IMPROVEMENTS IN ELECTRONIC PRODUCTS RAP

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Abstract. This paper describe the process flows, showing simplification that have occurred in the process of Reliability Assessment Program (RAP) in electronic products. Unlike conventional reliability prediction methodologies, which focus solely on part failure rates, the methodologies presented here incorporate design failure rates, manufacturing process failure rates and other causes for equipment removal.

Key words: Assessment Prediction, Similarity, Top-Down

1. INTRODUCTION

This paper continues the effort to develop and refine RAP methods. The methods primary rely on accurate field data that reflects the actual causes of failures experienced for similar products performing in-service under environmental conditions. These methods are usable for all areas requiring reliability assessment, such as design decisions and logistical support concerns. These assessment methods will provide more accurate reliability parametric results than one are typically familiar with and will enhance applications for electronic product reliability improvement.

Multiple methods are available depending on the degree of similarity that exist between the new and predecessor products. A similarity analysis method is the preferred method that is used where high degree of similarity exists. This assessment method is intended for four categories of use: equipment design decision, business decisions, system architecture decisions and safety assessment. One of the benefits for using this RAP methodology is to address all potential sources and causes of failure. Component failure rates have steady declined over the years to the point where other failure sources, such as design and manufacturing errors, can be dominant failure rates for a product. This is particularly true during initial introduction of a new product into field service. As another benefit, companies using this methodology will gain in the understanding of design and manufacturing processes that can be changed to improve product reliability.

2. FEATURES OF THE APPROACH

Figure 1 contains a high-level flow diagram describing the approach of the overall reliability assessment process. The similarity analysis process is a top down assessment approach using end electronic item field failure and performance data to derive failure rates for new end item designs. The assessment can be partitioned to hardware levels below the end item level, such as Shop-Replaceable-Unit (SRU) or Circuit Card Assembly and piece part type levels. An output of the similarity analysis is the determination of the end item products in-service which represent predecessor and items that are similar to the newly designed end item.

End item field failure and performance data of predecessor and items are compared to the characteristics of the new end item design, such as technology, functionality, parts count and design processes. Unlike traditional bottom-up methods, he offered process does not require complete parts lists, detailed drawings and schematics, part stress levels and specific environments. The relationship between an existing predecessor design and a proposed new design is sufficient. Some detailed information is not required and the new process can be applied earlier in the product development cycle. In addition to its early program application, the time and effort that are required to complete the end item failure rate prediction is significantly less than the traditional bottom-up approach.

3. MAIN ADVANTAGES

- ***Characterise How product Reliability Matures***

By tracking the failure rates of the products over time, product reliability can be characterised. A potential result of this tracking is a graph for each product that shows failure rates decreasing over time. This would demonstrate that reliability growth is achieved. A graphical way to demonstrate reliability growth is by using a Duan Growth Plot and linear regression. If the curve demonstrates a time period where a constant failure rate exist, this significant a mature product from a reliability perspective. In this situation, predicting the product reliability using an exponential distribution is possible. If the curve demonstrates an increasing failure rate, then causes of the failures need to be identified and corrective action taken.

- ***All Causes of Removals/Failures Analysed***

One of the advantages of the offered process is the determination of failure rates for all causes of end item removals and failures from systems in the field. Traditional prediction methods assume that all failures are attributed to component failures. After assessing and item field data and quantifying the available field failure and performance data, failure rates are ascertained for each cause of failure events.

- ***In-Service Lessons Learned Benefit New Product Reliability***

The results of any assessment should be verified with empirical data once the new design is placed into service and adequate time has elapsed (~2 years) so that field history can yield sufficient failure rate information to glean lessons learned. The in-service lessons learned should be used to further develop and enhance this dynamic prediction methodology, as well as benefit the reliability of the newly designed items. The offered RAP focus on actual causes of failure allows reliability improvement efforts to be concentrated on areas with the greatest potential to improvement efforts to be concentrated on areas with the greatest potential to improve electronic products reliability.

4. STEPS OF THE SIMILARITY ANALYSIS

The descriptions of the steps reference the spreadsheet shown in Figure 2.

- ***Review Products for which Field Data is Available***

Perform a comparison of the new product with products for which field data exist. This can be performed at multiple levels and against single or multiple predecessor products. In this simples form the similarity analysis can compare one predecessor product to a new product. The analysis can also use multiple predecessor products where each product is analysed separately and the individual results averaged. Rather than using whole products, the analysis can also be performed at the SRU level where each SRU in the new product is compared to predecessor SRUs.

The output of this step is the identification of one or more products that are sufficiently similar o the new end item, such that comparable levels of reliability are anticipated. Sufficient similarity is currently determined based on the analyst's knowledge of the products, their reliability drivers and experience using this process. If sufficient similarity is found with a fielded end item or assembly, enter the identification information for the new and predecessor product in the appropriate blocks of the form in Figure 2 (upper left and upper right ring hand corners).

In the decision block following this first step, if sufficient similar end item(s) or assemblies are not identified, then an alternate method for RAP should be used, with preference given to the failure cause model. Though "sufficiently similar" is not defined, it is expected that once experience is gained by using this methodology a clear definition will evolve.

- ***Identify Characteristics Differences***

Identify all characteristic differences between the new and predecessor products. Characteristic data is product-specific data for new and predecessor products related to their: (1) design process, (2) manufacturing Process and (3) product specific.

Design process data rates to the specific processes used during the development of a specific product. The data will be required for both new and predecessor products to evaluate the relative likelihood of developing a product free of design defects. The data should include enough detail to determine the process steps performed as well as the degree of rigor and timeliness of the process steps. This data will be used to evaluate the design processes and their ability to design a product free of design defects. Examples of this type of data include requirement definition/traceability, design analyses employed and degree of testing performed.

Manufacturing process data relates to the specific manufacturing process used for the product's assembly processes. This data evaluates the production build processes and their ability to manufacture defect-free products. Examples of this type of data include level of automated assembly, statistical process control usage, computer aided manufacturing usage and build technology.

Product-specific data consists of standard design and requirements data available for any product development. This data includes items such as parts lists and assembly drawings, which can be used to compare similar products. This data will be used to identify differences between products that could impact field reliability. The environmental conditions of the product's intended use applications are also considered. Examples of this type of data include fault detection capability, environmental requirements, technology maturity and customer training.

Each characteristic difference is entered into the first column of the example spreadsheet shown in Figure 2. The spreadsheet usage is effected by the number of predecessor end item used or if the analysis is being performed at an assembly or functional level. If multiple predecessor end items are to be analysed, a separate spreadsheet will need to be completed for each predecessor end item. If an assembly or functional level analysis is performed, a separate spreadsheet will need to be completed for each predecessor assembly or function.

- ***Quality Impact of Characteristic Differences on Physical Model***

Each characteristic difference, identified in the second step, is evaluated relative to the expected reliability difference between the new and predecessor item. This evaluation is quantified relative to the individual physical model categories. This quantification is key to the similarity analysis process ant their justification included in the RAP report.

- ***Incorporate Field Data***

This step involves incorporation of the field failure data for the predecessor end item or assembly into the Figure 2 spreadsheet. The field data is compiled to provide two pieces of information: (1) failure mode distribution by physical model category; (2) the overall end item or assembly failure rates.

- ***Compile Assessment***

All of the data for the assessment has been included in the spreadsheet in the previous steps. This step computes he new product failure rate using this data. The compilation method assumes a constant failure rate applies, which may not always be true. Alternate compilation methods may be developed as experience is gained. The spreadsheet in Figure 2 is depicted by the following formula:

$$\lambda = \lambda_p . \sum_{A=1}^{N} \left(D_A . F_A \right)$$

where λ is the new product failure rate; λ_p is the field failure rate for the predecessor end item or assembly; D_A is the failure mode distribution percentage for category N; F_A is the difference factor between the new and predecessor end item, or assembly, for category N; A is the number of the physical model category, which ranges from 1 to 7; N is the total number of physical model categories.

The above formula representation of the spreadsheet assumes no additional user-defined physical model categories. If this is not true then the maximum value of N will increase by the number of user-defined categories.

5. CONCLUSION

Any RAP program should include provisions for continuous improvement of both the product and process. As a product proceeds through its life cycle (design, manufacturing and field usage) additional data becomes available to enhance or validate the accuracy of the reliability assessment. Multiple assessments will be required throughout a product's life cycle to track changes in reliability.

Improvements in the assessment process can take many forms. Since one of the assessment method discussed in this paper utilise field data, the methods used to collect and analyse the field data should continually be reviewed for improvement. Characteristics such as completeness, accuracy and analysis methods are all subject to review and improvement. The model also relies on identification and quantification of characteristic differences in their processes.

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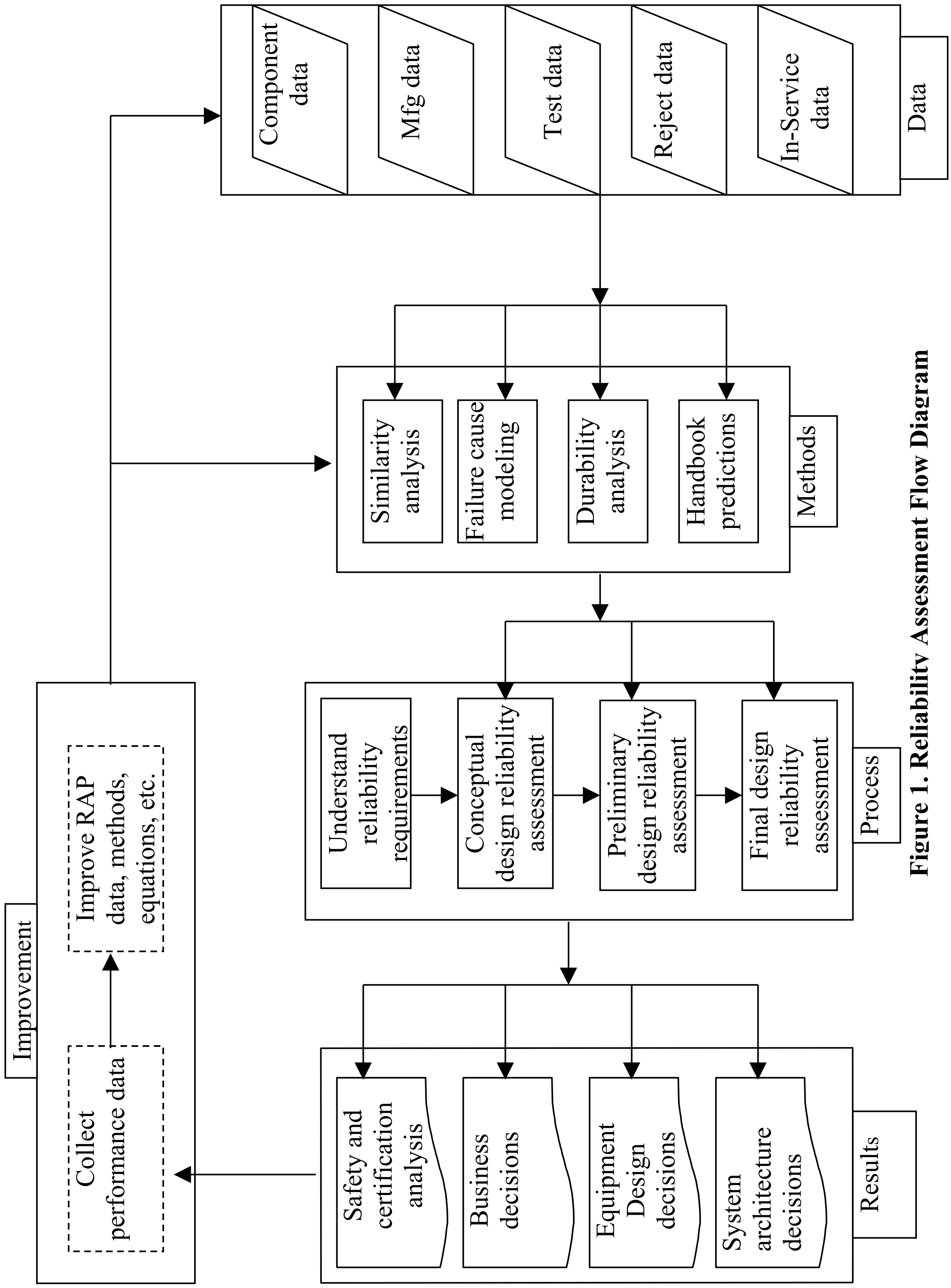

Figure 1. Reliability Assessment Flow Diagram

When entered into the spreadsheet the values are either

- Less than one to indicate a reliability improvement
- Greater than one to indicate a reliability reduction
- Equal to one indicating no impact on reliability. To reduce clutter on the spreadsheet a blank entry will be interpreted as a one

New Product Identification	PHYSICAL MODEL CATEGORIES									Predecessor Product Identificatio
Characteristic differences (category – description)	Category1	Category2	Category3	Category4	Category5	Category6	Category7	Category8	Category9	Comments
1. Two PWB's combined into one			0,9							
2. Reducted parts count into one	0,8			0,6						
3. A1 card moved to SM						0,8				
4. Performing RET on new product							0,8			
5. Combined A2 into ASIC	0,89		0,98	0,85	1,2					
Products of physical model impacts	0,712	1	0,882	0,51	1,2	0,8	0,8	1	1	
Exist product failure mode distribution	10%	10%	10%	20%	20%	20%	10%	0%	0%	
Failure rate impact per category	0,071	0,1	0,0882	0,102	0,24	0,16	0,08	0	0	
Failure rate ratio	0,841									

Figure 2. Similarity Analysis Form

Categories:1 – low complexity passives (resistor, capacitors, inductors); 2 – high complexity passives (transformers, crystal oscillators, passive filters); 3 – interconnections (connectors, flex type, printed writing, boards, solder joins); 4 – low complexity semiconductors (discrete semiconductors, linear and digital Ics); 5 – high complexity semiconductors (processors, memories, ASICs); 6 – manufacturing process; 7 – design process; 8 – other failure (removal) causes and above