START

Selected Topics in Assurance Related Technologies

Volume 2, Number 2

Parts Management Plan

Summary:

The goals of a Parts Management Plan (PMP) program are:

- The selection of parts and materials which can withstand the manufacturing environment and robustly perform the needed function for the design life of the product in the use environment
- To provide parts and materials cost-effectively whenever needed

Figure 1 describes the flow of a PMP process and identifies the various program tasks to be completed. Each of these tasks must be tailored to meet the specific needs of each system. The RAC publication "Parts Selection, Application and Control" (Reference 1) provides generic guidance in the development of this process.

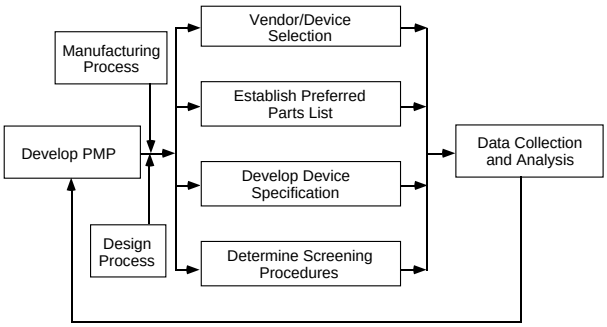

Figure 1: PMP Process Flow

Develop the PMP

Understanding, defining and implementing all the tasks involved in a parts management process is the key to its success, and should be fully described in the plan. The participation of the following functional disciplines are necessary to enable, in a concurrent engineering fashion, an effective process:

- Components Engineering
- Design (system and parts)
- Reliability Engineering
- Manufacturing Engineering
- User

Successful implementation of the PMP must have management participation and support to ensure cooperation among disciplines and resolve any differences based on the ultimate impacts on cost, schedule and performance.

Vendor and Device Selection

Major factors in implementing a PMP process are the evaluation, selection and management of vendors and components.

Vendor evaluation can be accomplished by analyzing his design, manufacturing, quality, and reliability practices. An audit/validation will assess whether a documented and baselined system exists and is being used. Representative questions such as those in Table 1 may be used as part of the audit/validation process.

Table 1: Representative Questions for Part Suppliers

- Is a quality program defined and implemented?
- Have potential failure mechanisms been identified?
- What corrective actions have been put in place?
- Are the manufacturing materials and processes documented?
- Are there process controls in place?
- Are parts manufactured continuously or is there intermittent production?
- What defect levels are present?
- Is there a goal in place for continuous improvement?
- Have life limiting failure mechanisms been designed out?
- Do lifetimes of failure mechanisms exceed the expected useful life of the product?
- Are efforts being taken to identify the causes of part failure and to improve the manufacturing process to alleviate their occurrence?
- Is the part screening process effective?
- Are design rules used and adhered to that result in high quality and reliability?
- Are design changes made only after analyzing and quantifying possible reliability and quality impact?
- Is customer notified of major changes?
- Does the supplier track and demonstrate on-time delivery?

Effective part qualification and evaluation methodologies are destructive physical analysis, life testing, continuous monitoring of defect levels and data analysis.

Critical Devices/Technology/Vendors

The following part characteristics are considered critical and require additional attention due to potential reliability, manufacturability or availability problems.

- **Performance Limitations:** due to stringent

environmental conditions or non-robust design practice
- **Reliability Limitations:** component/materials with life limitations, high defect rates, or the use of unrealistic derating requirements
- **Vendors:** those with a past history of delivery, cost performance or reliability problems
- **Old technology:** those with availability problems
- **New Technology:** parts fabricated using immature design and manufacturing technology

The first three categories require historical data to track and define actions to minimize their occurrence or provide alternate solutions. The subject of old and new technology can involve the generation of different procurement procedures for tracking technology maturity, obsolescence and hidden hybrids (i.e., those devices that fall between generic device categories and, as a result, are often incorrectly specified and tested).

Establishing a Preferred Parts List

An important step in meeting system requirements is the preparation of a Preferred Parts List (PPL) which identifies the types of components recommended for use. The parts selection and control program should strive for a level of standardization that minimizes the number of new parts entering the product and yet still be flexible enough to effectively utilize the advantages offered by new technology. Some consequences of designing a product without a PPL are listed in Table 2.

Develop Device Specifications

Part electrical, mechanical and physical characteristics should be defined in a device specification to be used for design, test and procurement. Applicable device electrical performance parameters, for all operating conditions, should be specified to the extent necessary to ensure product performance objectives are met, including reliability parameters. The part specification should be based on several factors including operating environments, worst case stress levels, lifetime and reliability requirements.

The "Analog Testing Handbook," Reference 2, provides detailed information for the specification of analog devices.

The following device specification formats are used:
- Standard Microcircuit Drawing (SMD)
- Specification or Source Control Drawing (SCD)
- Vendor Item Drawing (VID)

Table 2: Adverse Effects from Designing Without a PPL

- Selection of obsolete (or soon to be) and sole sourced parts and materials
- Possibility of diminishing sources
- Use of unproven or exotic technology
- Incompatibility with the manufacturing process
- Inventory volume expansion and cost increases
- Vendor quality may be difficult to monitor due to the added number of suppliers
- Loss of "ship-to-stock" or "just-in-time" purchase opportunities
- Limited ability to benefit from volume buys
- Increased cost and schedule delays
- Additional tooling and assembly methods may be required to account for the added variation in part characteristics
- Part reliability can decrease due to the uncertainty and lack of experience with new parts
- Automation efforts may be impeded due to the added variability of part types

Determine Screening Procedures

Parts screening consists of a series of successive stresses applied to parts. The intent of screening is to eliminate weak parts without shortening the life of the remaining parts.

Since manufacturing processes are not defect-free, the yield is less than perfect and there is no guarantee that parts surviving the manufacturing and screening process are defect-free.

The test requirements for specific parts must be carefully chosen to provide the most effective and economical trade-off between test costs and field reliability.

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 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 in 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 Rome Laboratory (formerly Rome Air Development Center) at Griffiss AFB.

Screening effectiveness is a strong function of the maturity of the part being screened. However, the maturity of a process can only be determined from empirical evidence that the process provides a high yield and is capable of producing parts that have a very low probability of containing defects. Table 3 illustrates this concept.

Original Equipment Manufacturers (OEMs) often have several choices when deciding which organization will perform the screen/test. These options include part manufacturers, part users (OEMs), and independent test labs.

Several factors should be considered when making such a decision. They are summarized in Table 4 along with a qualitative rating of each factor for each potential screen/test facility. It should be noted that this is a very subjective table and there will be large variations in the ratings depending on the specific set of conditions.

Design for Reliability

Methodologies should exist and be used to ensure that systems are designed and parts are applied in a robust manner. This observation illustrates the inseparability of part selection and application in the design and manufacture of a reliable system and illustrates the necessity of using a concurrent engineering approach. The following company specific methodologies are recommended:

- Guidelines for choosing component quality levels
- Design guidelines
  - Performance
  - Environmental/thermal
- Manufacturing/assembly procedures
- Performance/reliability demonstration plan

Table 3: Screening/Test Requirements vs. Maturity

Maturity	Corresponding Screening/ Test Requirements
Immature ↓ Mature	100% Screening ↓ Screens of Less Duration ↓ In-Process/Sample Testing/ Appropriate Screens

Design for reliability is the process of selecting a part or material and applying it in such a manner that results in high reliability under the worst case actual use conditions. Such an effort requires a structured approach during the part selection and design process. This process should also include:

- Definition of operating environments
- Establishment of lifetime requirements
- Use of reliability models to estimate lifetime under use conditions
- Estimates of reliability during the useful life
- Stress derating
- Analysis and design modifications to ensure robustness

There are several engineering analysis techniques and design tools that are useful in analyzing the robustness of a design. These include reliability assessment/lifetime analysis, derating, Failure Mode and Effects Analysis (FMEA) (with or without criticality analysis), Worst Case Analysis (WCA), Fault Tree Analysis (FTA), and Finite Element Analysis (FEA).

Design for Manufacturability

Of equal importance to the selection and application of parts is the manufacturing process to be used for their implementation. The best part used in a good design is useless, unless it can be utilized in a reliable and reproducible manner. Manufacturing process evaluation is especially important for new or immature technologies. Therefore, the manufacturability of equipment designs should be given equal weight with the part selection and application efforts.

Manufacturing Emulation

Procedures are required today to not only procure acceptable parts and materials, but also to ensure that the process steps from shipping to assembly do not destroy good components. It is not enough to qualify components to a standard qualification procedure (i.e., MIL-STD-883, TM5004 & TM5005) because some current assembly processes impose greater stress than those used previously. A classic example is surface mount technology, which uses soldering processes (i.e., vapor phase, infrared heating) that provide a very fast temperature transition to 220°C, creating a thermal shock which is greater than that used for component verification testing. This is exemplified by the use of plastic surface mount packages which, in some cases, have resulted in

Table 4: Relative Merits of Screen/Test Sources

Factor	Part Manufacturer	Part User (OEM)	Independent Lab
Test Cost	Low	High	Medium
Test Effectiveness	High	Medium-High	Medium-High
Timeliness	Good	Poor	Good
Data Integrity	Poor	Good	Good
Testing for Application Specific Parameters	Poor	Good	Poor

the "popcorn effect." This refers to a phenomena in which moisture is absorbed by the plastic encapsulant material and, upon exposure to the soldering thermal shock, the moisture vaporizes, causing the package to delaminate or crack due to the resulting high internal pressures.

In order to determine if components will perform reliably after exposure to handling and assembly stresses, a preconditioning procedure emulating these processes should be developed and applied.

Electrostatic Discharge

Static electricity is a serious threat to modern electronic devices. Even though electronic parts have been properly selected and applied, are on the preferred parts list, or have been procured in accordance with a qualification system such as MIL-PRF-38535, they can still be damaged by electrostatic discharge. For this reason, additional electrostatic discharge (ESD) controls are required. Therefore, it is essential that parts are selected with an eye toward their susceptibility to ESD damage, and that detailed precautions are taken to prevent ESD damage to electronic parts and equipment during their fabrication, storage and use.

Damaging electrostatic charges can easily be brought into assembly areas or into the parts storage area by people. They can also be generated in these areas during normal work movements.

Data Collection and Analysis

In the context of the parts management process flow, data resulting from the vendor/device selection; PPL and device specification development; and screening test definition processes should be analyzed to determine the effectiveness of the PMP. When identified as appropriate, changes should be made to the plan to improve its effectiveness.

For More Information:

1. "Parts Selection, Application and Control" (PSAC), Reliability Analysis Center, 1993.
2. "Analog Testing Handbook" (ATH), Rome Laboratory/ Reliability Analysis Center, 1993.
3. "Reliability Toolkit: Commercial Practices Edition" (CPE), Reliability Analysis Center, 1995.
4. "Best Practices - How to Avoid Surprizes in the World's Most Complicated Technical Process," NAVSO P-6071.

Future Issues:

RAC's selected topics in assurance related technologies (START) are intended to get you started in knowledge of a particular subject of immediate interest in reliability, maintainability and quality. Some of our upcoming topics being considered are:

- Commercial Off-the-Shelf Equipment
- Reliability Predictions
- Dormancy
- Mechanical Reliability
- Software Reliability

Please let us know if there are subjects you would like covered in future issues of START.

Contact Anthony Coppola at:

Telephone: (315) 339-7075
Fax: (315) 337-9932
E-mail to acoppola@mail.iitri.com

or write to:

Reliability Analysis Center
PO Box 4700
Rome, NY 13442-4700

About the Author:

John P. Farrell is a senior engineer for IIT Research Institute and serves as an advisor to the Reliability Analysis Center. Before joining IITRI, he was active in developing microelectronic reliability assurance procedures at the Air Force Rome Laboratory, formerly known as the Rome Air Development Center. At IITRI he has been active in technology transfer activities in both military and commercial microelectronics applications.

Mr. Farrell holds a bachelor's degree in Physics from Syracuse University. He holds the Defense Standardization Award for QML, VHSIC Pioneer Award, ISHM's Technical Achievement Award and the Outstanding Civilian Career Performance and Meritorious Civilian Service awards.