



## **Prognostics: MTBF, MTTF, Failure and Bathtub Curve**

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Are you confused about the meanings and use of the acronyms MTBF and MTTF, how they relate to each other and to failure rates and to failure distribution and a bathtub curve? I certainly understand why: the meanings of the terms have changed over time and their relationships are not clearly defined. Referring to Figure 1, the CBD1 and CBD2 signature curves represent slow and fast rates of failure of a population of units to form a failure distribution. That population has a Mean Time Before Failure (MTBF) and a Mean Time to Failure (MTTF). There is also a Mean Time Between Failure (MTBF) – oops, confusion #1 – which I have shown being related to the failure rate with an implied relationship to the failure distribution – oops, confusion #2.

Originally (circa 1993), MTBF was the acronym for Mean Time Before First (MTBF) failure and both MTBF and MTTF were defined for constant-failure rates (CFR) of electronic devices. MTBF (Between) was defined to contrast the relatively low failure rate of a 'useful life' region of a bathtub curve to the higher failure rates in the 'infant mortality' and 'wear out' regions (see Figure 2) – oops, confusion #3. A bathtub curve showing a prognostic trigger and distance is applicable when a 'canary' device is used as the trigger: an integrated-circuit device is deliberately designed to fail before a population of operational devices: when it fails (the canary dies), that means the operational devices are about to enter the wear-out region of the bath tub curve.

For prognostics, we are interested in the TTF1 (time-to-failure) period – the time it takes after onset of degradation of a particular unit for that unit to functionally fail – and we are interested in the TTF2 period – the expected time it takes after onset of degradation for a unit to fail at the lowest failure rate. As the plots in the figures illustrate, the time periods TTF1, TTF2, MTBF (before), MTBF (between), and MTTF are not the same either in meaning or in distance (time or rate). Figure 3 shows the relationship of a bathtub curve to a failure distribution and the two acronyms MTBF and the acronym MTTF. Hopefully that figure clears up some confusion rather than add more confusion.

### **References**

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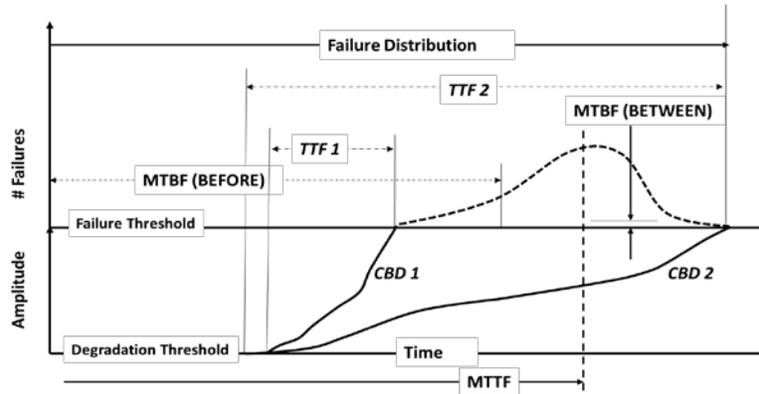


Figure 1: Plots relating CBD signatures to # of failures (failure rate)

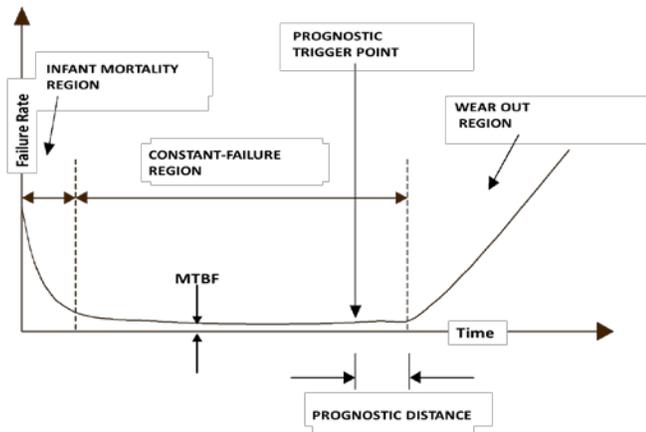


Figure 2: Classic bathtub curve with the notion of a prognostic trigger point and distance added

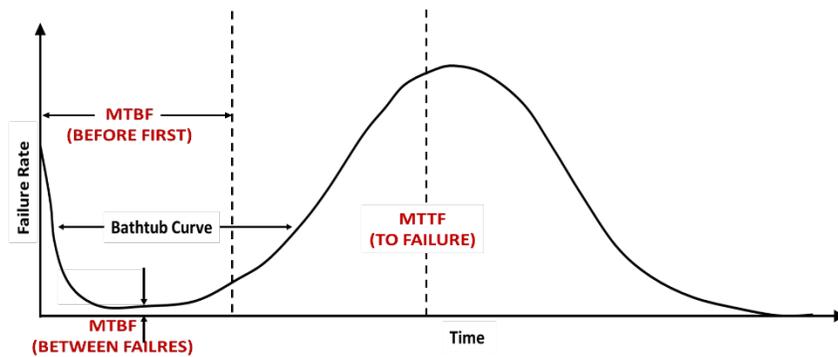


Figure 3: Plot showing relationship of a bathtub curve to a failure distribution, and MTBF and MTTF