Failure Rate On Demand

White Paper v5
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In many cases a rough failure rate estimate is required during the design stages of a product. For example: During early design stages, initial reliability and safety analyses are required in preparation for the Preliminary Design Review (PDR). Obtaining failure rates can take a lot of time, especially in large organizations where safety and reliability departments are separate. In order to solve this issue, we introduce a new method based on a web application that offers a secure and quick way to obtain failure rates for electrical components and assemblies. In this paper, we present the method and the special features, which simplify the process and save engineers time and effort.
Keywords: Failure Rate, MTBF, application, electronics.

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1. The need for quick failure rate calculations

Product development lifecycle usually follows the "V model":

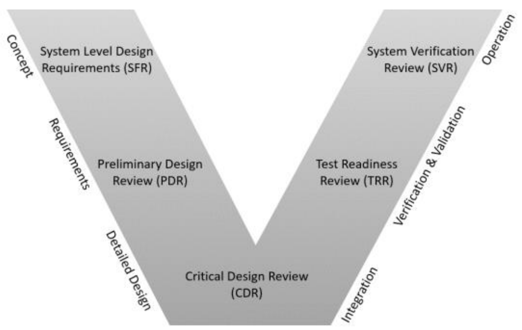

Fig. 1. Design reviews in the V model. Based on: SYSTEMS ENGINEERING FUNDAMENTALS (2001).

The left arm of the V model represents the top-down process of defining the product functionalities, assemblies, and components based on the product requirements. The right arm describes a bottom-up process of putting the components together, defining the interfaces between them, and finally operating and maintaining the product.
Several review sessions take place during the design stages, during which the safety and reliability are discussed.
According to NASA system engineering handbook (2016), the Preliminary Design Review (PDR) is required to include the "design solution definition" as well as "required leading indicator trends", therefore an MTBF assessment should be reviewed at the PDR, and in some cases even in earlier reviews.
Similarly, NASA Reliability and Maintainability (R&M) Standard for Spaceflight and Support Systems (2017), Reliability Analysis Methods table states that "Reliability Modelling (Prediction / Allocation)" should take place "Early in design and to support FMECA and FTA quantification".
The examples given above demonstrate the need for MTBF predictions in early development stages.
Obtaining failure rates during design is a challenge for large organizations where safety and reliability departments are separate.

2. The Solution

In order to deal with the challenge presented above, an easy to use web based application for quick MTBF prediction was developed. The following sections present details regarding the solution as well as an example project.

2.1 *Prediction Method*

The method is based on the popular Mil-HDBK 217 F2 (1991), Parts Count method with additional options covering modern components. The method has a standard structure for calculating failure rates of components and component groups:

$$\lambda = N \cdot \lambda_g \cdot \pi_Q \quad (1)$$

Where λ is the component failure rate, N is the number of identical components, λ_g is generic base failure rate for a specific family of components under a specific environment, and π_Q is the component quality factor.

For example:

λ_g for a Tantalum solid chip Capacitor in GB (Ground Benign) environment is 0.00014 FPMH (Failures Per Million Hours).

π_Q for "R" class of Established Reliability is 0.1.

Therefore, the failure rate of 10 such capacitors is 0.00014·0.1·10=0.00014 FPMH.

2.2 *Ease of Use*

Several unique features were implemented in the application in order to automate the MTBF prediction process and reduce the time needed to produce a report:

2.2.1 *Smart BOM Import*

The first step in the process is to import the Bill Of Materials (BOM) (P. Loughhead 2016). BOMs can originate from Computer Aided Design (CAD) or Product Lifecycle Management (PLM) software. The application includes a flexible import module that supports many BOM formats.

During import the BOM is consolidated i.e. all components with the same Part Number are grouped to one row with the relevant quantity. The consolidation ensures that data is inputted once rather than on several locations of the BOM. This reduces the engineer workload and also reduces the probability of input errors.

A key feature of the application is an AI module which reads the component description and extracts relevant information such as component family. The module is based on patterns from thousands of BOMs which were manually treated. This greatly reduces the need for manual data input.

If some information is missing in the component description field, user defined default values are used.

The result of the smart import is that initial calculation can take place immediately after import.

Table 1 presents an example BOM that was imported.

2.2.2 *BOM Editing*

The BOM edit interface allows the user to input manually failure rates for custom components, and edit any component parameter. Fig. 2 presents a screenshot of the BOM editing interface.

Table 1. Example BOM.

Part Number	Description	Qty
TAJC106K020R	CAP TANT 10UF 20V 10% 2312	10
GRM155R61A104KA01D	CAP CER 0.1UF 10V X5R 0402	18
GRM155R71H103KA88D	CAP CER 10000PF 50V X7R 0402	14
GRM033R60J104KE19D	CAP CER 0.1UF 6.3V X5R 0201	4
GRM1555C1H100JZ01D	CAP CER 10PF 50V NP0 0402	2
GRM188R71C104KA01D	CAP CER 0.1UF 16V X7R 0603	12
GRM1555C1H220JZ01D	CAP CER 22PF 50V NP0 0402	1
TAJA106K006R	CAP TANT 10UF 6.3V 10% 1206	1
GRM1555C1H330JZ01D	CAP CER 33PF 50V NP0 0402	1
ECJ-1VB0J475M	CAP CER 4.7UF 6.3V X5R 0603	4
ECJ-1VB1H103K	CAP CER 10000PF 50V X7R 0603	2
ECJ-1VB1H222K	CAP CER 2200PF 50V X7R 0603	2
GRM188R71C105KA12D	CAP CER 1UF 16V X7R 0603	2
ECJ-1VB0J474K	CAP CER 0.47UF 6.3V X5R 0603	2
F931A106MAA	CAP TANT 10UF 10V 20% 1206	1
ECY-29RA105KV	CAP CER 1UF 10V X5R 0508	1
EXC-CL4532U1	FERRITE BEAD 115 OHM 1812 1LN	1
02SUR-32S	CONN RCPT SUR 2POS .8MM TIN	1
CRCW04020000Z0ED	RES SMD 0.0OHM JUMPER 1/16W 0402	2
CRCW06031K00FKEA	RES SMD 1K OHM 1% 1/10W 0603	10
CRCW060310R0FKEA	RES SMD 10 OHM 1% 1/10W 0603	1
CRCW06032K00FKEA	RES SMD 2K OHM 1% 1/10W 0603	3
CRCW0402100RFKED	RES SMD 100 OHM 1% 1/16W 0402	3
CRCW040249R9FKED	RES SMD 49.9 OHM 1% 1/16W 0402	2
753083101GTR	RES ARRAY 4 RES 100 OHM 8SRT	4
MABACT0040	Transformers Audio & Signal 5-1000MHz IL 1.1dB Ctr Tap -40C +85C	1
ETC1-1-13	TRANSFORMER Radio freq.	1
LP3878MR-ADJ/NOPB	IC MOS Linear Voltage Regulator, Positive Adjustable 1 Output 1 V ~ 5.5 V 800mA 8-SO PowerPad 250 transistors, production 2012	2
ADC16V130CISQE/NOPB	IC DIG MOS ADC 16BIT 130MSPS LVDS 64WQFN 500 gates	1
AT24C02AN-10SU-2.7	IC EEPROM MOS 2/4/8/16K 2-WIRE BUS 2000 bits, production 2011	1
FIN1108MTD	IC DIG MOS REDRIVER LVDS 8CH 48TSSOP 100 gates, production 2012	2
FIN1101K8X	IC DIG MOS REDRIVER LVDS 1CH 1.6GBPS US8 20 gates, production 2009	1
LP5900SD-1.8/NOPB	IC LIN MOS REG LDO 1.8V 0.15A 6WSON 300 transistors, production 2013	2

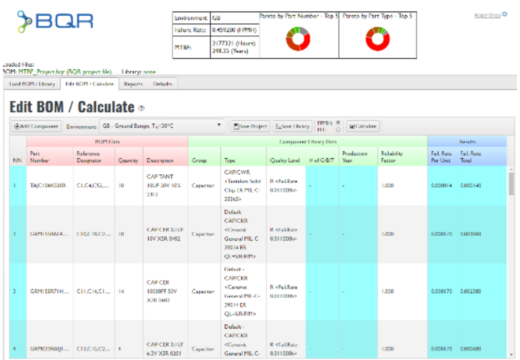

Fig. 2. Interface for editing the BOM parameters after import

2.2.3 *Component Library*

When working on a project, the components parameters can be saved to a library for reuse in later projects, thereby saving additional valuable time.

2.2.4 *Data Security*

Some companies consider the BOM to be sensitive information. In order to protect the user data, BOM data is not saved on the server. The server may process data during BOM import and calculations, but the data is deleted from the server as soon as the results are sent to the user client.

2.3 *Calculation and Report*

Once the BOM parameters are defined, the environment has to be selected (for example GM = Ground Mobile), and then the MTBF prediction can take place.

Several results are provided:

Summary chart:

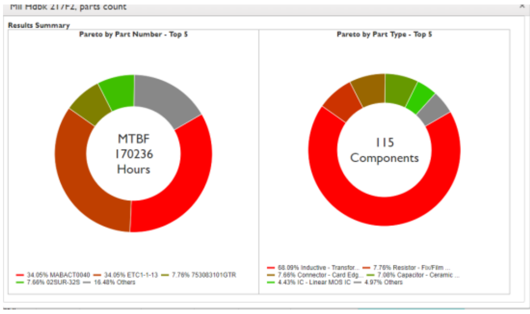

Fig. 3. Summary of MTBF prediction results and leading failure rate drivers

The following tables are also provided:

-Pareto report by component type: identify component types that contribute the most to the system failure rate

-Pareto report by Part Number: identify specific components that contribute the most to the system failure rate

-Detailed report

Table 2 presents the Pareto report by part type for the example project.

Table 2. Pareto Report by Part Type.

Group & Type	**Qty**	**Failure rate per Type (FPMH)**	**Contribution to system failure rate (%)**
Inductive: Trafo.RF <Transformer Radio Frequency>	2	4.000000	68.09
Resistor: FIX/RZ <Fix/Film Network MIL-R-83401 QL= MIL/Lower>	4	0.456000	7.76
Connector: PCB <Card Edge (PCB)>	1	0.450000	7.66
Capacitor: CAP/CKR <Ceramic General MIL-C- 39014 ER QL= S/R/P/M>	65	0.416000	7.08
IC: IC/LIN/MOS <Linear MOS IC>	4	0.260000	4.43
Resistor : FIX/RM <Fix/ Film Chip ER MIL-R-55342 QL= S/R/P/M>	21	0.147000	2.50
IC: IC/DIG/MOS <Digital MOS IC>	4	0.126000	2.14
IC: IC/EEPROM/MOS <Electrically Eraseable PROM MOS>	1	0.014400	0.25
Capacitor: CAP/CWR <Tantalum Solid Chip ER MIL-C-55365>	12	0.004320	0.07
Inductive: Coil.Fixed <Coil Fixed Inductor>	1	0.000470	0.01

2.4 *Insights*

The Pareto reports clearly show which components are the key contributors to failure rate, and it allows to easily conduct "what if" analyses. The calculated MTBF for the BOM in the example, under GM environment is: 170,236 hours. The Pareto report identified the RF transformers as key failure contributors. By changing the transformers' quality from "Military Non Established Reliability" to "Established Reliability", the MTBF increased to 347,924 (a factor of 2). Figure 4 presents Predicted MTBF for the example BOM under various environments (GB = Ground Benign, GF = Ground Fixed, GM = Ground Mobile, AIF = Airborne Inhabited, AUC = Airborne Uninhabited). Orange curve with diamond markers represents the original BOM. Blue curve with circle markers represents the BOM after improving the transformers quality, green curve with square markers presents the MTBF values for the BOM where all components have the highest quality levels, and red curve with triangle markers presents the MTBF values for the BOM where all components have the lowest quality levels.

The green and red curves in Figure 4 present the upper and lower MTBF boundaries that can be achieved by varying the components quality levels.

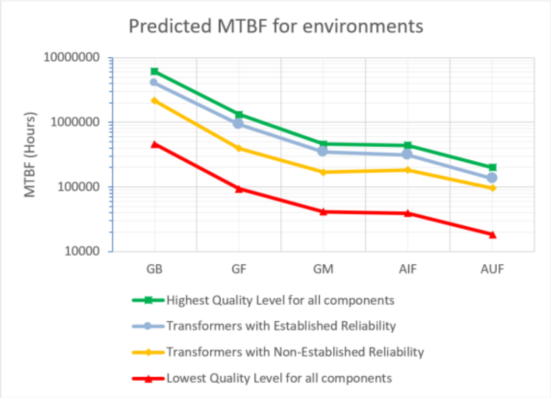

Fig. 4. Predicted MTBF for the example BOM under various environments.

3. Conclusion

A web application was presented for fast and flexible MTBF prediction that saves time and helps product developers to identify key failure drivers, and optimize the component quality levels.

Smart BOM import greatly reduces the probability of manual input errors as well as time for MTBF calculation.

In the future additional prediction methods will be added to the application, starting with Telcordia SR-332 Reliability Prediction Procedure for Electronic Equipment.

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