

## Reliability and Maintainability Programs – General

This section introduces high level considerations associated with the implementation of Reliability, Availability, Maintainability, Safety (RAMS) and Logistics engineering programs. In particular the interaction between various engineering disciplines, to which the more prominent engineering disciplines are:

- Program Management and Engineering;
- System Engineering;
- Reliability and Maintainability Engineering;
- Logistics Support Engineering;
- Safety Engineering;
- Testability Engineering;
- Configuration Management; and
- Quality Assurance.

The majority of programs can follow the guidelines as detailed in established program standards, such as Defense Standards, Military Standards, NASA, Society of Automobile Engineers (SAE) Standards and European Standards.

## Relationship with Engineering

It is important for the RAMS and Logistics Engineering groups to operate and function closely with other engineering groups such as Design Engineering, System Engineering, Configuration Management, and Quality Engineering.

For example design engineering may select a product which could have a profound negative impact on the Life Cycle Cost (LCC) of Ownership, or the design may or may not facilitate maintainability characteristics of an end item product or system. To have an effective positive impact, in terms of reliability and LCC, RAMS and Logistics Engineering must be included in the design and development loop and need to be active members in an integrated design engineering team. This relationship should commence from the onset of the pre-conceptual phase and be maintained through the following life cycle phase of design, development, production and deployment.

## Interrelationship with other "Ability Engineering" and Logistics Groups

The interaction between the Reliability, Maintainability Safety and Logistics Engineering groups should be implemented and coordinated as a single group effort, due in part to their



interdependencies and mutual vested interests. It can be best imagined like a mobile hanging from a ceiling, each of the "Abilities" and Logistics engineering groups, occupying a branch. If more emphasis were placed in one area than another, then the whole mobile would become unbalanced, impacting all the other elements. For example should the reliability engineering decide to achieve a system reliability by the use of redundant elements then this would have an impact upon logistics engineering. As more elements are used in a system configuration the more support resources will be required, hence increasing the Life Cycle Cost of Ownership. In another example, should a redundant architecture fail to take into consideration the need to partition the redundant elements for maintainability purposes, then the removal and replacement of a failed unit may require powering down the complete equipment. This could have a severe impact on a system that is required to provide a continuous service, such as an air traffic control center.

## Types of Programs

The approach that would be taken for a given program will be dependent upon several factors including, the size of the program and the technologies used. A large program, such as the development of a complete airplane, ship or train, would require more planning and implementation, than a much smaller program or project, such as the development of a medical apparatus or a VHF radio set. Other issues that would need to be considered maybe which additional RAMS tasks are necessary to ensure that the program objectives and requirements are achieved.

The technologies used may include whether the program is fully developmental or Commercial/Military Off-The-Shelf (COTS/ MOTS), or uses a combination of both.

**Developmental Program:** This type of program would benefit from an effective implementation of a RAMS and Logistics Engineering Program. The developmental program consists of all engineering phases, including conceptual, design, prototyping, production and deployment. In-addition careful planning and implementation would be a strategy, which details the reliability and maintainability characteristics and requirements.

**Non-Developmental Program:** This type of program may consist of using items that do not require development (and design), thus utilizing Off-The-Shelf (OTS) components, either military or commercial. Generally if a procuring agency is making an acquisition for a complete OTS system, then their real focus maybe geared towards the system's Reliability and Maintainability performance characteristics as well as the cost of

ownership at a higher system level. It would therefore be prudent to ensure that an acceptable Availability with an Optimum Life Cycle Cost is achieved. That is why various tradeoff studies are made between competing systems' component alternatives during the acquisition phase.

**Hybrid Programs:** These types of programs utilize a combination of developmental and non-developmental programs. Generally this type of program is found during medium to large scale projects, such as the complete development and acquisition of weapons system(s) and the supporting platform, such as a warship. The actual system platform may be designed to fulfill specific operational criteria, including reliability and maintainability parameters. However, the individual subsystems may be OTS and integrated into the overall system architecture.

**Alternative Support Directives Program:** This type of program could be seen during the mid-life update of an existing system or when a system is retired by one end user and is acquired by another. When a system was first developed and deployed, particular reliability, maintainability and logistics attributes were developed based upon a specific operational and maintenance profile. Various aspects to this profile may have changed since the initial deployment and other issues may have arisen also, such as the support capabilities from third and fourth line maintenance. This could be due to the Original Equipment Manufacturer, or OEM may no longer be in business or is unable to continue to support the new user. As a result the new user (or owner) needs to know where and how this system will and can be supported. This may include the assessment of complete logistics packages and assets, and the system's reliability field performance.

## Military Standards and Handbooks

RAMS and Logistics engineering activities have been captured in Military Standards and Handbooks. Supplementing these documents are other technical publication, textbooks, technical papers and information available on the Web. There is an unbounded amount of information available to the user.

Throughout this Web site, numerous references to various military standards and handbooks have been made. Even though the Military Specification system has undergone a dramatic overhaul resulting in many of these standards been canceled, does not detract from their usefulness, as many of these documents contain sound theory and practices, which are still called upon in various program requirements.

Various military standard or handbook has been canceled and is no longer applicable. However, these are a good source to obtain guidance for both programmatic and actual theory as related to reliability and maintainability.

There are many standards and handbooks used in the reliability, maintainability, safety and logistics engineering world. There are standards developed by the Department of Defense (DoD), the British Ministry of Defence, the Society of Automobile Engineers (SAE), NASA and other European Industries and Associations, to name but a few.

These standards can be adopted freely by an organization and integrated into and as part of their day-to-day system engineering Standard Operating Procedures and Policies, or a procurement authority may invoke their use. A supplier who want to supply a procurement authority, such as a government agency, commercial operator/ authority or a prime contractor with their product, may need to have a thorough and complete understanding of many of these standards. The following list captures a sample of some of the more widely recognized and used standards in industry, accompanied by a very brief description.

#### **MIL-STD-785: Reliability Program for Systems and Equipment, Development and Production**

This standard details general requirements and specific tasks for reliability programs. It is used for reliability program planning and includes task descriptions for basic application requirements including sections on program surveillance and control, for several life cycle phases of a product. The life cycle phases include design, evaluation, development and production testing. There are three distinct task groupings, 100, 200 and 300 series.

- **100 series** - addresses the program surveillance and control;
- **200 series** - addresses the design and evaluation tasks; and
- **300 series** - addresses the development and production testing (reliability).

This is a reliability program management document, which references to the subordinate detailed what-to-do standards.

#### **EN 50126: Railways Applications - The Specification and Demonstration of Reliability, Availability, Maintainability and Safety (RAMS)**

This European Standard as its name implies is used by the railway industry, and has been adopted by many leading railway manufacturing and support companies. This

specification considers all life cycle phases of a product, and is broken down into 14 distinct phases. The First Phase starts with Concept of a program/ product and follows the intermediary phases through to the final phase (14) addressing decommissioning and disposal. This standard details which organization is responsible for the various RAMS tasks and activities within each phase, such as the operating authority, main contractor, sub-contractors or even suppliers. This is a RAMS program management document.

### MIL-STD-470B Maintainability Program Requirements for Systems and Equipment

This standard details the general requirements for maintainability programs. The tasks detailed within can be tailored to address the needs, requirements and objectives for a given program and/ or project, at the optimum phase in its life cycle. There are three distinct task groupings, 100, 200 and 300 series.

- **100 series** - addresses the program surveillance and control;
- **200 series** - addresses the design and evaluation tasks; and
- **300 series** - addresses the evaluation and test (maintainability).

The topics detailed in these series are analyses and modeling, such as allocations, predictions, failure mode and effects analysis, and maintainability design criteria This is a maintainability program management document, which also refers to other engineering disciplines such as Safety, Human Factors and Logistics Support Analysis.

### MIL-STD-882C System Safety Program Requirements

This standard provides requirements for developing and implementing a system safety program to identify the hazards of a system over its entire life cycle. A main objective is ensure that hazards and mishaps are removed (or the risk thereof is reduced) from the inherent characteristics of a system by imposing design requirements and management controls. This is a safety program management document and the tasks detailed within, include system safety program plan and preliminary hazard analysis.

### MIL-STD-1388-1A Logistics Support Analysis

This standard details Logistic Support Analysis (LSA) guidelines and requirements for a program. There are five distinct task groupings, 100, 200, 300, 400 and 500 series.

- **100 series** - addresses the program planning and control;
- **200 series** - addresses mission and support system definition;
- **300 series** - addresses preparation and evaluation of alternatives;
- **400 series** - determines the logistics support requirements; and
- **500 series** - address the supportability assessment.

This standard makes reference to the Logistics Support Analysis Record (LSAR) database, MIL-STD-1388/2B (formally 2A). This is a LSA program management document. DEF STD 0060 PART 1 is the equivalent British Ministry of Defence, for the LSAR.

### MIL-STD-1472D Human Engineering Design Criteria for Military Systems, Equipment and Facilities

This standard presents human engineering principles, detailed design criteria, and practices to integrate humans (their requirements, including ergonomics) into systems and facilities. There are 15 sub-sections detailing various human factor attributes, ranging from controls and displays, workshop layout, environment to safety considerations. Section 5.9 details criteria, which should be taken into consideration for the maintainer, such as ergonomics, associated with handling and accessibility. This document contains extensive figures and tables on human parameters.

### IEC 300: Dependability Management

These are a series of International Standards (Norme Internationale) detailing the processes and requirements for implementing Dependability Management/ Gestion de la sûreté de fonctionnement. These (IEC/ CEI) standards are published bilingual, in English and French. This particular standard (300), is broken into sub parts and in the case of 300-3, this is future divided into sections, where each section is a stand-alone document.

- **Part 1 (300-1)** addresses Dependability Program Management;
- **Part 2 (300-2)** details Dependability Program Elements and Tasks; and
- **Part 3 (300-3)** details Dependability Management Application Guides.

**SAE JA1011: Evaluation Criteria for Reliability Centered Maintenance (RCM) Processes**

This is an SAE Standard, detailing specific criteria for implementation of a RCM process; with the focus being applied on the failure mechanisms of a component and where applicable what scheduled maintenance tasks should be implemented. The criteria which must be addressed within this standard, follows very much that of the criteria of a Failure Modes and Effects Analysis (ref to MIL-STD-1629). This standard requires that quantitative issues be taken into considerations such as probability of failure occurrences and the cost associated with the implementation of any scheduled maintenance tasks. The criterion within this SAE standard is partially based upon the RCM processes and concepts from MIL-STD-2173 - RCM requirements for Navel Aircraft, Weapon Systems and Support Equipment.