PRODUCT MATURITY METRICS

A concise and effective way to assess and communicate program risks

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"What we've got here is failure to communicate."

\- Captain, Road Prison 36

Over the last ten years various GAO audits and reports, Nunn-McCurdy breaches (high cost, delayed programs) and test/field failures all point to a DoD acquisition process that needed and still needs improvement. Some of the highlights of the GAO findings are:

- There is little incentive for DoD program managers to capture knowledge early in the development process
- In 2008 the cumulative cost growth of 96 major defense acquisition programs was $296 billion
- The total acquisition costs for these programs increased an average of 25% from first estimates
- The average delay in delivery to the war-fighter was 22 months
- DOD needs to do a better job ensuring acquisitions begin with realistic plans and baselines prior to the start of development

In January 2006 the "Defense Acquisition Performance Assessment" (DAPA) report, prepared for the Deputy Secretary of Defense, proposed sweeping changes to dramatically improve the DoD's ability to stabilize and integrate key elements of product acquisition including the practice of time certain development.

And, in an April 2009 report, the GAO further delineated a clear set of prerequisites that must be met by each program's acquisition strategy before a measurement of the program's health would be of real value, namely:

- Establishing and evolutionary, knowledge-based business case for each acquisition
- Separating technology development from product development
- Limiting time and requirements for product development to manageable levels
- Employing systems engineering early on in the process to arrive at realistic cost and schedule estimates

FIGURE 1

Yet despite years of workforce education and upgrade, tiger team interventions, independent program assessments, and numerous strategic studies ….there are few tools that can give a PM a warning about possible/probable issues and risks with sufficient lead time to enable the PM to make appropriate adjustments to make the program successful**.** To further illustrate this point; in 2010 DoD officials certified that six acquisition programs, including the F-35 Lightning II fighter and the DDG-1000 destroyer should continue under Nunn-McCurdy legislation.

Obviously, we still have a "failure to communicate."

Product Maturity Metric (PMMs)

PMMs are an outgrowth of Engineering Manufacturing Readiness Levels (EMRLs) developed initially for MDA in 2002 and later applied on a number of acquisition programs by MDA, DCMA and others. EMRLs were developed to address issues delineated in GAO reports and from lessons learned from acquisition programs. EMRLs provided a streamlined, easy to use, set of criteria and metrics to assess and communicate the degree to which a product was designed to be producible, affordable and sustainable. EMRLs have been the only concise and effective tool available to PMs to help them readily assess risks based on the maturity of their product at key milestones or review points. PMMS build on the experiences gained in applying EMRLs, the recommendations presented in GAO reports, the DAPA report, and best practices from industry.

As displayed in figure 2, PMMs consist of five product maturity gates tied to key decision points or milestones in product development and production. Although closely aligned with the DoD 5000.02 acquisition management system PMMs are applicable for any product developed on sound system engineering and product management principles. In addition, PMMs incorporate time certain development and delivery. This means delivering product capability within a constrained period of time – nominally in about six years from Milestone A for a complex product. Thus, time (schedule) is a key performance parameter.

This point was made clear in the July 2002 GAO report "Capturing Design and Manufacturing Knowledge Early Improves Acquisition Outcomes" which states:

> Companies have found that trying to capture the knowledge required to stabilize the design of a product that requires significant amounts of new content is an unmanageable task, especially if the goal is to reduce cycle times and get the product into the marketplace (or to the warfighter) as quickly as possible. **Design elements not achievable in the initial development were planned for subsequent development efforts in future generations of the product,** but only when technologies were proven to be mature and other resources available.

Likewise, the 2006 DAPA report states:

> There is a need to shift to Time Certain Development and make "schedule" a Key Performance Parameter. Developmental programs must change their focus to deliver useful military capability within a specified time (nominally no more than six years for major platforms) from Milestone A.

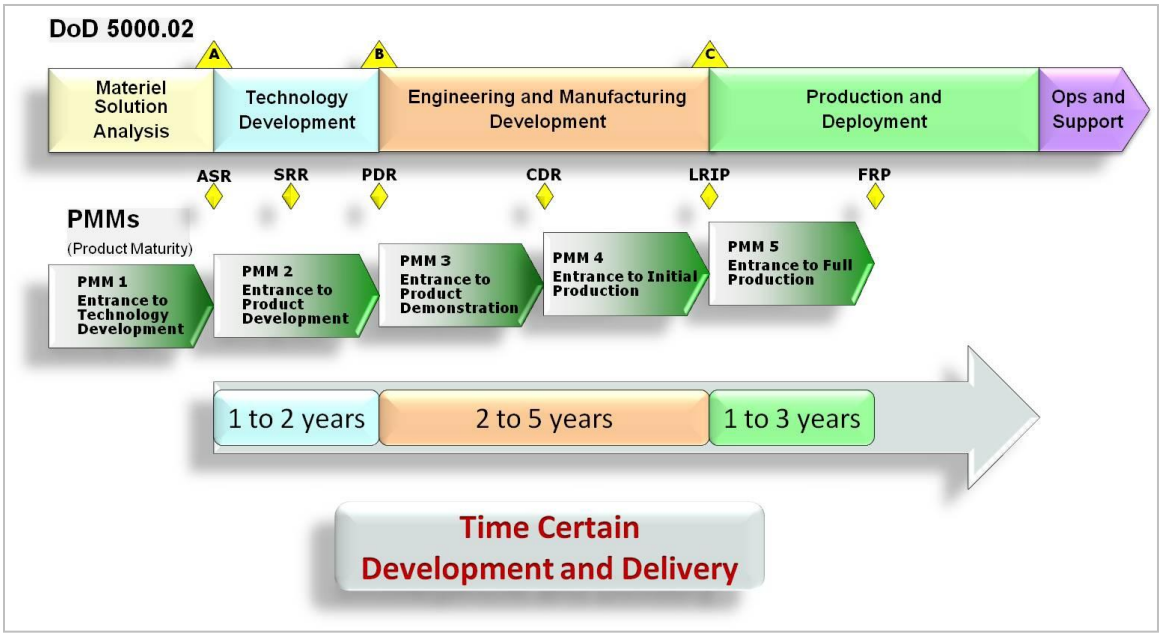

FIGURE 2

Phased Maturity

PMMs also incorporate the concept of phased maturity. The subsystems, components and items that comprise a product should be more mature (higher PMM) than the final product. The justification for requiring phased maturity is that concurrently developed subsystems, components, and items, and related technologies, along with the inevitable design changes that occur, compound the risks as these immature products are integrated into the final product.

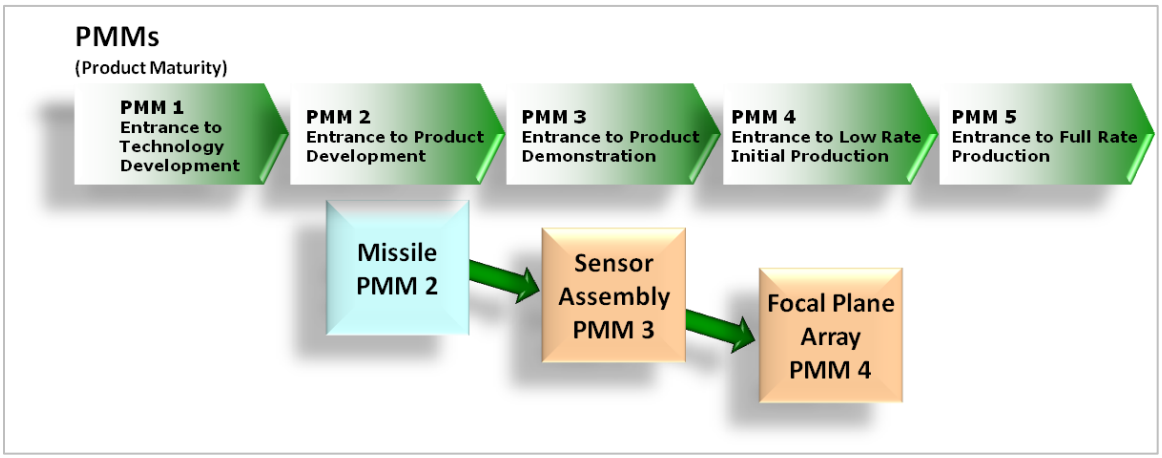

FIGURE 3

Phased maturity, illustrated in figure 3, is an application of the industry best practice noted in the 2002 GAO report and quoted here earlier "*. . . trying to capture the knowledge required to stabilize the design of a product that requires significant amounts of new content is an unmanageable task. . .*" Design elements not "achievable in the initial development", those not mature enough to be integrated, were planned for subsequent development efforts in future generations.

Product Maturity Gates

The five PMM gates, each consisting of the same twenty criteria with metrics specific for each gate, measure product maturity at all phases of design, development and production. This establishes a level of risk at each product development milestone. Data used for an assessment is based on actual events and activities, and requires specific metrics to be met to reduce the risk of transition of the product to the next phase.

At Milestone A (PMM 1), best practices dictate that a product management team should be in place. The team must insure that subsystems, components, and items in the design baseline are at the required maturity, that the product will meet the requirements of the Initial Capabilities Document, and that an Alternate System Review (ASR), or the equivalent, has been completed. Although the product design is still immature, the key subsystems under consideration should meet PMM 2 metrics and components and items under consideration should meet at least PMM 3 to reduce risk for continued product development.

While not a gate, at the System Requirements Review (SRR), a PMM 2 assessment provides the PM a gauge to measure progress toward completion of preliminary design within the schedule and cost. PMMs can be easily used to evaluate the thoroughness and depth of a SRR.

Milestone B (PMM 2), the point at which preliminary design and the PDR are complete, is the entry point for engineering and manufacturing development. PMMs can be used at the PDR to provide an assessment of the thoroughness of the PDR as well as overall product development maturity and risks. **It is critical at this decision point that the product design be mature in the sense that technology development is complete. Sub-systems, components, and items are more mature than the product into which they are integrated.** For example, in Figure 3, at product Milestone B, PMM metrics require key subsystems have completed critical design and CDR (PMM 3 met), and lower level products have at least been tested in prototype or pre-production configuration (between PMM 3 and 4).

At CDR (PMM 3) the product design should be stable and ready for initial pre-production builds suitable for development test and evaluation. Consequently, all subsystems should have completed initial qualification testing and are ready for initial production (PMM 4). All lower levels in the supply chain should meet at least PMM 4 metrics.

At the decision point for Low Rate Initial Production (LRIP) development test and evaluation should essentially be complete, the design should be complete with minimal or no engineering changes to the product design as well as subsystems, component and items. The product and all deliverables in the supply chain should meet PMM 4 metrics.

The decision to proceed to Full Rate Production (FRP) is based on LRIP performance and the ability at all levels in the supply chain to meet the requirements of FRP and the PMM 5 metrics.

Performing a PMM Assessment

PMM assessments can be accomplished by a few highly experienced individuals in a non-obtrusive way during regularly scheduled program reviews (ASRs, PDRs, CDRs, and IPRs). PMMs utilize normal program deliverables and review documentation.

- PMM assessment provides a quick snapshot of product status with minimal impact on resources.
- PMMs provide the PM the ability to clearly display the status, objectively and uniformly across the supply chain utilizing a simple stoplight risk identification schema.
- PMMs provide the PM the ability to prioritize issues from the identified high risks that need to be immediately managed or reduced.

- PMMs contribute to risk mitigation plans, investment strategies, acquisition strategies, life cycle logistics support, safety, and milestone decisions in a consistent and balanced manner.

A top down look at the WBS is often the starting point for the identification of risks. Prior to beginning an assessment, the identification of the product WBS and where the product is in the development cycle must be accomplished. The identification of WBS level and relationships, and development cycle position dictates which gate is to be used. Assessments must be based on documentation (data and metrics) coming out of design reviews and program reviews and can be made more thoroughly and unobtrusively when the PMM independent assessment is accomplished as part of normal program reviews. Many critical and pacing deliverables are at the subcontractor and supplier levels. This could lead to a bottom up approach in which assessments begin at critical or problematic suppliers and continue up the supply chain.

PMMs can also be readily applied between gates or major reviews to assess product maturity or progress toward meeting the entrance metrics of the next gate or major review. For example, post Milestone B, an assessment can be performed utilizing a few highly experienced individuals and key product team personnel. This provides the PM a gauge of the progress of product development toward CDR and an opportunity to focus on high risk areas quickly and resolve issues before CDR.

FIGURE 4

PMM Templates

PMM Templates consist of a summary sheet and detail sheets (figure 4). The summary sheet provides a roll-up of the risk ratings for the twenty criteria. The five detailed worksheets expand on the 20 criteria and their associated metrics with guidance and space for comments, observations, and evidence. The criteria are the same for PMM 1 through 5, but the metrics are increasingly mature for successive PMM gates. Each metric is rated using a simple color coding (green, yellow, and red) rating criteria.

- Green means that the assessed criterion meets (satisfies) the entrance requirement for the gate and is within cost and schedule.
- Yellow means that the assessed criterion does not meet the requirement currently, but that it will be met without impact to cost of schedule.
- Red means that the assessed criterion does not satisfy the entrance requirements for the gate and **will impact cost/schedule.**

PMM Assessment Reporting

There are two concise, easy to read, and informative ways to sum up the assessed risks, a block format and a flag format. This example displays total assessed risks in the flag format (figure 5).

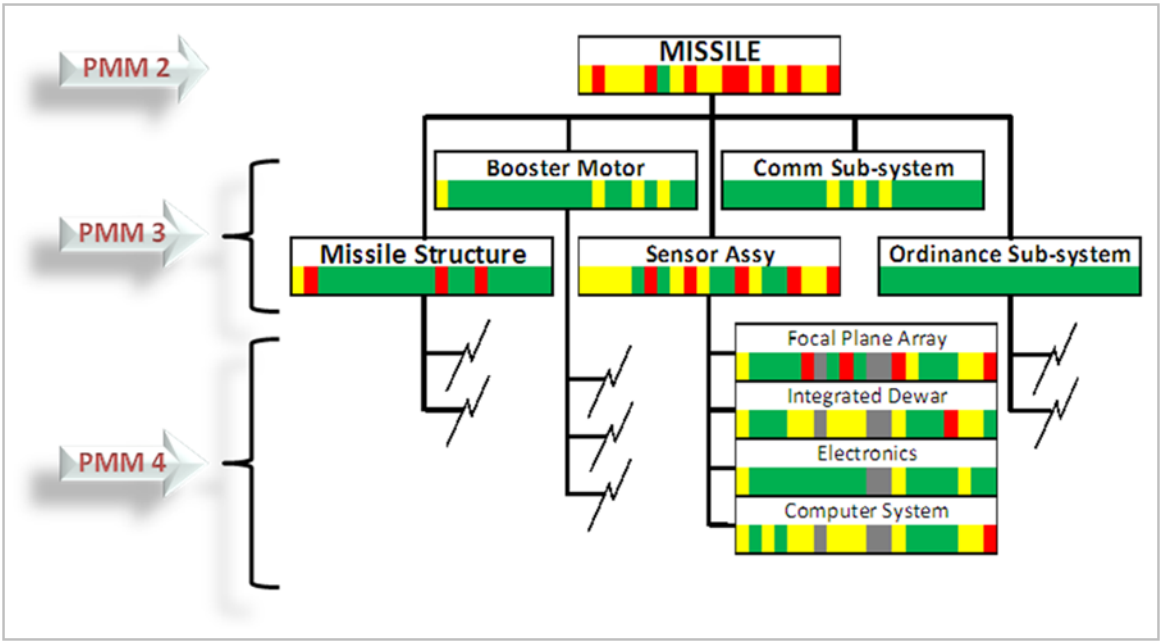

FIGURE 5

This format is consistent with a WBS type display of the product and its subsystems, components and items. At the left are the PMM at which the assessments have been accomplished starting with PMM 2 for the product (missile). The flag block shows, from left to right, the rating for each criterion for the product and lower levels in the supply chain that are assessed. As shown, subsystems are assessed at PMM 3 and lower levels at PMM 4. The product rollup displays the highest risk found in the supply chain. The rationale is that if there is a risk (yellow or red risk rating) assessed in the product supply chain, then that level of risk should be closely managed by the PM to assure that the risk burn down progresses according to the risk burn down plan.

The assessment performed at the product level might also have risks, e.g., a red risk rating, which would give the particular criterion a red in addition to a red risk rating from lower levels in the supply chain. The point is that the summary risk rating at the product level includes the risks found at the product level, not just a rollup of supply chain risks.

SUMMARY

PMMs provide the product manager, product support team and independent reviewers with an easy to use, resource friendly means to:

- Assure systems engineering is employed early on in the development process
- Assure realistic plans and baselines are in place **at the start of development**
- Measure technology and design maturity **before entering product development**
- **Limit time and requirement for product development to manageable levels**

PMMs enable the product manager to capture knowledge early in the development process and reduce the risks of cost, schedule, and performance problems. With PMMs, the product manager and others have the ability to concisely and effectively assess product development risks as part of scheduled product status reviews, in addition to major milestones or gate reviews. In addition, with PMMs the product manager has the criteria and metrics to assess product development status and risks at the product level, as well as lower WBS (lower levels in the supply chain).

PMMs assure that "failure to communicate" is not an option!