

Why is Reliability important?



- Have you experienced things fail in the daily life?
- More significant safety issues: Aircraft, Nuclear, Space shuttle,.....
 - Challenger Accident 01/28/1986
 - Columbia Accident 02/01/2003
 - Discovery launching 07/26/2005
- Consequences of Unreliability
 - Lots of \$\$ at stake
 - Time wasted
 - Psychological effect
 - Effects on national security

- Intense global competition and increased customer expectations
 - improve Q&R, reduce product development cycle **time**, reduce product life-cycle **costs**

- Rapid advances in technology
 - more complex and sophisticated systems
 - more challenges for reliability

Emphasis on Quality and Reliability (Q&R)



- Increasing pressure on manufacturers to produce products with high quality and reliability
- What is the difference between quality and reliability?
- What is the intuitive meaning of reliability?

Definitions of Reliability



- **Informal:** " Reliability is quality over time" (Condra,1993)
- **Technical:** Reliability is the probability that a component or system will perform a required function for a given period of time when used under stated operating conditions

Example of Reliability Definition



The reliability of windshield wiper arms at 100,000 cycle is 0.8

- **Definition of failure**
 - Windshield wiper arms do not work properly
- **Definition of time scale**
 - Cycles
- **Definition of operating conditions**
 - Frequency of your wipers
 - Number of rain days in your area

A Measure of Reliability



- Reliability is a probability which is a function of “time”
- T= “time”-to-failure random variable
- Reliability at time t = 100s:
 $R(100) = P(T \geq 100)$
- More generally, reliability at time t:

$$R(t) = P(T \geq t)$$

Reliability Function

Other Names for Reliability Data



- Life Data
- Failure Data
- Time-to failure (TTF) data “time”
- Time-between-failure data
- Survival data
- Event-time data

Actual Applications

Case1

In a large electronics company that manufactures small electrical parts such as resistors capacitors, transistors, and inductors, a new component is experiencing a high failure rate. In order to meet government contract specifications, the function being performed by this component must have a 90 percent or better reliability over a 4-hour mission in high-stress environment design engineers can not redesign the component because of the cost and time required. **what should the company do ?**

Actual Applications

Case2

The Notso Reliable manufacturing company has been experiencing a high number of failures with its five-year-old industrial robot used for arc welding . once the unit fails, it is often down for what is considered to be an excessive length of time for repair. Downtime costs the company \$750 an hour in lost production and repair costs. A replacement unit will cost \$21, 000. The company wishes to determine whether it is economical to replace the unit. The unit was advertised as having a 10-year design life. **Should the company replace the unit?**



➤ **Maintainability**

The probability that a failed component or system will be repaired to a specified condition within a period of time.

➤ **Availability**

The probability that a component or system will perform its required function at a given point in time when used under stated operating conditions.

RAM: Reliability, Availability and Maintainability

Relationships among RAM



	Definition	Purpose of study
Reliability	Probability of <u>nonfailure</u> over time	<ul style="list-style-type: none"> ○ Increasing design life ○ Eliminating or reducing the likelihood of failures
Maintainability	Probability of <u>repair</u> in a given time	<ul style="list-style-type: none"> ○ Reducing downtime
Availability	Percentage of operating time over a specified time interval (combined effect of <u>both the failure and the repair</u> process)	<ul style="list-style-type: none"> ○ Increasing available operating time

The Basic Needs for Equipment

- The basic needs related to all equipment are:
 - Performance
 - Reliability
 - Maintainability
- These needs when met, they provide the greatest **availability**.
- High **performance** from **reliable** equipment designed with poor **maintainability** will result in high **costs**.
- (since the design characteristics that speed return of down equipment to a running state with minimum requirements for time, resources, manpower and technical skills does not exist.)

Design Issues: Maintainability, Reliability, and System Effectiveness

➤ **Reliability:**

Deals with the increasing of the anticipated life of the equipment (making it operable for an anticipated life cycle at optimum availability)

➤ **Maintainability:**

Deals with simplifying of the equipment maintenance so that maintenance can be performed both effectively and inexpensively (means that the equipment will be down for service and repair for a considerably smaller proportion of time)

The degree to which the **reliability** and **maintainability** are incorporated in a product determines the system effectiveness and customer satisfaction.

The Objective of Designing for Maintainability and Reliability



- The objective of designing for maintainability is to: Provide equipment that can be served and repaired efficiently and effectively.
- The objective of designing for reliability is to: provide equipment that is durable while performing its intended functions over the life cycle at optimum availability.

- Once the design has been completed and released to manufacturing, **the reliability** of the product has been determined and it can not be altered without redesigning the product.
- Improving the maintainability after developing the product is both **difficult and costly**.
- It is extremely desirable that reliability requirements of facilities be included in the design specifications and that design give attention to maintainability.

- No product can be assumed to have **100% reliability** at any point in its life.
- **Successful designs** should have **100% maintainability**.
- **High reliability** is achieved by **proper selection** of sound engineering principles, materials, sizing, manufacturing processes, inspection, testing, and total quality control.

Purpose to Study RAM



- Improve the Reliability- last a long time
- Improve the Maintainability- easily repair
- Improve the Availability of the product

Reliability Concepts



Diagnostic
Technologies

Reliability
Concepts

Examples

Reliability

Reliability can be defined as a discipline related to the design, development, test, and manufacture of an item, so that it successfully performs a certain task, under specified conditions, for a certain length of time or number of cycles with a specified probability.

BREAKDOWN: Failure resulting in the non-availability of equipment.

FAILURE: The termination of the ability of equipment to perform its required function.

Reliability Concepts



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FAULT: An unexpected deviation from the requirements which require corrective action.

REPAIR: To restore an item to an acceptable condition by the renewal, replacement or replacement of damaged or worn parts.

MTBF (Mean Time Between Failures): Average time a system will run between failures. The MTBF is usually expressed in hours. This metric is more useful to the user than the reliability measure.

MTTR (Mean Time To Repair): is the time taken to repair a failed hardware module.

Reliability Concepts

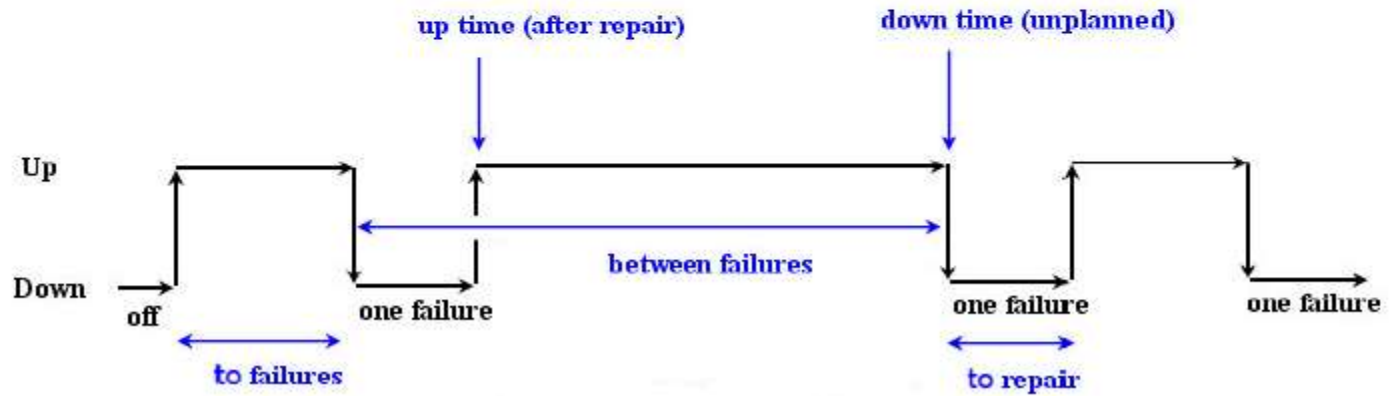


Diagnostic Technologies

Reliability Concepts

Examples

- Mean time to failure (MTTF) → Up time
- Mean time to repair (MTTR) → Down time
- Mean time between failures (MTBF=MTTF+MTTR) → Operating time
- Availability is $MTTF/MTBF$



Example



Diagnostic
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Reliability
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Examples

Example

What is the Reliability of these Parts and Systems?





Failures

Failure

The termination of the ability of equipment to perform its required function

Failure
Distributions

Failure Types

- Catastrophic
- Degradation
- Drift
- Intermittent

Examples

Failures

Failure
Distributions

Examples

Examples of Failure Effects

- Noise
- Erratic Operation
- Inoperability
- Instability
- Intermittent Operation
- Impaired Control
- Impaired Operation
- Roughness
- Excessive Effort Requirements
- Unpleasant or Unusual Odour
- Poor Appearance

Failures

Failure
Distributions

Examples

Examples of Failure Modes

- Cracking
- Deformation
- Wear
- Corrosion
- Loosening
- Leaking
- Sticking
- Electrical Shorts
- Electrical Opens
- Oxidation
- Vibration
- Fracturing