Agency Perspective – AFRL

Vision of the Need for Model-Assisted Approaches to POD Determination

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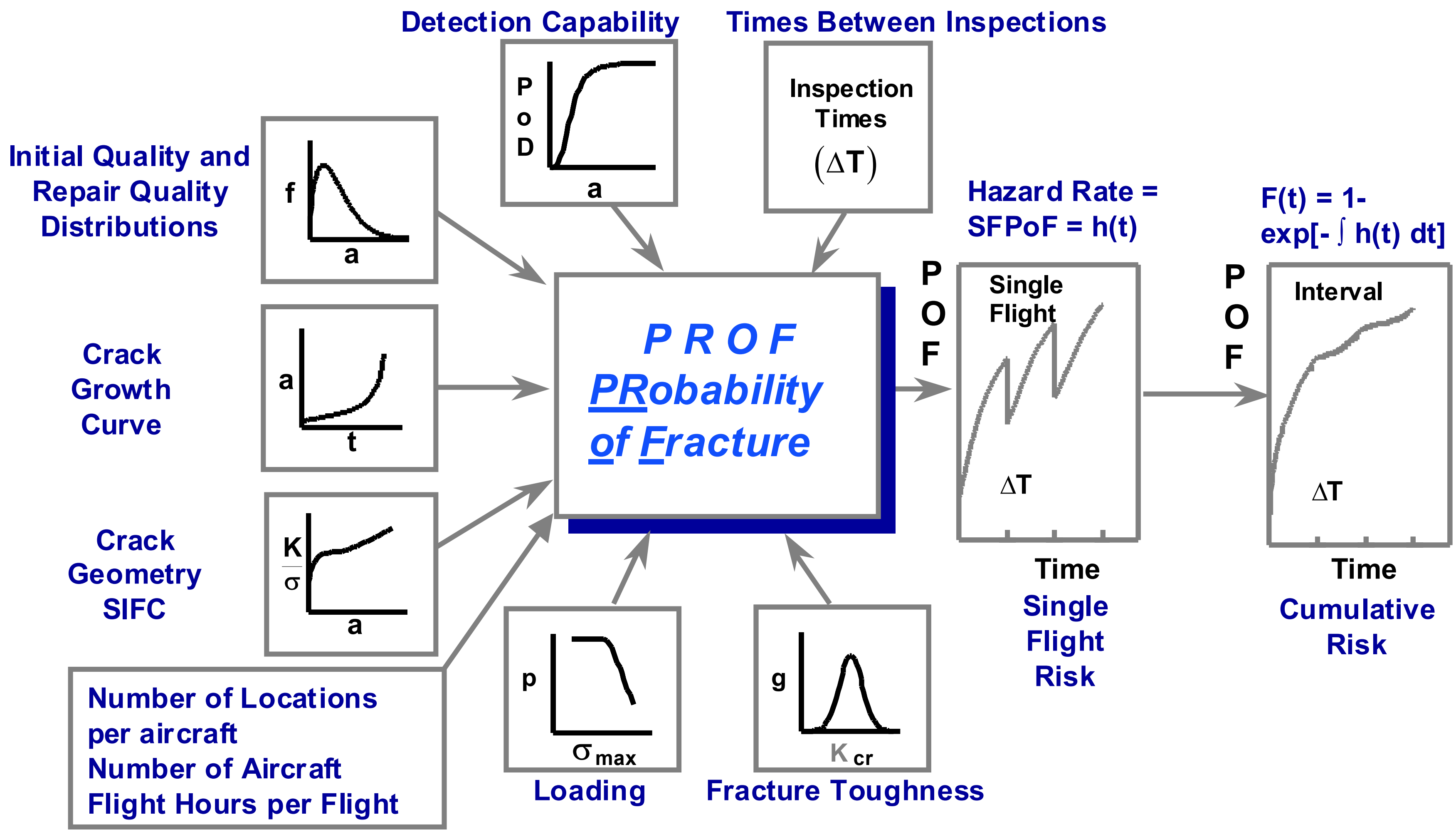
- Matt Golis
- Tom Moran

Wave of Requirements and Technologies

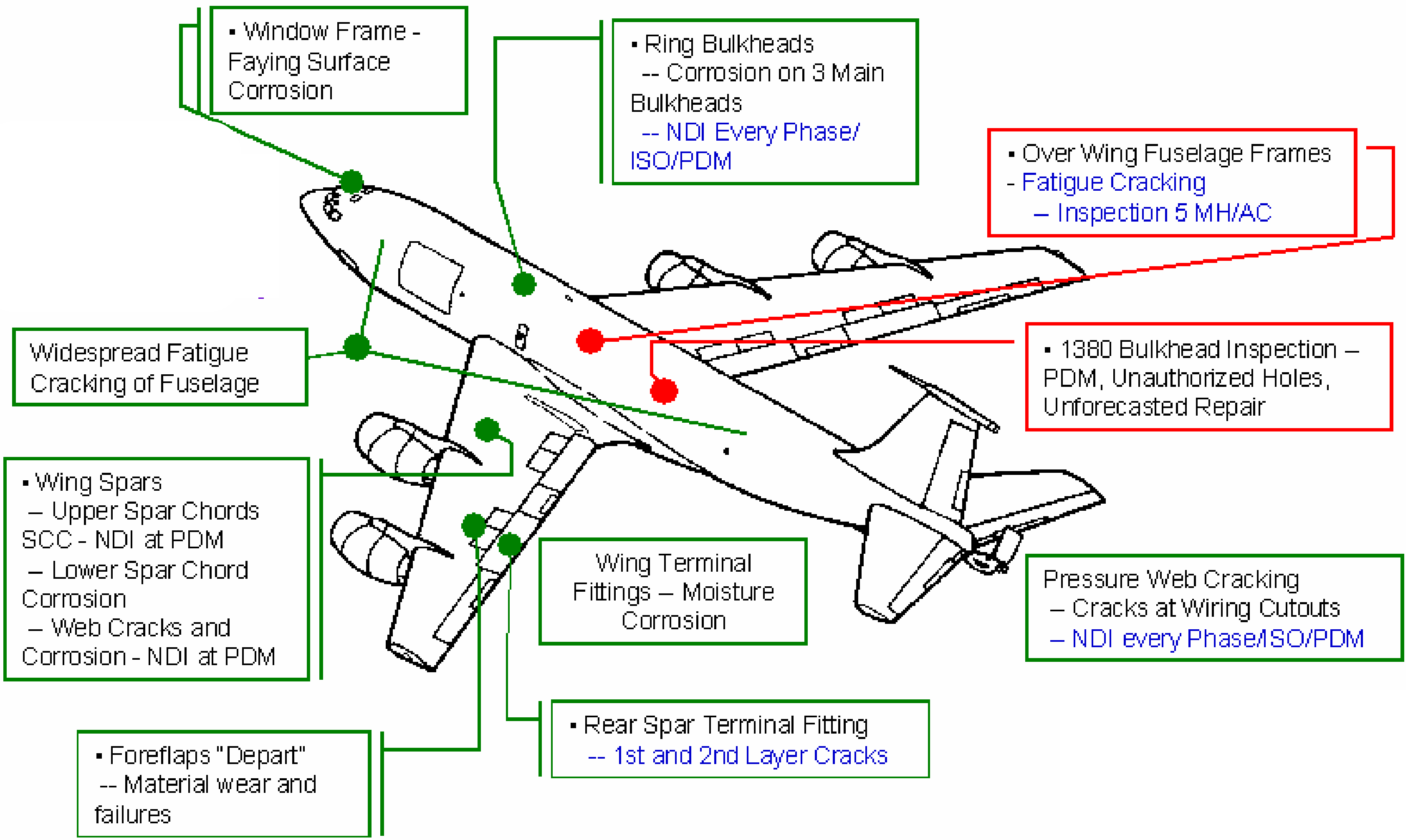
- Man-hours for NDT scheduled to increase dramatically!
- Need to insert new technologies into the field, faster and cheaper!
- Implementation of inspections without POD undermines NDE!
- Damage tolerant risk analysis techniques demand Quantitative NDE!

(Gallagher, Babish, and Malas, 2005)

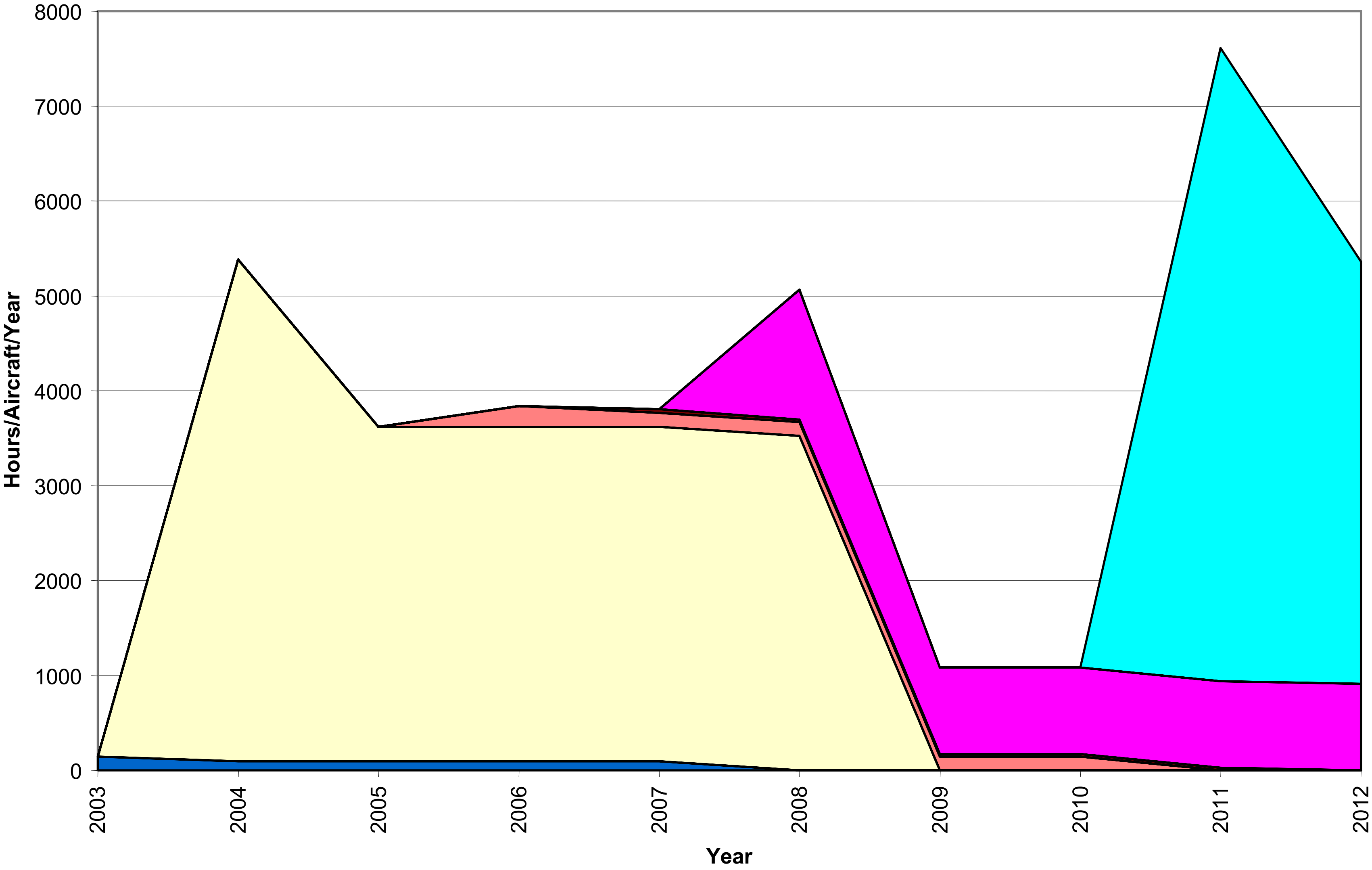
Risk Analysis Input parameters



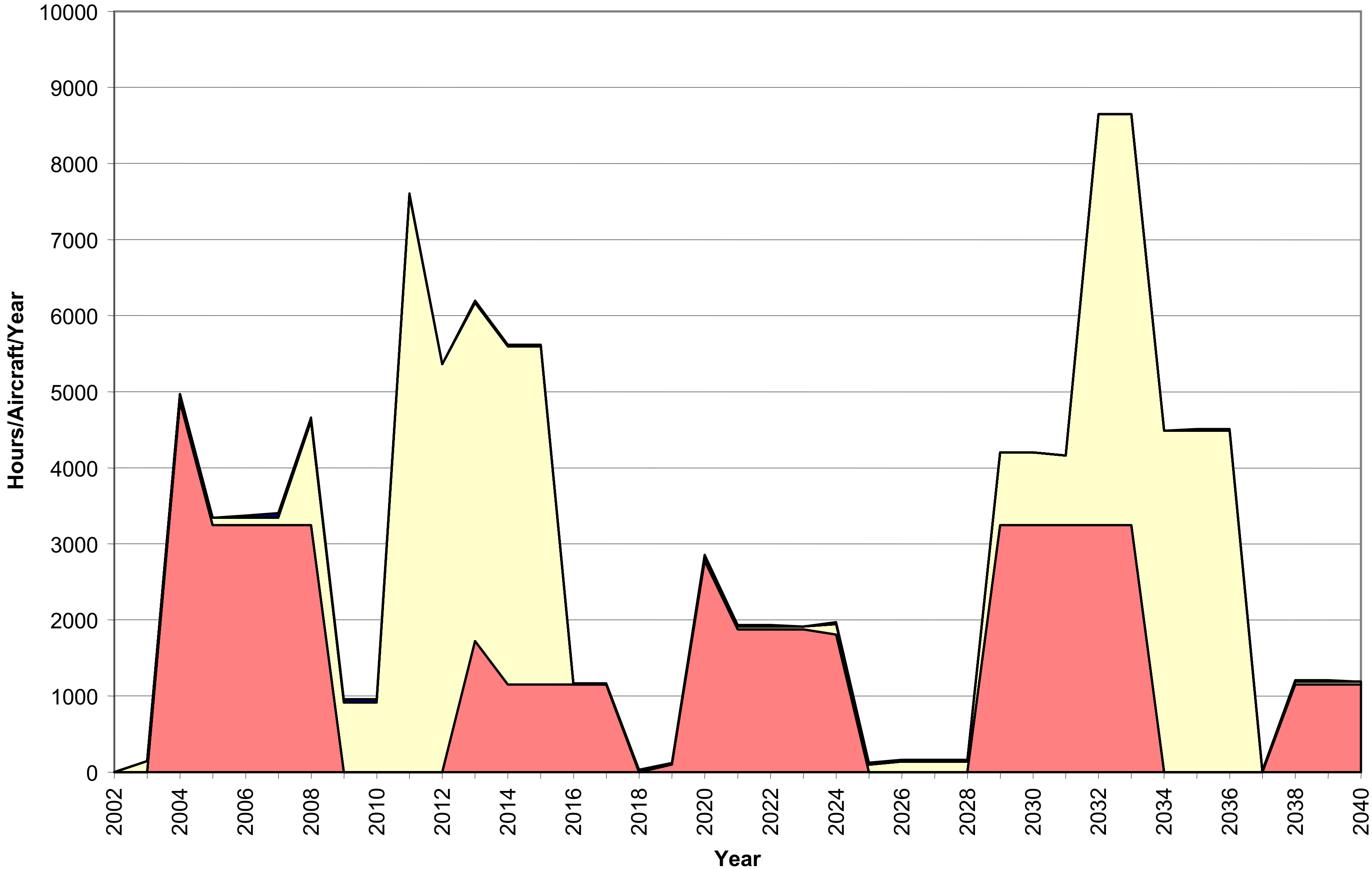
Typical Maintenance Issues



Near Term Inspections



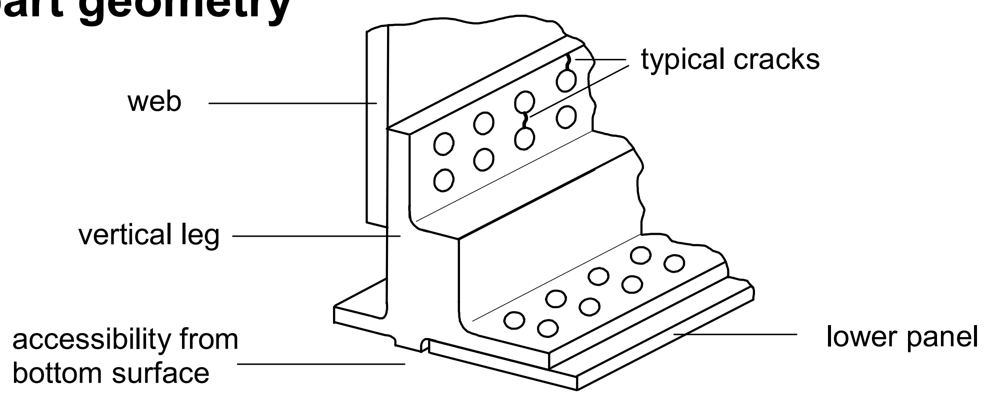
Life Time Inspections



General Challenges for POD Evaluation

- Address High Costs for Performing Existing POD Evaluation
  - High cost of parts (material) *(B1 wing carry through)*
  - High cost of flaw creation *(corner cracks, alpha particles)*
  - Labor to perform POD study
- Additional Opportunities using Model-Assisted Approaches
  - Streamline validation of new technologies for in-field application
  - Improve confidence in NDE techniques for complex inspections
    - Address wide variations in flaw characteristics and location
    - Address variations in part geometry

Ex: C-130 Beam Cap Holes



Prior POD Validation Studies

- Have Cracks Will Travel (1979) (crack detection)
- Retirement for Cause (RFC) (crack detection)
- WRALC / SAIC UltraImage Int. (Aging Aircraft Program Office) (1997 - 2004)
  - C-141 Splice Joint (crack detection)
  - C-141 Weep Hole (crack detection)
  - C-130 Hat Section / C-130 Rainbow Fitting Holes (crack detection)
  - C-130 Beam Cap Holes (crack detection)
- AFRL - Aging Aircraft Program Office / Sandia NL
  - FastFocus system – RD Tech (2003) (crack detection)
- ACDP UDRI (corrosion detection)
- Sandia NL Studies
  - 727 Fuselage Lap Joint Lower Skin (crack / corrosion detection)

Future Need for POD Determination
(Transfer Function Approach)

- Address transition of techniques to other aircraft (with varying part geometry and/or material properties)
  - from C-141, C-130, KC-135 etc.
  - to A-10, C-5, C-17 etc.

- Address costs for validation of new technologies
  - New sensors
    - EC: MWM, RFEC, GMR arrays
    - UT: Phased arrays (FastFocus, TESI program)
  - New techniques (Pulsed EC)

(Full POD validation exists for original part and technique)

Future Need for POD Determination
(Transfer Function Approach)

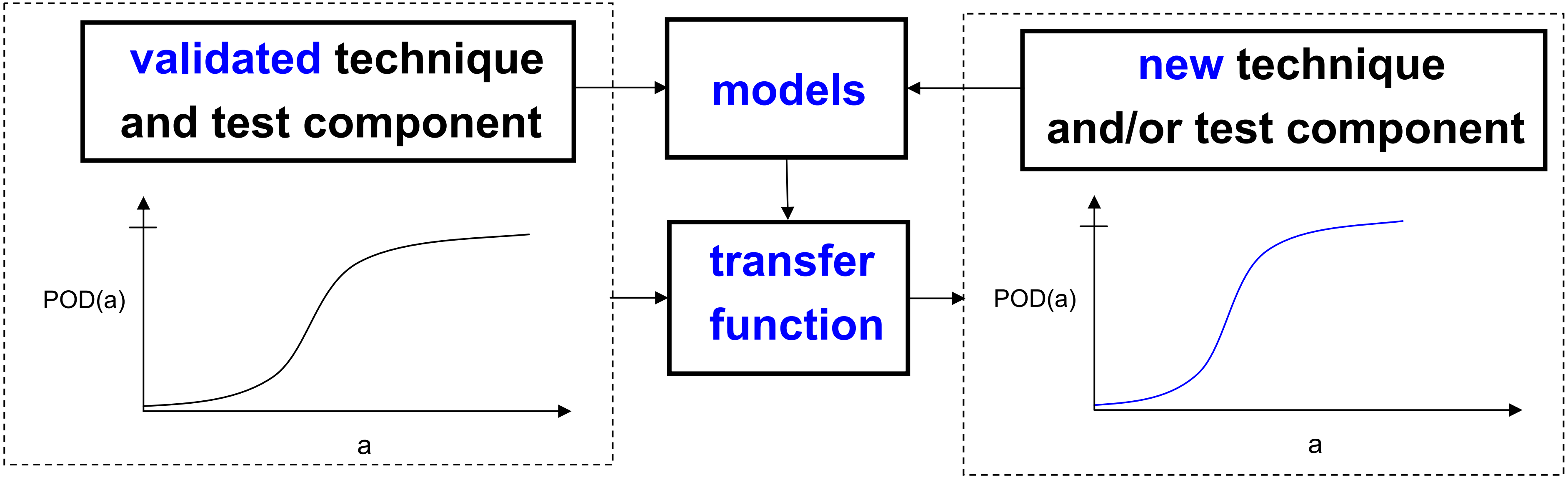
- Use lower cost manufactured flaws for full POD and extrapolate POD results for real flaws using *accurate simulations and/or prior empirical data*
  - EDM notches for real cracks
  - Simulated defects in engine components

- Reduce number of experimental samples required for a full POD and extrapolate POD results for real flaws using *accurate simulations and/or prior empirical data*

What is a POD Model Transfer Function?

Approach: Extrapolated POD (M. Golis)

- **Description:**
  - POD results have been well established (RFC)
  - Minor changes in equipment (probes) or part geometry
  - Assess equivalent POD without need a full-scale evaluation
- **Diagram:**



What is a POD Model Transfer Function?

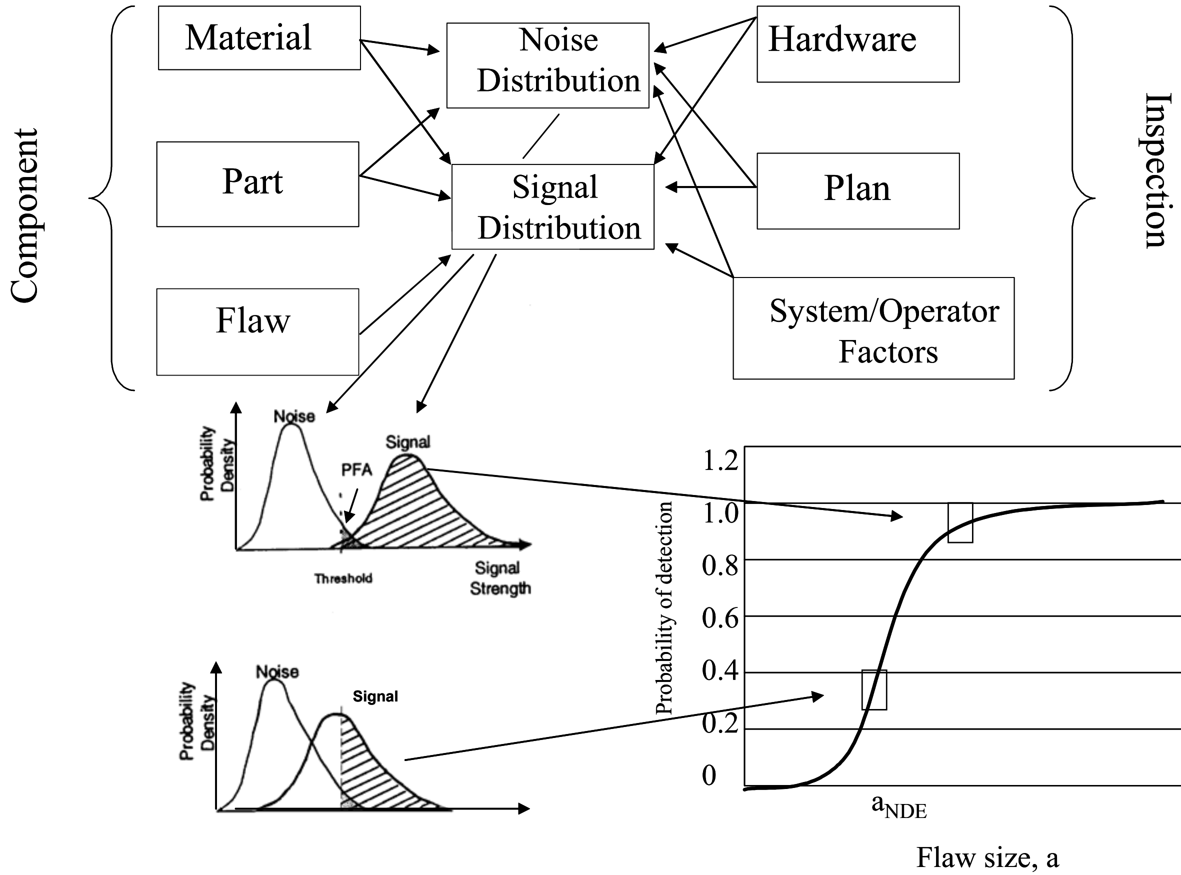
Approach: Extrapolated POD

- **Potential methodology**
  - **Apply protocol to evaluate key parameters impacting NDE (NDE Insight, modify protocol for model-based evaluation)**
  - **Construct models for validated system and new system *(system = technique and test component)***
  - **Evaluate model-based POD (for intrinsic capability with key application parameters) for both validated and new systems**
  - **Calculate transfer function between two model-based PODs**
    - ***linear transformation (?)***
    - ***nonlinear transformation (?)***
  - **Apply transfer function to original POD for validated system to estimate new system POD (incorporating human factors)**

What is a POD Model Transfer Function?

Approach: Modular POD (B. Thompson)

- **Quantify signal and noise distributions using a modular assessment via simulated and experimental studies**



What is a POD Model Transfer Function?

Approach: Modular POD (B. Thompson)

- **Methodology**
  - Identify factors whose influence can be simulated using a physics based model
  - Develop appropriate model
  - Verify its accuracy in the laboratory through well controlled experiments
  - Use simulation tool to predict mean response and those components of variability controlled by well understood physical phenomena
  - Quantify additional sources of variability not controlled by well understood physical phenomena or associated with variations of input parameters that cannot be fully controlled in the production environment
  - Compute POD

Future Need for POD Determination (New POD Models)

- POD model relationships and validation studies for multiple quantitative measures to characterize a single flaw parameter
  - Operators use multiple features for making calls (C-scan, B-scan image data)
  - Automated Signal Classification also will take advantage of multiple features -> translate to final classification call
- POD model relationships and validation studies for multiple quantitative measures to characterize multiple flaw parameters
  - Corrosion (thickness loss, spatial extent, SCC, exfoliation)
  - Geometric flaws in engine components (3D POD)
- Validating NDE techniques with flaw classification procedures incorporating model-based inverse methods