

MTBF

“Your Mileage May Vary”

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“It's tough to make predictions,
especially about the future.”

- Yogi Berra



Hardware Reliability is a performance parameter same as

- Power efficiency or weight
- voltage regulation or Processor speed

Common approach is to define reliability in terms of “life expectancy”

“ life expectancy” :

- Is a measure of the time interval that a device will perform per its given specifications (usage conditions, duty cycle, etc.)
- This interval is referred to as Mean-Time-Between-Failure (**MTBF**)

MTBF is applicable to equipment that is repairable, after failure

- a component is replaced and the system returns to service
- and the time interval between component replacement and the next failure is measured.
- If a non-repairable system, MTTF is used (Mean Time To Failure)

MTBF vs. Failure Rate to Measure Reliability

Dell's experience with using MTBF to specify life expectancy:

- Confuses people not well versed in reliability engineering
- Does not adequately specify reliability over the customer's life cycle
- MTBF is frequently confused with expected life or useful life

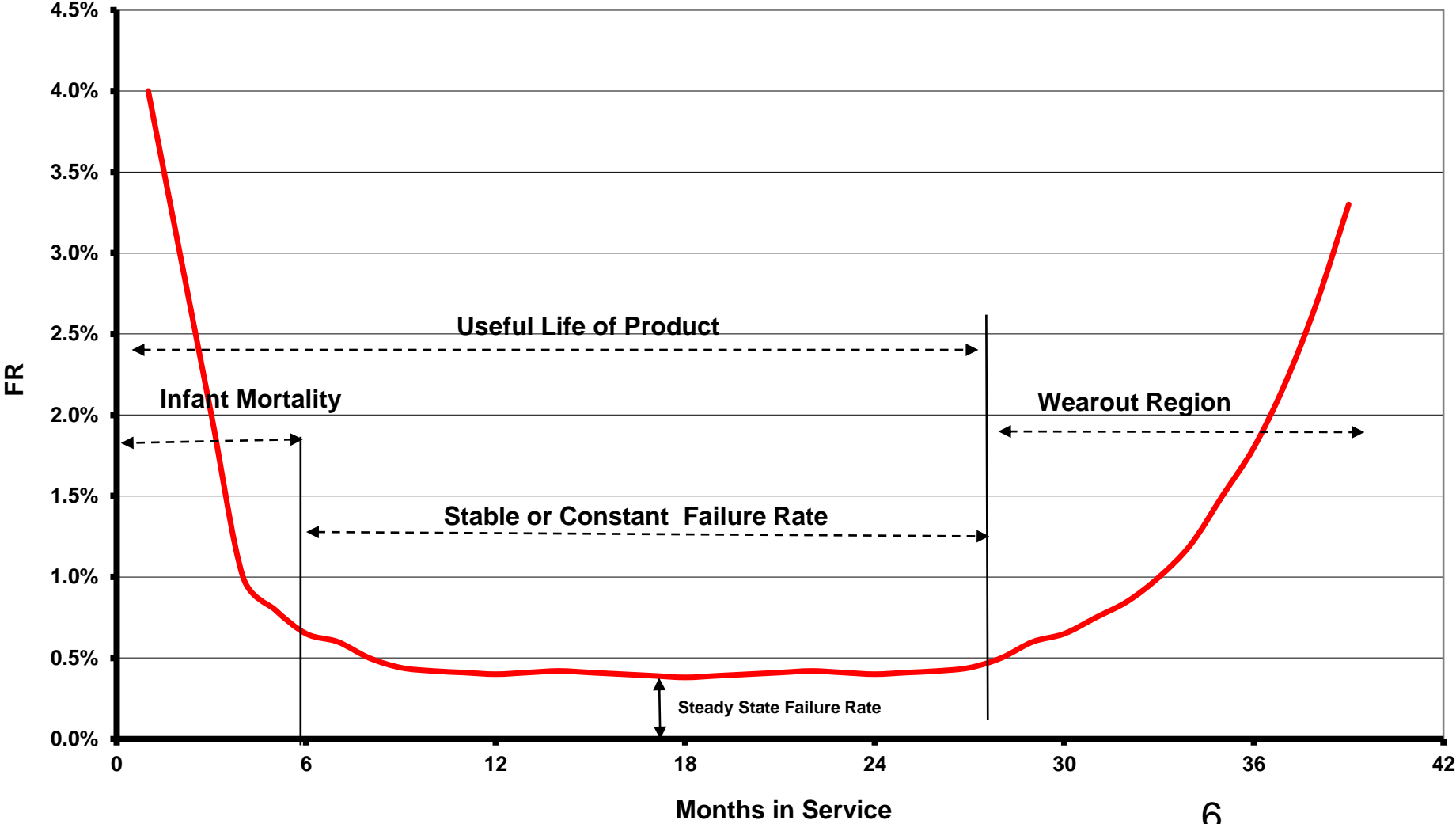
Dell has chosen to use the Failure Rate parameter to define our reliability performance:

- **FR** is the incremental change in the number of failures within a total device population over a given time interval
- **FR** = $1 / \text{MTBF}$ (in the steady state area of the bathtub curve)

The combination of FR and Useful Life provide an adequate product reliability specification

MTBF vs. Failure Rate to Measure Reliability

Typical Failure Rate vs. Time Plot



Theoretical Computer Reliability specification

- $FR \leq 2.5\%$ per Year
- User profile assumption: 150 POH/week for 95th percentile customer
- Useful life ≥ 5 Years

FR calculations

- Annual POH = 7800 Hrs per year
- $FR = 2.5\% / \text{Yr} = 0.025 / 7800 = 3.205 \text{ E-6 failures per hour}$

$$MTBF = 1 / FR = 312,000 \text{ hours (35.6 yrs.)}$$

- Primary uses of reliability predictions
 - Initial assessment to determine if reliability goals can be met
 - Comparison of competing designs
 - Identification of potential design problems & critical parts
 - Customer requirement (RFQ, etc.)
- Evaluations of reliability design alternatives and trade-offs.

Why Reliability Predictions?

Inputs to other critical business tasks – activities

- FTA (Fault Tree Analysis)
- Spare Parts
- Warranty Cost
- LCC (Life Cycle Cost)

Why can't we just "run a test" to prove a product's reliability???

Reliability test programs usually occur too late in program cycles to support early program decisions

You can't afford to run tests on reliable products in a high volume, commercial environment!

Prediction Issues

- Incorrect assumptions about applied stresses to components
- Unrealistic part quality assumptions & incomplete specifications
- Optimistic estimates of user environment and user profile
- Temptation to game the numbers with no real design impact
- Garbage In – Garbage Out issue with all modeling efforts

Field Reliability Data issues

- Inconsistent counting : Maintenance actions = hardware failure
- Human factors / operator errors / procedure errors
- Conflict of interest between subcontractors and suppliers
- Limited failure validation tests and FA on field returns
- Maintenance policy issues
- Field FR data tends to be Mean or Average values
- Not all customers use and abuse the product equally

MIL-HDBK-217 “G”

- Original Standardized Prediction Method
- Updated in December 2010
- $\lambda_{Widerstand} = \lambda_b \cdot \pi_T \cdot \pi_P \cdot \pi_S \cdot \pi_Q \cdot \pi_E$

Telcordia (Bellcore) SR-332 issue 3

- Formerly AT&T Bell Labs
- Latest release in Jan 2011
- $\lambda_{SSi} = \pi_{Gi} \cdot \pi_{Qi} \cdot \pi_{Si} \cdot \pi_{Ti}$

217Plus (formerly PRISM)

- Reliability Information Analysis Center (RIAC)
- $\lambda_S = \lambda_A(\pi_P\pi_{IM}\pi_E + \pi_D\pi_G + \pi_M\pi_{IM} + \pi_E\pi_G + \pi_S\pi_G + \pi_I\pi_E + \pi_N + \pi_W\pi_E) + \lambda_{SW}$

GJB/z299B

- Chinese standard
- Similar to the MIL-HDBK-217

CNET 93

- France Telecom
- Similar to MIL-HDBK-217

IEC TR 62380

- Formerly IDF 2000
- Based on rel. handbook UTE 80-810
- Newer version of the CNET 93 standard

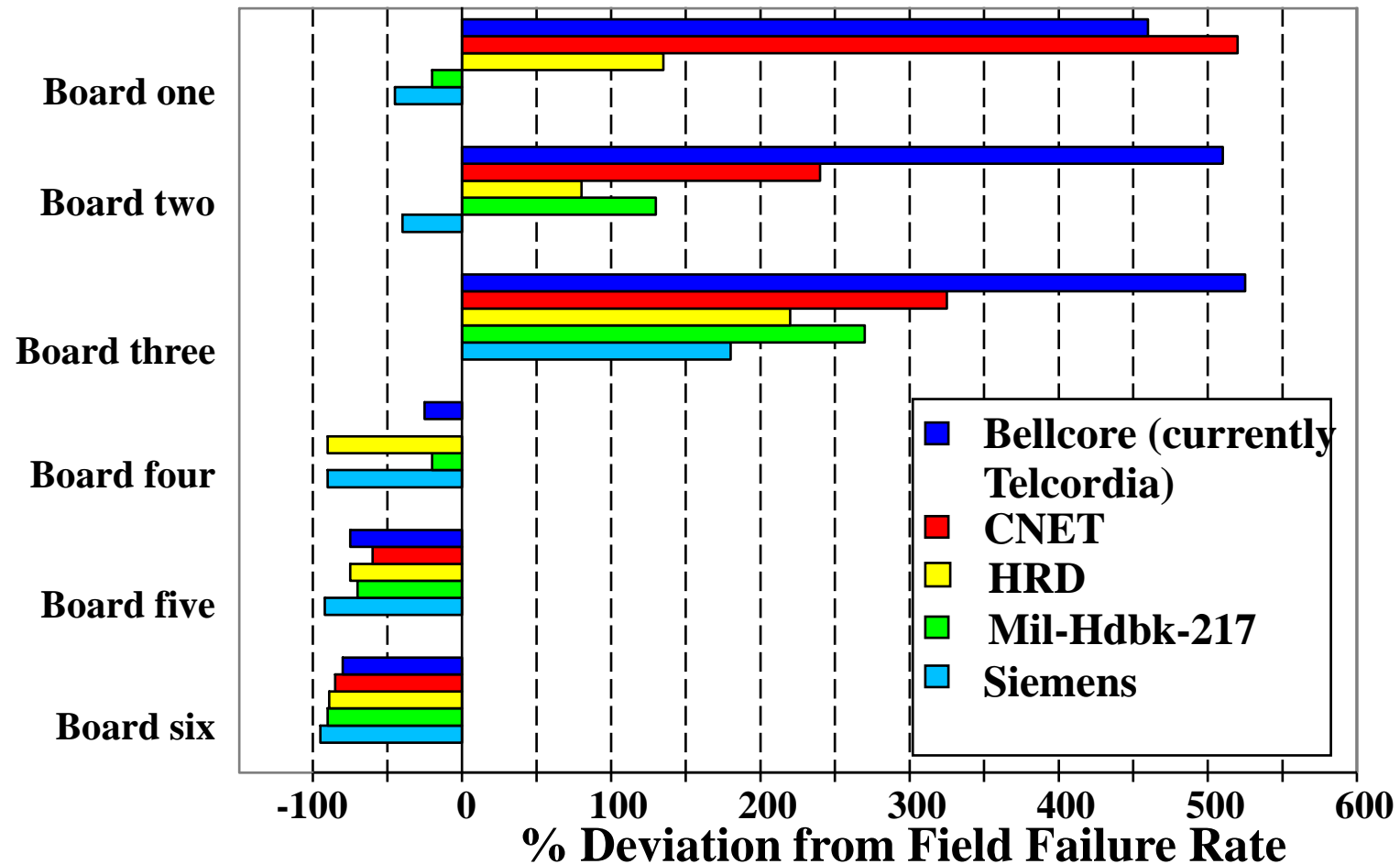
HRD5

- British Telecommunications plc
- Similar to CNET 93

NSWC-98/LE1

- Mechanical reliability guide

And Others!



Jones, J. and Hayes, J., "A Comparison of Electronic Reliability Prediction Models," *IEEE Transactions on Reliability*, Vol. 48, No. 2, pp. 127-134, 1999

POF attempts to identify the “weakest link” ; design then modified to extend life to exceed the system life requirement

POF advocates are strong critics of most MTBF prediction methods

- Claim POF is superior approach
- Too many key design & use parameters are ignored

POF attempts to model individual failure mechanisms

- How long before a specific failure mode occurs based on a specific failure mechanism
- Approach requires many component models and input parameters

Traditionally:

- 1) POF is very time consuming and expensive to do it thoroughly & correctly
- 2) POF is not universal in coverage; there are not POF models for every failure mechanism
- 3) Some new developments addressing these issues are promising

Typically “stand alone” problem compared to electronics

- Different/unique component types
- Customer profile, use and abuse becomes significant factor
- Different failure modes and mechanisms

Reliability focus is on useful life and wearout issues

Analysis approaches

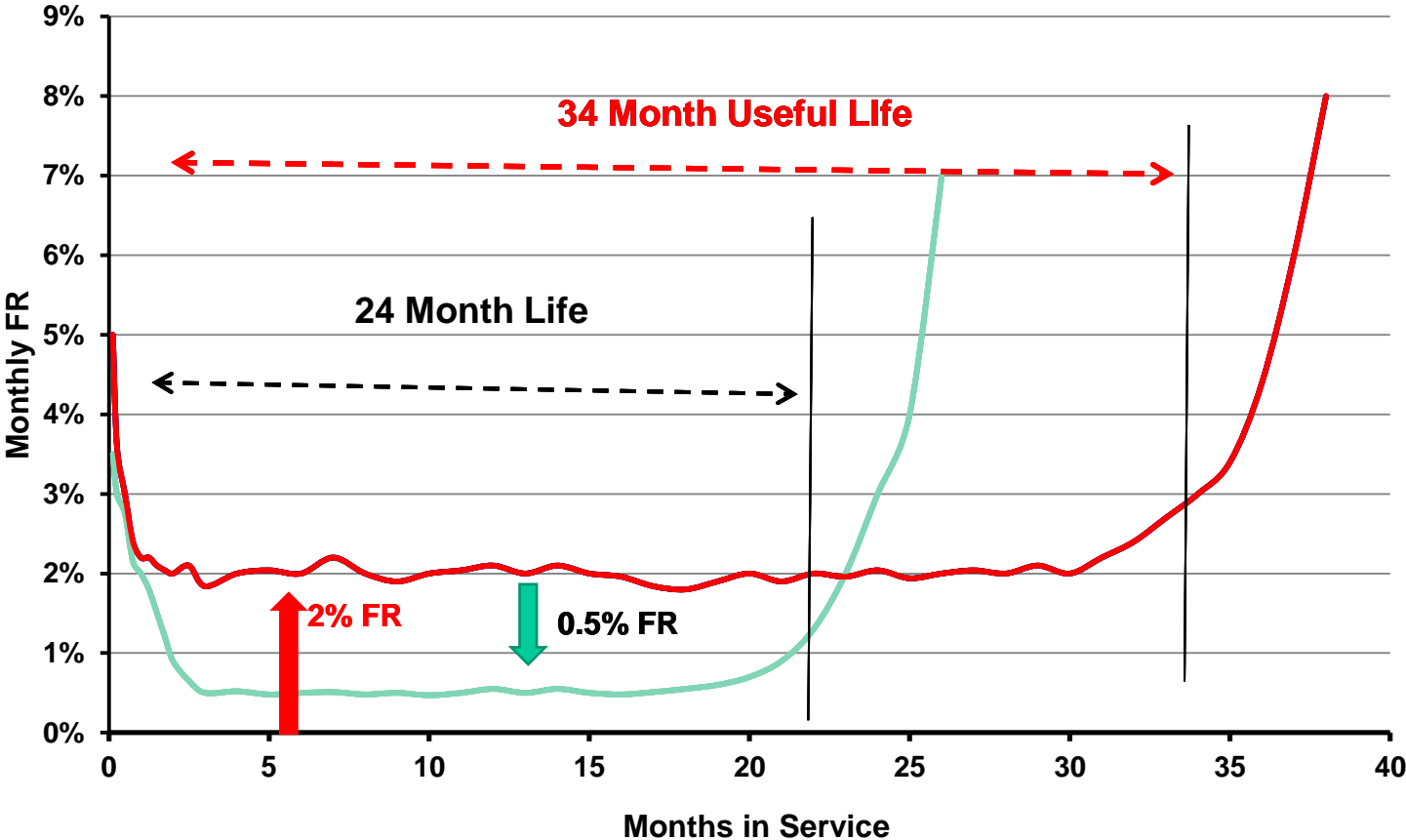
- Part failure data analysis (Weibull)
 - Empirical relationships (B10 bearing life models)
 - Stress / Strength analysis (finite element analysis)
 - NSWC handbook / procedure for mechanical equipment
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- Most Standard Prediction Methods ignore mechanical failures
Example: notebook hinges

- **Myth #1: A portable system with the higher predicted (Telcordia, etc.) MTBF is more reliable**
 - Fact: Predicted MTBF typically only considers a few failure mechanisms that relate to electronics
 - Not considered in reliability prediction
 - Solder joint cracking and/or the effects of gluing BGAs
 - Shock-related failures, such as HDD damage
 - Key caps falling off
 - LCD glass cracking
 - ETC.
- **Question: Why isn't the Telcordia predicted MTBF of a ruggedized notebook higher than the base platform?**
 - Answer: Because the mechanical failure modes that the ruggedized is designed to resist are not accounted for in MTBF predictions.

- **Myth #2: The predicted (Telcordia, etc.) MTBF should reflect field performance.**
 - Fact: Predicted MTBFs rely on a number of assumptions and “fudge factors”.
 - Component stress levels are not constant during product use.
 - “Fudge factors” such as environment and quality level, may have little correlation to field performance.
 - Different companies performing predictions probably use different values for these multipliers.
 - Studies have attempted to correlate field performance and predicted MTBF.
 - Most have shown little correlation.
 - This is especially true of general purpose products, such as PCs, that can be used in multiple environments.

- **Myth #3: The predicted MTBF is how long I should expect the product to last.**
 - Fact: When the predicted MTBF time occurs, 63% of the products should have failed. (NOTE: requires constant failure rate assumption)
 - By definition, the MTBF is a mean, not the time to first failure.
 - The distribution used to model failures in electronics is not symmetric, so the mean does not occur at 50%. (exponential distribution)
 - Many confuse MTBF with Useful Life!
 - Also to consider: MTBF is typically given in hours, and the translation of hours to years needs to reflect the expected duty cycle.

Failure Rate vs Useful Life



Comments & Recommendations

- Try to talk about Failure Rate vs. MTBF
- Be sure to include Useful Life discussion for completeness
- The more mobile the device, the more difficult to predict Failure Rate and Useful Life (more diverse usage profile)
- You usually can't afford to run reliability tests on reliable products!
- The best MTBF/Failure Rate/Useful Life prediction is Field Data!