ACCELERATING FIBER OPTIC AND PHOTONIC DEVICE TECHNOLOGY TRANSITION VIA PRE-QUALIFICATION RELIABILITY AND PACKAGING DURABILITY TESTING

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Introduction

Central to the Defense Acquisition Management System are a series of acquisition milestones (A, B and C) and Systems Engineering Technical Review (SETR) process events. SETR process events occur within the five acquisition process phases shown in Figure 1. The purpose of the Technology Maturation and Risk Reduction (TMRR) phase is to reduce technology, engineering, integration, and life-cycle cost risk so that subsequent development, production, and sustainment phases can be successfully accomplished with increased confidence. This phase would include competitive prototype demonstrations focused on technology maturation of critical technologies, key risk reduction activities, and the establishment of a system allocated requirements baseline. The technical feasibility of the system allocated requirements baseline, exemplified at the Preliminary Design Review (PDR) prior to entering the Engineering & Manufacturing Development (EMD) phase, is informed by integrated system representative prototype demonstrations conducted in a relevant environment (i.e., Technology Readiness Level 6 or TRL-6). The TMRR phase should reflect close collaboration between the Science & Technology community, the user, and the system developer.

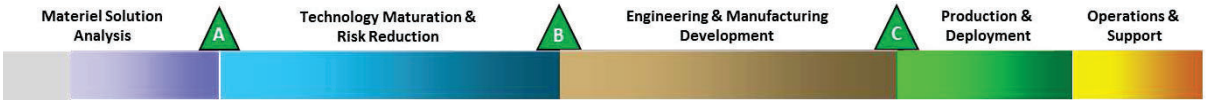

Figure 1. Defense Acquisition Phases and Milestones.

The SETR process provides a rigorous and structured means of evaluating the progress of an emerging design to be compliant with program and customer objectives over the acquisition life-cycle. In the same spirit, a Technology Readiness Assessment is used to further document sufficient technical maturity has been achieved prior to entering EMD. Demonstrating TRL-6 is of paramount importance to opening the door for technology transition opportunity discussions for any new or novel fiber optic components and photonic devices when considering acceptance into a program EMD phase.

Engineering & Manufacturing Development (EMD)

EMD is the start of system development and typically considered formal program initiation. The purpose of the EMD phase is to develop, build, and test a product to verify that all operational and derived requirements have been met, and to support production or deployment decisions. Entrance into EMD is dependent upon a recognized Concept of Operations, approved Capability Development Document, and a system specification consistent with the system allocated requirements baseline outlined at PDR. The technology maturity of the baseline design in support of required user capabilities is gauged within the bounds of mission relatable scenarios and the derived technology operational requirements. The EMD phase develops the product baseline and transforms the preliminary design into a producible design. The goal is to complete the development of a system or increment of capability, complete full system integration, develop affordable and executable manufacturing processes, complete system fabrication, and test and evaluate the system before proceeding into the Production & Deployment phase.

Technology Readiness Assessment (TRA)

The TRA is a systematic metrics based process that assesses the maturity of Critical Technology Elements to be used in the development and production of complex weapon systems. A technology

element is “critical” if the system being acquired depends on this technology element to meet operational requirements and if the technology element or its application is either new or novel or in an area that poses major technological risk during detailed design or demonstration. The TRA scores the current readiness level of selected system elements using defined Technology Readiness Levels (TRLs), highlighting critical technologies and other potential technology risk areas. This formal TRA complements the program manager’s responsibility to pursue all risk reduction efforts needed to ensure that adequate technological maturity is reached before Milestone B approval is sought. An early evaluation of technology maturity conducted shortly before Milestone A supports the planning of these risk reduction efforts during the TMRR phase of the acquisition process.

Technology Readiness Level 6

Military/aerospace fiber optics and photonics technology developers working in the science & technology/research & development realm are striving to accelerate the transition of new passive and active fiber optic components and photonic devices to next generation aerospace systems. TRL-6 (system/subsystem model or prototype demonstration in a relevant environment) represents a major step up in establishing the technology readiness of a fiber optic component or photonic device. TRL-6 requires testing prototypes in a high-fidelity laboratory environment or in a simulated operational environment. The prototype fiber optic component or photonic device under test form factor should be near the desired configuration in terms of performance, space, weight, and volume. Military and aerospace standards can be referenced to translate the intent of the “high-fidelity laboratory environment or in a simulated operational environment” phrase into engineering test plans. Measurements should be performed at both the “nominal” and “corners / extremes” of the environmental and signaling input/output envelopes.

By definition TRL-6 designation going in to EMD does not imply that a given device or component’s reliability is adequate for lifetime performance in the relevant operational environment. Lifetime performance is usually ascertained during EMD via full-scale device reliability testing and packaged component durability testing, also known as qualification testing. Thus, the lifetime performance reliability of a new TRL-6 fiber optic component or photonic device, or the lifetime performance durability of a new TRL-6 packaged device or component is usually not completely known before EMD.

Risk Management Applied to Avionics Fiber Optics and Photonics

Program managers are trained to manage risk and to be ‘risk averse’. A new fiber optic component or photonic device with uncertain reliability and packaging durability presents significant risk to prospective avionics suppliers or users. Thus, fiber optic and photonic device reliability and packaging durability verification and validation during the TMRR phase weighs heavily on program management’s decision to pursue a new fiber optic or photonics technology going into EMD. New photonic device examples include advanced lasers, transmitters, wavelength converters, modulators, photodetectors, receivers and other related planar lightwave, hybrid, and integrated photonic circuits for digital network and RF-over-Fiber applications. Connectors, splices, fiber and cable are examples of new fiber optic components.

AIR 6318

SAE AS-3 Fiber Optics and Applied Photonics established an Aerospace Information Report - AIR 6318 Aerospace Photonics Technology Readiness Advancement and Insertion via Verification and Validation of Active Photonic Device Reliability and Packaging Durability task group in 2015. The purpose of the AIR 6318 task group is to reach consensus on the proper path forward for reducing reliability and packaging durability risk for active photonic devices that are destined for EMD.

Conclusion

AIR 6318 is expected to define a subset of full qualification test procedures for discrete and packaged photonic devices. The test procedures will be aimed at establishing program management confidence in emerging photonic devices prior to Milestone B for subsequent acceptance into EMD.