Technical Measurement

A PSM Collaborative Project

Presentation for PSM User Group Conference
18 July 2003

Garry Roedler
Principal Systems Engineer
Chair, Systems Integration Process Review Board
Lockheed Martin Management and Data Systems
garry.j.roedler@lmco.com

Practical Software and System Measurement

Objectives

- Determine how Technical Measures relate to other measures and indicators
- Create guidance on technical performance measurement that:
  - Supplements existing general measurement guidance
  - Provides a consistent approach for projects
  - Provides information for predictive usage
  - Is based on lessons learned across DoD and industry
  - Is supported by appropriate implementation mechanisms (e.g., templates, examples)

Background/Approach

- Leverage existing proven guidance from across DoD and industry
  - Focus on what is specific to technical performance measurement
  - Build of previous PSM/INCOSE work
  - Point to PSM and INCOSE for basic measurement guidance
- Collaborate between PSM, INCOSE and industry companies to:
  - Leverage industry resources and knowledge
  - Influence industry guidance to be consistent
- Obtain understanding of state-of-the-industry via administration and analysis of questionnaires
- Issue a "white paper" on TPM information and guidance
- Incorporate guidance into other documentation, where applicable

Organization of White Paper

1. Executive Summary
2. Introduction
3. Description of technical measurement and types of technical
4. Demographics of use per Technical Measurement Questionnaire

The next 3 sections walk through Technical Measurement using the PSM measurement approach

5. Establishing commitment for technical measurement
6. Planning Technical Measurement
7. Performing Technical Measurement

The remaining sections include addition information to assist the planning and implementation of the technical measurement

8. TPM Checklist
9. Application of Technical Measurement in IPTs
10. Candidate measures matrix for various application domains (preliminary draft)
11. Technology Readiness Levels
12. References

Description of technical measurement and types of technical measures

- *What is technical measurement?*
- *What types of measures are applied?*
- *Use of the measures*

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*

Measures of Effectiveness (MOE)

- *"Operational" measures of success that are closely related to the achievement of the mission or operational objective being evaluated, in the intended operational environment under a specified set of conditions*
  - *Stated from the user/customer viewpoint*
  - *Focused on most critical mission performance needs*
  - *Independent of any particular solution*
  - *Actual measures at end of development – estimates prior*
- *MOEs are used to:*
  - *Compare operational alternatives*
  - *Investigate performance sensitivities to changes in assumptions from the user view*
  - *Define operational requirement values*
  - *Assess achievement of intended purpose*
    - *Mission needs for performance, suitability, and affordability*
    - *Operational success criteria*

Measures of Performance (MOP)

- *Measures that characterize physical or functional attributes relating to the system operation*
  - *Supplier's viewpoint*
    - *"System" technical requirements vice user needs*
  - *Measured under specified testing or operational conditions*
  - *Derived from MOEs (many to one)*
  - *Assesses delivered solution performance against critical system level specified requirements*
  - *Risk indicators that are monitored progressively*
- *MOPs are used to:*
  - *Compare alternatives to quantify technical or performance requirements as derived from MOEs*
  - *Investigate performance sensitivities to changes in assumptions from the technical view*
  - *Define Key Performance Parameters (KPPs)*
  - *Assess achievement KPPs*

Technical Performance Measures (TPM)

- *Measures used to assess design progress, compliance to performance requirements, and technical risks*
  - *Focus on the critical technical parameters of specific system elements*
    - *Definition includes the projected performance, such as a performance profile with tolerance bands of acceptable variance*
    - *Measures includes range, accuracy, weight, size, availability, and many others*
  - *Derived from the MOPs (many to one)*
  - *Measured as solution is designed and implemented*
    - *Estimates the values of essential performance parameters of the design through engineering analyses and tests*
    - *Tracked against performance profile with projected final value*

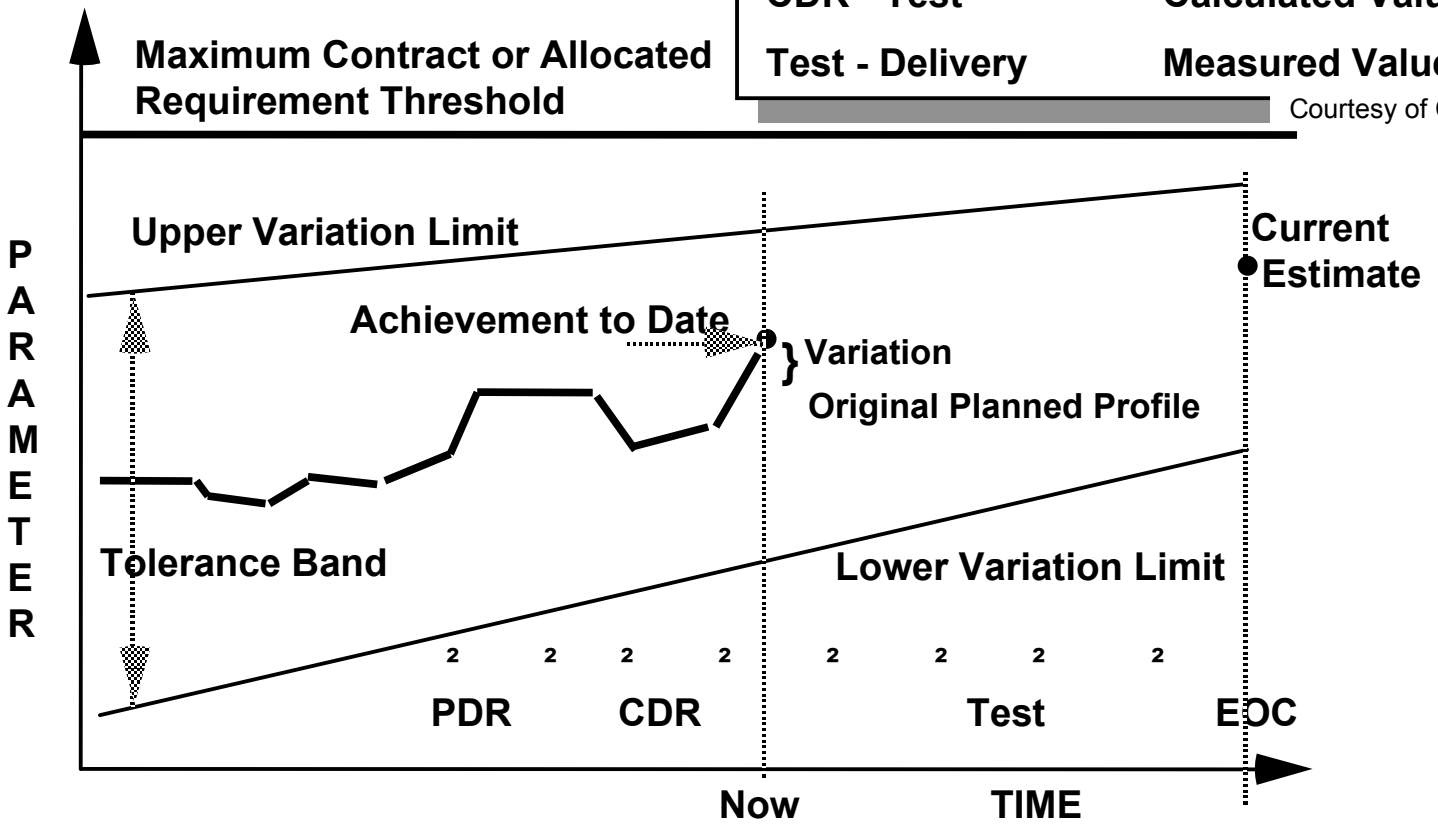
Technical Performance Measures (TPM)

- ***TPMs are used to:***
  - ***Forecast the values to be achieved***
  - ***Identify differences between actual versus planned performance***
  - ***Assess and predict progress towards achieving the performance values***
  - ***Determine the impact of these differences on system effectiveness***
  - ***Provide an indicator of risks and problems requiring management attention (early identification)***
  - ***Determine where opportunities exist to make design trades to reduce overall risk (e.g., where positive margins exist)***
  - ***Support assessment of system element design alternatives or impacts of proposed change alternatives***

Other Technical Measurement Concepts

Development Phase	Measurement
Through PDR	Estimated Value
PDR - CDR	Allocated Value
CDR - Test	Calculated Value
Test - Delivery	Measured Value

Courtesy of CSM



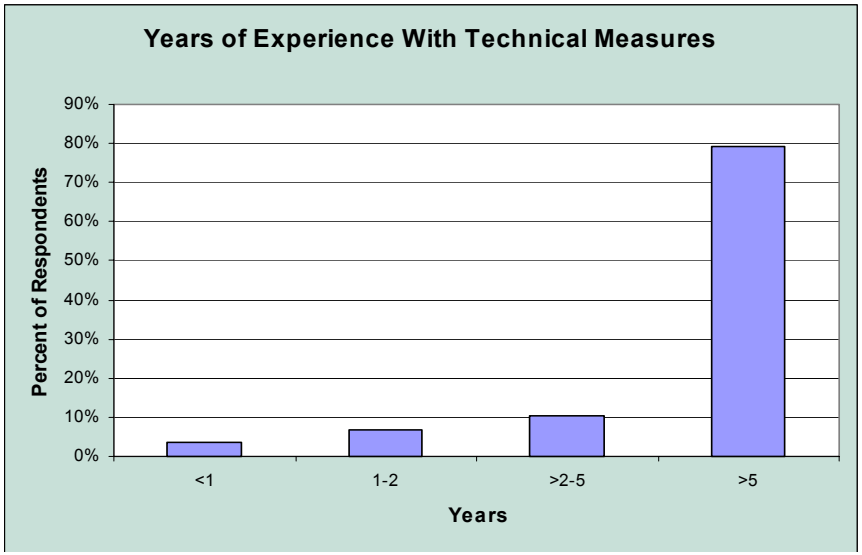
Uses of Technical Measures

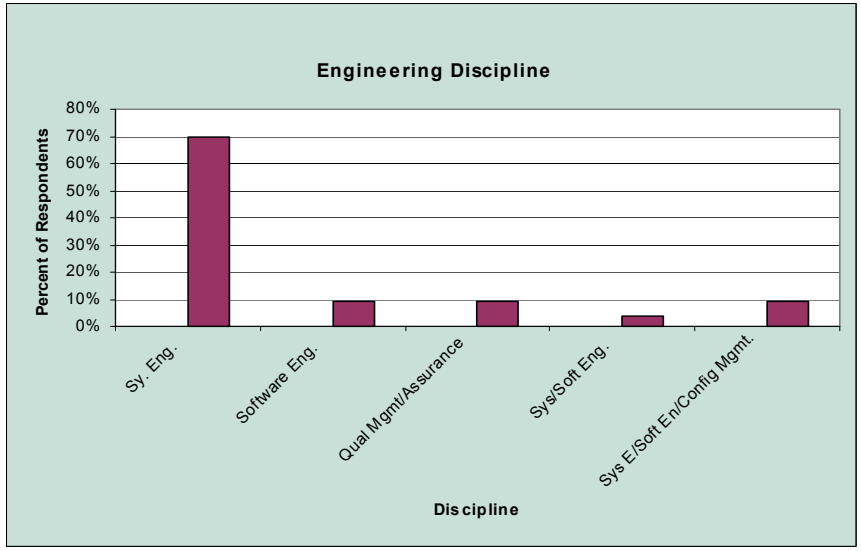
- *Indicators of Operational Objectives*
  - *Ability of technical solution to meet mission needs*
- *Indicators of Technical Solution Progress*
  - *Track progress against plan through life cycle*
- *Indicators of Compliance to Performance Requirements*
  - *Predict likelihood of meeting performance rqts.*
- *Indicators of Technical Risk*
  - *Alert mgt of potential performance deficiencies before irrevocable cost/schedule impact occurs*

Demographics of Use Per Technical Measurement Questionnaire

- *Respondent Demographics*
- *Usage of MOEs, MOPs, and TPMs*

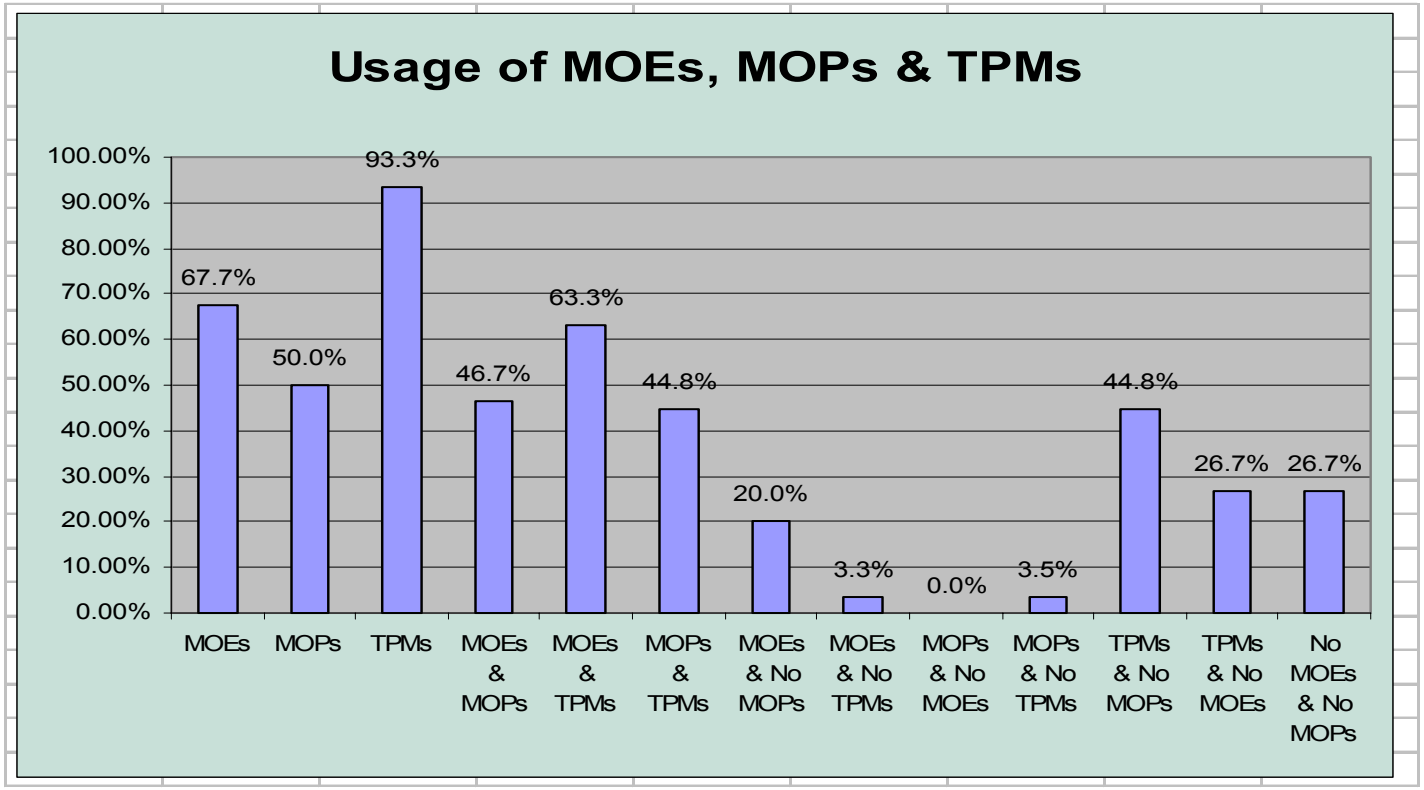
Questionnaire Respondent Demographics





- *Wide range of roles with significant experience in technical measurement and leadership*
- *Majority of respondents:*
  - *Had > 5 years experience*
  - *Systems and software engineering*
- *Roles included:*
  - *Company Pres./VP*
  - *Tech./engrg. fellows*
  - *Engrg. directors/mgrs*
  - *Principal/lead engrs*
  - *Engrg. process program directors/chairs*
  - *QA staff*
  - *Measurement leads/staff*

What types of measures are used?



- *MOEs, MOPs and TPMs were all used by the respondents, but in varying degrees*
  - *Nearly all used TPMs; majority used MOEs; half used TPMs*
  - *Some orgs use a hierarchy of TPMs, vice using MOE/MOPs*
  - *MOE/MOPs not often flowed down to subcontractors*

Establishing commitment for technical measurement

- *General practice*
- *Who are the stakeholders?*
- *Establishing joint objectives between Acquirer and Supplier*

Technical Measurement Stakeholders

Primary Stakeholders	MOE	MOP	TPM
Customer/Acquirer	X	X	
Engineering Staff of Supplier		X	X
Integrated Poduct Team (IPT)	X	X	X
Quality Management	X		

Note: Each listed item was required to have >40% of respondents identify it as a primary stakeholder.

- ***Results shown from questionnaire***
- ***Primary stakeholders vary depending on the type of technical measure***
  - ***Acquirer is concerned with MOE and possibly MOP***
  - ***Supplier engineering staff focuses on the measures of the chosen technical solution***
  - ***IPT interest spans all, since formed of both Acquirer & Supplier***
  - ***Quality management focused on customer satisfaction***

Establishing Joint Objectives

- *Establishment of joint measurement objectives and information needs between the acquirer and supplier organizations is a good practice*
  - *Saves resources and improves communication*
- *Includes establishing agreement on:*
  - *Information needs*
    - *What common information is needed through the life cycle?*
    - *Which can be addressed by same measures and indicators?*
  - *Level of effort, responsibilities, tasks*
    - *Determine which tasks can be jointly supported*
  - *Maximizing communication, including IPTs*
    - *Plan for reviews*
  - *Common reporting formats*

Planning Technical Measurement

- *Determining and prioritizing information needs*
- *Identifying candidate technical measures*
- *Selecting and specifying technical measures*
- *Integrate into the project processes*

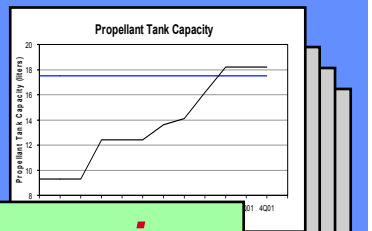
Planning Technical Measurement

Establish Mission Operational Objectives → Establish System Performance Requirements → Establish Lower-level Technical Requirements

Information Needs

Select & Define MOEs	Select & Define MOPs	Select & Define TPMs	Plan Analysis, Models & Progress	Perform Technical Measurement

Measures of Effectiveness	Measures of Performance	Technical Performance Measures
1. Service Life	1. Propulsion Capacity	1. Propellant Tank Capacity
2. Mission Critical Ops	2. Battery Cycle	2. Thruster Efficiency
3. ……	3 Solar Cell Life	3. Propellant Energy/Volume
	4. ……	4. Propellant S/S Reliability



2-12 MOEs, Avg. = 6

1-10 MOPs Per MOE, Avg. = 5

1-7 TPMs Per MOP, Avg. = 4

Increasing Resolution & Periodic Insight

Increasing Scope of Technical Solution

Planning Technical Measurement

PSM Product-Related Measurement Information

Information Category	Measurable Concept	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-Maint.	Time to Restore Maintenance Actions
	Efficiency	Utilization Throughput Timing
	Portability	Standards Compliance
	Usability	Operator Errors
	Dependability-Reliability	Failures Fault Tolerance

An example set of candidate measures is being created – but it will not be exhaustive

Primary Drivers for Information Need and Measure Identification

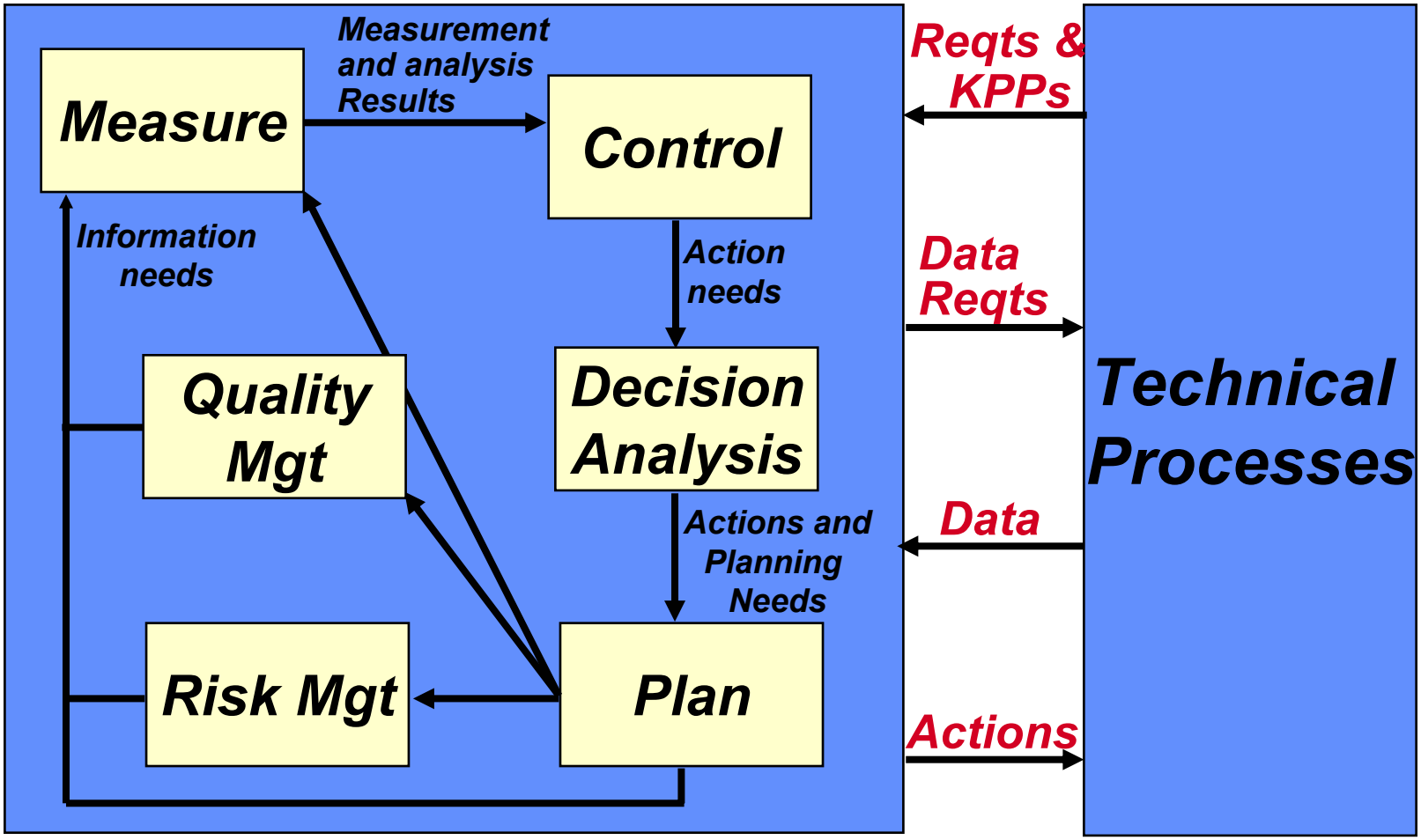
Primary Drivers	MOE	MOP	TPM
Historical Operational Information	X		
Operational Risks	X		
User Priorities	X		
Measures of Effectiveness		X	
Customer Priorities		X	X
Key Performance Parameters		X	
Technical Requirements		X	X
Technical Alternatives Considered		X	X
Measures of Performance			X
Note: Each listed item was required to have >40% of respondents identify it.			

- ***Insight can often be determined through review of:***
  - ***Systems Engineering documentation***
  - ***Mission or technical specification requirements***
  - ***Acquisition documentation***
- ***Prioritization factors:***
  - ***Magnitude of the contribution to the overall performance***
  - ***Maturity of necessary technologies***
  - ***Ability to discriminate among technical alternatives***

Selection Guidance

MOE	MOP	TPM
Provides insight into at least one operational objective or mission requirement	Must enable calculation of at least one MOE	Technical risks (including feasibility of requirements)
MOEs should not be strongly correlated • They should provide insight into different aspects of the operational alternative	Based on Key Performance Parameters (KPP)	Should have ability to support trades among possible solutions for achieving Key Performance Parameters (KPP)
Select and define in the context of the operational objective • No predefined MOEs or values	May be related for insight into a specific system characteristic or alternative	Strongly influenced by quality requirements
Select and define independent of the alternatives at hand • They represent an independent means to collectively evaluate the alternatives	Focus on technical risks at the system level	Should have ability to track adherence to technical constraints (including physical, technology, and performance)
Select only a few MOE/MOPs • May be an order of magnitude more TPMs	Should collectively provide insight into system affordability	Should have ability to show relationship to cost, schedule, quality objectives, and risks
	Should be able to be linked to future testing of alternatives and chosen KPPs	Should be traceable to applicable WBS elements

Integration into processes



Note: Not all relationships shown – only those relevant to this discussion.

Performing Technical Measurement

- *Collect and process data*
- *Analysis of technical measures*
- *Making decisions using technical measures*

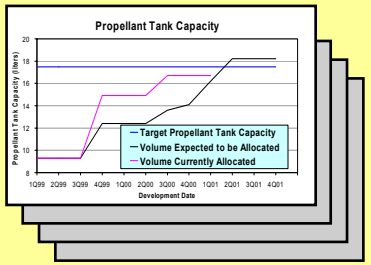
Performing Technical Measurement

Design and Implementation Of Technical Solution → *Monitor And Control*

Planning Measurement

Collect & Process Data

Analyze Measures & Take Action



Performing Measurement

Collect and Process Data

- *Collect both planned and actual data values*
- *Data for MOE/MOPs will vary with the test environment*
- *Collect data at a level appropriate to provide insight into KPP progress and localize issues*
- *Question unusual trends and inconsistencies*
- *Develop clear and concise definitions to guide data collection - know what the data means*
- *Aggregate and normalize data*
  - *Include relationships of TPMs to MOPs & MOPs to MOEs*
- *Distinguish between updated estimates and actual data*

Applying PSM Analysis Types

- **Estimation Analysis**
  - Projections of product attributes, quality, and performance, including the establishment of initial performance profiles, tolerance bands, and thresholds
  - Establishes target values or numerical expectations for subsequent activities and parameters
- **Feasibility Analysis**
  - Assesses realism of achieving the estimated values per the progress plan or performance profile
  - Conducted during the initial planning activity and at all subsequent replans
- **Performance Analysis**
  - Analysis conducted to determine whether development is meeting the plans, assumptions, and targets
  - Should be conducted periodically once a project has committed to a plan

Analysis Guidance

Estimation Analysis	Feasibility Analysis	Performance Analysis
Identify predictions needed, key drivers of variation, relation-ships between measurable attributes of the drivers	Determine risk, cost, schedule, and quality impacts reflected by the KPP estimated values	Track actual performance against progress profiles/plans
Collect data for the attributes of the drivers	Investigate whether:	Show acceptable ranges of variation that correspond with risks and constraints
Determine quantitative relationships/models	• Performance parameters have been achieved before	
• May include data from other TPMs	• Current technology supports the desired performance within known constraints	Identify variances of achieved values from plan
Generate estimate using model	• Relationships of identified risks	• Indicates current risk level from process, technology, or
Adjust estimate as necessary to account for:	• Degree of control over risks to progress	
• Engineering trades	If risk/impact is unacceptable, then:	Assess impacts of the variances
• Technology capability & constraints	• Identify alternative design solutions and estimates, or	Periodically assess achieved values
Establish expected growth profiles or other progress plans for the TPM based on estimates	• Identify and implement risk handling strategies	• Understand success of corrective/preventive actions
Track TPMs against the progress plan/profile and update estimates with partial actual data as it becomes available. Apply rolling wave planning techniques, where applicable.	Perform decision analysis and take action	• Identify new risks
Establish confidence intervals based on amount of actual data		

Make Recommendations

- ***Results must be clearly understood by the decision makers***
- ***Corrective actions are determined based on the risk level and assessment***
  - ***May require replanning, process adjustments, new estimates, changes to design solution, etc.***
- ***Desired actions may not be possible***
  - ***May have to optimize within project or system constraints***

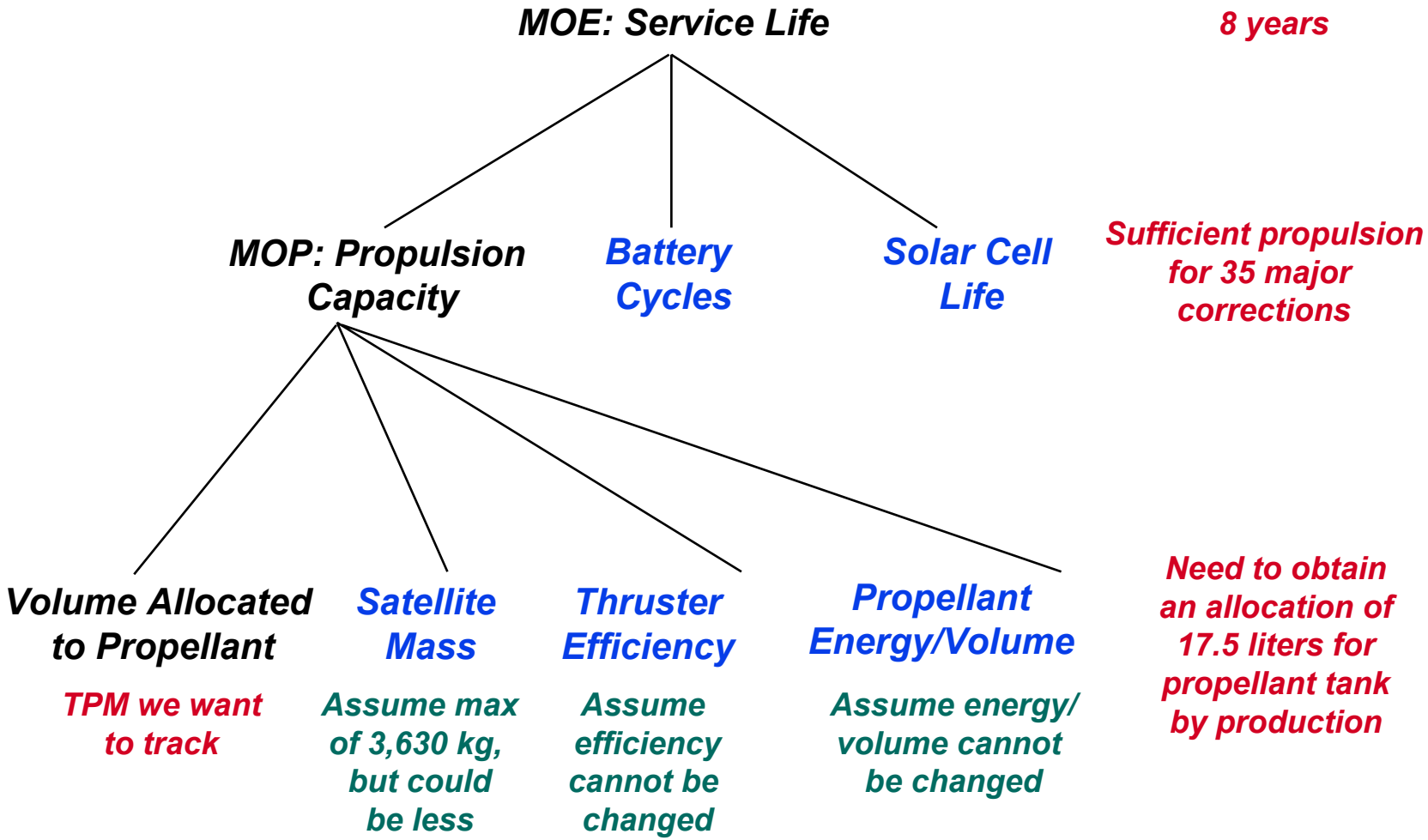
Additional Contents of the White Paper

- *TPM Checklist*
- *Application of Technical Measurement in IPTs*
- *Candidate measures matrix for various application domains (preliminary draft)*
- *Technology Readiness Levels*
- *References*

What Remains?

- First draft complete – small review team
  - Review during July
  - Comment resolution in August
- Final draft to wide distribution
  - Review in September
  - Comment resolution in October

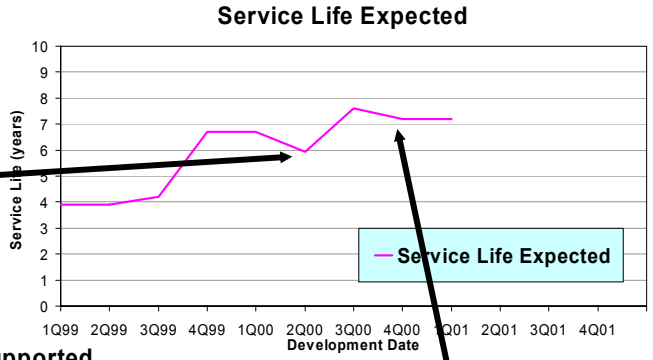
Notional Example in Satellite Development

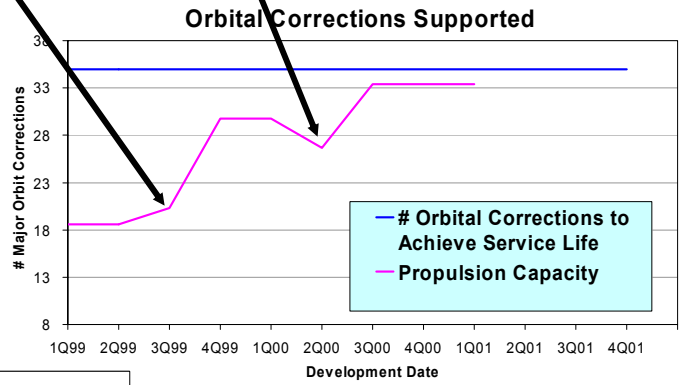


Notional Example in Satellite Development

Battery size and weight reduction announced, reducing satellite mass

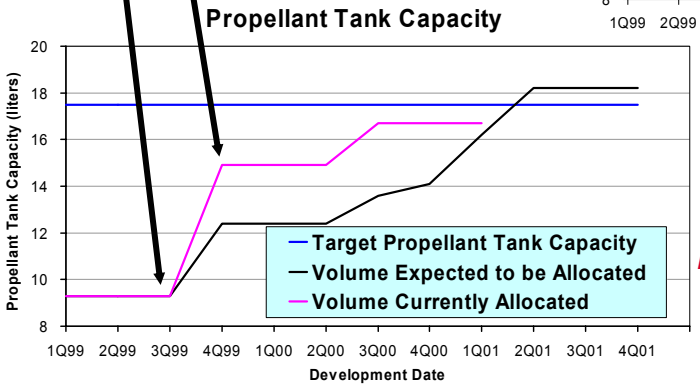
Testing shows thrusters not as efficient as expected





MOP influences MOE

Propellant capacity increased due to battery reduction



TPM influences MOP

Testing shows that batteries may fail earlier than estimated