Technical Performance Measures for Complex Programs

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Abstract – *Like other aspects within systems engineering, technical performance measures are initiated early within the systems engineering life cycle (i.e., requirements analysis phase) of any major system development effort. In today's world, major programs within the aerospace community are challenged by significant changes in technology, procedures and processes. Because of these changes, program managers as well as systems engineers need a better way to manage cost, schedule and technical performance. Technical performance measures provide a method to help plan, monitor, manage risk and control technical effectiveness. This paper provides an overview of the need for technical performance measurement, its concept and its implementation for reducing cost, schedule and technical risk and to assist program managers as well as other systems engineers with a better way to gauge and overcome conflicting constraints to meet requirements and deliverables within a timely fashion.*

Keywords: Technical performance measures, risk management, cost, master schedule, systems-of-systems, systems engineering, baseline, requirements.

1 Introduction

Technical performance measures provide a method to help plan, monitor, manage risk and control technical effectiveness. They provide data on the key technical and integration issues. The technical performance measurement process is an evolutionary program management method which builds on the two traditional strengths of earned value management (cost and schedule performance indicators) by adding a third dimension – the status of technical achievement. By combining cost, schedule and technical progress into one comprehensive method, program managers as well as systems engineers are able to assess the progress of their entire program. Demonstrating values that signal potential risks or meeting specification requirements and design to cost goals provide important feedback to management to view. Technical performance assessments depend on the use of engineering analysis, test and evaluation to make periodic evaluations of the program in achieving the performance parameters it has established for the system. Technical performance measures identify any engineering or other technical problems requiring management attention and forecast the impact of the program's cost, schedule and ultimate performance of any out of tolerance condition. This helps provide management the complete status of the system.

Unfortunately, many major programs within the aerospace community do not consider technical performance measures within their system developments. One of the reasons is that large systems are rarely built from scratch and many large programs contain or use legacy components including existing hardware, software, architecture and old or out dated processes and procedures. Integration across stakeholders, individual capabilities, systems-of-systems, deficiencies in major programs and expanding needs can introduce risk by delaying deliverables, impacting current system capabilities, increasing cost and causing schedules to be pushed out further.

The strategy outlined in this paper came about due to the lack of following a systems engineering process and from working on a task where program management did not see any value in following a systems engineering process. For example, by following a systems engineering process and understanding the stakeholders' wants and needs, technical performance measures can provide insight to see if and when the capability or functionality will be provided, how risks can impact the capability or functionality and if cost or schedule impacts will cause the program major concerns. Technical performance measurement is crucial work that needs to be done up front within the systems engineering life cycle. If not, the best and most efficient decision may not be made by management for the program and in the long run may increase cost which then leads to schedule delays which then leads to termination of the program.

A systems engineer with an understanding of the systems engineering life-cycle is well qualified to determine where and when technical performance measures should be used, how to implement technical performance measures, how to identify risk, how to mitigate the risk and what impact it will have on the system to increase a customer's satisfaction.

2 The Need

Programs face significant challenges in balancing cost, schedule and performance to successfully deliver needed capabilities in time and within budget. Many challenges stem from the large number of programs which involve a broad base of stakeholders, each independently managing their own program schedule and program risks. The challenges to successful systems development are

complex, multi-dimensional and far-reaching. Some of the challenges are:

- Integration across stakeholders, individual capabilities, programs, systems-of-systems, organization and expanding needs
- Cross domain and program dependencies, including technical, schedule and budget dependencies
- Transformation of cross-functional domain roles and responsibilities
- Leadership turnover
- Stakeholder commitment and support
- Gaps in key research and development
- Varying and sometime competing, business cases
- Potential requirements creep.

From an organization perspective, large scale programs require an organizational method to identify individual program dependencies while providing a platform for organizational visibility. The need for technical performance measures results from baselines being disconnected and inconsistent and decisions not being made with a consistent understanding of cost, schedule, performance and risk impacts. Technical performances measures link cost, schedule and performance baselines to allow common consistent evaluation of program progress and impacts across all dimensions. Technical performance measures highlight deficiencies in the baselines and aid in maturing the baselines. This will allow management a mechanism to make ley decisions to manage progress in a collaborative and controlled manner.

The aspects for implementing Technical Performance Measures consist of the following:

- Technical Achievement – Designed to prioritize, influence, advocate solutions by ensuring complete assessment of the system is considered, identifying and understanding the relationship across multiple domains, capabilities and enablers.
- Master Schedule – Documents the significant accomplishments necessary to complete the work and ties each accomplishment to a key program event.
- Risk Management – Overall process structure to systematically and consistently identify, analyze and manage opportunities and risks.

Figure 1 below provides a full integrated perspective for the three aspects for implementing technical performance measures.

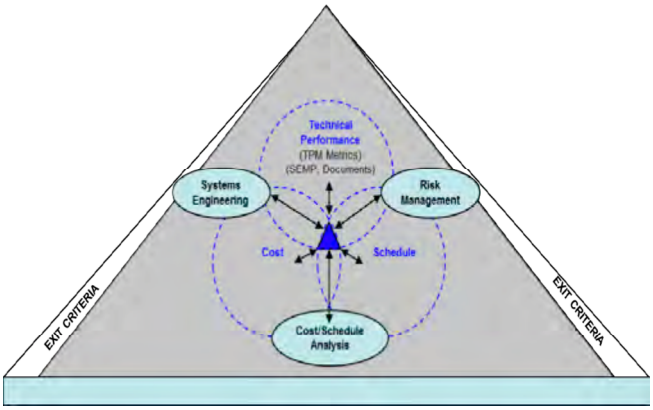

Figure 1. Technical Performance Measures

2.1 Technical Achievement

Technical achievement is the development of a widely distributed systems-of-systems effort among the various stakeholders and the synchronization of activities to both deliver benefits and efficiencies and provide common assurance of a successful outcome to all components of the organization. It is designed to prioritize, influence, advocate and validate technical solutions by ensuring complete assessment of the system, identifying and understanding the relationship between different programs across multiple domains, capabilities and enablers. The benefits of incorporating technical achievement include:

- Identifying technical risks and interdependencies that occur at interfaces between domains, enablers and cross-cutting factors linked to the master schedule and risk management
- Characterizing the issues from a global perspective and formulating mitigation strategies to reduce integration barriers for mitigation strategies
- Providing guidance for both policy-makers and researchers.

2.2 Master Schedule

The master schedule is a tool that documents significant accomplishments necessary to complete the work and ties each accomplishment to a key program event. The master schedule provides consistent communication and coordination across multiple programs. It provides effective cross-program planning, monitoring and control of key events and prioritization of activities

and resources. The benefits of incorporating the master schedule include:

- Electronically integrating high level activities and milestones from each stakeholder's detailed schedule
- Identifying the critical path
- Highlighting relationships and dependencies between stakeholder schedules
- Identifying schedule risks.

2.3 Risk Management

Risk Management is a tool used to manage and capture risk across multiple domains. The benefit of having risk management includes:

- Capturing and recording risks in a risk register
- Utilizing a common work breakdown structure for management and control
- Identifying, analyzing, addressing and adjudicating risks through a consistent process.

3 The Concept

Technical performance measures take selected critical product elements of the contract work breakdown structure and provide a means of monitoring the technical status throughout the program [1]. This will ensure that program strategic and tactical decisions are based on a systematic, integrated assessment of performance, schedule and risk factors. Technical parameters to be reported and tracked are determined through identification of technically critical areas from review of systems engineering documentation, development of specification requirements and planned contractual performance incentives and the relationship to systems measures of effectiveness. Technical performance can be analyzed using terms such as technical risk, current, planned, baseline, tolerance band, threshold and objective values. The technical performance measures process integrates technical achievement with existing earned value using risk assessment to provide a robust management method to identify, as early as possible, the technical deviations in a program to allow for effective cost and schedule risk mitigation. The key artifacts reflect the program baseline to enable the development of alternatives that support program management decision making. Scenarios are developed as well to flow down changes to detailed baselines upon approval.

3.1 Benefits

The initial benefit of linking the baselines is that issues related to the baseline maturity, scope and inconsistencies are identified. Linking cost, schedule, performance and risk baselines requires a minimum level of maturity and a common structure to allow cross-referencing. Through the linking process, deficiencies and gaps in the baselines become apparent very quickly and can be addressed right away. The ongoing benefit of linking the baselines is that once the baselines are linked, technical performance measures provide the benefit of having a consistent cost, schedule, performance and risk infrastructure to evaluate program performance and analyze trades. Systems engineers using technical performance measures will ensure that every change proposal presented to the configuration change board will have common and consistent cost, schedule and risk impact analyses. Additional ongoing benefits include forecasting operational, functional and performance capabilities across multiple programs.

3.2 Lack of Technical Performance Measures

Two initial questions that many systems engineers ask throughout multiple programs are: Why is technical performance not being utilized today? and Why is it that program managers do not work with the systems engineering team to better gauge their programs? These questions and others continue to arise throughout systems engineering practice. Utilizing technical performance measures is a part of doing good systems engineering and following a systems engineering process. Technical performance measures link cost estimating, schedule strategy and risk management with technical aspects. Often the baselines are created to "check the box" in their own silos and are of insufficient maturity to perform technical performance measurement.

Very few systems engineers have this capability or training to implement or understand how to utilize technical performance measures. This is because many systems engineers work on programs that do not follow any systems engineering process. Because of this, many systems engineers do not understand all aspects within the systems engineering life cycle. Very few organizations have the tools to link these activities. These organizations often do not meet their objectives on time, cost increases as the program moves forward and eventually the contract or program is terminated. Using technical performance measures is not complicated. However, technical performance measurement is a rigorous process that offers a lot of benefits.

4 The Approach

The following steps are necessary to start a technical performance measurement process [2].

- Program managers must assess the current maturity (dependencies, overlaps, shortfalls, commonality, etc) of a program's baseline products.
- Mature the products in order to update the integrated baseline for the overall program.
- Use the integrated baseline to conduct quick reaction analysis of potential impacts to the program.
- Coordinate updating of the baselines as needed.

The following list explains how to apply technical performance measures effectively.

- Assess Problem Statement. (Processes: Stakeholder Expectations, Constraints, Scenarios)
- Identify affected technical products and processes (Processes: Architecture Design, Technical Metrics)
- Identify affected Work Breakdown Structure areas and create proposed Work Breakdown Structure for each alternative, including resource needs (Process: Management planning, Process planning, Effort planning, Resource planning)
- Identify master schedule elements based on work breakdown structure changes and create proposed schedule changes to address alternatives (Process: Process planning, Effort planning, Resource planning)
- Identify affected risk elements and characterize risk for each alternative (Process: Risk Management)
- Integrate and present decision factors to program management. (Process: Decision Analysis, Technical Analysis, Technical Review)
- Update progress toward meeting requirements.

5 Tracking, Monitoring and Reporting

The initial coordination and review meeting should be held with team leads, systems engineers and program managers to identify and discuss what technical performance measures have been identified/tracked since the beginning of the program and the technical performance measures reporting process. At this time, a Technical Performance Measures Manager should be established as well as an Integrated Product Team Lead within the organization. Monthly or quarterly meetings should then be established to update data and discuss status of the technical performance metrics and progress being made within the program. Also, in some cases, a progress plan meeting will need to be held with the Integrated Product Team Leads to provide an update and assessment of technical progress for the program. Participants in the monthly or quarterly meeting should include Systems Engineers, Program Manager, Integrated Product Team Leads, Configuration Manager and Risk Manager. Others may be invited based on the outline of the organization or if a specific topic requires additional attention from other team members. Some of key areas that should be discussed during these quarterly meeting include:

- Configuration Management updates
- Status
- Performance metrics
- Engineering process measures
- Integration measures
- Software measures
- Reliability measures
- Maintainability measures
- Human Factors measures

At the meeting, the team will check to see if any of the data contained in the key areas identified causes any impact to the program. The team will then update the progress and status of the key areas identified above. If any high risk has been identified, the group may decide to meet weekly or bi-weekly to come up with a mitigation strategy. The group will then review and go over every possible option to mitigate the risk so that it will not have any impact on meeting the program's deadlines.

6 Conclusions

Technical performance measurement is part of doing good systems engineering and following a standard systems engineering process. The process of applying technical performance measures is rigorous and not easy. However, it is a process that provides major benefits to organizations by providing a bigger picture with which to manage progress of the program. Technical performance measures help organizations to reduce cost and identify risk early in order to mitigate and discover schedule discrepancies and provide value to the program such that deliverables will be met in a timely fashion.

Acknowledgment

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