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)
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

- \( FR = \frac{1}{MTBF} \) (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

- **Useful Life of Product**
- **Infant Mortality**
- **Stable or Constant Failure Rate**
- **Wearout Region**

**Steady State Failure Rate**

**Months in Service**

0.0% 0.5% 1.0% 1.5% 2.0% 2.5% 3.0% 3.5% 4.0% 4.5%

0 6 12 18 24 30 36 42
Theoretical Computer Reliability **specification**

- FR ≤ 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% / Yr = 0.025 / 7800 = 3.205 E-6 failures per hour

MTBF = 1 / FR = 312,000 hours (35.6 yrs.)
Why Reliability Predictions?

- 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
- $\lambda_{\text{Widerstand}} = \lambda_b \cdot \pi_T \cdot \pi_P \cdot \pi_S \cdot \pi_Q \cdot \pi_E$

Telcordia (Bellcore) SR-332 issue 3
- Formerly AT&T Bell Labs
- Latest release in Jan 2011
- $\lambda_{\text{SSi}} = \pi_{Gi} \cdot \pi_{Qi} \cdot \pi_{Si} \cdot \pi_{Ti}$

217Plus (formerly PRISM)
- Reliability Information Analysis Center (RIAC)
- $\lambda_S = \lambda_{IA}(\pi_P\pi_M\pi_E + \pi_D\pi_G + \pi_M\pi_M + \pi_E\pi_G + \pi_S\pi_G + \pi_I\pi_E + \pi_N + \pi_W\pi_E) + \lambda_{SW}$

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!
IEEE Comparison of Prediction Models

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

- 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

- 34 Month Useful Life
- 24 Month Life
- Monthly FR
- Months in Service

- 2% FR
- 0.5% FR
• 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!