etc.)***
    - ***Functional Correctness (Defect density, Design simplicity, Design robustness, etc.)***
    - ***Efficiency (Usage Rates, Required performance, etc.)***
    - ***Portability (Portability, Compatibility, Interoperability, etc,)***
    - ***Usability (Human Factors, ease of operation,etc.)***
  - ***Can be used to track necessary improvement in these***

Measures of Effectiveness (MOEs)

- ***Measures of the operational effectiveness***
  - ***Looks at the systems' capability to achieve mission success within the total operational environment***
    - ***Customer/Acquirer view***
    - ***Measurement occurs at end of development***
  - ***Requires identifying the most critical performance requirements***

Measures of Performance (MOPs)

- ***Measures that characterize physical or functional attributes relating to the system operation***
  - ***Focuses on:***
    - ***Quantify technical or performance requirements as derived from MOEs and MOSs***
    - ***Key performance requirements in the system specification***
      - ***Can help define/refine performance requirements***
    - ***Identification of critical technical parameters for which TPMs should be derived to track***
  - ***Based on technical requirements rather than customer view (mission needs)***
- ***Derived from MOEs and MOSs***

Technical Performance Measures (TPMs)

- ***Measures to assess design progress, compliance to performance reqts, and technical risk***
- ***Derived from MOPs***
- ***TPMs and MOSs often overlap***
  - ***e.g., Mean Time Between Failure (MTBF) provides insight into both effectiveness and suitability***
- ***Focus on specific performance related reqts as incorporated in the design solution***
  - ***Can include range, accuracy, weight, size, availability, power output, throughput, and other product characteristics related to critical operational reqts.***

Technical Performance Measures (TPMs)

- ***An attribute of a system that can be measured to determine how well a system is satisfying or meeting a technical requirement or goal.***
  - ***Provides an assessment of the product design by estimating the values of essential performance parameters of the design through engineering analyses and tests.***

Technical Performance Measures (TPMs)

- ***TPMs are used to:***
  - ***Forecast the values to be achieved through the planned technical effort***
  - ***Measure differences between the achieved values and those allocated to the product by the systems engineering process***
  - ***Determine the impact of these differences on system effectiveness.***

Technical Performance Measures (TPMs)

- ***The purpose of a TPM is to:***
  - ***Provide visibility of actual versus planned performance***
  - ***Provide early detection or prediction of problems requiring management attention***
  - ***Support assessment of technical impact of proposed change alternatives.***

Examples of Product Measures

MOE: Data system must be able to process mission critical functions with 0 failures

MOS: System 'ilities requirements

MOP: System must be able to provide uninterrupted computing for 100 hours

TPM: Fault tolerance, redundancy, failure rate, etc.

Examples of Product Measures

MOE: Satellite must perform normal ops for expected life of system

MOS: Life expectancy of the satellite under normal ops is 10 years

MOP: Propulsion subsystem life must be equal to or greater than 10 years

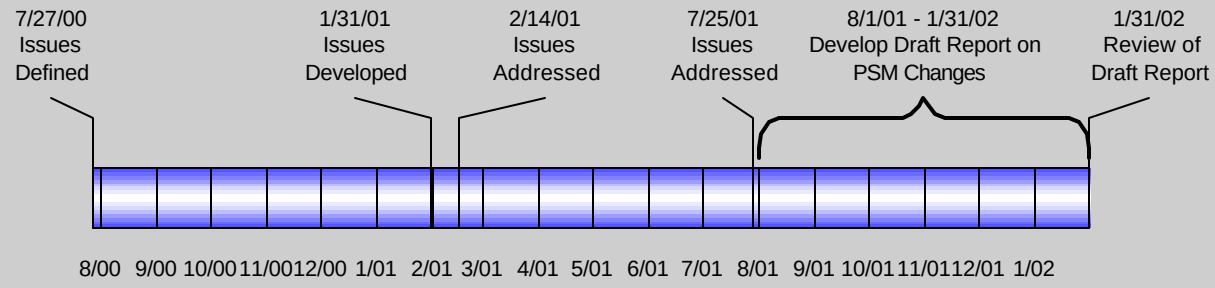
TPM: Propellant usage, attitude correction, vehicle weight, prop. tank size, etc.

Workshop Results to Date

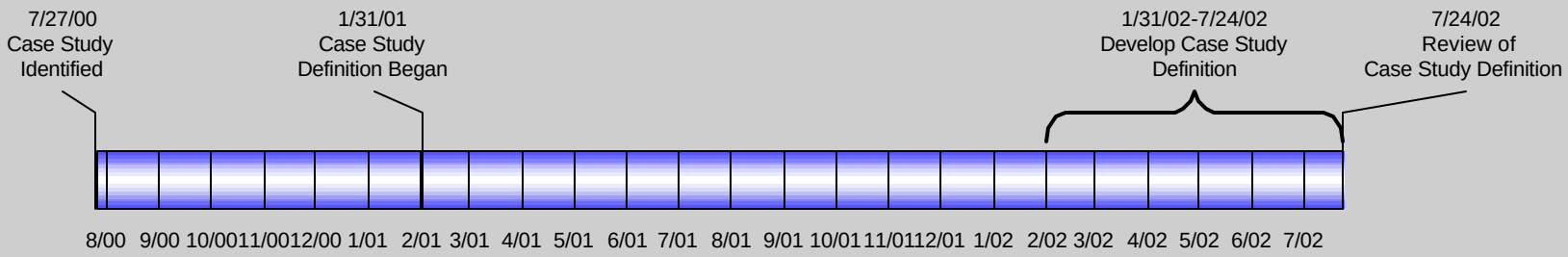
- ***New Guidance Development***
  - ***Tailor Measures***
  - ***Apply Measures***
- ***Case Study Development***

Results of Prior Workshops

Changes required to Tailor Measures and Apply Measures Activities



Definition of a Case Study



Progress to February 2001 on New Guidance Development

Legend

Issue addressed prior to July 2001

Issue to be worked in July 2001

Issues and questions regarding the use of MOE/MOS/MOP/TPMs in Tailoring

- Trace of critical customer needs, system requirements, or design attributes to measures
  - Incorporate additional guidance into the issue identification and prioritization
- Clear definitions and examples for several domains
- Selection and examples of measures for Life Cycle Maintenance
  - Supportability
  - Proving original MOEs
- Break "Technical Performance" and "Physical Dimensions" into a few additional measures

Issues and questions regarding the use of MOE/MOS/MOP/TPMs in Tailoring

- Prioritization of technical parameters to identify candidate TPMs
- How to integrate into the Life Cycle processes
  - Definition of data sources (including allocations, models, early testing)
  - Definition of when to analyze and use
- Volatility of critical requirements

Drivers for these measures

- ***MOEs***
  - ***Mission need***
  - ***Operational scenario and risks (including congingency planning)***
- ***MOPs***
  - ***Technical risks***
  - ***Key performance parameters (KPP)***
  - ***System affordability***

Drivers for these measures (Cont.)

- ***TPMs***
  - ***Technical risk***
  - ***Quality requirements***
  - ***Technical constraints (including physical, technology, performance)***
- ***MOSs***
  - ***Decided to defer development of MOSs for this pass***

PSM Measure Change Recommendations

- ***Revisit physical dimensions - what is meant is much broader than dimensions, i.e., should it be physical characteristics, product attributes)***
- ***Revisit technical performance measure***
- ***Recast both of the above into indicator, derived measure, base measure***

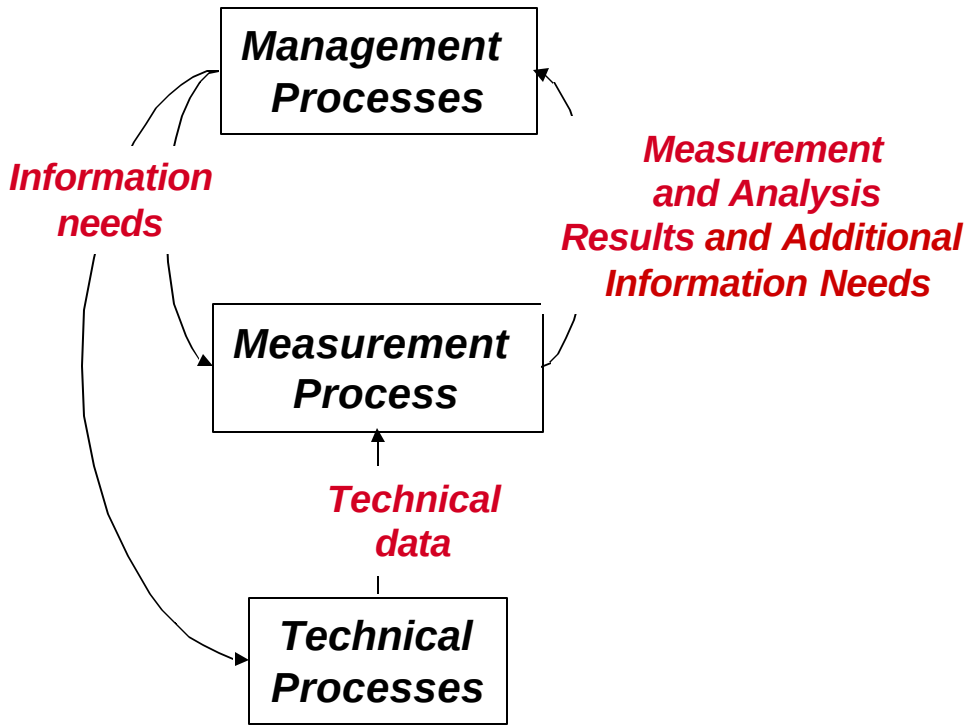
TPM prioritization drivers

- Risks (including feasibility of requirements)
- Ability to support trades among possibilities for achieving KPPs (i.e., trades among potential solutions)

Integration into Life-cycle processes

- ***Strongly tied to risk management***
- ***Requirements analysis***
- ***Decision analysis***
- ***Quality management***
- ***Technology change management***

Integration into processes



Issues and questions regarding the use of MOE/MOP/TPMs in Applying

- How to update estimates with partial actual data as it becomes available
  - Estimates, Designed/Modeled, and Actual Values
- Description and examples of forecasts, thresholds, and growth functions
  - How to establish or use predictive models from the measurement results
- Guidance and example of how to analyze across measures to support trades
  - Assumes that the Trade Study will identify additional information needs to measurement activity
- How to perform estimation, feasibility, and performance analysis

Progress to February 2001 on Case Study Definition and Development

Case Study Outline Requirements

- ✓ *Modernization project - incremental fleet replacement by customer*
- ✓ *Show how MOE/MOP/TPMs were chosen and defined from customer issues*
- *Show how measures were integrated into the life cycle processes (including O&M)*
- *Show estimation, feasibility and performance analysis*
- *Show trades that were needed due to exceeding one of the TPMs*
- *Show alternatives and recommendations*

Case Study Outline Requirements (Cont.)

- ***Include a description parallel to the technical one for the programmatic setup of the project and monitoring using measurement information***

Case Study Description

- *Commercial Transportation*
- *Establish 1-2 MOEs (Market Definition)*
  - *Journey Cost Constraints*
  - *Passenger/Cargo Capacity and Range Needs [Journey Definitions]*
  - *Journey Schedule Performance Needs*
- *Establish 3 MOPs (System Mission Definition)*
  - *Direct Operational Cost Requirement [Budget]*
  - *Aircraft Range of X miles*
  - *Aircraft capacity of Y passengers and Z cargo*
  - *At least 98% of scheduled aircraft departures must be capable of push back from the gate w/in 15 mins of scheduled time (a.k.a., dispatch reliability)*

Case Study Description (Cont.)

- ***TPMs (Project Definition)***
  - ***Fuel Consumption Rate***
  - ***Scheduled/Unscheduled Maintenance Costs***
  - ***Predicted Cost per passenger mile***
  - ***Dry aircraft weight***
  - ***Drag***
  - ***Aircraft/element reliability, availability, supportability***

Case Study Outline

- Project overview
  - Introduction
  - Project description
    - Needs statement
    - Motivation
  - Project environment
- Tailoring Measures
  - Define MOEs
  - Trade analysis-modify or build new
  - Define MOPs
  - Technology
  - Feasibility analysis

Case Study Outline (Cont.)

- *Project engineering*
  - *Identify alternatives*
  - *Select alternative*
  - *Perform risk analysis*
  - *Define TPMs*
  - *Implement solution*
    - *Monitor TPMs*
    - *Actions when TPMs was exceeded*
      - *Mitigation actions*
      - *Trades*
    - *Show roll-up to MOP/MOE*

July 2001 Workshop Discussion

The following slides were intended to frame a discussion addressing the 9 open issues

Results are incorporated for the 6 issues that were addressed

Issues and questions regarding the use of MOE/MOP/TPMs in Tailoring

- Issue 1: Selection and examples of measures for Life Cycle Maintenance
  - Supportability
  - Proving original MOEs
- Issue 2: Break "Technical Performance" and "Physical Dimensions" into a few additional measures
  - Consider changing name of "Physical Dimensions" to "Product Attributes"
- Issue 3: Volatility of critical requirements

Issue 1: Selection and examples of measures for Life Cycle Maintenance

- ***Supportability***
  - ***Expand scope to include Maintainability, ILS, Testability, Transportability***
- ***Identify TPMs that apply to or carry through post-deployment***
- ***Continually Monitoring original MOEs on an ongoing basis during operations and particularly after maintenance and enhancement actions***
- ***Measure Customer Satisfaction since it is influenced by Life Cycle Maintenance***
- ***Others***

Issue 2: Break "Technical Performance" and "Physical Dimensions" into a few additional measures

- Technical performance

- Physical dimensions

Discussion on this topic was deferred due to time

Issue 3: Volatility of critical requirements

- ***Ideas for mitigating effects of requirement volatility on SE product measures***
  - ***Integrate technical product measures with measures for schedules and resources to make relationships visible***
  - ***Perform feasibility analysis on the integrated set of measures developed above***
  - ***Perform impact analysis when considering changes (modeling may help)***
  - ***Use information derived from requirements tools as additional inputs to TPMs***
  - ***Possible resource for guidance is http://www.processimpact.com/articles/qualreqs***

Issues and questions regarding the use of MOE/MOP/TPMs in Applying

- Issue 4: How to update estimates with partial actual data as it becomes available
  - Estimates, Designed/Modeled, and Actual Values
- Issue 5: Description and examples of forecasts, thresholds, and growth functions
  - How to establish or use predictive models from the measurement results
- Issue 6: Guidance and example of how to analyze across measures to support trades
- Issue 7: How to perform estimation, feasibility, and performance analysis

Issue 4: How to update estimates with partial actual data as it becomes available

- ***Guidance on use of Estimates, Designed / Modeled, and Actual Values***
  - ***As applicable, use expected growth profiles for the TPM and track the TPM against the profile***
  - ***Apply Rolling Wave planning, where appropriate***
  - ***Establish confidence intervals based on the amount of actual data***
    - ***Apply statistical techniques***
    - ***Can quantify how much risk remains in meeting the TPM threshold or objective value***
    - ***Use of % complete (analogous to earned value) towards establishing level of confidence***

Issue 5: Description and examples of forecasts, thresholds, and growth functions

- ***How to establish or use predictive models from the measurement results***
  - ***Identify what predictions are needed***
  - ***Identify key drivers of variation***
  - ***Identify relationships between measurable attributes of the drivers***
  - ***Collect data for the attributes of the drivers***
  - ***Determine quantitative relationships/models***
    - ***May include data from other TPMs***

Issue 5: Description and examples of forecasts, thresholds, and growth functions (Cont.)

- ***Thresholds***
  - ***Establish loose thresholds based upon engineering judgment and standards***
  - ***Collect data on the product and process as the process is performed***
  - ***Refine thresholds based on actual data (at least until statistically significant)***

Issue 6: Guidance and example of how to analyze across measures to support trades

- ***Ideas??***

Discussion on this topic was deferred due to time

Issue 7: How to perform analysis

- Need to look at PSM guidance (Part 4, Chapter 3) for types of analysis, and determine what to add for SE product measurement
  - Estimation analysis
  - Feasibility analysis
  - Performance analysis

Discussion on this topic was deferred due to time

Issue 7 (Cont.)General analysis concepts

- ***Basic indicator concepts - any additions?***
- ***Structured analysis model - still applies***

Discussion on this topic was deferred due to time

Issue 7 (Cont.) Estimation analysis guidance

- Use analysis model to see inter-dependencies
  - You may be able to quantify some parameters "upstream" of Product Quality
  - Then you can use estimators that have known relationships to SE product measures to make predictions
- Estimation task
  - Select approach
  - Map approach and calibrate model
  - Compute estimate
  - Evaluate estimate

Discussion on this topic was deferred due to time

Issue 7 (Cont.) Estimation analysis guidance

- Estimation approaches
  - Parametric models
  - Activity-based models
  - Analogy
  - Simple estimating relationships
  - Others??
- Any special estimating guidelines for SE products?

Discussion on this topic was deferred due to time

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Issue 7 (Cont.) Feasibility analysis guidance

- Generally relates an estimate (or plan) for some measurable attribute to a plan
- Assesses realism of achieving the estimated values
- Any special guidelines for evaluating target values for SE products?

Discussion on this topic was deferred due to time

Issue 7 (Cont.) Performance analysis guidance

- Performance analysis task
  - Compare planned value versus actual
  - Assess impact
  - Predict outcome
  - Evaluate alternatives
- What are the special considerations for SE product measurement?

Discussion on this topic was deferred due to time

Issue 8: Wrapping up this project - are we done yet?

- Ken and Garry will consider all of the ideas developed over the last year as they develop a paper on this topic
  - Want to capture the thoughts for new PSM guidance before moving on to developing a case study
  - Will work off remaining issues via email discussions
- Paper is intended to provide direction for development of additional SE content in PSM version 5

Issue 9: Disposition of the SE Product Case Study

- Does the current list of ideas captured on the slides sufficiently convey what is needed in the case study?
  - Yes – try to identify a real project that we can get description and data from as a basis
- Who will continue this effort?
  - Need a project/workshop leader
    - INCOSE MWG will take Case Study as project and share with PSM
    - Chris Miller willing to work with the lead or as co-lead
    - Work with Betsy Clark on level of content and format
  - Need a cadre of committed contributors
    - Solicit INCOSE MWG and JCAWG for assistance
    - Solicit FAA, Lockheed Martin, SPC