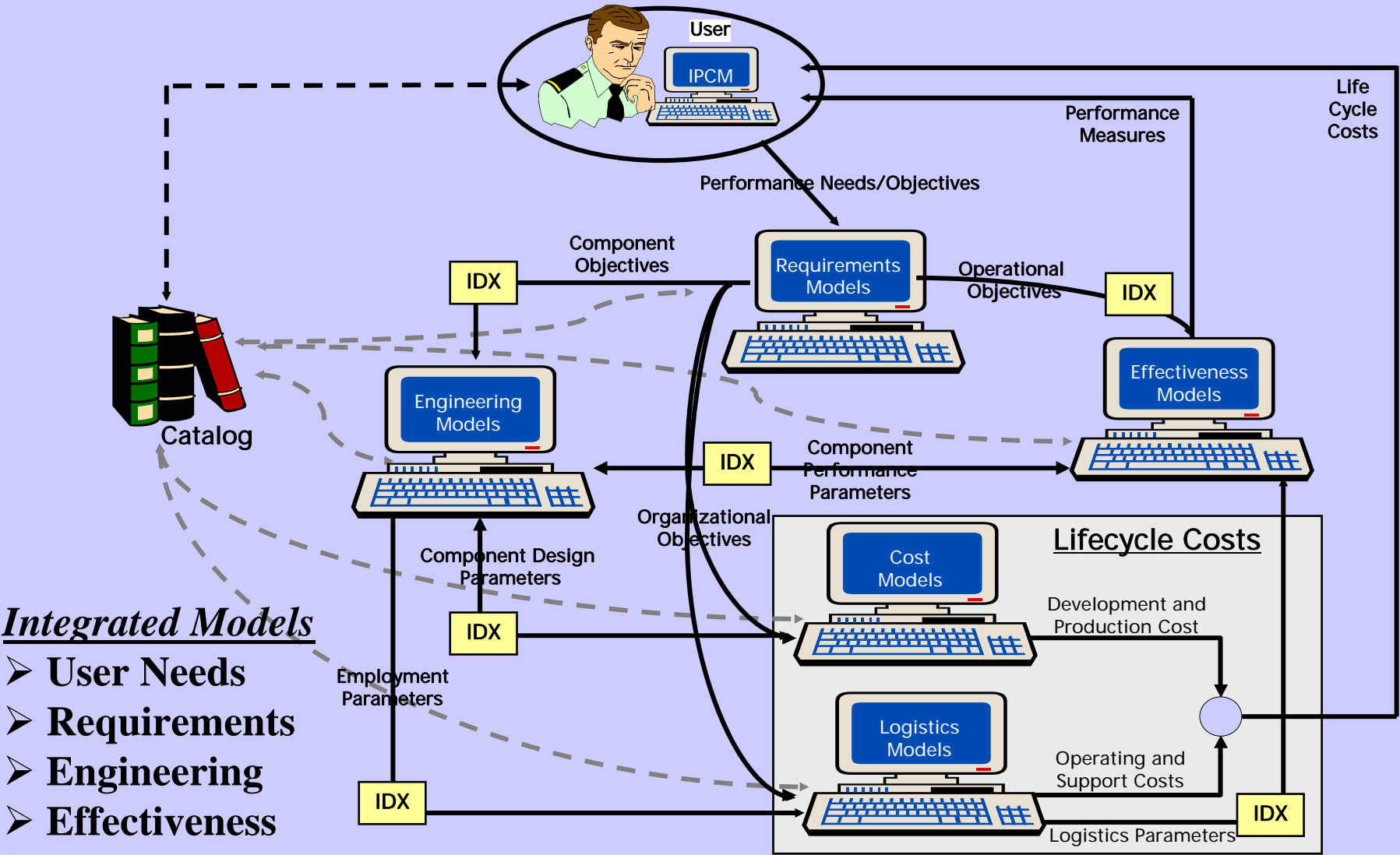


Total and Seamless Integration & Collaboration: Leverages NIST's \$21.5M Advanced Technology Program



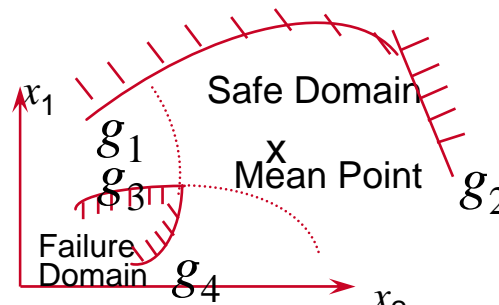
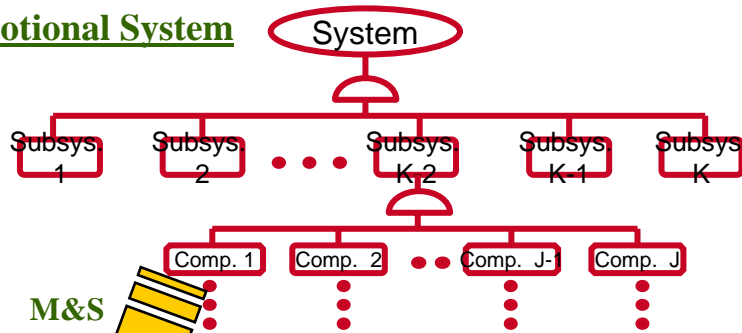
Integrated Models

- User Needs
- Requirements
- Engineering
- Effectiveness
- Logistics
- Cost

Principles, Tools & their Products for RMS TRL Maturity Achievement

- Advanced Physics-based, Probabilistic and Bayesian M&S used as early as TRLs2
- Modeling & Simulation of Conceptual technology applications derives requirements/Mission Need
- Continuity of Adv'd Physics-based tools applications into higher TRLs assures rapid knowledge-based technology maturation cycle.
- Modeling & Simulation begins even with no data, no configuration and only technology concepts to derive requirements assess RMS needs, fit to system of systems

Notional System

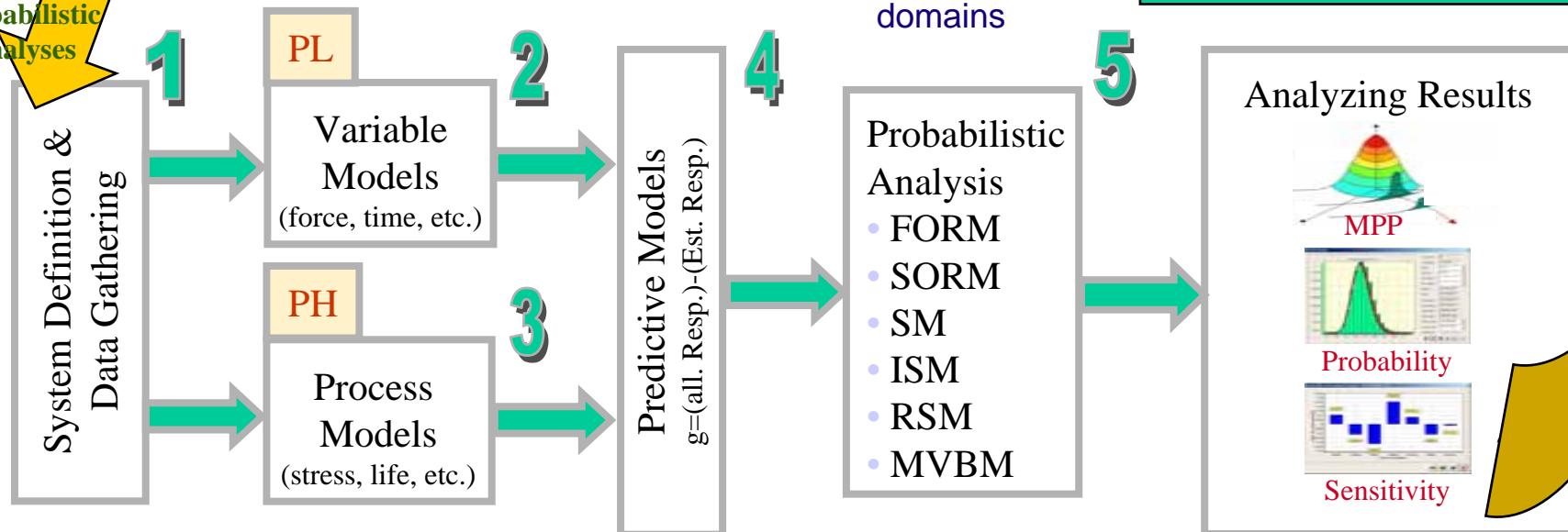


c: Define safe and failure domains

Results of M&S, Advanced Physics Tools

- Concepts & Technology emerge
- Bayesian Approaches; PREDICT
- Model concepts
- Concepts Simulated in war fight
- Derive Performance Reqts
- Apply Probabilistic Physics in
- Notional applications
- Determine RMS Drivers
- Determine Limit state functions
- Early KPP evolution

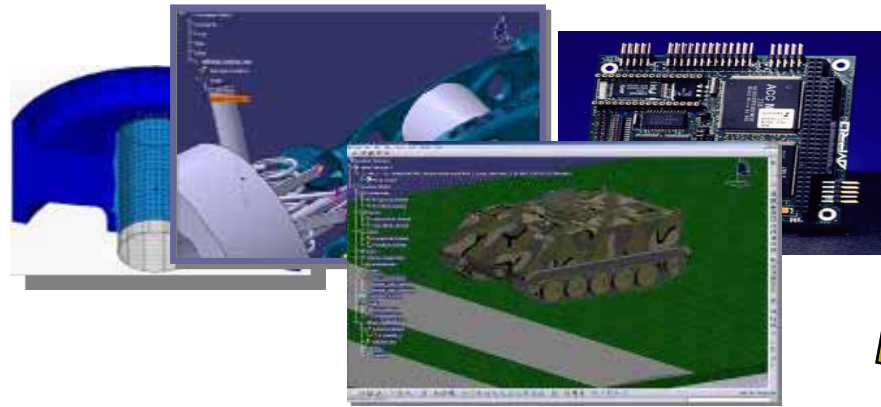
M&S
Bayesian
Physics
Probabilistic
Analyses



Principles, Tools & their Products for RMS TRL Maturity Achievement

- TRLs 4-5: Framework for identifying RMS Drivers – defined Operational Environments, imposed stresses, desired performance, define reqts for RMS
- Best Practices for component/technology research begin with Advanced Physics-based Probabilistic and multi-physics M&S.
- Tools:

- Finite Element Analyses
- Computational Fluid Dynamics
- Dynamic Simulations
- Multi-Body Physics
- Thermal and Fatigue Analyses
- Probabilistic Analyses
- Reliability/RMS Analytics



Products of Tools



Most probable points

IMPACT of Tools

- ✓ Identify Most Likely Failure Modes/Mechansims
- ✓ Determine Uncertainty/Risk in ALL parameters
- ✓ Model the multi-physics of all Performance
- ✓ Quantitative Risk Assessments of all failure prob.
- ✓ Understand Sensitivities of all key parameters
- ✓ Quantitative TRL maturity measures
- ✓ “Design-in” better inherent performance & RMS

Physics of Failure

AMSAA Leads Army initiative
w/ CALCE Consortium



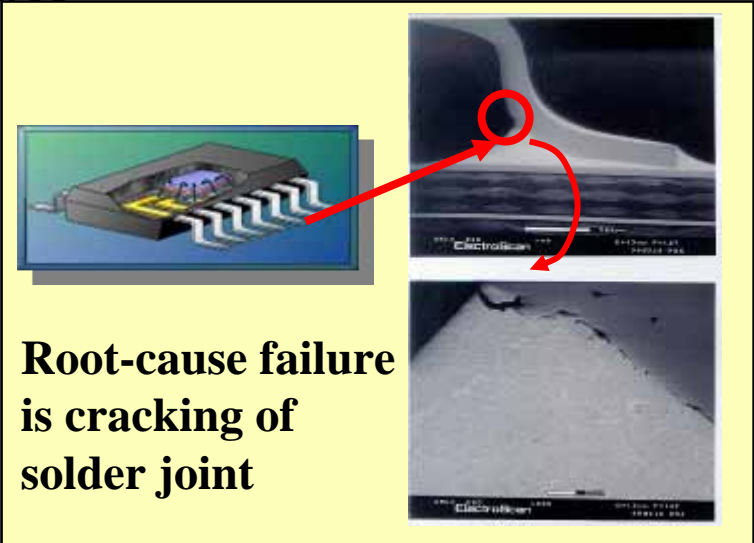
Stress (e.g., vibration) is propagated from system level to failure site



- Science-based approach to reliability
 - Model the root causes of failure (e.g., fatigue, fracture, corrosion & wear)
- Failure models & CAD tools developed
 - By industry/academia/government
 - To address specific materials, sites, & architectures

Benefits

- Design in reliability
- Eliminate failures prior to test
- Better chance of passing test
- Increased fielded reliability
- Improved prognostics
- Decreased O&S costs



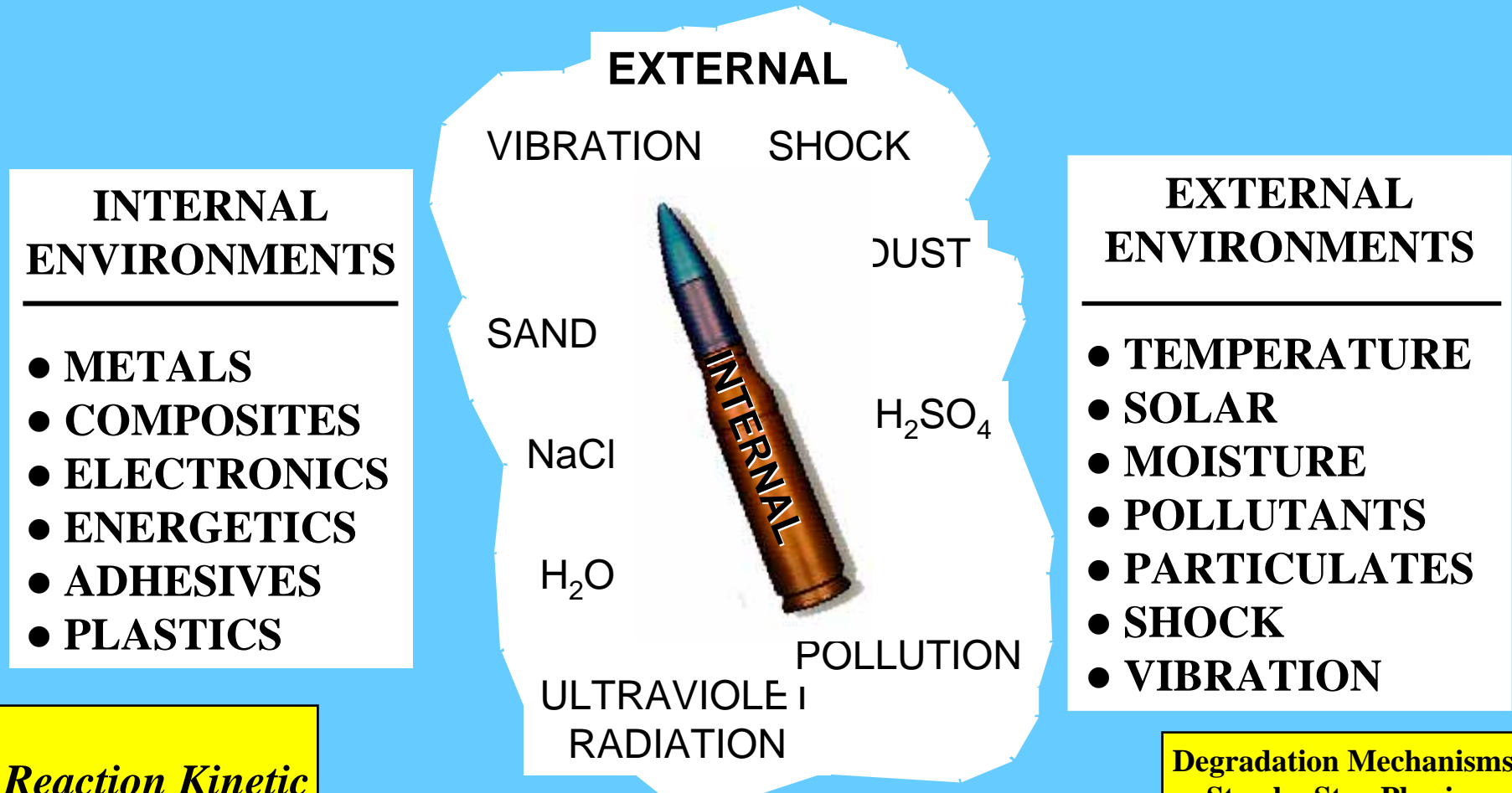
**\$ Millions in Savings and Increased Reliability for Many Systems
Continuing to promote PoF use with PMs**

Joint STARS GSM, Bradley BFIST, ARC-210 Radio, Comanche, THAAD, Paladin & more

Technology Maturity – Physics-based Measures

Physics of Performance & Failure - Understanding the Relationship

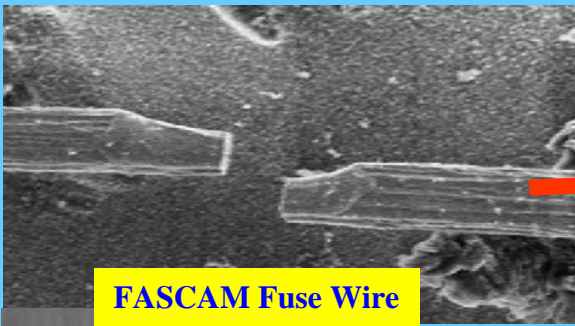
Understand -----Control ----- Sustain Control



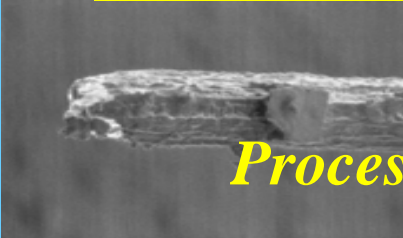
*Reaction Kinetic
Modeling*

Time, a Critical Factor

Degradation Mechanisms
Step by Step Physics
Initiators
Accelerators



FASCAM Fuse Wire



Process Sensitive ...



The Army has experienced significant materiel losses through undetected degradation during deployment



Exudate

Deterioration Sensitive ...

Marginal Design...



Corrosion



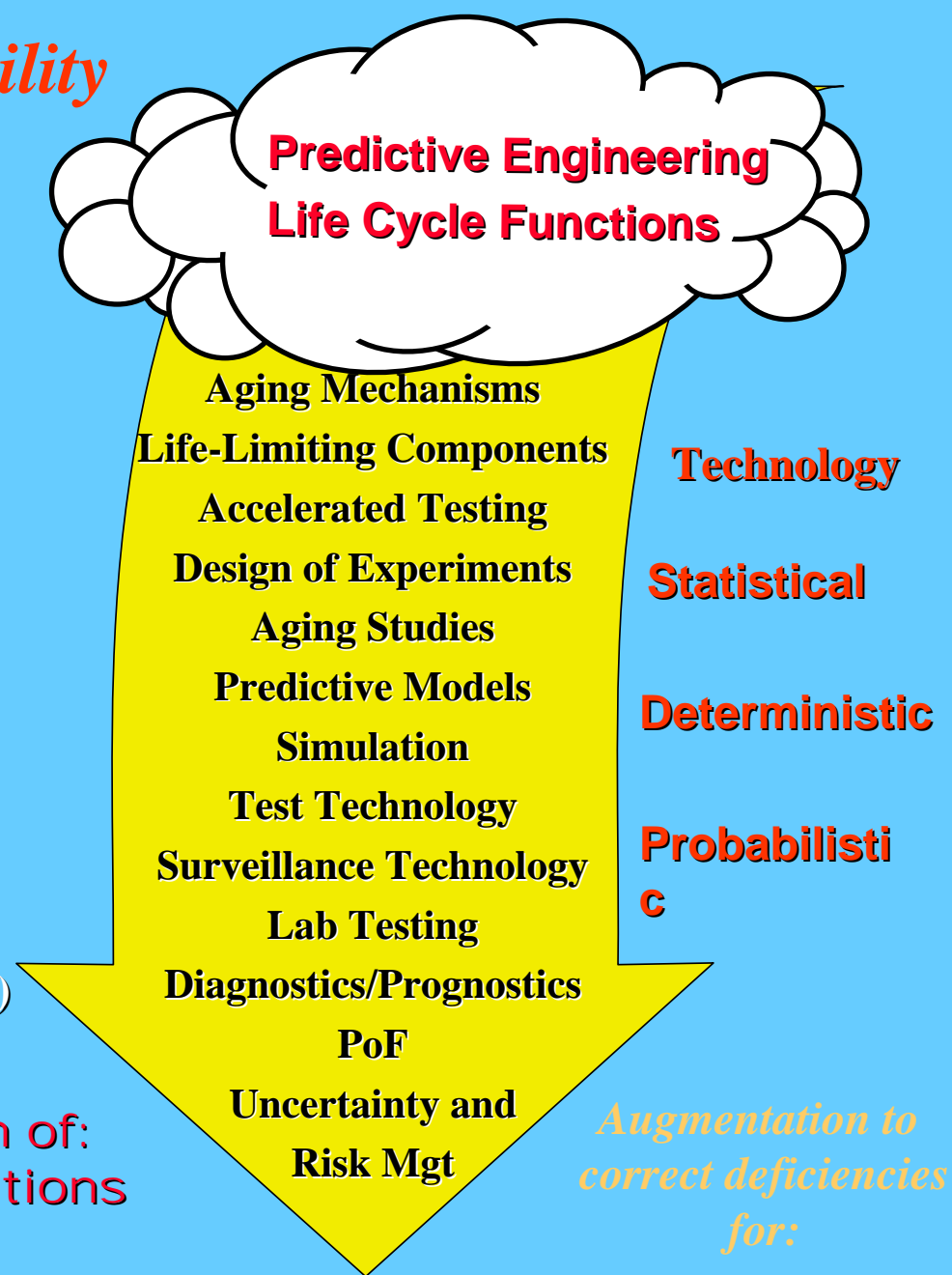
Skive Glue Joint



Traditional Life Cycle Reliability Assurance Functions ...

- Safety, Reliability, Availability & Maintainability Rationale
- Failure Modes & Effects Analysis (FMEA)
- Fault Tree Analysis (FTA)
- SRAM Mathematical Modeling
- Reliability Growth Modeling
- Design Reliability Engineering
- Design Factors of Safety
- DT/OT Test Analysis
- Process Capability/Process Quality
- Environmental Stress Screening (ESS)
- ASRP Test & Evaluation

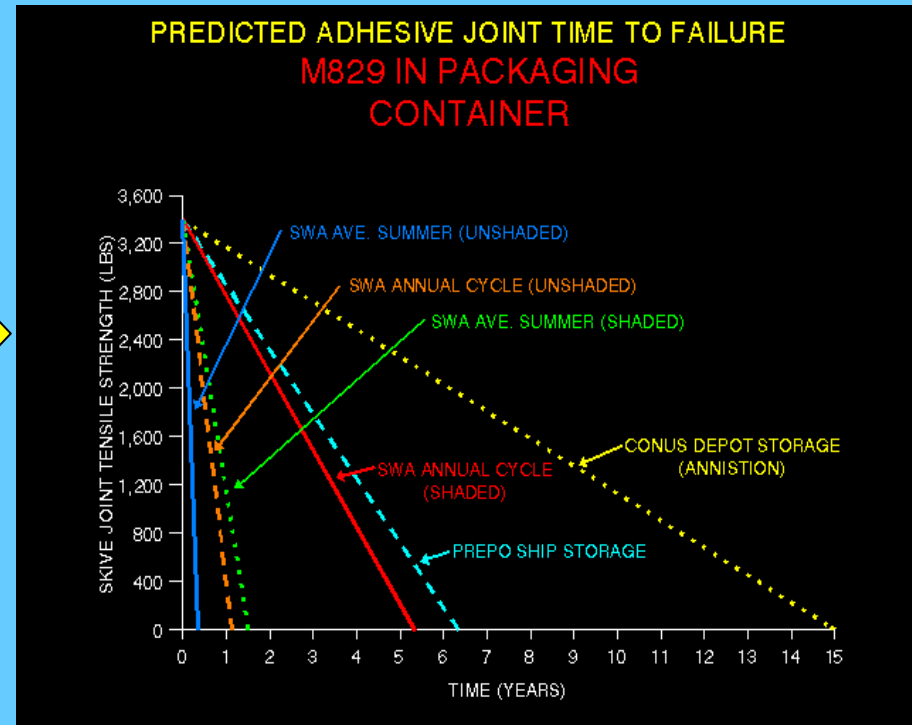
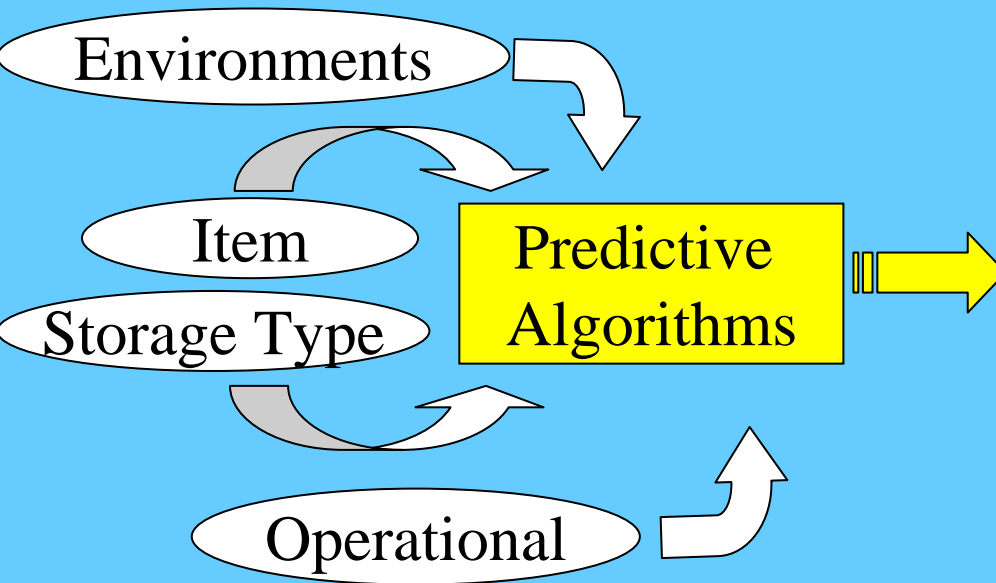
**Reliability & Safety as a function of:
Design & Operational Conditions**



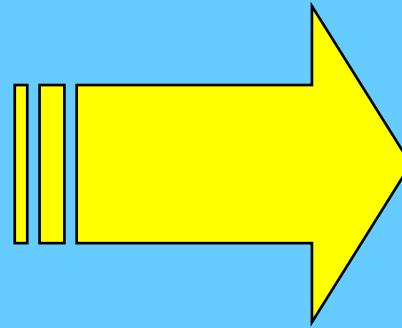
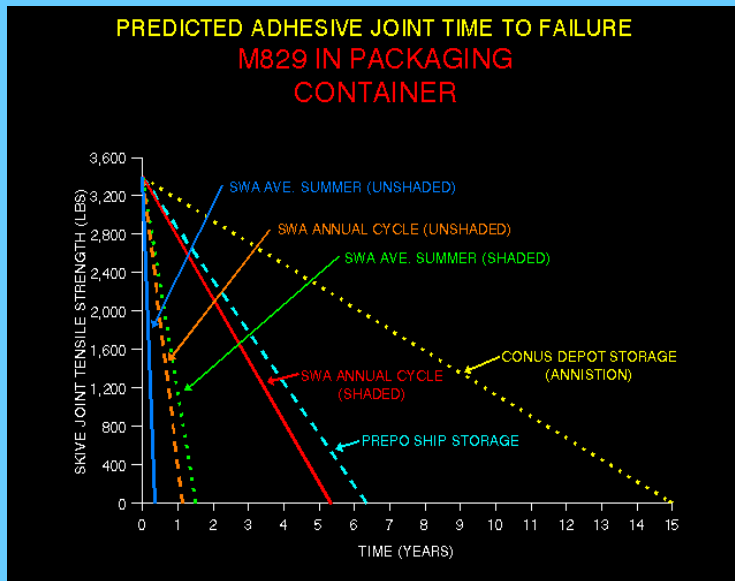
AGE-RELATED DEGRADATION

Life Cycle Analysis

Model Development

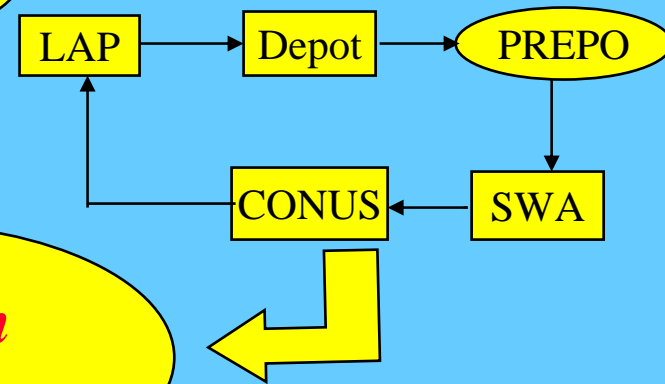


Life Cycle Analysis

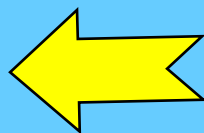


Life Cycle Simulation

- Total LC Log Process
- Total Ownership Costs
- Cost As an Independent Variable (CAIV)



Decision Morphology



LC Manager PEO/PM

- Surveillance Frequency
- Maintenance
- Condition Code
- Priority Usage
- Prepositioning
- Foreign Military Sales
- Demil
- Obsolescence