TECHNOLOGY DRIVEN. WARFIGHTER FOCUSED.

Physics of Failure - The Critical Path to Saving $M in T & E

Dr. W. Forrest Crain
410-278-6614
DSN 298-6614

Agenda

- Cost of Failure
- Background
- Test & Evaluation Environment
- Problem Statement & Benefits
- What AMSAA is doing with Physics of Failure
- What AMSAA is doing with the Reliability Scorecard
- Physics-of-Failure Successes
- Challenges
- Summary

What is the Cost of Failure?

Type of Business	Lost Revenue per Hour
Retail Brokerages	$6,450,000
Credit Card Sales Authorization	$2,600,000
Home Shopping Channels	$113,750
Catalog Sales Centers	$90,000
Airline Reservation Centers	$89,500
Cellular Service Activations	$41,000
Package Shipping Services	$28,250
Online Network Connect Fees	$22,250
ATM Service Fees	$14,500
Supermarkets	$10,000

continued

source: "Ready when chips, lines are down; Firm offers clients work space in crises," Margaret Webb Pressler, Washington Post, Washington, Dec. 18, 1999, pg. E1 & U of MD CALCE Center

What is the Cost of Failure?

LAPTOP LAWSUIT*

Major corporation agreed to $2.1 Billion Settlement for selling allegedly defective laptops.

AN AUTOMOTIVE RECALL

Dear ___ Customer, This notice is sent to you in accordance with the requirements of the National Traffic and Motor Safety Act. ____ has decided that a defect which relates to motor vehicle safety exists in certain _____ vehicles. ... Windshield wiper motors may fail after a year or more... as a result of *cracked solder joints* on the *controller circuit board*.

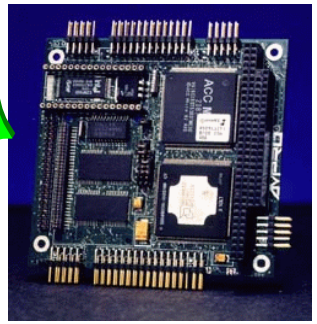
MISSION FAILURE AND/OR LOSS OF LIFE

**Wall Street Journal, 1 Nov 99 pg.1*

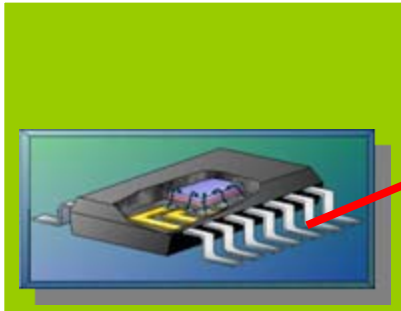
Background

PoF – A Comprehensive Engineering Based Reliability Approach

Stress (e.g., vibration) is propagated from the system level to a failure site



- Also termed “Physics of Failure” (PoF), “Predictive Technology”, “Predictive Engineering”, “Physics of Reliability” and models the root causes of failure that include fatigue, fracture, corrosion, and wear.
- Industry, academy, and government develop failure models and CAD tools that address specific materials, failure sites, and design architectures.



Failure root-cause is cracking of solder joint

Benefits

- Influence design early
- Eliminate failures prior to test
- Increased chance of passing test
- Enhanced fielded reliability
- Improved prognostics
- Decreased O&S costs

Test & Evaluation Environment

- May not be enough time in schedule for desired test
- Funding may be insufficient
- Test asset availability limited; assets may be expensive, scarce, or needed for the war effort
- T&E IPT process highly competitive as proponents for each element's evaluation push to ensure that their data requirements will be met
- Testers and evaluators in a difficult position – under pressure to make do…
- Need to include new approaches that leverage test activities to provide more information

Need to get the most from every test!

Problem Statement and Benefits

- Problem Statement: The Army requires Physics of Failure (PoF) throughout the materiel acquisition life cycle to mitigate current cost, schedule, and performance issues.

- Benefits
  - PoF, relying on physics-based analysis, provides Testers, Evaluators, and Program Managers the ability to field highly-reliable materiel.
  - PoF ensures that Testers, Evaluators, and Program Managers get the most out of every test.

What is AMSAA Doing with PoF?

- Supporting T&E and acquisition communities with Physics-of-Failure (PoF) analysis
  - System-level dynamics models, component finite element models, fatigue-life models
    - Reveals the underlying physics of the hardware in its mission environment
    - Outputs include:
      - ✓ Forces acting on a system
      - ✓ Displacements of components
      - ✓ Accelerations
      - ✓ Stress levels
      - ✓ Weak points of the design

PoF enables the Army to…

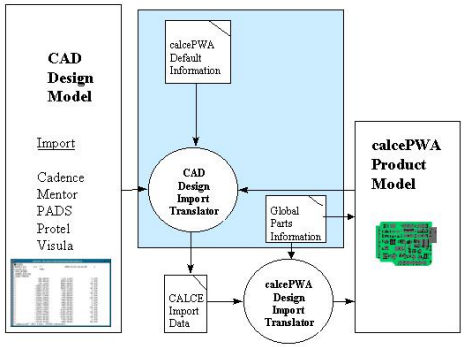
✓Anticipate & understand test performance

✓Not be surprised by test performance

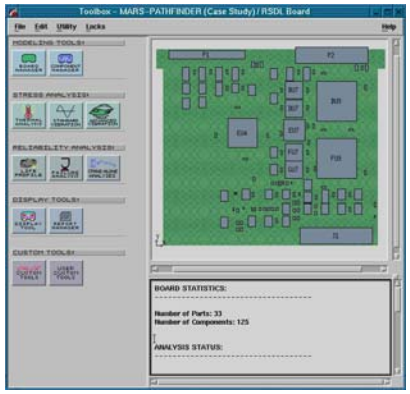
  - What can the Army do with these new insights?
    - Work with ATEC, PMs, RDECs, & contractors to fix the components responsible for poor system reliability
    - Make meaningful and helpful suggestions for corrective action approaches
    - Encourage contractors to use the best analysis tools
    - Provide peer-level review of contractor designs and suggestions
    - Reap the benefits of increased customer knowledge

Increased Knowledge	→ Increased Warfighter Benefit	Lower Life-Cycle Cost	Better Performance	Higher Reliability

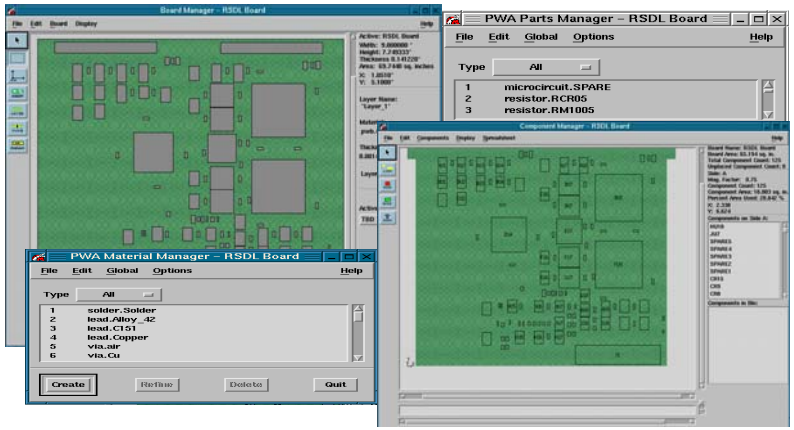
Physics-of-Failure Process for Electronics



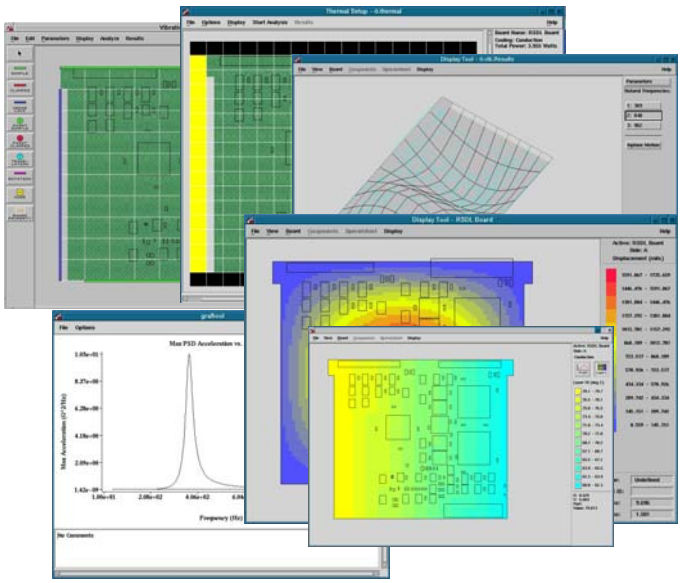
Support for importing CAD design files



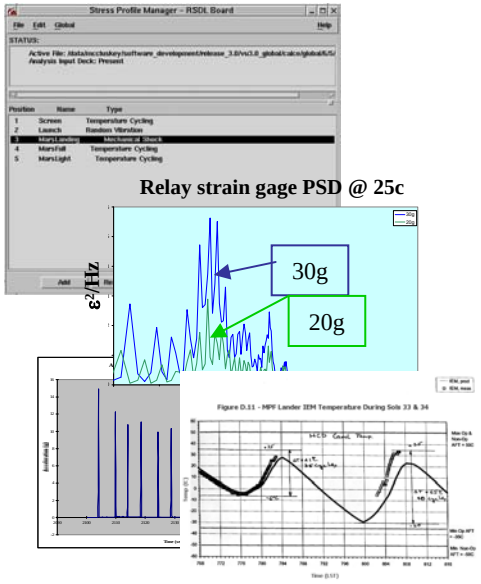
Toolbox



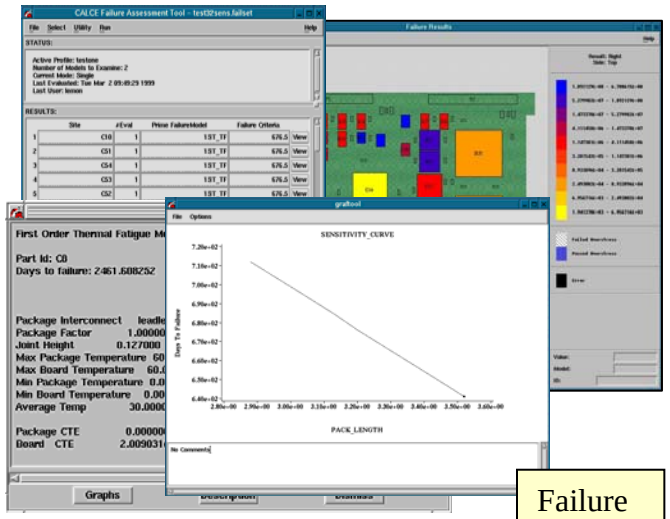
Product Modeling and Databases



Load Transformation



Environment Characterization



Failure Risk Assessment & Sensitivity Analysis

Failure Model Plug-ins

What is AMSAA doing with the Reliability Scorecard?

- 8 Scorecard Categories
  - Reliability requirements and planning
  - Training and development
  - Reliability analysis
  - Reliability testing
  - Supply chain management
  - Failure tracking and reporting
  - Verification and validation
  - Reliability improvements
- For each Scorecard Category there are several elements with associated rating criteria

Identify weak performers early using this structured and analytic approach

One example element from the Reliability Analysis Scorecard Category

ELEMENT	**Critical loads and stresses are characterized; life cycle environment and operation duty cycle stresses are characterized**	
CRITERIA	Clearly define estimates of life-cycle user and environmental loads, update periodically, verify with measurements on pre-production systems/products. The developer must characterize the critical loads and stresses. Validate with additional testing and data collection.	Green
	Estimate life-cycle user environmental loads from "like-systems" in similar operational environments. Measurements not verified on actual system through testing and data collection.	Yellow
	Life-cycle user environmental loads and duty cycle stresses are not defined.	Red

Encourages use of Physics-of-Failure analysis

AMSAA Reliability Program Scorecard

Tools & Forms

Ranking

#6 of 36 items

How is ranking calculated?

User Reviews

Contents | Activity

Assess reliability before testing

Long Description

This MS Excel-based tool may be used to qualitatively score the elements of a Reliability Program.

The covered elements are:

1. Reliability Requirements and Planning
2. Training and Development
3. Reliability Analysis
4. Reliability Testing
5. Supply Chain Management
6. Failure Tracking and Reporting
7. Verification and Validation

Just a Few of the PoF Success Stories

Surveillance System

- Analysis showed commercial ciruit card OK

$1.2M Saved

Tri-Service Radio

- Identified weak link in design

$27M Cost Avoidance

Army Vehicle

- Reduced testing through M&S

$500K Cost Avoidance

Tactical Receiver

- Reliability design enhancements incorporated

Power Supply

- Significant failures reduced with minimal cost fix

Reliability Improved

Mobile Bridge

- Reduced testing

$1.5M Savings

New Missile System

- PoF analysis on Plastic Ball Grid Array

Evaluate New Technologies

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Identified Challenges

- Lead-free electronics
- Counterfeit parts
- No Fault Founds
- Still a lack of routine application of electronics Physics-of-Failure analysis early in the development process
- Continued use of MIL-HDBK-217 instead of rigorous engineering practices

Summary

- PoF, relying on physics-based analysis, provides Testers, Evaluators, and Program Managers the ability to field highly-reliable materiel.
- PoF ensures that Testers, Evaluators, and Program Managers get the most out of every test.
- PoF analysis tools can significantly contribute today.