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8. Effectively Adapting and Utilizing MRL Criteria

8.1 Introduction

The development of MRLs has been a joint industry and government activity for over a decade. The participants have been experts in both manufacturing and acquisition from numerous DoD OEMs/suppliers, academia, and government. The assessments of manufacturing readiness utilizing MRL criteria have been used on numerous programs with excellent results in identifying and managing manufacturing risk.

In reviewing the successful programs, there are some basic attributes that stand out. First and foremost is having trained Subject Matter Experts (SME) involved in the assessment of manufacturing readiness based on the MRL criteria. Their expertise is essential in not only assessing readiness, but also in adapting the MRL criteria to the given situation. Assessments using the basic MRL criteria will support most applications with only minor adaptions. Terms such as “production relevant”, “production representative”, “pilot line”, and “rate tooling” may have different meanings for S&T, ship, or a space program as opposed to programs for ground vehicles, aircraft, or electronics; therefore notional definitions have been defined within this document in order to clarify the intent of specific terminology.

This chapter provides the user with insight in adapting the MRL criteria to specific situations. Some MRL threads or sub-threads have multiple criteria to address; and while not all criterion may be applicable, the thread or sub-thread should not be ignored. Instead, the thread or sub-thread should be consider only those applicable criterion. While adaptations for assessment can be made for a specific technology or application, traceability to MRL criteria must be maintained to provide a sound foundation for risk management.

8.2 MRL Criteria in the S&T Environment

8.2.1 Introduction

Adapting MRLs effectively in the S&T environment is probably the most challenging of all the various situations in implementing MRLs. MRLs were designed to measure the manufacturing readiness of a product and/or process as it matures towards production. However, in early S&T there is often very little linkage of the research being performed to a product or a specific production program. Therefore, some of the questions have to

be adapted to address the goals of an S&T environment (e.g. to obtain fundamental knowledge). Since the MRL criteria was developed anticipating a natural progression to a production program some of the criteria (e.g. models, cost projections, specific acquisition requirements, etc.) will need to be adapted to assess the specific S&T objectives. The primary objective for using MRLs is to improve the decision makers' ability to understand and mitigate manufacturing risk in development efforts transitioning from S&T to acquisition. Our ability to transition technology smoothly and efficiently from concept, into the lab, onto the factory floor, and into the field is essential to be cost effective and reduced cycle times in an acquisition program.

8.2.2 Basic Research

The earliest effort in the S&T process is **Basic Research**. The purpose of Basic Research is the systematic study of the fundamental science and phenomenology based upon observable facts without regards to a specific process or product. The application of the MRL criteria in Basic Research is limited to the extension of observations for the potential use or purpose of the scientific discovery. As the application of this new knowledge into a notional product matures, information becomes available highlighting potential downstream manufacturing risks and provides insight into new manufacturing processes, industrial base, and cost goals that need to be developed to achieve innovative new products. These identified risks should be considerations in the Applied Research phase. MRL 1 – 3 criteria indicate the desired manufacturing knowledge for Basic Research.

8.2.3 Applied Research

The next phase of the S&T process, **Applied Research,** is a systematic study to gain knowledge to determine the means by which a recognized and specific user's need may be met. Applied research translates basic research into solutions for broadly defined user needs. Typically, this level of research includes identification, paper studies and analysis of material, laboratory bench experimentation and process approaches. Applied Research is taking the knowledge of process/science and demonstrating application of the fundamental principles learned in basic research. It is generally performed in a laboratory environment where small samples are developed to allow measurement and observation of process and technique. The resulting item should have materials and processes that can be assessed. Upon completion of Applied Research, application of these processes and techniques is ready for demonstration on a prototype. MRL 4 criteria indicate the desired manufacturing knowledge for Applied

Research, provides an assessment of the manufacturing feasibility of the S&T project, and should be useful in deciding the next steps.

8.2.4 Advanced Technology Development (ATD)

ATD is a systematic application of knowledge or understanding directed toward the development of useful materials, devices, systems or methods, including the design, development, and improvement of prototypes and new manufacturing processes to meet specific requirements. The results of ATD are proof of technological feasibility and assessment of subsystem and component operability and producibility rather than the development of hardware for service use. ATD includes the functions of design engineering, prototyping, and engineering testing.

This phase of S&T requires a much greater degree of collaboration between the S&T and Acquisition communities than Basic or Applied Research. Use of the MRL philosophy is a valuable tool in assessing and maturing manufacturing capability for new technology that should be major concern to whomever receives the technology. Therefore, adapting the MRL criteria to ATD should be a joint effort between the S&T and Acquisition communities. Furthermore, the manufacturing maturity targets should be understood, and agreed upon by both parties, with respect to the MRL criteria. The goal is to understand, minimize, and manage the risk associated with manufacturing maturity as the ATD transitions into an acquisition program. MRL 5 – 6 criteria indicate the desired manufacturing knowledge for ATD.

8.2.5 Examples of Adaption.

S&T efforts funded by the S&T community are not usually funded beyond the S&T effort. This puts the S&T community in a dilemma when their goal is to reach MRL 6 by the end of their S&T program. The MRL criteria contain acquisition language that may not be relevant to S&T funded efforts as the acquisition language refers to budget estimates, process capability, and target yields for pilot line, LRIP, and FRP and in some cases milestone C. Reaching MRL 5 for S&T programs would be impossible if the MRL criteria were stringently applied. In addition, many MRL 5-6 criteria such as those dealing with quality, design, materials, facilities and workforce are very valuable in reducing manufacturing risk for technology transition. Therefore, it is recommended the MRL criteria be adapted to take advantage of valuable risk reduction benchmarks while not being penalized by benchmarks that do not apply.

For example, in MRL criteria 4-6, Thread C. – Cost and Funding, there are references to budget and cost estimates to reach MS B and MS C. If an S&T program is only funded

through ATD (or earlier), then these criteria may be considered not applicable to the specific S&T effort. In general, references to future activities relevant to a follow-on program not funded by the S&T effort are not applicable to the situation being assessed.

Likewise, MRL criteria 5, Thread E. – Process Capability and Control; and Thread I. – Manufacturing Management, speak to target yields and make/buy evaluations for pilot line, LRIP, and FRP. These criteria may also be considered not applicable if the S&T effort is not funded to consider such benchmarks as this would be considered out of the scope of the S&T effort.

In addition, Sub-thread E.1 – Modeling & Simulation (Product & Process), should be evaluated to determine what level of modeling and simulation is appropriate for the application being assessed. In some cases, extensive modeling and simulation is required while in other cases a simple spreadsheet calculation is sufficient. In this case, a simple spreadsheet calculation is adequate to meet these criteria.

MRL 6 criteria require solutions and processes to be demonstrated in a production relevant environment. Prior to conducting a manufacturing assessment, the production relevant environment for the application should be agreed upon by all stakeholders and trained SMEs. The definition of production relevant environment (Section 2.4) should serve as a helpful guide. In some cases a laboratory environment is acceptable as a production relevant environment, if some production line realism is present and can demonstrate manufacturing readiness or identify potential risks to manufacturing processes.

Some MRL threads or sub-threads have multiple criteria to address. One criterion may not be applicable, but the others may be, therefore the thread or sub-thread should not be ignored. If one of the criterion has reference to an acquisition or a follow-on program, that criterion may not be applicable; however another criterion may be applicable. Do not ignore those criteria that are applicable.

8.2.6 Summary

Adaptation of MRL criteria to S&T programs is challenging, but there are several key attributes that can help. First and foremost is participation of an SME trained in assessment of manufacturing readiness. It is critical that the stakeholders work together to understand what is needed to meet the MRL criteria in their application. Tying MRL criteria to program objectives, providing analysis of the criteria with respect to program developments, and identifying potential risks that need to be managed moving forward are all areas where trained SMEs can provide assistance. Assessments of manufacturing must stay focused on the manufacturing risks of transitioning a

technology from the lab to production and should consider impact on product success. Finally, managing manufacturing risks improves the ability to transition technology smoothly and efficiently and is essential for cost effective and reduced cycle times in an acquisition program.