Designing for Supportability

Driving Reliability, Availability, and Maintainability In...

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Weapon systems must provide a needed capability, meet user needs as evidenced by operational effectiveness and operational suitability, and must be affordable. While operational effectiveness addresses the degree of mission accomplishment in the intended environment, operational suitability addresses the degree to which a system can be satisfactorily placed in use, given reliability, availability, maintainability (RAM), supportability, and ownership cost, among other factors. These requirements are tested and quantified prior to fielding by the initial operational test and evaluation (IOT&E) process, and assessed against defined criteria. As illustrated in Figure 1, total ownership costs (TOC) incurred during the operations and support (O&S) phase may constitute 65 percent to 80 percent of total life cycle cost (LCC).

How then do we address the problem of high TOC while still meeting the warfighter's requirements? We do so by focusing on the causes of high TOC in both system design (quality) and logistics footprint (quantity). This includes the application of skills and processes in the areas of RAM, supportability, and supportability analysis as part of the revitalized systems engineering processes required by the 2009 Weapon Systems Acquisition Reform Act (WSARA).

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...While Driving Costs Out

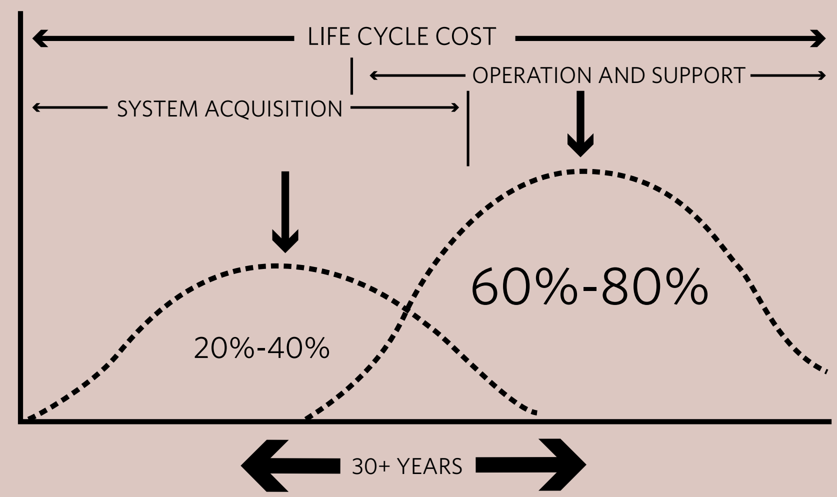
Supportability Analysis Framework

Supportability measures the degree to which a system can be supported both in terms of its inherent design characteristics of reliability and maintainability and the efficacy of the various elements of product support, to include the spare parts, tools, and training required to operate and maintain it.

Supportability analysis is a structured methodology to ensure the system is designed for supportability and the product support elements are identified and available to the user. The affordable system operational effectiveness (ASOE) model addresses the contributions of both system design (quality) and logistics footprint (quantity) to total ownership cost.

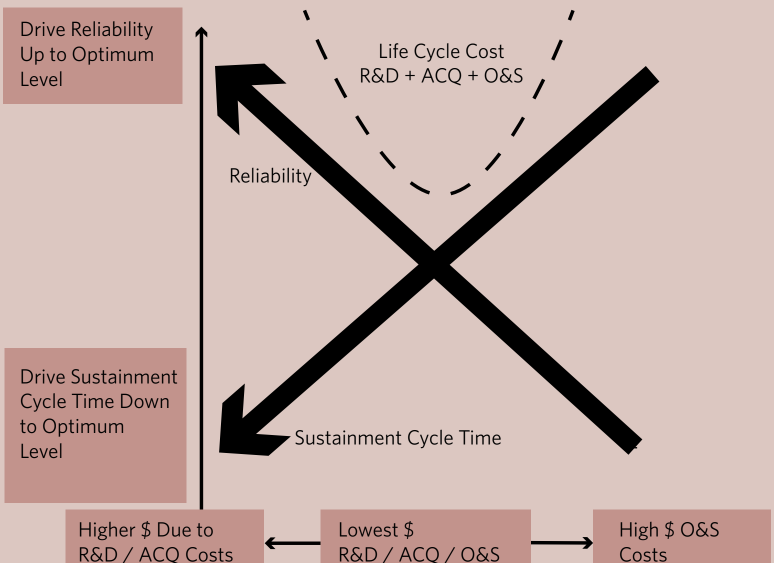
The ASOE model comprises two components. System design for operational effectiveness (SDOE) focuses on the impact of reliability and maintainability as design parameters and their role in meeting operational effectiveness and suitability requirements. The second component, the supply chain model (SCM) focuses on

Figure 1. Life Cycle Cost Distribution



Nominal Life Cycle Cost Distribution

Figure 2. Reliability, Availability, Maintainability—Life Cycle Cost Trade Space



the logistics activities that enable effective sustainment. (A full description is provided in *Designing and Assessing Supportability in DOD Weapon Systems. A Guide to Increased Reliability and Reduced Logistics Footprint*, available at the Acquisition Community Connection website.)

Together, the two models define a RAM/LCC trade space, as illustrated in Figure 2. The trade space bounds the values of reliability and sustainment cycle time to achieve the lowest LCC. The balancing is conducted throughout the life cycle to ensure an optimized solution. While early-phase considerations may exhibit higher R&D and acquisition costs due to the cost of implementing RAM programs, the reduction in O&S costs due to the improved performance and decreased sustainment costs far outweighs implementation costs.

Cumulatively, the models define the supportability and supportability analysis activities conducted collaboratively by the systems engineering and life cycle logistics domains, and provide a powerful and effective means of ensuring life cycle suitability for O&S.

The Supportability Analysis Life Cycle Framework in Figure 3 identifies key supportability analysis activities and their relationships, and serves as the framework for this process. The framework is described in terms of three distinct yet integrated processes.

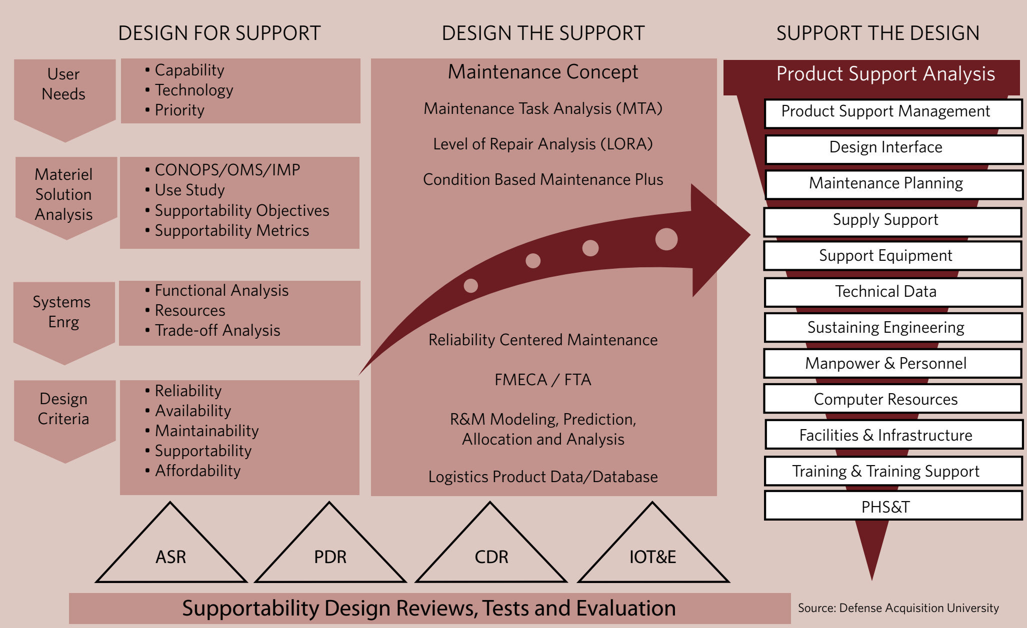
Design for Support

Decisions made up front during the early phases have a profound effect on life cycle cost. As illustrated in Figure 4, design decisions made by Milestone B establish a "cost commitment" of approximately 70 percent of a system's LCC, while actual "cost expended" values are still a small percentage of total expenditures.

"Design for support" activities begin at the earliest life cycle phase when user needs are identified, capabilities defined, and priorities established. During this phase, supportability objectives, their associated metrics, and the initial trade studies are conducted within the systems engineering/life cycle logistics process and result in the preferred system design and sustainment architectures with specific design criteria.

Key to these activities is the development of the maintenance concept, which specifies the levels of maintenance and their capabilities and assigns the preventive and corrective tasks to be accomplished at each level. The maintenance concept provides the construct by which systems engineering/life cycle logistics tasks are conducted. The tasks include reliability and maintainability (R&M) modeling, prediction, allocation and

Figure 3. Supportability Analysis Life Cycle Framework



Source: Defense Acquisition University

analysis; failure mode, effects and criticality (FMECA); fault tree analysis (FTA); and condition-based maintenance plus (CBM+), and reliability centered maintenance (RCM).

The output of these tasks is the assessment of the impact of the system's R&M design characteristics on performance and sustainment. Improvements in RAM are achieved by the elimination of single points of failure, improved mean time between failure (MTBF) through the use of redundancy, and the reduction of mean time to repair (MTTR), through the implementation of accessibility, modularity and testability concepts. Overall reductions in maintenance are also achieved by CBM+ and RCM programs that focus on conducting maintenance based on the evidence of need rather than defined schedules.

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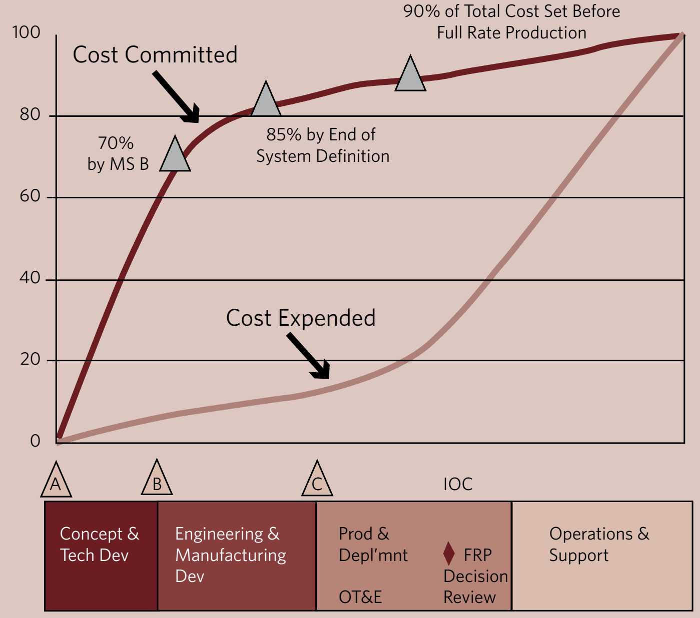
From both a cost and logistics perspective, the level of repair analysis (LORA) is the most important business decision made in the program office. The LORA uses the detailed maintenance information provided by the maintenance task analysis (MTA), as well as operational factors and economic criteria to allocate the repair/disposal actions throughout the levels of maintenance, and to provide an LCC estimate for use in decision making. The LORA provides the information needed to finalize the maintenance concept as well as initiate maintenance planning activities.

Design the Support

The "design the support" process is based on the output of the design for support process as described previously—i.e., the spares, common, peculiar, and unique tools and discrete and automatic test equipment, facilities, and maintenance training that must be specified and procured. For example, support equipment recommendation data (SERD) is generated as part of the product support analysis (PSA) process to specify measurement requirements and determine if existing equipment can be used or whether new equipment must be designed and procured. A properly tailored product support package, based on the technical requirements of the system, will yield the most affordable and operationally ready capability.

The DoDI 5000.02 acquisition process includes the preliminary design review (PDR) and the critical design review (CDR) to ensure requirements are defined, traceable throughout the design and that governance evaluates the effectiveness of their implementation and the implications on performance, cost, schedule and sustainment. The DoD systems engineering process uses the defense acquisition program support (DAPS) methodology to review the design and ensure supportability metrics are defined, implemented in the design as criteria, and that the design reflects their impact on the system in meeting performance and sustainment requirements.

Figure 4. Cost Committed vs. Cost Expended Curves



DAPS provides the tailorable framework for conducting program reviews to assist program managers and DoD decision makers in preparation for milestone decision reviews. The methodology provides a standardized approach to conduct program reviews, and allows for the participation of a broad cadre of subject matter experts.

Chapter 9 of the *Defense Acquisition Guidebook* addresses the developmental test & evaluation (DT&E) and operational test & evaluation (OT&E) processes as the principal methods of ensuring the achievement of user needs as expressed in key performance parameters (KPPs).

DT&E provides the verification and validation of the systems engineering process and must provide confidence that the system design solution is on track to satisfy the desired capabilities. Rigorous component and sub-system DT&E enables performance capability and reliability improvements to be designed into the system early. DT&E events should advance to robust, system-level and system-of-systems level T&E, to ensure that the system has matured to a point where it can enter production, and ultimately meet operational employment requirements.

OT&E focuses on testing the system in its intended use environment where two primary metrics reign: operational effectiveness and suitability. Operational effectiveness is the overall degree of mission accomplishment of a system when used by representative personnel in the environment planned or expected for operational employment of the system considering organization, doctrine, survivability, tactics, vulnerability, and threat. Operational suitability is the degree to which a system can be satisfactorily placed in field use, with consideration given to reliability, availability, compatibility, transportability, interoperability, wartime usage rates, maintainability, safety, human factors, manpower supportability, logistics supportability, documentation, training requirements, and natural environmental effects and impacts.

From both supportability and supportability analysis perspectives, DT&E and OT&E combine to provide quantitative measurement and qualitative assessment of both performance in terms of reliability and maintainability, and the effectiveness of the product support infrastructure and sustainment resources.

Support the Design

The "support the design" process is implemented through the resources of the Integrated Product Support (IPS) Package, as discussed in Appendix A of the *DoD Product Support Manager Guidebook* and is the ultimate outcome of the supportability analysis process. As shown in Figure 3, the 12 IPS elements are defined as a result of a robust product support analysis and provide the assets required for effective sustainment of the system.

Conclusion

Weapon systems must provide a needed military capability, meet user needs as evidenced by operational effectiveness and operational suitability, and must be affordable. Ensuring affordability starts at the earliest phases of a system's life cycle, where decisions drive acquisition costs and essentially lock in O&S costs. The supportability analysis process provides a tool that can be collaboratively used by the systems engineering and logistics domains to address the impact of the design characteristics of reliability, availability, and maintainability on the system design and the logistics footprint to achieve program outcomes.

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