STRUCTURING A PROBABILISTIC MODEL FOR RELIABILITY EVALUATION OF PIPING SUBJECT TO CORROSION-FATIGUE DEGRADATION

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Research work

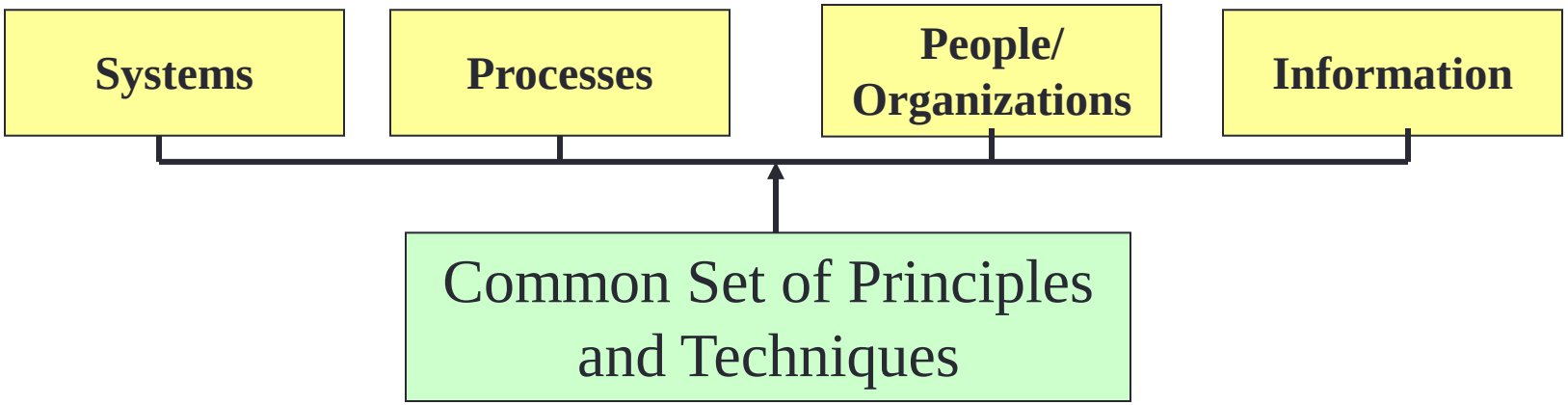
- Probabilistic model for reliability evaluation of piping subject to corrosion-fatigue degradation : Dr. Mohamed Chookah
- Pitting corrosion modeling : Abdallah Al Tamimi and Taher Abu Seer
- Advanced probabilistic modeling for reliability evaluation of piping subject to multi-site fatigue and other environmental stresses : Abdallah Al Tamimi (PhD Candidate)
- Probabilistic-mechanistic approach to modeling stress corrosion cracking: Gary Wu
- Classification and probabilistic model development for creep failures of structures: a study of X-70 carbon steel: M. Nuhi

Reliability Engineering Graduate Program

- World's largest and most comprehensive concentration of education and research activities in risk, reliability, and safety of engineered systems and processes
- Offering MS, PhD, and Graduate Certificate in Reliability Engineering and Risk Analysis
- 21 Graduate Courses in diverse areas of risk, reliability and safety.

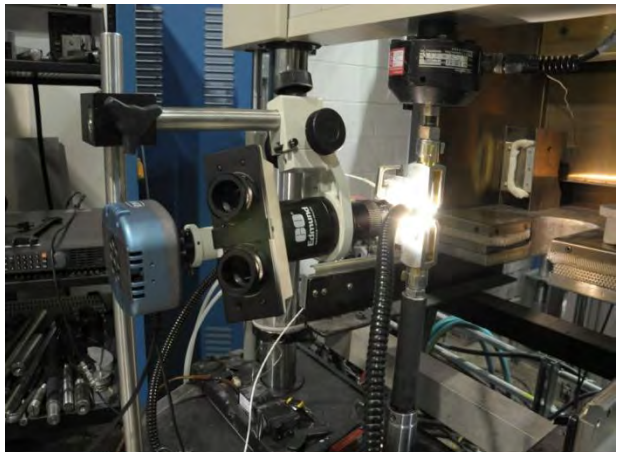
Centre for Risk and Reliability (CRR)

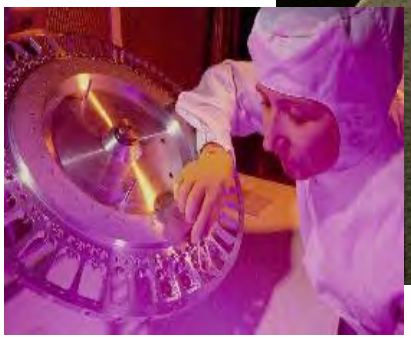
- Formed in 2003, umbrella organization for many of the risk and reliability research and development activities in the Clark School of Engineering
- 23 Full Time, Adjunct, and Affiliate Faculty

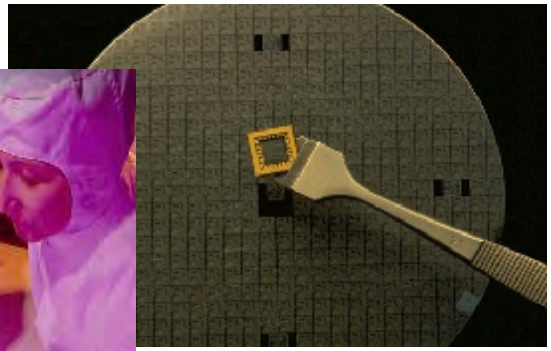


CRR Research Laboratories

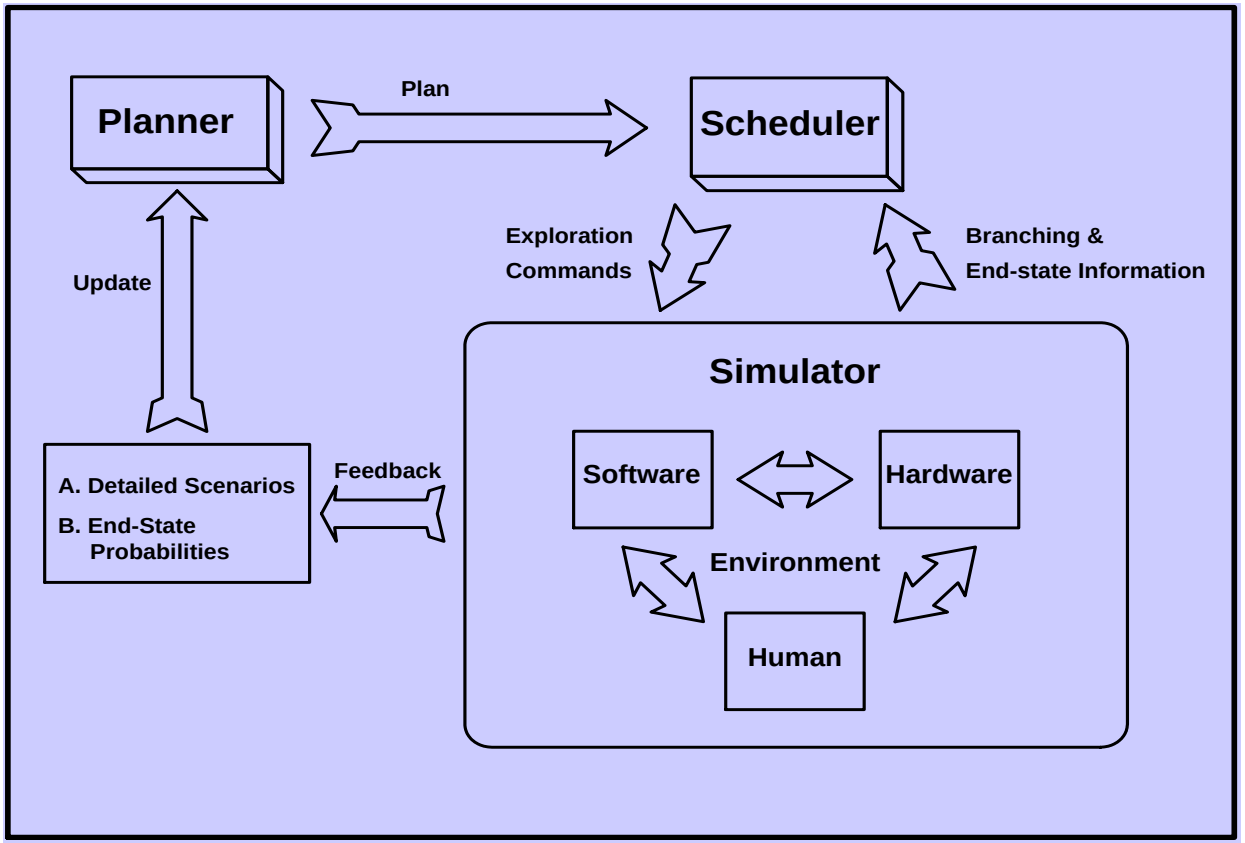
- **Hybrid Systems Reliability Laboratory**
- **Information Assurance Laboratory**
- **Human Reliability Laboratory**
- **Microelectronics Reliability Laboratory**
- **Mechanistic and PPoF Laboratory**







High Level View of the New DPRA Platform (SimPRA) (A. Mosleh –NASA)



Risk Based Design

Dynamic PRA of X-ware Systems

Objective

Pitting and Fatigue leading to Pipe Failure - Ductile Iron

Corrosion Inside the Pipe

Predict the extent of degradation to prevent or reduce consequences

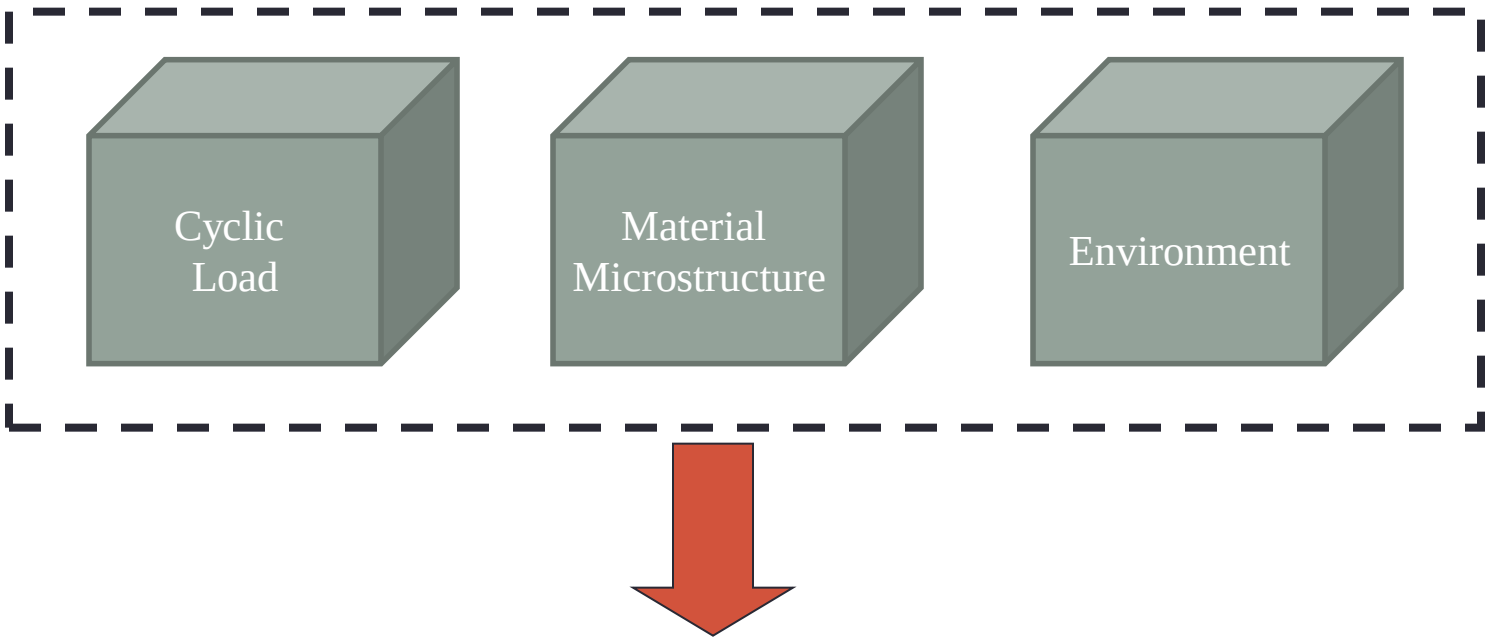
→ **here comes the need for probabilistic Models**

Objective

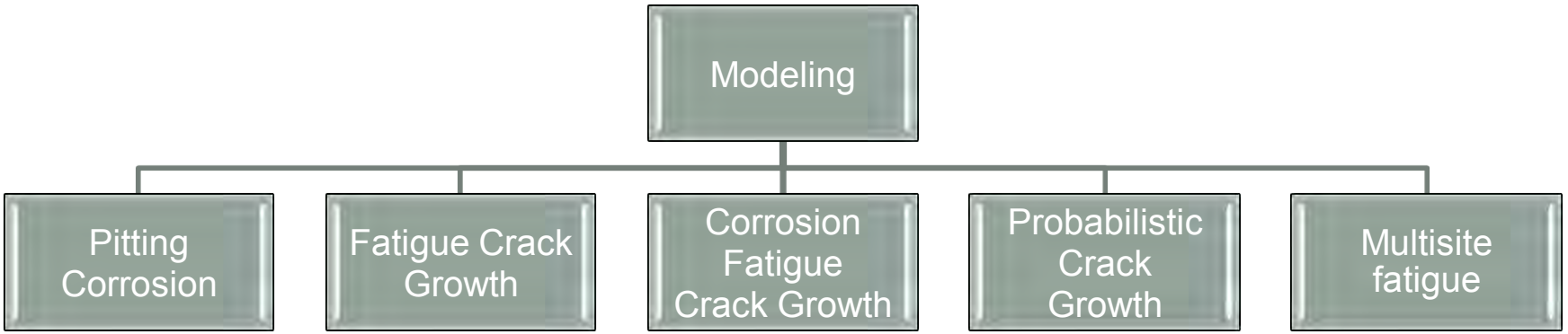
- Why Physics based probabilistic model?
  - PoF (Physics of Failure) models capture material degradation and failure mechanism and forms the basis for prognosis and health management of structures
  - Probabilistic models can adequately represent all of the factors that contribute to variability
    - Materials properties
    - Environmental stresses
    - Human and sensor-based inspections
    - Human and other detection errors

Example: Corrosion-Fatigue Modeling

- Basic degrading elements

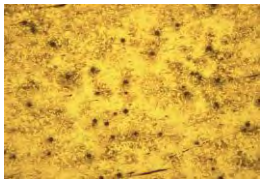


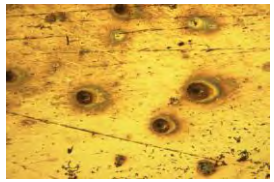
Example: Corrosion-Fatigue Modeling (Cont.)



Pitting Corrosion

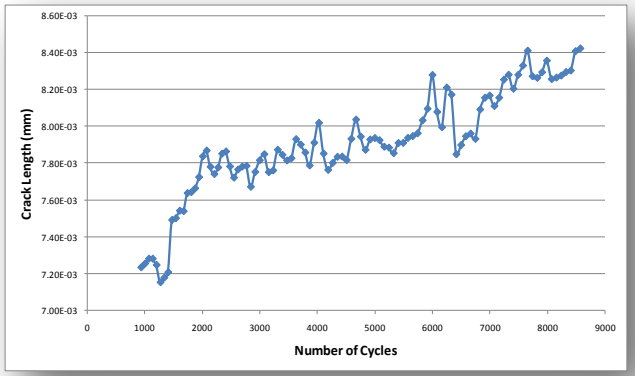
- Pitting Corrosion is an electrochemical oxidation reduction process, that occurs within localized holes on the surface of metals coated with a passive film.
  - A pitting corrosion model was constructed
  - one conference paper was published





Corrosion Fatigue Testing

- Corrosion fatigue experimental work was done using in UMD labs

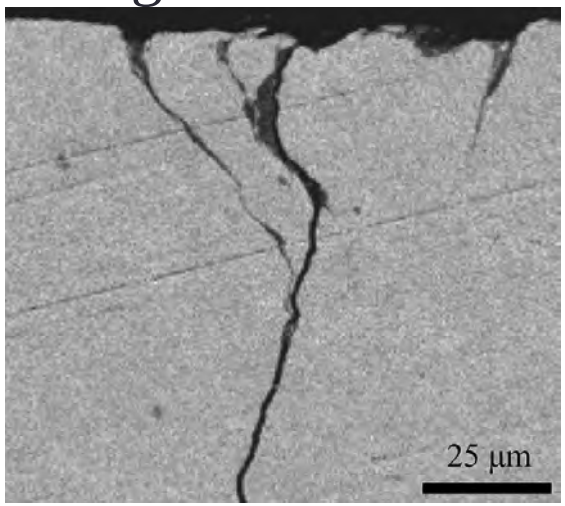


$$a = A \cdot \sigma^{0.182} \cdot \nu^{-0.288} \cdot I_p^{0.248} \cdot N^{1/3} \quad +$$

$$B \cdot \sigma^{3.24} \cdot \nu^{-0.377} \cdot I_p^{0.421} \cdot N^2 \cdot e^{(4\times10^{-10} \cdot \sigma^{2.062} \cdot \nu^{0.024} \cdot N)}$$

Multi-Site Corrosion Fatigue

- simultaneous development of fatigue cracks at multiple sites in the same structural element, such that fatigue cracks may coalesce to form one large crack



- This will lead to having a realistic model that could be used in the industry
- The experimental work will be done in collaboration with Honeywell corrosion lab facility in Houston, Texas

Vision for Next Phase Research

- Multi-Site Pitting and Corrosion Fatigue
- Incorporation of Inspection and Sensor Data and Updating of the Models Developed: Pitting, Corrosion-Fatigue, Stress-Corrosion-Cracking, and Creep
- Accounting for Uncertainties in Visual and Sensor-Based Inspection Data
- Bayesian Updating of the Models using ADNOC data and Experiences in Past Pipeline Failures
- Risk Management and Decision Making for Operational, Replacement and Maintenance Policies

THANK YOU