START Selected Topics in Assurance Related Technologies
Volume 7, Number 1

Sustained Maintenance Planning

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Introduction

Readiness is the ability of forces or equipment to deliver designed outputs without unacceptable delay. While "readiness" is associated more with combat forces, it can also be used to describe how well an enterprise is poised to impact or respond to commercial marketplaces. The term comprises human resources and equipment (weapons systems, e. g.) among its many elements. *Affordable* readiness is that level of readiness that can be sustained within some budget or at minimum life-cycle cost. The discussion here is about the support necessary to keep equipment ready (a contribution to overall readiness) at an affordable cost. Affordable readiness encompasses four separate but related ways to look at support for weapons systems or industrial machinery:

- Total Cost of Ownership
- Sustained Maintenance Planning
- Flexible Sustainment
- Rightsourcing

That is, total cost of ownership, or life-cycle cost, cannot be minimized unless:

- maintenance planning is continually reviewed for system optimization (sustained planning);
- performance-based specifications and metrics are used to adjust existing support concepts and operations; and
- innovative procurement strategies are used to find the best sources of supply, labor, and materials to support the system.

This START sheet addresses the concept of Sustained Maintenance Planning (SMP). (The RAC has also published a closely related sheet on Flexible Sustainment.)

Background and Concept

Innovative maintenance planning and execution can extend the useful life of a system. Maintenance management's functions are to cost effectively maintain the system to achieve mission objectives with minimal downtime, and to introduce upgrade and modification programs that improve operational capability as required. To accomplish this, maintenance managers must plan for and execute preventive and corrective maintenance that is based on an in-depth understanding of how the system is performing when compared to design limitations. When done correctly, the useful life of a system can be extended safely and operational readiness and system effectiveness are more affordable.

In an era of fierce competition for scarce resources, it is no longer sufficient or competitive to develop a maintenance plan during development, and then implement that plan without change over the life of a system. That happened—still does, in commercial industry—all too often when development and production (build) organizations transferred systems with static maintenance plans to owners unprepared to do the required sustaining engineering. Fortunately, modern, proven concepts (e.g., Just-In-Time logistics, Integrated Product Teams, seamless transition, etc.) and powerful communications and computer-based information systems and analytical tools enhance the capability to do dynamic and iterative maintenance planning. Such planning, and its judicious execution optimize the use of scarce resources, and make readiness more affordable.

To maximize the benefits of applying these concepts, the U. S. Navy's Naval Aviation Systems Command (NAVAIR) identified key processes that are known collectively as Sustained Maintenance Planning (SMP). SMP is defined as:

" ***An iterative process that ensures the highest affordable aviation weapons system reliability by using the broad range of aviation metrics to analyze effectiveness and performance of each weapons system's maintenance programs, continually improve maintenance documentation and recommended improvements across the entire spectrum of ILS elements***"

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The goals of SMP are to:

- have a set of iterative processes that use maintenance metrics to evaluate the effectiveness of a maintenance plan in achieving desired availability;
- have life-cycle process for establishing and adjusting Preventive Maintenance (PM) requirements for all levels of maintenance; and
- ensure the desired levels of reliability are obtained for a system, either through actual or near-achievement of inherent reliability, or through the identification of the most significant candidates for redesign.

High field reliability, coupled with optimized maintenance, translates directly into *affordable readiness.*

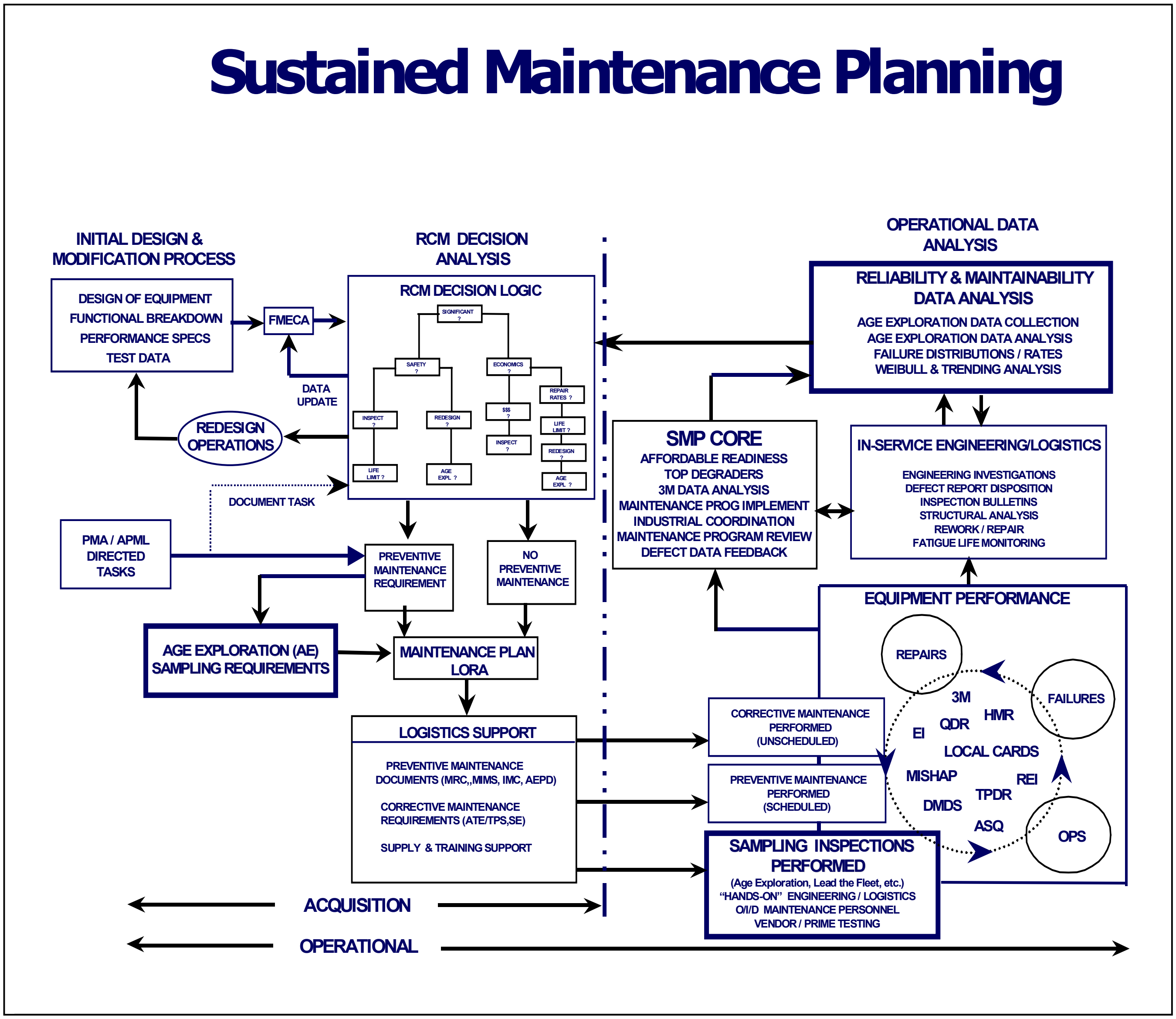

Figure 1. The Sustained Maintenance Planning Process

SMP Components

Figure 1 shows the SMP process, and is similar to Figure 6-16 in the Management Manual Draft NAVAIR 00-25-406, Design Interface Maintenance Planning. Figure 1 depicts SMP as an overarching *closed-loop process that encompasses continual review of established maintenance plans* to ensure the most cost-effective maintenance is being performed on fielded systems. The two key components of SMP are:

- Reliability-Centered Maintenance
- Age Exploration.

Reliability-Centered Maintenance (RCM) is an extensive process unto itself, and applies to all levels of maintenance. It is well defined in another Management Manual, NAVAIR 00-25-403, Guidelines for the Naval Aviation Reliability-Centered Maintenance Process. RCM is readily adaptable to any system, industrial ones included, having mission or output requirements over some system life (life cycle). Essentially, RCM is a process that can be used to first establish and then adjust maintenance procedures and activities based on projected and observed fielded system performance. That performance can be characterized through the analysis of expected and actual system or component failures and tracking trends over time to determine maintenance plan effectiveness. Also, reliability can be improved by implementing results of engineering activities such as Failure Modes, Effects, and Criticality Analysis (FMECA). Proposed solutions and changes to maintenance plans should routinely be subjected to the rigors of cost-effectiveness analysis. A depiction of the activities constituting Sustained Maintenance Planning is contained within Figure 1.

Age Exploration (AE) is the second key component of Sustained Maintenance Planning. AE tasks can range from reviews of usage or failure data (e. g., Navy's 3-M, Air Force's 66-1) to actual inspections or tests to monitor age-related phenomena such as wearout, fatigue, longer response times, and degradation caused by exposure or storage. Ideally, AE tasks would be limited to the durations needed to collect sufficient data and update RCM analyses.

The key to both RCM and AE is a commitment to apply the significant resources that may be required to collect and analyze performance data. It follows that only with such a commitment can SMP be meaningful and successful.

Closing the loop in Figure 1, AE program results are integrated into and with RCM activities, which in turn are used to refine maintenance plans and improve their cost-effectiveness. Reiterating these activities over the life of a system and implementing the resulting solutions cost-effectively are the essence of **Sustained Maintenance Planning**.

Implementing SMP

As shown in Figure 1, implementing SMP actually begins early with the initial design activities of the early Acquisition Phase during Design Interface. It is then that the initial FMEAs are accomplished, maintenance concepts are developed, critical performance parameters are defined, and data gathering and data analysis schemes are formulated. The ability to **sustain** that initial **maintenance planning** and refine maintenance plans as required, throughout the life of a system, depends on an adequate resource commitment to gather and analyze data cost-effectively and intelligently throughout the life of the system.

For Further Study

Web Sites. Additional information on SMP can be obtained from the following web sites. In addition, many of the publications in the list that follows can be downloaded from these sites.

a. http://www.deskbook.osd.mil

b. http://www.nalda.navy.mil/rcm/403/403desc.htm

c. http://www.nalda.navy.mil

d. http://www.nalda.navy.mil/3.6/coo/

e. http://www.acq-ref.navy.mil/

Publications

a. Joint Aeronautical Commanders' Group. Flexible Sustainment Guide, Change 2. December, 1998.

b. Naval Air Systems Command. Draft NAVAIR 00-25-406, Management Manual, Design Interface Maintenance Planning. Washington, D. C.: Commander, NAVAIR, January, 1999.

c. Naval Air Systems Command. Maintenance Trade Cost Guidebook. Washington, D. C.: Cost Department, NAVAIR-4.2, October, 1998.

d. Naval Air Systems Command. Joint Service Guide for Post Production Support Planning. Patuxent River, MD: Logistics Policy and Processes, AIR-3.6.1.1, October, 1997.

e. Naval Air Systems Command. NAVAIR 00-25-403, Management Manual, Guidelines for the Naval Aviation Reliability-Centered Maintenance Process. Washington, D. C.: Commander, NAVAIR, October, 1966.

f. Naval Air Systems Command. Contracting for Supportability Guide. Patuxent River, MD: Logistics Policy and Processes, AIR-3.6.1.1, October, 1997

Other START Sheets Available

RAC's Selected Topics in Assurance Technologies (START) sheets are intended to get you started in knowledge of a particular subject of immediate interest in reliability, maintainability, supportability and quality.

94-1 ISO 9000

95-1 Plastic Encapsulated Microcircuits

96-1 Creating Robust Designs

96-2 Impacts on Reliability of Recent Changes in DoD Acquisition Reform Policies

96-3 Reliability on the World Wide Web

97-1 Quality Function Deployment

97-2 Reliability Prediction

97-3 Reliability Design for Affordability

98-1 Information Analysis Centers

98-2 Cost as an Independent Variable

98-3 Applying Software Reliability Engineering (SRE) to Build Reliable Software

98-4 Commercial Off-the-Shelf Equipment and Non-Development Items

99-1 Single Process Initiative

99-2 Performance Based Requirements (PBRs)

99-3 Reliability Growth

99-4 Accelerated Testing

These START sheets are available on-line in their entirety at http://rac.iitri.org/DATA/START.

About the Author

Stephen G. Dizek is a Senior Engineer with IIT Research Institute, where he has worked on projects related to Reliability, Cost-Benefits Analysis, and Decision Support. Before joining IITRI, he worked in industry as Reliability and Sustaining Engineering Manager for design, build, and fielding of precision, automated, robot-based materials handling systems. Earlier, he spent 15 years with Dynamics Research Corporation (DRC) and The Analytic Sciences Corporation (TASC) as Manager and Technical Director for weapons systems projects on reliability, warranty, logistics, risk analysis, decision support, and the development and implementation of sequential Bayesian techniques for assessing dormant systems. Prior to that, a 22-year United States Air Force career included acquisition assignments to Electronic Systems Division, the MINUTEMAN SPO at the Space and Missile Systems Organization, and Aeronautical Systems Division.

Mr. Dizek holds a BS in Mathematics (minor in Mechanical Engineering) from the University of Massachusetts, an MS in Systems Engineering (Reliability) from the Air Force Institute of Technology (AFIT), and an MS from the University of Southern California in Systems Management. He is a resident graduate of the United States Naval War College's School of Naval Command and Staff, and earned graduate-level certificates from AFIT in Systems Software Engineering and Systems Software Acquisition. He has presented papers to numerous RAMS, SOLE, NAECON, and NES / ICA symposia, workshops, and chapter meetings, and guest-lectured at AFIT, DSMC, and TASC.

About the Reliability Analysis Center

The Reliability Analysis Center is a Department of Defense Information Analysis Center (IAC). RAC serves as a government and industry focal point for efforts to improve the reliability, maintainability, supportability and quality of manufactured components and systems. To this end, RAC collects, analyzes, archives in computerized databases, and publishes data concerning the quality and reliability of equipments and systems, as well as the microcircuit, discrete semiconductor, and electromechanical and mechanical components that comprise them. RAC also evaluates and publishes information on engineering techniques and methods. Information is distributed through data compilations, application guides, data products and programs on computer media, public and private training courses, and consulting services. Located in Rome, NY, the Reliability Analysis Center is sponsored by the Defense Technical Information Center (DTIC). Since its inception in 1968, the RAC has been operated by IIT Research Institute (IITRI). Technical management of the RAC is provided by the U.S. Air Force's Research Laboratory Information Directorate (formerly Rome Laboratory).