Design for Reliability (DfR) Seminar

OBJECTIVES

DfR highlights a series of Selected Reliability topics and explains when to use them. Topics are chosen from each phase of the 4 product life cycle - Concept, Design, Prototype and Manufacturing. We start out in the Concept Phase by showing you how to set good goals and how to then take these goals and write a Reliability Plan. Then we take the best techniques from the next 3 phases and explain how to integrate each of these together to make a cohesive reliability program.

WHO SHOULD ATTEND

This course is intended for those involved in design, test, or analysis, who want a better understanding of advanced reliability concepts for the purpose of improving the reliability of their product.

MODULE LIST

This seminar will highlight a series of Selected Reliability topics and will answer the question of why each technique is important. We will also introduce how to use each technique. The major topics we will cover are:

(1) DfR Overview/Introduction Module
(2) Planning for Reliability – Assessments, Goals, and Plans Module
(3) Reliability Modeling and Prediction Module
(4) Design for Availability Module
(5) Thermal Analysis Module
(6) Derating Analysis
(7) Failure Modes, Effects, and Criticality Analysis (FMECA) Module
(8) Fault Tree Analysis (FTA) Module
(9) Design of Experiments (DoE) Module
(10) Human Engineering/Human Factors Analysis Module
(11) Warranty Analysis/Design for Warranty Cost Reduction Module
(12) Critical Parts Management Module
(13) Design for Extreme Environments Module
(14) Highly Accelerated Life Test (HALT) Module
(15) Rel Demo Test (RDT)/Accelerated Life Test (ALT) Module
(16) Root Cause Analysis (RCA) Module
(17) Highly Accelerated Stress Screen (HASS) Module
(18) Restriction on Hazardous Substances (RoHS) Module
(19) Outsourced Design and Reliability Module
(20) Mechanical Reliability Module
(21) Software Reliability (from Concept to Testing) Module

(the amount of time we spend on each varies by audience. For in-house seminars, we let you choose which you want to include).

This seminar will help you define reliability goals, metrics, plans and schedules and then manage the activities, all within a product life cycle perspective. It will also monitor and improve processes to measure reliability related costs. From this seminar, you will be able to establish and monitor processes to track reliability growth as well as assist production and supply chain groups in reliability assurance strategy development. This seminar is targeted at the engineers responsible for product reliability who will be using these reliability techniques.

DETAILED OUTLINE

(1) DfR Overview/Introduction

- Reliability Integration
  - Reliability vs. Cost
  - Product Life Cycle Matrix
  - The need for Integration
- Integration Phases
  - Integration in the Concept Phase
  - Integration in the Design Phase
  - Integration in the Prototype Phase
  - Integration in the Manufacturing Phase
- Definition of Reliability

(2) Planning for Reliability – Assessments, Goal Setting/Metrics, and Program Plan

- Assessments
  - Motivation
  - Steps
  - Checklist
  - Examples
  - Reliability Maturity Grid
  - Applications
  - Observations
- Reliability Program Philosophies – Measurements vs. Growth
- Goal Setting
  - 5 elements of a Reliability Goal
  - Metrics
  - Benchmarking
  - Gap Analysis
- Reliability Program Plan
  - Elements of a Plan
  - How to Choose the Tools that go into a Plan
  - How to Plan for Integration
  - Reliability Schedule
- Class Goal Setting/Plan Writing Workshop
- Integrating Goal Setting into a Reliability Program
  - Letting a Reliability Goal drive a program

(3) Reliability Modeling and Prediction Module

- Reliability Modeling
  - Reliability Block Diagrams
  - Series Models
  - Parallel Models
    - Active Parallel
    - Standby Redundancy
  - Availability
    - Availability Calculations
    - Highly Available Systems
  - Reliability Allocation Modeling
  - Integrating a Reliability Model into a Reliability Program
    - Using Modeling Results to Drive System Architecture

- Reliability Predictions
    - Definitions
    - Standards Available
    - Controversy of Prediction Accuracy
    - Data Sources
    - Parts Count Method
    - Parts Stress Method
    - π Factors in a Prediction
    - Software Tools Available
    - Examples
    - Integrating a Reliability Prediction into a Reliability Program
        - Using Prediction Results to Plan an Accelerated Reliability Test

(4) Design for Availability Module

- Understanding System Availability Requirements
    - High Availability vs. Perceived Reliability
- Designing for Availability
    - Downtime Design Allocation
    - Failure Detection
    - System Repair
        - Complexity vs. Speed
        - System Reboots
        - Restart Levels
        - Redundancy – The Big Hammer
    - Long-Term Software Defects
        - Software Aging and Rejuvenation
        - Forced System Reboots and Restarts
- Availability Fault Insertion Testing

(5) Thermal Analysis Module

- Thermal Modeling
    - Benefits
    - Software Tools Available
- Thermal Mapping
    - Thermocouples
    - Infrared Cameras
    - Thermal Airflow Comparison
- Types of Thermal Failures
- Integrating Thermal Analysis into a Reliability Program
    - Using Thermal Analysis Results in a Reliability Prediction
    - Using Derating Analysis Results to Plan an Accelerated Reliability Test

(6) Derating Analysis Module

- Definition
- Standards Available
- Derating vs. Uprating (using components beyond spec)
- Examples
- Integrating Derating Analysis into a Reliability Program
    - Using Derating Analysis Results to Plan an Accelerated Reliability Test
    - Combining Derating Analysis with Thermal Analysis

(7) Failure Modes, Effects, and Criticality Analysis (FMECA) Module

- Definitions
- Objectives of a FMECA
- Standards Available
- References
- Software Tools Available
- Types of FMECAs
  - Design FMECA
  - Process FMECA
  - System FMECA
  - Functional FMECA
  - User FMECA
  - Software FMECA
- 10 Steps of a FMECA
  - Step 1: Review the Process/Design
  - Step 2: Brainstorm potential failure modes
  - Step 3: List potential effects of each failure mode
  - Step 4: Assign a severity rating for each effect
  - Step 5: Assign an occurrence rating for failure modes
  - Step 6: Assign a detection rating for modes/effects
  - Step 7: Calculate the risk priority numbers
  - Step 8: Prioritize the failure modes for action
  - Step 9: Take action to eliminate/reduce high-risk
  - Step 10: Calculate the resulting RPN
- FMECA Team
  - Role of the Facilitator
  - Power of Consensus
  - Tools of a Team
- SWFMEA
  - Differences with Mechanical or Electrical FMEA
    - Process vs. Product SWFMEA
  - Reviewing the Design
    - Determining the Level of Analysis
  - Defining the Appropriate Failure Modes
  - Information Requirements for the Review
  - Frequency vs. Complexity
  - Iterative Process with FTAs
- Examples
- Class FMECA Workshop
- Integrating FMECA into a Reliability Program
  - Using FMECA Results to Plan an Accelerated Reliability Test

(8) Fault Tree Analysis (FTA) Module

- Definitions
- Symbols of an FTA
- FTA Methodology
- Software Tools Available
- Integrating FTA into a Reliability Program
  - Using FTA during Reliability Block Diagramming
  - Using FTA Results during Failure Analysis

(9) Design of Experiments (DoE) Module

- Introductions/Objectives
- Definitions
- Overview
- Conducting a Main Effects Experiment
    - Selecting the Factors and Levels
    - Assigning Factors to the Array
        - Dealing with Interactions
    - Selecting Effects and Analysis Criteria
    - Analysis Statistics during DoE
        - Signal-to-Noise Calculations
        - ANOVA
- Software Tools Available for DoE
- DOE in Product Design
- Review of Practical Aspects of Conducting an DOE
- DOE Methods
    - Classical Method
    - Taguchi Method
- DOE Examples
- Class DoE Workshop
- Integrating DoE into a Reliability Program
    - When to use Design of Experiments in Conjunction with an Accelerated Reliability Test

(10) Human Engineer/Human Factors Analysis Module

- Definitions
- Areas of Consideration
    - Safety
    - Workmanship/Manufacturing
    - Maintenance
- Maintainability and Preventive Maintenance (PM)
    - Maintainability Analysis
        - Maintainability Predictions
    - Preventive Maintenance (PM) Analysis
        - PM and Hazard Rates
    - Reliability, Maintainability, and Availability Tradeoff
    - Designing for Maintainability and Availability
- Integrating Human Factors Analysis into a Reliability Program
    - How to use Human Factors Analysis in planning for HALT and HASS
    - How to use Maintainability and Preventive Maintenance in conjunction with HALT and HASS

(11) Warranty Analysis/Design for Warranty Cost Reduction Module

- Introduction
- Definitions
  - What is Warranty?
  - Types of Warranties
    - Hardware Warranties
    - Software Warranties
- Cost of warranty: Business and financial basics
  - How big are our warranty costs
  - Evolving warranty metrics
  - How to get warranty information
  - Warranty claims by sector
- Warranty Event cost model and its application
  - Commonly used models
    - Reliability Analysis Based Model
    - Cost Pool Based Model
  - Warranty Cost Model
- Warranty cost drivers and cost reduction strategies
  - Making warranty cost reduction choices
  - Projecting warranty savings
  - Design alternatives
  - Decisions that drive warranty costs
  - Case Study
- Revisiting warranty cost drivers, cost reduction strategies and the development life cycle
  - Warranty cost drivers
  - Importance of Support Strategies and Support Technology Roadmaps
- Outsourcing Design Model (ODMs)
  - The Different Development Models and what they are called
  - How Warranty Supplier Cost Recovery is Affected by Model
  - Warranty issues of outsourcing design
- Strategy: Supplier cost recovery
  - Why Warranty Supplier Cost Recovery is Becoming More Important
  - Types of Supplier Warranty Cost Recovery
  - Different Annualized Failure Rate (AFR) Thresholds Often Used in Supplier Warranty Cost Recovery
  - Effectiveness of Simple Supplier Cost Recovery
  - Cost Drivers in Warranty Cost Recovery
  - Tracking How Well Cost Recovery Processes Are Performing
  - Schemes for Fully Recovering The Cost of Warranty
  - Key Success Factors for Full Cost Recovery Schemes
- Strategy: Aggressive new product engineering at product launch
  - New Product Engineering Learning Curve
  - Case Study
- Integrating Warranty Analysis into a Reliability Program
  - How to use AFR to drive warranty decisions

(12) Critical Parts Management Module

- Programs for Suppliers
    - Reliability Critical Items and Critical Environments List
        - Critical Materials
        - Critical Environments
    - Material Selection and Control
- Lot Acceptance Testing (LAT)
    - The Need for LAT
        - Qualification Program Failure Challenges
        - End of Line Verification Failures
        - Outgoing Inspection Expenses
        - Incoming Inspection Expenses
    - Why LAT Works
    - LAT Process
        - Process Development / Logistics
        - Documentation
        - Set LAT Process with the Supplier
        - Review data provided by the Supplier for the lot delivered
        - Testing (sample testing if required)
        - Statistical analysis of the data & test results
        - Approve/Reject the lot delivered
- Integrating Critical Parts Management into a Reliability Program
    - How to use Critical Parts List when Planning a HALT
    - How to use LAT in conjunction with RCA

(13) Design for Extreme Environment (Vibration, Shock, Temp, Pressure) Module

- Introductions/Objectives
- Pretest documentation
    - Test plan - differs from procedure - needed content - sample test plan
    - Test procedure
    - Outline of sample test procedure
- Temperature testing
    - Test requirements
    - High temperature/Low Temperature
    - Storage/non-operating and Operating tests
    - What test can reveal
    - Appropriate operation during exposure to test environment; pitfalls
    - Test equipment
        - Chambers - their heating, cooling and control
        - Instrumentation: sensors, readouts, recording
    - Setting up for a typical test
    - Conducting the actual test
    - Recording of data
        - Data reduction
- Vibration Testing
    - Introduction: terminology, structural resonant behavior, passive and active isolation
    - Sinusoidal vibration measurements: units, sensors, readouts, errors
        - Calibration of sensors and systems; traceability to NIST
        - Complex vibration; introduction to spectrum analysis
    - Sinusoidal vibration testing
        - Electro-hydraulic and electrodynamic shakers; theory, tradeoffs, limits
        - Power amplifier theory, operation, limitations, distortion effects
        - Controls for sinusoidal vibration testing
        - Sinusoidal vibration test practice

            - Interpretation of standards; Government and commercial
            - Controversial test methodology: tracking filters, multiple sensors
    - Introduction to random vibration
        - Sources of random vibration in service and transportation
        - No possible equivalence to sinusoidal vibration
        - Terminology and definitions
        - Spectral density measurement and analysis - the frequency domain
        - Probability density - the time domain
        - Random vibration testing
            - Controls
            - Combined environment (CERT) testing; reliability tests, e.g. MIL-STD-781
        - Accelerated testing; HALT and HASS
            - Fatigue Calculations
            - Single vs. multi-axis vibration
            - Pneumatic repetitive-shock machines
        - Environmental stress screening (ESS) of electronics hardware production
        - Vibration and shock test fixtures; fixtures for stress screening
            - Recommended designs, materials, fabrication methods
    - Gunfire vibration testing
- Shock Testing
    - Instrumentation for measuring shock in service and during tests
    - Sensors, readouts, errors; calibration
    - Shock spectrum analysis; shock response spectrum
    - Shock testing machines; limitations
    - Use of shaker for shock testing
- Other Climatic Tests - subtopics for each similar to temperature testing
    - Temperature shock testing
    - Pressure/Altitude testing
    - Humidity testing
    - Solar radiation testing
    - Rain testing
    - Immersion testing
    - Icing/Freezing rain testing
    - Fungus testing
    - Salt fog testing
    - Sand and Dust testing
    - Explosive atmosphere testing
- MEOST (Multiple Environment Over Stress Testing)
    - Introduction to MEOST
    - Different environments to consider
    - Equipment used during MEOST
- Reporting on the Test
    - Who will use the information?
    - Content/Format - presenting data
- Integrating Design for Extreme Environments into a Reliability Program
    - When to use which kinds of tests/when to stimulate (test to failure) vs. when to simulate (test to spec)

(14) Highly Accelerated Life Test (HALT) Module

- Definitions
- Origins of HALT
- Benefits
- How it Works
    - Test to Fail, Redesign, Retest approach
- Why it Works
    - Basics of Stress vs. Time acceleration
    - Stress-Strength Analysis
    - Margin Discovery Process
- HALT Process
    - Step 1: Write the HALT Plan
    - Step 2: Secure/procure test equipment & software
    - Step 3: Build the fixture
    - Step 4: Perform HALT (Determine product robustness)
    - Step 5: Post HALT Failure Analysis/Corrective Action (CA)
    - Step 6: Repeat HALT (Verify Corrective Action)
    - Step 7: Periodic HALT for On-going evaluation
- Summary of HALT Results at an Accelerated Reliability Test Center
- Examples/Case Studies
    - Relevance of Failures
- Failure Analysis Process
    - Distributed Defect Tracking System
    - Ask Why 5 Times
- Disciplines Required for HALT
- Basic Design Guidelines for HALT
- Sample Size for HALT
- HALT Margins Guideline
    - Thermal
    - Vibration
- HALT Margins Guideline
- Commitment Needed for a Successful Program
- Summary

(15) Reliability Demonstration Test (RDT)/Accelerated Life Test (ALT) Module

- Definitions
- Types of Demonstration Tests
    - Failure Free Testing
    - Sequential Testing
        - Time Terminated Tests
        - Failure Terminated Tests
    - Accelerated Life Testing
        - Statistics for an ALT
            - Exponential Distribution
            - Weibull Distribution
        - ALT Parameters
            - Length of Test
            - Number of Samples
            - Goal of Test
            - Confidence Desired
            - Accuracy Desired
            - Cost

            - Acceleration Factor
                - Field Environment vs. Test Environment
                - Acceleration Factor Calculation
            - Wear-out Factor (Slope of Weibull Distribution)
        - Acceleration Factor Models
            - Arrhenius Model
            - Eyring Model
            - Coffin-Manson
            - Norris-Lanzberg
            - Others
            - Determining Acceleration Factor by Experimentation
        - HALT vs. ALT: When to Use Which Technique?
            - Comparison Between HALT and ALT
            - Combining ALT with HALT
            - Developing ALT from HALT
            - Examples of Products for HALT and ALT
    - On-Going Reliability Testing
        - Comparison Between ORT and HASA
- Integrating RDT into a Reliability Program
    - How to Use the Results of HALT in Planning an RDT
    - How to Use the Results of Reliability Predictions in Planning an RDT

(16) Root Cause Analysis (RCA) Module

- Definitions
- RCA Systems
  - Types of RCA Systems
  - RCA System Flowchart
- Software Tools Available for RCA Systems
- HW RCA
  - RCA Tools and Techniques
    - Information Gathering
    - Failure History
    - Reliability Tools During RCA
      - Fault Tree Analysis
      - Fishbone
      - Stress-Strength Analysis
      - DOE
    - Non-Destructive Evaluation (NDE) Lab Techniques
      - Electrical Characterization
      - Visual Inspection
      - X-ray Microscopy
      - Thermal Imaging
      - SQUID Microscopy
      - Acoustic Microscopy
    - Destructive Evaluation Lab Techniques
      - Cross-sectioning
      - Decapsulation/Delidding
  - RCA Case Studies/Examples
  - Integrating RCA into a Reliability Program
    - How to use RCA in conjunction with a HALT
    - Using other Reliability Tools (FTA, DOE, etc) during RCA
- SW RCA
  - RCA Tools and Techniques
    - SW Defect Source Categorization
    - Defect Distributions
    - Fishbone Diagrams
  - Data Analysis
    - Systemic Analysis
    - Historical Trending
  - Improvements
    - Reviews
    - Pairs Programming
  - RCA Audits
    - Trending Improvements
    - Spot Checking
  - Case Study Presentation
    - Data Review
    - Findings
    - Conclusions

(17) Highly Accelerated Stress Screen (HASS) Module

- Definitions
- Benefits of HASS
- HASS Process
    - Planning for HASS
        - Determine product needs and throughput
        - Determine which stresses to apply
        - Obtain functional and environmental equipment
        - Understand manpower needs
        - Determine Assembly Level HASS will be performed at
        - Determine location of HASS (in-house or at an outside lab or contract manufacturer)
    - Fixture Development/Qualification
    - Review of HALT Results
    - Profile Development
        - Proof of Screen Effectiveness
        - Proof of Life
- Typical Defects Found During HASS by Environment
- Proving Return on Investment (ROI) for HASS
- HASS Results
- HASA
    - Definition
    - Steps to HASA
    - When to Switch to HASA
    - HASA results
    - Statistics for HASA
- Integrating HASS into a Reliability Program
    - How to use the results of FMECA and a Reliability Prediction in planning a HASS
    - Using the HALT Results to develop a HASS profile
    - Linking Repair Depot with HASS by Sending "No Trouble Found" (NTF) hardware back to HASS

(18) Restriction on Hazardous Substances (RoHS) Module

- Definitions
- Current Reliability Concerns with RoHS
    - Tin Whiskers
    - Kirkendall Voiding
    - Conductive Anodic Filament (CAF)
    - Moisture Sensitivity Levels are Higher
    - Temperature Cycling Effects on Long-Term Reliability
    - Vibration/Mechanical Loading Effects Due to Stiffer Solder
    - Issues with Through Hole Components
    - Issues with PCBs
- Recommended Solder Types
- Recommended Plating Materials
- Steps to Achieving High Reliability during RoHS Transition
    - Assessment
    - Education
    - Assuring Compliance
        - BOM Scrub (Component Review)
            - Review Component Specifications
            - XRF Testing
            - Chemical Analysis
        - Audit Manufacturer
            - Review Manufacturing Process
            - Take Samples and Perform Cross-Sectioning
    - Design Reviews
    - Qualification Testing

(19) Outsourced Design and Reliability Module

- Definitions
- Differences between outsourcing designs and outsourcing manufacturing
- How to manage outsourced design projects
- The roll of reliability and quality in outsourced designs
- How to develop good test spec requirements for outsourced designs
- Integrating an outsourced design in within the rest of a reliability program

(20) Mechanical Reliability Module

- Definitions
- Finite Element Analysis (FEA)
    - Definitions
    - Simulation Tools
    - Software Tools Available
    - Examples
- Tolerance and Worst Case Analysis
- Probabilistic Design System (PDS)
    - Monte Carlo Simulation
    - PDS for Design for Six Sigma (DfSS)
- Fatigue and Fracture Mechanics
    - Motivation
    - Fracture vs. Strength Criteria
    - Brittle vs. Ductile Material
    - Applications of Fracture Mechanics
    - Test Techniques for Fracture Properties
    - Fracture and Fatigue
    - Fatigue Growth
    - Cyclic Fatigue Loading
    - Examples
- Failure Analysis Techniques for Mechanical Reliability
    - Forensic Methodology
    - Failure Analysis Tools
- Integrating Mechanical Reliability into a Reliability Program
    - Using FEA when planning a HALT

(21) Software Reliability Concepts Module

MODULE LIST

This seminar is comprised of the following training modules. A description of each module follows the list below:

(1) Software Development Life Cycle Best Practices
(2) Reliability Concepts for Software
(3) Integrating Reliability Practices into the Software Development Life Cycle
(4) Development Phase Reliability Practices
(5) Software Fault Tolerance
(6) Software Reliability Testing
(7) Software Reliability Planning

Each training module is described in the following section.

(1) Software Development Life Cycle Best Practices

Despite the commonality of software development practices across industries, companies generate products with different levels of quality and reliability. For this reason, this module focuses on “best practices” for defect removal shared by companies that consistently produce high quality software. After presenting a methodology for measuring defect removal efficiency at each development phase, we then evaluate the effectiveness of integrating various practices into your existing life cycle. We conclude the module with a closer look at design and code inspections; what works, what doesn’t and why.

(2) Reliability Concepts for Software

This module reviews the basic software reliability concepts. To clarify the source of frequent ambiguity, Quality vs. Reliability is examined closely and the characteristics of reliable software are identified. Defects, faults and failures terminology and a 2-level failure classification scheme are established. General reliability concepts that apply to software are presented, including failure rates, system availability, interface robustness, and fault tolerance.

(3) Integrating Reliability Practices into the Software Development Life Cycle

Companies follow various approaches in an attempt to develop reliable software. These traditional approaches are examined for their strengths and weaknesses. Then, a practical approach is introduced that allows for the reliability practices to be integrated by developers into the software life cycle. As with any project, the path to achieving reliability goals is defined by a plan. Next, modeling concepts are introduced as sources for early prediction and late estimation of defect and failure rate data. Design and implementation reliability practices are reviewed and grouped based on objectives. Reliability testing goals and techniques are reviewed for their contribution to the test cycle and reliability criteria. Finally, measurements and metrics are presented as a foundation for all reliability practices.

(4) Development Phase Reliability Practices

This module reviews various reliability practices that apply during the design and implementation phases. System functionality is captured in usage profiles developed from the architectural specification and refined throughout the design phase. Then various analysis techniques are reviewed. The system and HW failure analyses can be leveraged in defining software failure modes. The software can then be analyzed to identify critical and vulnerable sections as focal points for inspections and fault tolerance. We also review guidelines for high reliability derived from the software safety development. This module shows how to mitigate the occurrence of interface defects as a major source of run-time failures by defining robust interface specifications and enforcing them with defensive programming techniques.

We present a review technique that combines aspects of several existing inspection methods and utilizes historical data, failure analysis results and usage profiles to identify defects that are likely to result in run-time failures.

(5) Software Fault Tolerance

For systems running at customer installations, fault tolerance offers a last line of defense against failures by focusing on increasing availability. Fault tolerance has become synonymous with either hardware redundancy or software exception handling. This module presents several valuable, but lesser-known, techniques to address many common failure scenarios. This module also addresses the general case with guidelines to evaluate fault tolerance techniques and incorporate them into an overall system design. For systems that are continuously running over very long periods of time, the concept of software rejuvenation is introduced to counteract software aging effect.

(6) Software Reliability Testing

This module addresses reliability practices during both unit and system-level testing.
The most prevalent failures encountered during development, testing and early deployment are trivial, run-time failures characterized as deterministic and easily reproducible, even after a system restart or reboot. The main goal of unit testing should be to identify as many of these types of failures as possible for removal, prior to system-level testing.

The techniques used to achieve these goals are:

- Interface robustness testing using equivalence classes and boundary value analysis
- Testing fault tolerant code
- Practical usage of code coverage
- Defect density analysis using change management
- Certifying 3rd party software

Traditional system-level testing incorporates various types of testing to verify functionality and detect failures for repair. Usage profiles increase the efficiency of traditional testing by providing mechanisms for test case definition and prioritization. Moreover, these usage profiles can drive reliability testing to determine software failure rates and measure reliability growth.

(7) Software Reliability Planning

All too often, development organizations seek to improve the reliability of their product software but are uncertain of how to define and achieve their reliability goals. This module demonstrates how this can be accomplished by developing a reliability plan. Initially, the planning endpoints must be determined by assessing the current reliability baseline and defining the reliability targets of the current project. Then, the elements of a reliability plan are reviewed, including establishing goals, making initial predictions, measuring progress, and verifying reliability at each phase.