Another Look at Today's Reliability Engineering

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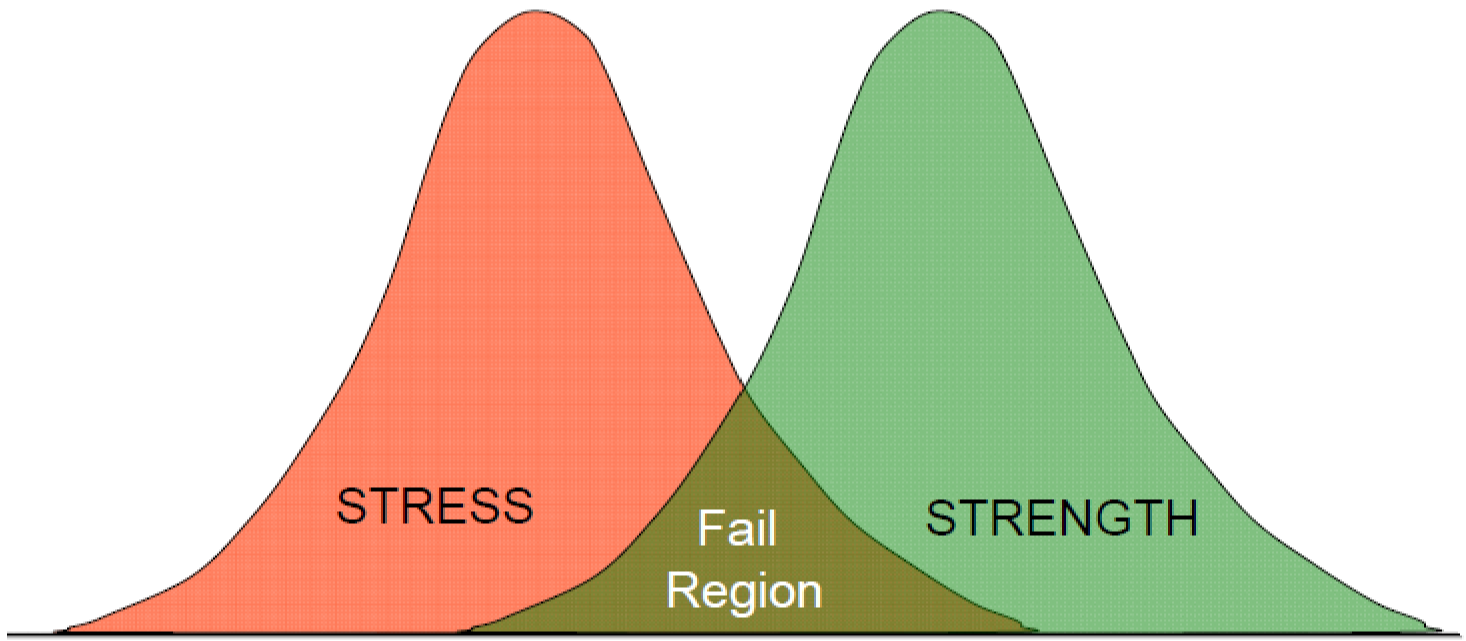
How is Reliability Engineering Changing?

- Reliability is no longer a separate activity performed by a distinct group within the organization.
- Product reliability goals, concerns and activities goals, are integrated into nearly every function and process of an organization
- Each organization must factor reliability into every decision in order to ensure production of a successful product.
- The old Test-Analyze-and-Fix philosophies no longer have a place in today's design process due to continuous cost reduction pressures and reduced design cycles.
- ***We need to Design for Reliability (DfR).***

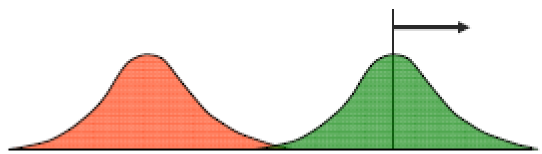
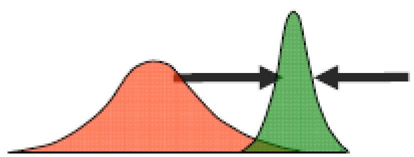
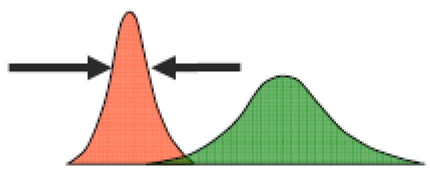
Designing for Reliability

Stress Analysis and Test

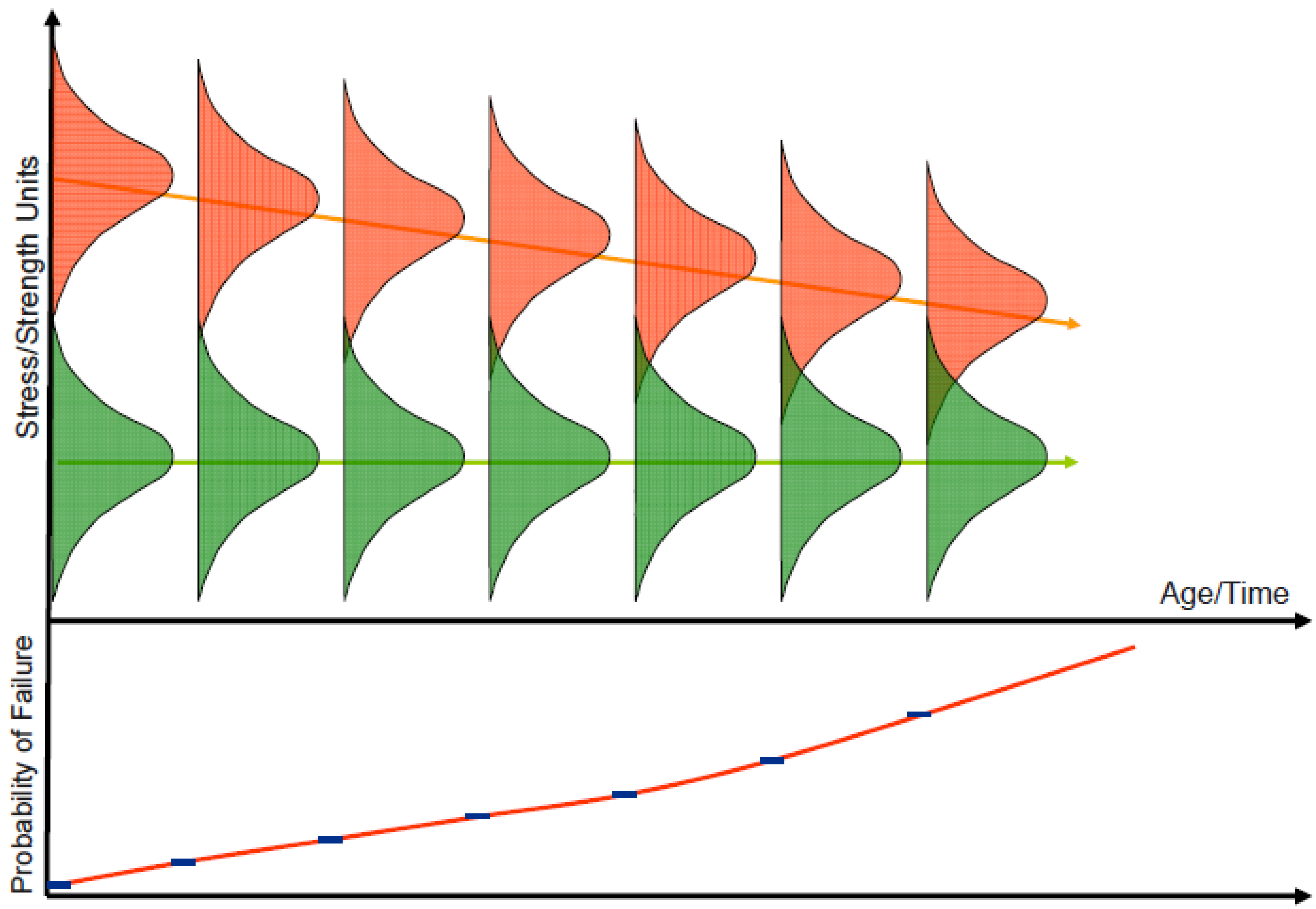
- **Quantify product limits & understand user stresses**
- **Products fail due to variations or limited environments where stress exceeds strength**
- **Stress and strength distributions:**



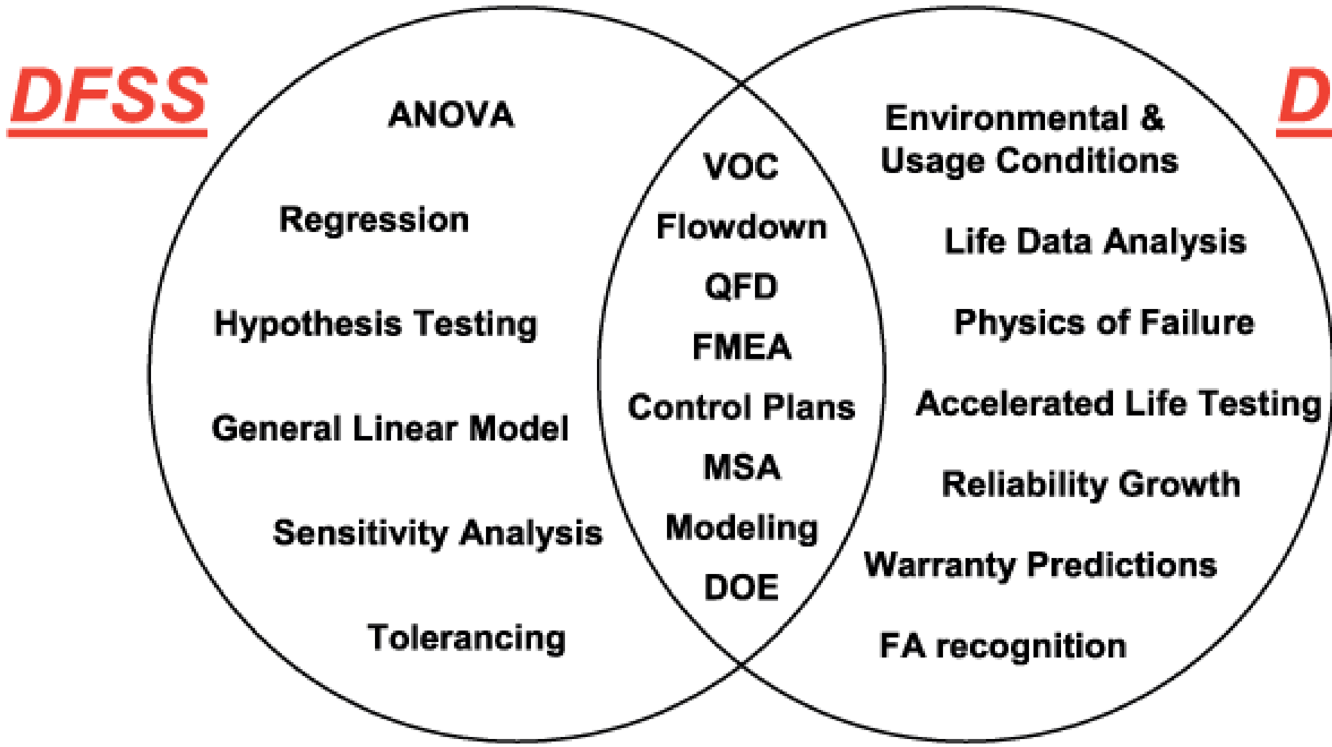
How do we strategize for DfR?

	Increase Design Margins
	Reduce Variation in Product Strength
	Reduce Effect of Usage/ Environment

Stress-Strength vs Age



Robust Design Tools



DFSS and DFR Tools: Differences and Commonality

The Legacy of Reliability Predictions

Some Traditional Sources of Surrogate or Generic Item Failure Rate (λ) Models and Data

- MIL-HDBK-217F (Reliability Prediction for Electronic Parts; 1995)
- Electronic Part Reliability Data (EPRD-97)
- Non-Electronic Parts Reliability Data (NPRD-95)
- IEEE Std 500-1984 (Reliability Data for Nuclear-Power Generating Stations)
- Guidelines for Process Equipment Reliability Data with Data Tables (Center for Chemical Process Safety, 1989)

The Legacy of Reliability Predictions

What Are some Issues and Concerns with the Classical Approach and Data Sources?

- **Approach results in point estimates of failure rates – no uncertainty estimates available.**
- **Pretty much forced into using constant failure-rate model for estimating reliability.**
- **Difficult to determine environmental conditions inherent in source data and differences between new application environments and data source environments.**
- **Doesn't account for different causes of failures in failure data.**
- **Many generic data sources are outdated**

Reliability Predictions Today

- What have we learned about Reliability Predictions in the past 20-30 years?
  - Too much emphasis on MTBF
  - Not enough on Failure Rates (λ) and Duty Cycles (in % of Time)
  - Not enough on Environmental Application Factors
  - Often, it is not <u>One</u> Weibull Curve, but many succeeding Weibull curves
  - Confusion between MTBF, MTTF (or MTTFF)

Reliability Predictions Today

Are Reliability Predictions Reliable?

A Comparison of Circuit Card Assembly Observed Failure Rates to Predicted Failure Rates from FIDES, PRISM® (a precursor to 217 Plus™) and MIL-HDBK-217 is shown below:

Circuit Card Assembly	Operational Failures per 10^6 Hours for Shipboard Environments			
	Observed Failure Rate	FIDES Failure Rate	PRISM Failure Rate	MIL-HDBK-217 Failure Rate
Digital Correlator	2.08	2.75	0.45	5.58
RF Synthesizer	4.16	5.51	0.9	6.32
+/- 12V Power Supply	1.56	6.76	1.9	9.67
Average Delta from Observed		2.41	1.74	4.59

Reliability Predictions Today

- There is a broad consensus that reliability prediction is very valuable for use in assessing and comparing alternative design options and other trade studies when the prediction is based on historical performance of similar or predecessor components/systems (and with adjustment for environmental and process factors).

- Newer methodologies and data sources have improved technologies and are bringing more fidelity to the prediction process.

Reliability Predictions Today

What's (Relatively) New in Reliability Prediction Data, Tools, and Methodology?

- Alion's System and Part Integrated Data Resource (SPIDR™)
- International Association of Oil & Gas Producers (OGP) Guide for finding and using reliability data for Quantitative Risk Assessment
- RiAC's Nonelectronic Part Reliability Data (NPRD-2011) Handbook
- IEEE Std 493-2007, Chapter 10, Summary of equipment reliability data Tools and Methods
- "Handbook of 217 Plus™ Reliability Prediction Models" (RiAC)
- FIDES (developed by a consortium of European companies)
- "Handbook of Reliability Prediction Procedures for Mechanical Equipment," NSWC-06/LE10, January 10, 2006
- OALC Reliability Prediction Software & Application Pack

What’s New in Spares Predictions?

Can the number of spares needed for the parts that comprise a System be predicted?

Yes; we can utilize the Chi Square distribution to predict with a confidence interval between 50 to 99%, for the next X to Y months, how many of each will be required based on historical usage of the system’s parts.

Integrating Accelerated Testing

- **Prototype Phase**
  - **Accelerated Test to Failure (HALT, Step Stress, Specific Stresses and Failure Modes, Find Material and Component Limits)**
- **Design Margin Confirmation Phase**
  - **Quantitative Accelerated Life Test (STRIFE)**
  - **<u>Test to Failure, Do Not Rely on Success-Based Compliance Testing</u>**
- **Production Validation**
  - **Demonstrate Corrective Action is Effective**
  - **Validate Final Product Made on Production Tools**

Predictive Modeling and Reliability Centered Maintenance

Can the reliability characteristics of a system's parts be analyzed to support Predictive Modeling and Reliability Centered Maintenance (RCM) analysis?

Current practices are to utilize the Weibull Distribution to determine the reliability characteristics of a system's sub-assembly & parts to determine the reliability/survivability of all parts for a specified duration, which allows in-depth Predictive Modeling analyses (using tools like TLCM-AT) and RCM analyses to be conducted to optimize the operation and sustainment of systems.

New Reliability Engineering Tools

Whole Life Engineering (WLE)

- **WLE is made up of multiple specialty disciplines**
  - **Reliability**
  - **Maintainability**
  - **Testability**
  - **Safety**
  - **Logistics**
  - **Human Factors/Ergonomics**
- **Emphasis on increasing collaborative nature of WLE analyses to optimize task efficiency**
  - **Combine multiple analyses into as few database tools as possible**
  - **Automate data transfers to avoid manual data entry between remaining tools**
  - **Quantify system safety results and provide traceability to other WLE analyses**

New Reliability Requirements

Automotive Industry Action Group (AIAG) & ISO/TS-16949

AIAG Reliability Maturity Assessment Categories

- Reliability Planning
- Design for Reliability
- Reliability Prediction & Modeling
- Reliability of Mechanical Components & Systems
- Statistical Concepts
- Failure Reporting & Analysis (FRACAS)
- Analyzing Reliability Data
- Reliability Testing
- Reliability in Manufacturing

How is Reliability Changing?

- Understand Failure Mechanisms
- Consider Use of DOE to Help Estimate:
  - Stress Factors with Most Effect
  - Probability of Failure at Specified Use Level
  - Probability of Failure at Maximum Stress
  - Interactions to help define Life-Strength Relationship
- Understand Operating and Design Limits
- Clarify Use Level Stress Application

Production Validation Testing

- ➢ Repeat selected Qualification Tests on any changes in product or process
- ➢ Test samples made on Production Processes
- ➢ On-Going Reliability Test (ORT)
  - HASS – Highly Accelerated Stress Screening
  - HASA – Highly Accelerated Stress Audit
  - Periodic HALT Re-Test on Production Units

Software Reliability

- Capability Maturity Model® Integration (CMMI),
- Version 1.3 CMMISM for Development (November 2010)
  - From Carnegie Mellon University,, Software Engineering Institute –
  - http://www.sei.cmu.edu/cmmi/
  - Plan-Do-Check-Act process
- SEI Core Measures:
  - Size, effort, problem count, schedule

Sources & References

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