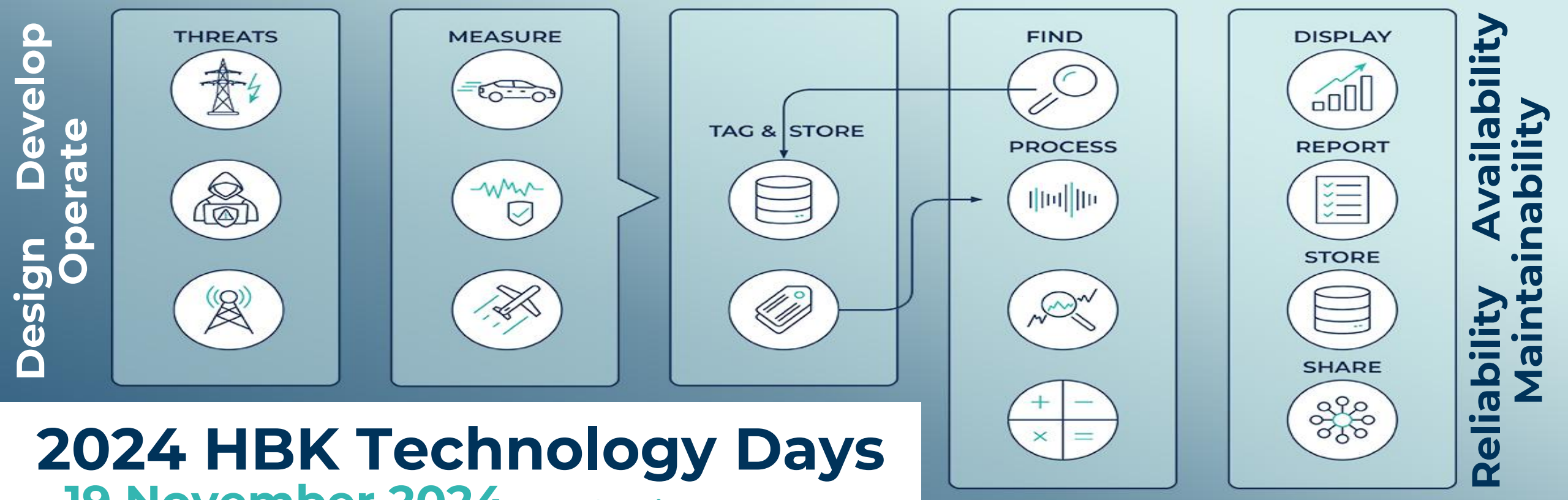




2024 HBK Technology Days

19 November 2024

Session 5: Reliability Engineering from Limited Failure Data

Standards in Lambda Predict

1. Electronic components in commercial and military applications.
2. Electronic components in commercial applications.
3. Failure rate models for electrical, electronic and electromagnetic components.
4. Electronic and electromechanical components.
5. Mechanical components, such as seals, springs, pumps, valves, brakes, etc.

- Standards based reliability prediction – A method to estimate reliability before test or field data are available



Gabriele Serpi,
Senior Application Engineer – Reliability, HBK

Standards based reliability prediction – A method to estimate reliability before test or field data are available

▲ Abstract

- In the early stages of product design, it is often necessary to estimate the reliability of one or more design alternatives. Most reliability analysis tools require times to failure data, either at the component or at the system level, to estimate reliability. Standards based reliability prediction is a method to estimate the reliability of a product before test or field data are available.
- Each reliability prediction standard (MIL-HDBK-217F (MIL-217), Bellcore/Telcordia, FIDES, NSWC Mechanical and Siemens SN 29500) includes mathematical formulas to calculate the failure rate of several components. Typically, the failure rate for each component is the base failure rate for that type of component modified by multiplying factors based on:
 - Physical characteristics such as size or rated voltage
 - Application characteristics such as operating temperature or environment
- In today's competitive electronic products market, having higher reliability than competitors is one of the key factors for success. To obtain high product reliability, consideration of reliability issues should be integrated from the very beginning of the design phase. This leads to the concept of reliability prediction. Historically, this term has been used to denote the process of applying mathematical models and component data for the purpose of estimating the field reliability of a system before failure data are available for the system.

Standards based reliability prediction – A method to estimate reliability before test or field data are available

- ▲ About the presenter, Gabriele Serpi,
Senior Application Engineer – Reliability, HBK
 - Gabriele Serpi is a Certified Reliability Professional and holds an M.S. degree in Electronic Engineering. Gabriele works as Senior Application Engineer with HBK for 13 years. He has a broad experience in Weibull analysis, Accelerated Life Testing, RAM analysis, Standard Based Reliability Prediction, FMEA analysis and other reliability methodologies.

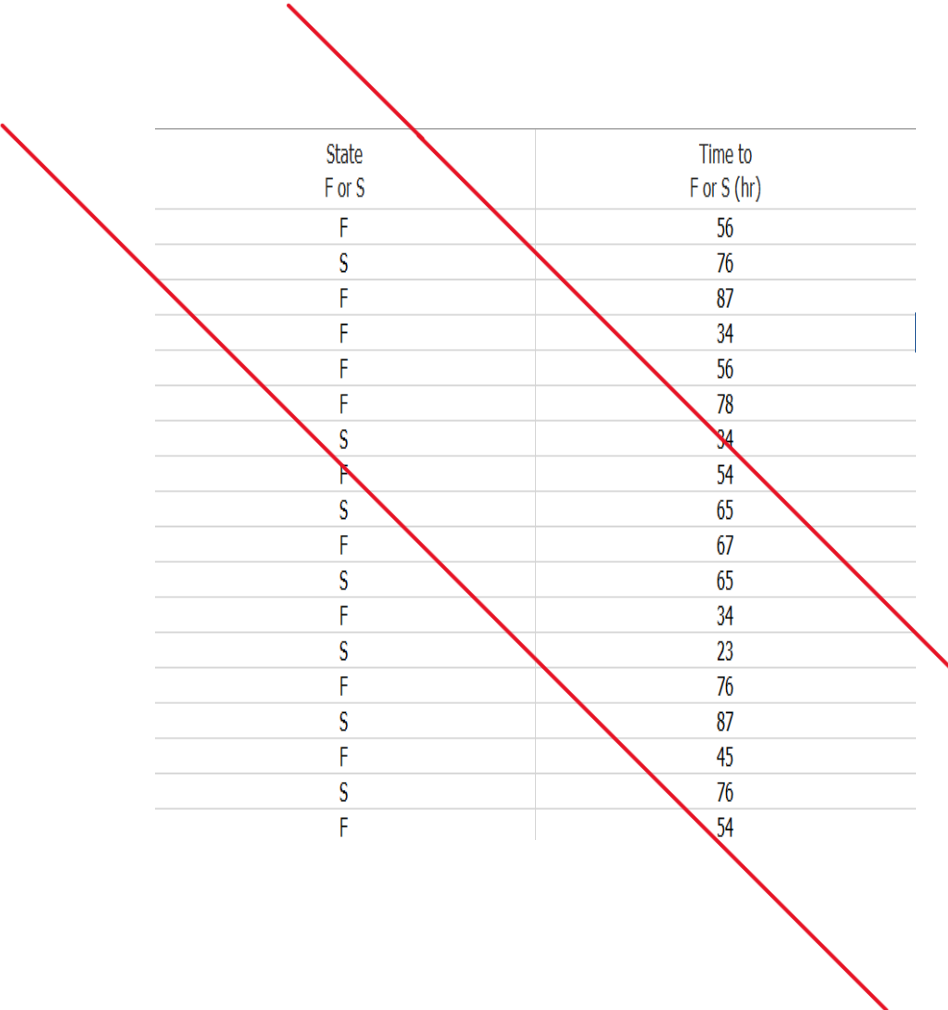
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STANDARDS-BASED RELIABILITY PREDICTIONS - A METHOD TO ESTIMATE RELIABILITY BEFORE TEST OR FIELD DATA ARE AVAILABLE

Gabriele Serpi
Senior Application Engineer
Certified Reliability Professional

Why do we use Standard Based Reliability Prediction

- Most reliability analysis tools require times to failure data, either at the component or at the system level, to estimate reliability.
- Standards based reliability prediction is a method to estimate the reliability of a product **before test or field data are available**.



State F or S	Time to F or S (hr)
F	56
S	76
F	87
F	34
F	56
F	78
S	34
F	54
S	65
F	67
S	65
F	34
S	23
F	76
S	87
F	45
S	76
F	54

Why do we use Standard Based Reliability Prediction (cont'd)

- Standard Based Reliability Prediction allows the engineer to:
- Compare design alternatives.
 - Identify the highest contributors to the system failure rate.
 - Perform trade-off studies, such as increasing redundancy versus using higher quality parts.

Name	Category	Contribution
MIL-HDBK-217F	MIL-HDBK-217F	1.0000
Switch	Switch	0.8301
Meter, Elapsed Time	Meter, Elapsed Time	0.1622
IC TRANSCEIVER	Micro, Digital	0.0022
IC TRANSCEIVER	Micro, Digital	0.0020
IC INVERTER	Micro, Digital	0.0019
Microprocessor, Digital	Microprocessor, Digital	0.0005
Micro, Digital	Micro, Digital	0.0002

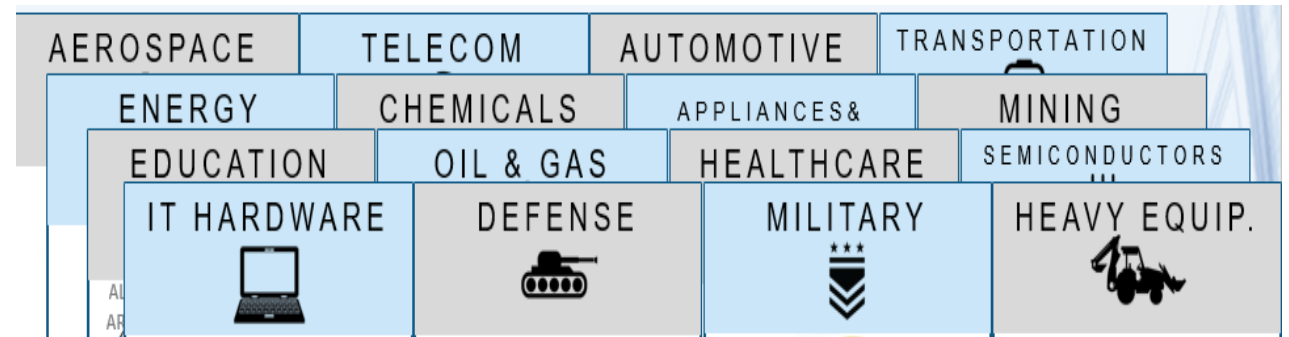
Remark about Standard Based Reliability Prediction

None of the applications listed in the previous slide require an exact match between the predicted failure rate and the failure rate of the fielded system.

Who needs Standard Based Reliability Prediction

Standard Based Reliability Prediction is applicable to many industries:

- Automation
- Automotive
- Aviation
- Electrical and home appliances
- Military
- Naval
- Rail
- Space
- Telecommunications
- Etc.



Standards Based Reliability Prediction

- To perform a standard based reliability prediction analysis, some prediction standard are employed.

$$\lambda_p = \lambda_b \pi_T \pi_A \pi_R \pi_S \pi_C \pi_Q \pi_E$$

- Each Reliability Prediction standard offers a set of mathematical formulas to model and calculate the failure rate of a variety of components

$$\lambda_{BB_i} = \lambda_{G_i} \pi_{Q_i} \pi_{S_i} \pi_{T_i}$$

$$\lambda = \lambda_{\text{Physical}} \cdot \Pi_{\text{PM}} \cdot \Pi_{\text{Process}}$$

Standards in Lambda Predict

- The MIL-HDBK-217F standard (*Reliability Prediction of Electronic Equipment*) provides reliability prediction models for electronic components in commercial and military applications.
- The Bellcore/Telcordia standards provide reliability prediction models for electronic components in commercial applications.

NOT MEASUREMENT SENSITIVE
MIL-HDBK-217F
2 DECEMBER 1991
SUPERSEDING
MIL-HDBK-217E, Notice 1
2 January 1990

MILITARY HANDBOOK

RELIABILITY PREDICTION OF ELECTRONIC EQUIPMENT



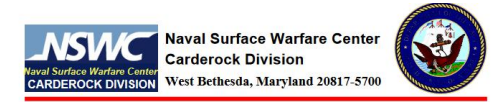
Reliability Prediction Procedure for Electronic Equipment

Telcordia Technologies Special Report
SR-332
Issue 3, January 2011
Updated February 2011

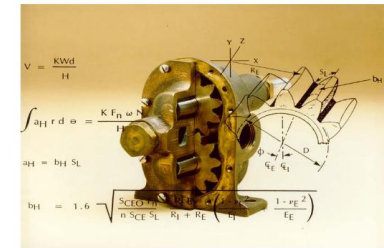


Standards in Lambda Predict

- The *Handbook of Reliability Prediction Procedures for Mechanical Equipment (NSWC)*, provides reliability prediction models for mechanical components, such as seals, springs, pumps, valves, brakes and more.
- The FIDES Guide provides a reliability prediction methodology based on physics of failure, and provides failure rate models for electrical, electronic and electromagnetic components.



Handbook of Reliability Prediction Procedures for Mechanical Equipment



FIDES guide 2009
Edition A
September 2010

Reliability Methodology
for Electronic Systems



Standards in Lambda Predict

- The Siemens SN 29500 standard provides reliability prediction models for electronic and electromechanical components.

SIEMENS

SIEMENS NORM

**SN
29500-1**

HINWEIS 1 / NOTE 1
Ausgabe / Edition 2015-04

ICS 31.020

Deskriptoren: Ausfallrate, Bauelement, Erwartungswert, Zuverlässigkeit
Descriptors: Failure rate, component, expected value, dependability

Ersatz für Ausgabe 2014-10
Supersedes Edition 2014-10

Choice of Reliability Prediction Standards in Lambda Predict

- The choice of a reliability prediction standard is based on your particular needs related to the design in question, unless you have some contractual requirement to use a certain standard.

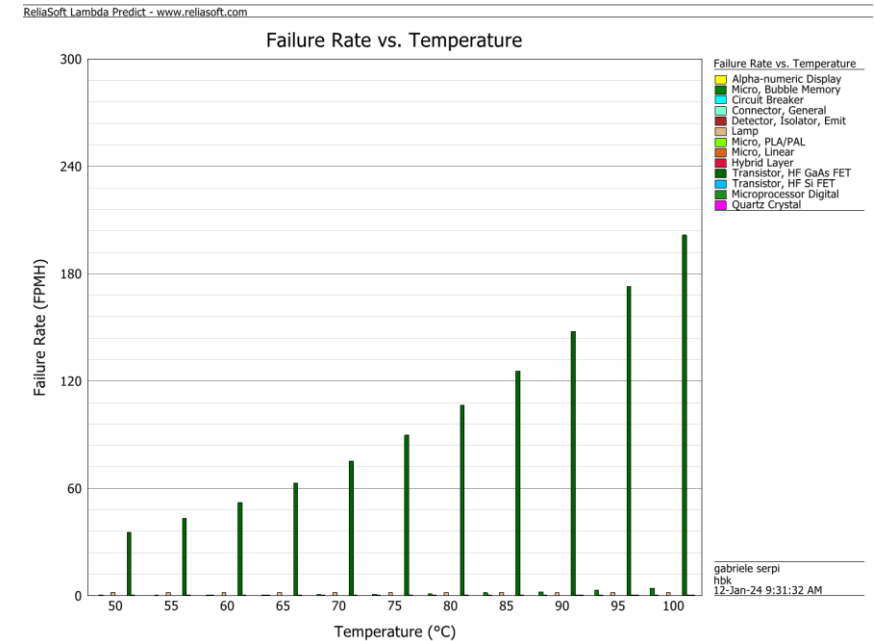
System: MIL217	MIL-HDBK-217F	1	17.5736 FPMH	
Block 1	Block	1	0.0422	
Alpha-numeric Display	Alphanumeric Display	1	0.0017	
Micro, Bubble Memory	Micro, Bubble Memory	1	0.0395	
Block 2	Block	1	0.3455	
Circuit Breaker	Circuit Breaker	1	0.3400	
Connector, General	Connector, General	1	0.0026	
Block 3	Block	1	1.8267	
Detector, Isolator,	Detector, Isolator,	1	0.0009	

- You can also mix and match standards, so You may choose one standard that cover electronic components and another that includes the mechanical components.

FIDES	FIDES	1	7.7788E+04 FITs	1.2855E
Aluminum Capacitor	Aluminum Capacitor	1	20.5908	4.8561
Resistor	Resistor	1	0.4614	2.1679
Switch	Switch	1	49.8373	2.0061
Integrated Circuit	Integrated Circuit	1	1.7926	5.5781
Discrete Semiconductor	Discrete Semiconductor	1	1.4620	6.8401
Linked Block	Linked Block	1	7.7714E+04	1.2861
NSWC-11	NSWC-11	1	77.7138 FPMH	1.2868E
Accumulator [Assembly]	Accumulator [Assembly]	1	14.3232	6.9811
Seal, Static	Seal, Static	1	1.2867	7.7721
Spring, Extension/Compression	Spring, Extension/Compression	1	0.1544	6.4781
Actuator	Actuator	1	0.0594	1.6821
Valve, Poppet	Valve, Poppet	1	10.8217	9.2401
Accumulator Cylinder Wall	Accumulator Cylinder Wall	1	2.0010	4.9971
Chain Drive	Chain Drive	1	26.4500	3.7801
Brake Friction Lining	Brake Friction Lining	1	4.4381	2.2531
Bearing	Bearing	1	32.5025	3.0761

Introduction to Lambda Predict

- Lambda Predict facilitates every step of the standards based reliability prediction analysis process.
- The software supports the major reliability prediction standards.



How to use Lambda Predict

- The items that make up a system be can be divided into blocks and each block can hold other components.
- The failure rates of each component are calculated and showed into the system hierarchy.

	Name	Category	Quantity	Failure Rate(t=INF)
ML	System: MIL217	MIL-HDBK-217F	1	17.5815 FPMH
	Block 1	Block	1	0.0501
	Alpha-numeric Display	Alphanumeric Display	1	0.0017
	Micro, Bubble Memory	Micro, Bubble Memory	1	0.0395
	Resistor	Resistor	1	0.0077
	Block 2	Block	1	0.3455
	Circuit Breaker	Circuit Breaker	1	0.3400
	Connector, General	Connector, General	1	0.0026
	Block 3	Block	1	1.8267
	Detector, Isolator, Emit	Detector, Isolator, Emit	1	0.0009
	Lamp	Lamp	1	1.8255
	Hybrid Block	Hybrid Block	1	0.0044
	Micro, PLA/PAL	Micro, PLA/PAL	1	0.0017
	Micro, Linear	Micro, Linear	1	0.0023
	Hybrid Layer	Hybrid Layer	1	-
	IA, Plated Through Holes	IA, Plated Through Holes	1	15.3086
	Transistor, HF GaAs FET	Transistor, HF GaAs FET	1	15.1384
	Transistor, HF Si FET	Transistor, HF Si FET	1	0.1701

Case study

- CMOS integrated circuits are used for applications such as converters, sensors, interfaces, frequency synthesizers/generators/rectifier etc. A manufacturer needs to estimate the CMOS's reliability, even with a rough first cut estimate, early in the design phase because **the cost of addressing reliability issues increases 10-fold as he moves through the development process.**
- The CMOS (laboratory application, 1 gate, case temperature 48 C, 75mW power dissipation, 28 C/W Junction Temperature) has package with a 5 pin Non- Hermetic SMT.

Case study

- According to the MIL-HDBK-217 reliability prediction standard , the type of model used for the CMOS is the following one:

$$\lambda p = (C1 * \pi T + C2 * \pi E) * \pi Q * \pi L$$

Where:

- λp is the part failure rate;
- C1 is the die complexity failure rate;
- πT is the temperature factor;
- C2 is the Package failure rate;
- πE is the environment factor;
- πQ is the quality factor;
- πL is the learning factor.

Case study

- Failure rate estimations are based on the Reliability Standard:

1) Die complexity failure rate.

CMOS has only 1 gate and , according to the standard, when:
No. Gates goes from 1 to 100 -> **C1 = 0.01**

2) $T_j = T_{case} + (Thermal\ resistance * Power\ dissipated)$

$$T_j = 48^{\circ}C + (28^{\circ}C/W * 0.75W) \rightarrow \pi T = 0.2962$$

Die Complexity Rate	0.0100
Technology	Comp Metal Oxide Semicon
Number of Gates	1

Temperature Factor	0.2962
Ambient Temperature (°C)	30
Case Temperature (°C)	48
Junction Temperature (°C)	50.8
Junction Temp Calc Model	Measured Case Temp
Technology	Comp Metal Oxide Semicon
Power Dissipation (W)	0.1
Theta Case/Ambient (°C/W)	50
Theta Junction/Case (°C/W)	28

Case study

3) Package failure rate

$$C2 = 3.6 * 10^{-4} * Np^{1.08}$$

The package is a 5 pin Non- Hermetic SMT

C2= 0.02

4) Environment factor

According to the standard:

Laboratory instruments and test equipment, medical electronic equipment, business and scientific computer complexes, and missiles and support equipment in ground silos -> **$\pi E = 0.5$**

The CMOS is used for some laboratory application, therefore **$\pi E = 0.5$** .

Package Rate	0.0020
Package Type	Non-Hermetic SMT
Number of Active Pins	5

Environment Factor	0.5000
Environment	Ground, benign

Case study

5) Quality factor

$$\pi Q = 2 + (87 / \sum \text{Points Valuations})$$

CMOS has a standard screening consisting of temperature cycling, constant acceleration, electrical testing, seal test and external visual inspection, in the sequence given. Therefore, Point Valuations = (50 Points + 30 Points) = 80 Points.

$$\pi Q = 2 + \left(\frac{87}{50+30} \right)$$

$$\pi Q = 3.08$$

6) Learning factor

When Number of years since introduction to field use is bigger than 2 -> $\pi L = 1$.

As the CMOS has been manufactured for several years - > $\pi L = 1$.

Quality Factor	3.0875
Quality, Microelectronics	Use Point Valuation
Total Point Valuation	80

Learning Factor	1.0000
Number of Years in Production	2

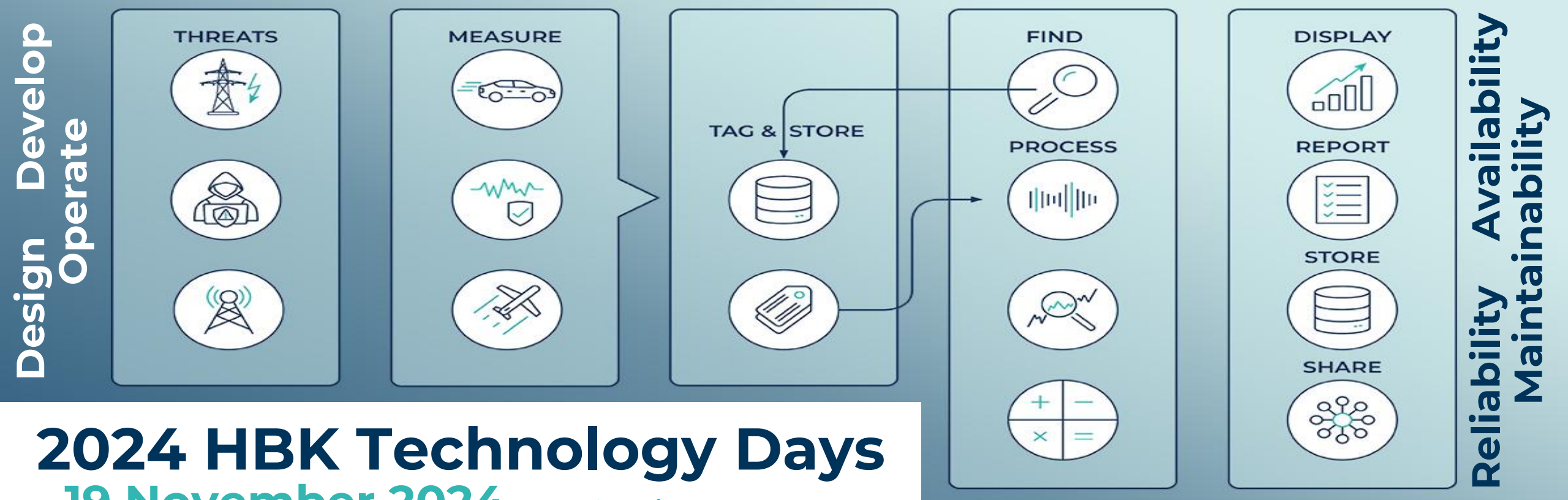
Case study

- Therefore, the part failure rate, $\lambda p = (0.01 * 0.2962 + 0.002 * 0.5) * 3.08 * 1 = (0.002962 + 0.001) * 3.08 = 0.0039 * 3.08 = \mathbf{0.0123 \text{ FPMH}}$

Name	Category	Failure Rate(t=INF)
 MIL-HDBK-217F	MIL-HDBK-217F	0.0123 FPMH
 CMOS	Micro, Digital	0.0123

Properties	Values
Compiled By	
Reviewed By	
Die Complexity Rate	0.0100
Technology	Comp Metal Oxide Semicon
Number of Gates	1
Environment Factor	0.5000
Environment	Ground, benign
Learning Factor	1.0000
Number of Years in Production	2
Package Rate	0.0020
Package Type	Non-Hermetic SMT
Number of Active Pins	5
Quality Factor	3.0875
Quality, Microelectronics	Use Point Valuation
Total Point Valuation	80
Temperature Factor	0.2962
Ambient Temperature (°C)	30
Case Temperature (°C)	48
Junction Temperature (°C)	50.8
Junction Temp Calc Model	Measured Case Temp
Technology	Comp Metal Oxide Semicon
Power Dissipation (W)	0.1
Theta Case/Ambient (°C/W)	50
Theta Junction/Case (°C/W)	28

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MIL-HDBK-217F



Bellcore/Telcordia



FIDES



Siemens SN 29500



NSWC Handbook

