Bridging The Different Worlds Of Reliability: Defense, Industry, & Academia

Presented by:

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Reliability

- **Reliability is concerned with avoiding failures** of equipment and processes by proper design and careful operation of the equipment by trained personnel in a specified environment for a given time interval.
- **The ultimate aim of reliability is a failure free environment**

Are you living in a big R environment?

Maintenance ≠ Reliability ≠ Availability

- ❖**Maintenance is concerned with retaining an item in an operable condition; and quickly correcting failures,** which are driven by a natural law of system entropy changes.
- ❖**The ultimate aim of maintenance is minimizing maintenance costs and downtime. Maintenance helps support inherent reliability.**

Are you living in a big M environment?

Business

- ❖**Business is all about making money.** This requires a balance between avoiding or repairing failures so processes operating to make money. **In the end, reliability and maintenance are all about money.**
- ❖In the game of strategy called chess, pawns will be lost. The game is over when the king is lost! **In business: the process is the king, and the pawns are the equipment.**

Are you living in a big $ environment?

Reliability Concepts

- ❖Reliability is **not a physical attribute**, you can't touch it, feel it, or point to it!—but it's real and everyone wants it.
- ❖Reliability is measurable but it takes lots of **time and or cycles to measure**—high reliability is difficult to quantify!
- ❖Reliability parameters are **difficult to explain and understand** but everyone expects reliability.

Reliability Concepts-Cont'd

- ❖**Reliability is a performance attribute.** It affects product function, operating costs, and maintenance repair costs.
- ❖**Reliability determines if a product is available** to perform it's intended function.
- ❖**Perfect reliability is never achieved.** The complement, **unreliability**, drives failures, maintenance activities, frustrations, and costs.

Reliability and People

❖Reliability [like safety] is everyone's business, and **it starts in design—mitigate human failures!!!**

❖Humans have significant impact on reliability:

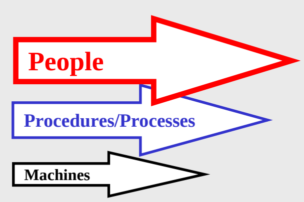
- ☹ **unintentional malpractice** ←Opps! I did what?
- ☹ **intentional malpractice** ←Airplanes, buildings and 9/11!

❖**Make it easy for the human to do the right thing; make it difficult for the human to do the wrong thing!** Then human reliability improves.

Failure Roots

❖ Mature Nuclear Power Plants

People	38%
Procedures + Processes	34
Equipment	28



❖ Want a modern example, read BP's reports:

Final Report:
http://www.bp.com/liveassets/bp_internet/us/bp_us_english/STAGING/local_assets/downloads/t/final_report.pdf

Baker Report about BP:
http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/SP/STAGING/local_assets/assets/pdfs/Baker_panel_report.pdf

If you're a ……

- ❖Adage: If you're a **carpenter**, most of your problems must look like **nails**.
- ❖If you're in **defense**, most of your problems must look like…….**specifications & tests**.
- ❖If you're in **industry**, most of your problems must look like…….**failures & money**.
- ❖If you're an **academic**, most of your problems must look like……..**math/statistics & money**.

Defense

Source:
Blueprints for Product Reliability: RBPR-1
System Reliability Center (formerly the Reliability Analysis Center)

Activity	Tasks and Description	Define Reliability Program	Develop Reliability Requirements	Design For Reliability	Assess Reliability Progress	Measure Product Reliability	Ensure Reliable Performance
DESIGN	**Critical Item Control**. Monitoring in-house and suppliers' activities to reduce the risk to product reliability from items identified as critical. Can include hardware and software.	X			X		X
	Critical Item Identification. Cataloging items that have relatively high impact in determining product reliability. Can include hardware and software.			X			
	Derating. Limit maximum allowable stresses on a part to a designated value below its rated maximum stress in order to improve its reliability.			X			
	Design Reviews. Formal or informal independent evaluation and critique of a design to identify and correct hardware or software deficiencies.	X		X	X		
	Environmental Characterization. Determination of the operational stress the product can be expected to experience.		X	X			X
	Fault Tolerance. Designing alternate means to continue operation when components of a product fail.		X	X			
	Parts Application. Using parts under design rules intended to assure that they will operate reliably under the expected operational stresses.			X			
	Parts Selection. Choosing parts that will be effective and reliable in the planned application and which wshould be available at reasonable cost during the product's life.			X			
	Supplier Control. Monitoring suppliers' activities to assure that purchased hardware and software will have adequate reliability.	X			X		X
	Thermal Design. Consideration of heat generation and dissipation in the product in order to prevent reliability problems caused by the effects of temperature.			X			

Defense-Cont'd

Activity	Tasks and Description	Define Reliability Program	Develop Reliability Requirements	Design For Reliability	Assess Reliability Progress	Measure Product Reliability	Ensure Reliable Performance
ANALYSIS	**Allocations**. Translation of product reliability goals into reliability goals for the components making up the products.		X	X			
	Design Of Experiments. Systematically determine the impact of process and environmental factors on a desired product parameter, in order to reduce product variability by controlling the factors.			X	X		X
	Dormancy Analysis. Determine the effects of expected periods of storage or other non-operating conditions on the reliability of the product.		X	X	X		
	Durability Assessment. Determine whether or not the mechanical strength of a product will remain adequate for its expected life.		X	X	X	X	
	Failure Modes, Effects & Criticality Analysis (FMECA). Systematically determine the effects of part or software failures on the product's ability to perform its function using deductive logic. This task also includes FMEA.			X	X	X	X
	Failure Reporting Analysis & Corrective Action Systems (FRACAS). A closed-loop system of data collection, analysis and dissemination to identify and correct failures of a product or process.			X	X	X	X
	Fault Tree Analysis (FTA). Using inductive logic to determine the possible causes of a defined undesired operational result.			X	X	X	
	Finite Element Analysis (FEA). Determine the mechanical stresses present in products through simulation by decomposing the product into simple elements.			X	X		
	Life Cycle Planning. Determine reliability (and other) requirements by considering the impact over the expected useful life of the product.	X	X	X	X	X	X

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Defense-Cont'd

Activity	Tasks and Description	Define Reliability Program	Develop Reliability Requirements	Design For Reliability	Assess Reliability Progress	Measure Product Reliability	Ensure Reliable Performance
ANALYSIS-Continued	**Modeling & Simulation**. Creation of a representation, usually graphical or mathematical, for the expected reliability of a product, and validating the selected model through simulation.		X	X			
	Parts Obsolescence. Analysis of the likelihood that changes in technology will make the use of a currently available part undesirable.	X		X	X		X
	Predictions. Estimation of reliability from available design, analysis or test data, or data from similar products.		X	X	X	X	
	Repair Strategies. Determine the most appropriate or cost effective procedures for restoring operation after a product fails.	X		X			X
	Sneak Circuit Analysis (SCA). Investigation to discover the existence of unintended signal paths in a product.			X	X	X	
	Thermal Analysis. Analysis of the heat dissipations, transfer paths and cooling sources to determine if part/product temperatures are consistent with reliability needs.		X		X		
	Translations. Determine product design goals (i.e., product reliability) from the user's oerational requirements.		X				
	Worst Case Circuit Analysis (WCCA). Analysis of the effects of variability in the components of a product on the produt's performance.			X	X	X	

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Defense-Cont'd

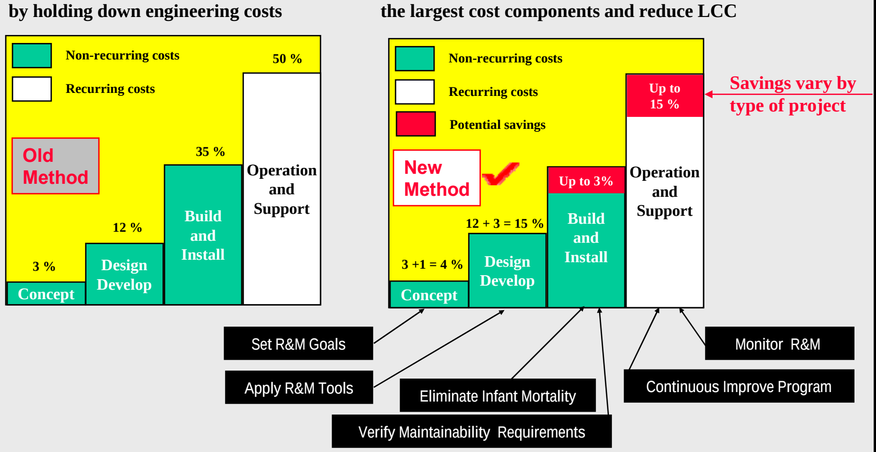
Activity	Tasks and Description	Define Reliability Program	Develop Reliability Requirements	Design For Reliability	Assess Reliability Progress	Measure Product Reliability	Ensure Reliable Performance
TEST	**Accelerated Life Test**. Testing at high stress levels over compressed time periods to draw conclusions about the reliability of a product under expected operating conditions, based on formulated correlation factors.			X	X	X	
	Environmental Stress Screening (ESS). Operating a product under high stress to identify defects (by causing the to become failures) in order to eliminate them before a product is shipped to the end user.						X
	Production Reliability Acceptance Test (PRAT). Testing a product during production to assure that its reliability has not degraded.					X	X
	Reliability Development Test (RDT)/Reliability Qualification Test (RQT). Testing a product to demonstrate whether its reliability requirement has been achieved.					X	
	Reliability Growth Test (RGT)/Test Analyse and Fix (TAAF). Testing a product to identify reliability deficiencies in order to eliminate their causes.				X	X	
	Test Strategy. Determination of the most cost effective mix of tests for a product.	X		X	X	X	X

❖ For Defense, meeting important test profiles successfully is a prime criteria for getting paid.

Industry's (SAE's) View Of RAM

Save up front and defer costs until later by holding down engineering costs

Use strong R&M engineering tools to reduce the largest cost components and reduce LCC



Source: SAE Reliability and Maintainability Guideline for Manufacturing Machinery and Equipment, 2nd edition, M-110.2

Industry's Big Picture For RAM

Short List Of Reliability & Maintainability Activities Over The Life Cycle Phases

The Big PictureTasks	Concept & Proposal Phase	Design & Development Phase	Build & Install Phase	Operation & Support Phase	Conversion Or Decomm. Phase
Set Availability Requirements	X				`
Set Reliability Requirements	X				
Set Maintainability Requirements	X				
Define Functional Failures	X				
Define Environment/Usage	X				
Define Capital Budgets and Make TradeOff Decisions	X	X			
Set Design Margins		X			
Design For Maintainability		X			
Make Reliability Predictions		X			
Do FMEA & Fault Tree Analysis		X			
Do Preliminary Cost Of Unreliability		X			
Conduct Design Reviews		X			
Make Machinery Parts Selections		X			
Do Tolerance/Process Studies		X			
Do Critical Parts Stress Analysis		X			
Do Reliability Qualification Testing			X		
Do Reliability Acceptance Testing			X		
Do Reliability/Maintainability Growth Improvement		X	X	X	
Collect Failure Reports & Analize			X	X	
Provide Data Feedback	X	X	X	X	X

Tailor the matrix to avoid too little or too much emphasis on RAM. Meet needs of the business. Make the effort cost effective! Keep profitability in mind.

Industry's Concepts For RAM

R&M Practices For Concept & Proposal Phase

Tasks For Phase 1: Concepts And Proposal	User	Supplier
Preliminary Availabilitly, Reliability, and Maintainability Planning	X	X
Define The Availability, Reliability, and Maintainability Plan	X	X
Implement Lessons Learned	X	X
Specify Availability, Reliability, and Maintainability Requirements	X	
Define How Machinery Will Be Used	X	
Specify Duty Cycles For Equipment	X	
Define Environment For Machinery	X	
Define Continuous Improvement Monitoring	X	X
Define Equipment Life In Throughput Terms	X	
Establish Data Collection Details For R&M	X	X
Develop Application Specific R&M Program Matrix	X	
Develop R&M Program Planning Worksheet Details	X	
Establish Criteria For R&M In Design Reviews	X	X

Tailor the details to avoid too little or too much emphasis on RAM. Meet needs of the business. Make the effort cost effective! Keep profitability in mind.

Design Review Objectives

Concept Review: Focuses on feasibility of the proposed design approach with budget restrictions

Preliminary Design Review: Verifies adaptability of evolving design to meet technical requirements

Final Design Review: Validates the design and analysis are complete and accurate

Build: Addresses issues from equipment build and runoff testing

Installation: Do failure investigation of problems--Do continuous improvement

Industry's Design/Develop For RAM

Reliability & Maintainability Practices For Design & Development Phase		
Tasks For Phase 2: Design And Development	User	Supplier
Verify Design Margins (Safety Factors) & Do Stress Analysis		X
Specify How Critical Machinery Components Will Be Selected		X
Do Failure Modes and Effects Analysis:		X
Process FMEA	X	
Machinery FMEA		X
Do Fault Tree Analysis & HAZOPS	X	
Do Design Reviews		X
Do Tolerance/Process Studies		X
Generate Reliability Block Diagrams For Reliability Analysis		X
Do Accelerated Testing To Validate Critical Equipment Details		X
Do Maintainability Design Details To Minimize Downtime/Meet Max Time Limits		X
Define Maintenance Manuals, PM Requirments & CM Details		X
Prepare Spare Parts List & Spare Parts Inventory Plans	X	X
Prepares Details of Built-In Diagnostic Equipment For Maintainabiltiy	X	X
Prepares Details of Captive Hardware For Rapid Maintainability	X	X
Identify Spare Parts To Be Managed Based On Criticality	X	X
Define Maintenance Procedures For Adjustments/Replacements/Repairs	X	X
Define Visual Management Techniques For Workplace Awareness	X	X
Define Modularity Of Physical and Functional Units For Removal/Replacement		X

Industry's Build/Install For RAM

Reliability & Maintainability Practices For Build & Install Phase		
Tasks For Phase 3: Build And Install	User	Supplier
Verify Attainment Of Specific R&M Goals During Testing		X
Do Preliminary Evaluation Of Process Performance To Eliminate Infant Mortality		X
Do Dry Run Testing In Vendors Facilities For A Set Duration (e.g., 1-day no failures)		X
Collect Reliability Data During Supplier Acceptance Testing As Future Precursor	X	X
Collect Reliability Data During Acceptance Testing In User's Plant After Installation	X	X
Do Root Cause Failure Analysis To Permanently Eliminate Failures		X

Industry's Operation/Support For RAM

Reliability & Maintainability Practices For Operation And Support Phase		
Tasks For Phase 4: Operation And Support	User	Supplier
Implement R&M Data Collection, Analysis, & Feedback System From Start Up	X	X
Implement Proactive Planned Maintenance Program For PM and PdM	X	
Implement R&M Growth Program Using Data, RCA, & Visual Displays Of Data	X	X
Implement Closed Loop Failure Reporting & Corrective Action System	X	X
Implement User/Supplier Data Exchange Of R&M Data To Reduce Cost On Both Sides	X	X
Implement Feedback Model On R&M Issues For User/Supplier Benefit	X	

Industry's End Of Life For RAM

Reliability & Maintainability Practices For Conversion And Decommission Phase		
Tasks For Phase 5: End Of Life Decisions For Conversion And/Or Decommission	User	Supplier
Implement Retool Decisions For Make/Buy/Modify/Sell	X	X
Implement Remanufacture Decisions For Make/Buy/Modify/Sell	X	X
Implement Rebuild Decisions For Make/Buy/Modify/Sell	X	X
Imprelemt Retrofit Decisions For Make/Buy/Modify/Sell	X	X
Implement Rework Decisions For Make/Buy/Modify/Sell	X	X
Implement Lessons Learned For Future Plant Improvements	X	X
Decontaminate/dispose Of Unneeded Assets With Permits As Required	X	

❖ For Industry, forming partnerships with suppliers is an important arrangement. End users define what's needed. Suppliers don't get paid until the system is operational and meeting contract requirements.

Academia & Reliability

- ❖Engineering education usually focuses on a deterministic environment of how systems work using fundamental laws and rules—**"always build them so they don't fail"**.
- ❖Engineering education, less frequently, focuses on how systems fail, the effects of failure, and the likelihood of failure with cost consequences—**three exceptions**: Chemical Engineering, Nuclear Engineering, & Reliability Engineering.

Academia & Reliability-Cont'd

- ❖Reliability papers and texts require complicated math/statistics for academic peer acceptance.
- ❖Good procedures and practices plus the art of engineering now viewed as too '50's and not up to peer standards—(**however end users value these understandable and useful tools**).
- ❖It's **big science** and **little art** of engineering with emphasis on probabilistic risk assessment.

Academia & Reliability-Cont'd

- Academics need students for a viable program, and upon graduation the students need jobs.
- Viable programs need to be sold to students **and** patrons who finance the programs with grants, endowments, and gifts.
- Buyers of academic technology want to avoid failure problems generating financial losses, legal and government actions; and reputation loss, while taking reasonable risk to stay out of jail.

Academia & Reliability-Cont'd

- In the end, academics must sell programs to get support money for both short term and long term programs
- As in most practical aspects of life, it's less about the technology and more about the practical aspects of using the math/statistics to get the money for sustainable programs!!
- The relationship of academia and reliability is simple: **No cash means no programs!**

Note The Similarities

- **Defense-**
  Specifications→Tests→Performance→Money
- **Industry-**
  Specifications→Performance→Money
- **Academia-**
  Students→Math/Statistics→Patrons→Money
- **Reliability for each interest group is about preventing failures. In the end it contains the same theme of money!**

Common Problems For Defense, Industry, and Academia

- Never enough time or money for the job
- Use the technology to manage the money issues where
  $Risk = POF*$Consequence
- Don't take too much risk!—you can't afford the $'s
- Don't take too little risk!—you waste too many $'s
- Know when to accept and when to reject the $Risk of failures. Use reliability technology to manage $Risks.

$Risk = POF*$Consequence with R+UR=1 and UR=POF

In Summary: Defense, Industry, Academia

- Three different views of reliability. Three different perspectives. Defense and industry are coming closer together but not merging with academia.
- In the end, reliability issues are **NOT** about math and statistics!
- Reliability issues are about finding problems, preventing failure occurrences and **removing the high cost of failures** by selling an action plan to the organization for solving money problems.
- **In the end, reliability is all about money for defense, industry, and academia. The bridge for the three groups is money.**