Reliability Modeling

Systems Safety Course

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What is Reliability Modeling?

- A topic with applications in many fields that it is not easy to find. It is a language that is understood by the vast majority of workers in relevant fields, covering engineering, also social sciences, and medicine law.

What is Reliability Engineering?

- Is a field that deals with the ability of a system or a component to perform its required function(s) under stated conditions for a specified period of time.
- That particular will predict whether a product will fail or not.

Objectives of Reliabilty

- Reduce Failures
- Identify and correct causes when failures do occur
- Find ways of coping with failures
- Estimate the reliability of new designs and analyze reliability data

Introduction to Reliability

- What is reliability ?
  - Reliability is an index that estimates dependability (consistency) of data.
  - The probability that an item will perform a required function without failure under stated conditions for a stated period of time. (Almost Impossible)!!!!!
  - Reliability can also be expressed as the number of failures over a period of time.
  - Durability is also aspect of Reliability.

Introduction to Reliability

- Why teach Reliability Engineering?
  - It encompasses training
  - Teamwork
  - Discipline
  - Application of the most appropriate methods.

  - - Reliability engineering is, ultimately, effective management of engineering.

What is Reliability?

- Defined by Reliability R(t)
- The probability that a system performs a specified function or mission under given conditions for a prescribed time.

$$r_{XX} = \frac{\sigma_T^2}{\sigma_M^2} = \frac{\sigma_T^2}{\sigma_T^2 + \sigma_E^2} = r_{TM}^2$$

Introduction to Reliability

Reasons to be concerned with reliability

- Reasons to be concerned with reliability
  • Provides a measure of the extent to which an examinee's data, reflects random measurement error.
  – Measurement errors can be caused by examinee-specific factors.
  • motivation
  • concentration
  • fatigue
  • boredom
  • momentary lapses of memory
  • carelessness in marking answers
  • expired luck in guessing
  – Measurement errors which can be caused by test-specific factors.
  • ambiguous or tricky items
  • poor directions
  – Measurement errors can which be caused by scoring-specific factors.
  • non-uniform scoring guidelines
  • carelessness
  • counting or computational errors.

What makes Reliability Different?

- It represents the statistical distribution of a product lifetime. (Product Lifespan)
- It entails the interest in the distribution tails (for example, determining the time at which 1% of the product will fail), rather than the mean life and its standard deviation.
- The prevalence of censored data (Analyzed Information)
- The use of accelerated testing to help measure and improve reliability
- The frequent need to evaluate the reliability of systems made up of often replaceable parts, each with their own lifetime distributions.

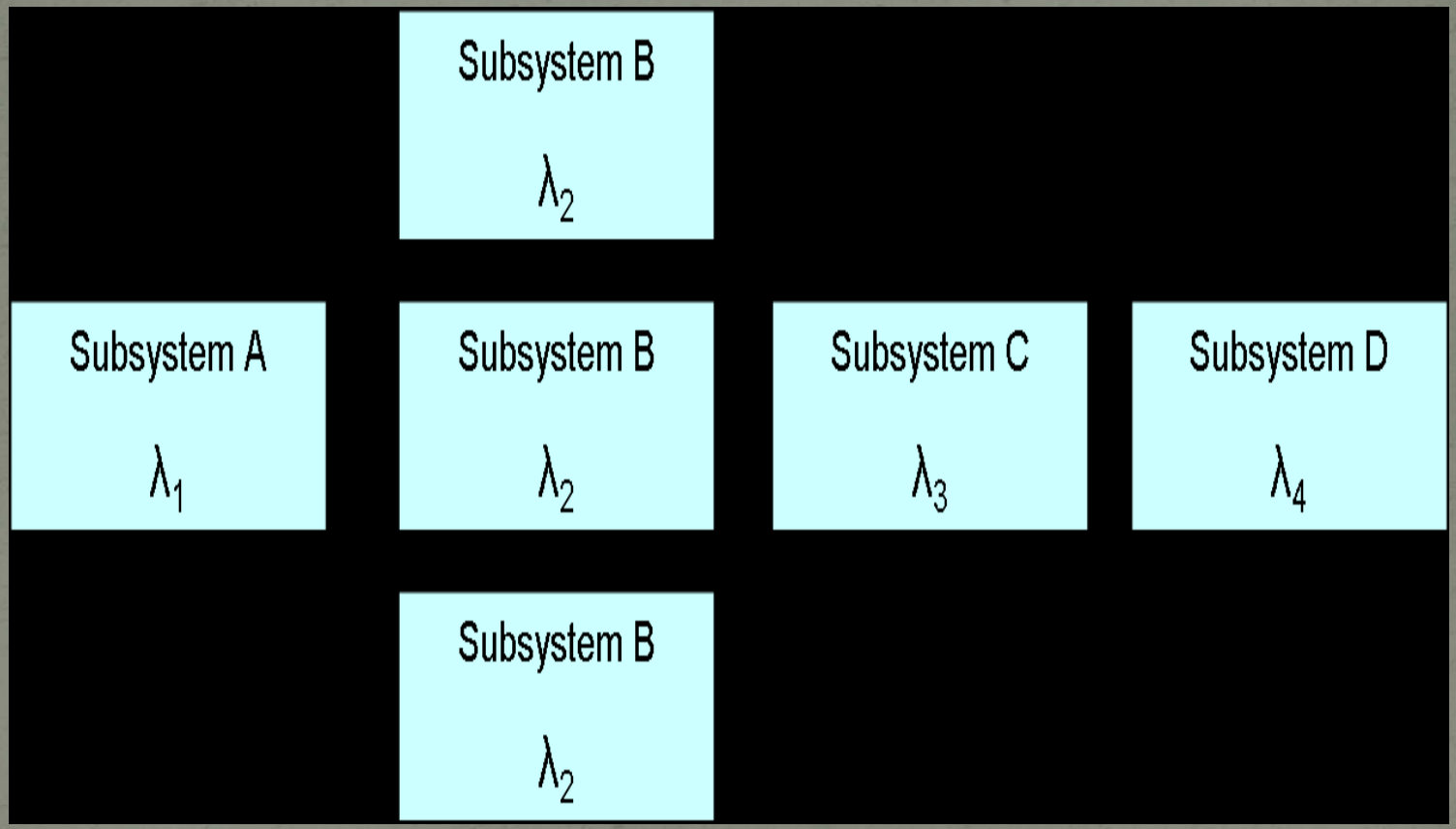
Reliability Functions

- What are the functions & associated performance standards?
- Primary Function:
- ––the main reason why the asset exists
- Secondary Functions:
- ––**E**nvironmental integrity
- ––**S**afety/Structural integrity safety
- ––**C**ontrol/Containment/Comfort
- ––**A**ppearance
- ––**P**rotection
- ––Economy/Efficiency
- ––**S**uperfluous function

Reliability Block Diagram

- Is a diagram method for showing how component reliability contributes to the success or failure of a complex system.
- RBD is also known as a dependence diagram (DD).
- A RBD or DD is drawn as a series of blocks connected in parallel or series configuration.
- Each block represents a component of the system with a failure rate.
- Parallel paths are redundant, meaning that all of the parallel paths must fail for the parallel network to fail.

Reliability Block Diagram



Mean Time Between Failures (MTBF)

- Reliability is quantified as MTBF (Mean Time Between Failures) for repairable product. The formula for calculating the MTBF is
- (Theta) = T/R.

  (Theta) = MTBF
- T = total time
- R = number of failures

Mean Time To Failure

- MTTF (Mean Time To Failure) for non-repairable products.
- MTTF is the number of total hours of service of all devices divided by the number of devices.
- (gamma) = T/N

  (gamma) = MTTF
- T = total time
- N = Number of units under test.

Example of MTBF and MTTF

- Example: Suppose 10 devices are tested for 500 hours. During the test 2 failures occur.
- The estimate of the MTBF is:
  - (theta) = $\frac{10*500}{2}$ = 2,500 hours / failure

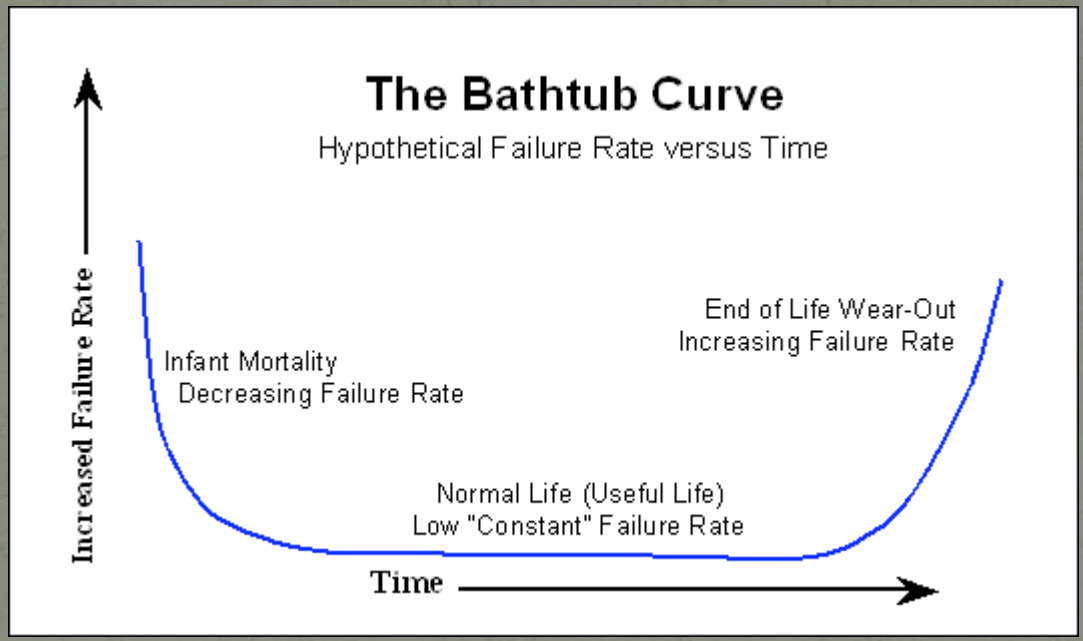
Example of MTBF and MTTF

- (gamma) = $\frac{10*500}{10}$ = 500 hours / failure.
- If the MTBF is known, one can calculate the failure rate as the inverse of the MTTF. The
- formula for (Lambda) is:
- (Lambda) = $\frac{1}{(\text{theta})\ T} = \frac{r}{}$
- where r is the number of failures.

Example of MTBF and MTTF

- Once a MTBF is calculated, what is the probability that any one particular module will be operational at time equal to the MTBF? We have the following equation:
- $R(t) = e^{-t/MTBF}$.
- But when t = MTBF
- $R(t) = e^{-1} = 0.3677$
- This tells us that the probability that any one particular module will survive to its
- calculated MTBF is only 36.8%.

The Bathtub Curve



When Should We Use Reliability?

- Stress Analysis
  - Prior to release of a design to production
  - Prior to implementation of design changes
- Reliability predictions should be done at all stages of design
  - Early design stage- Reliability Prediction may a rough estimate
  - Late design stage- Reliability Prediction is refined
  - Fielded system- revised prediction can incorporate field data for future use
  - As design matures, impact of failure needs to be addressed
  - During process design
  - Prior to implementing new or updated processes

Summary of Reliability

- Summary
  - What: Analysis Toolkit
  - Why: Enhance Product Improvement
    Reduced Cost
  - When: Early for Design Feedback
    Prior to Completion to Validate Goals
  - Benefit: Reduced Field Failures
    Reduced Warranty Costs
    Better Customer Relations

Failure Analysis in Emergency Diesel Generators in Nuclear Power Plants due to Maintenance Issues

- In the U.S., an average of roughly one diesel generator has failed when needed each year since 1997. Government researchers who examined diesel generator failures in the U.S. from 1997 to 2003 calculated the average odds that a diesel generator would fail to work at some point during an eight-hour run were slightly greater than 2 or 3 percent, depending on which database was analyzed.