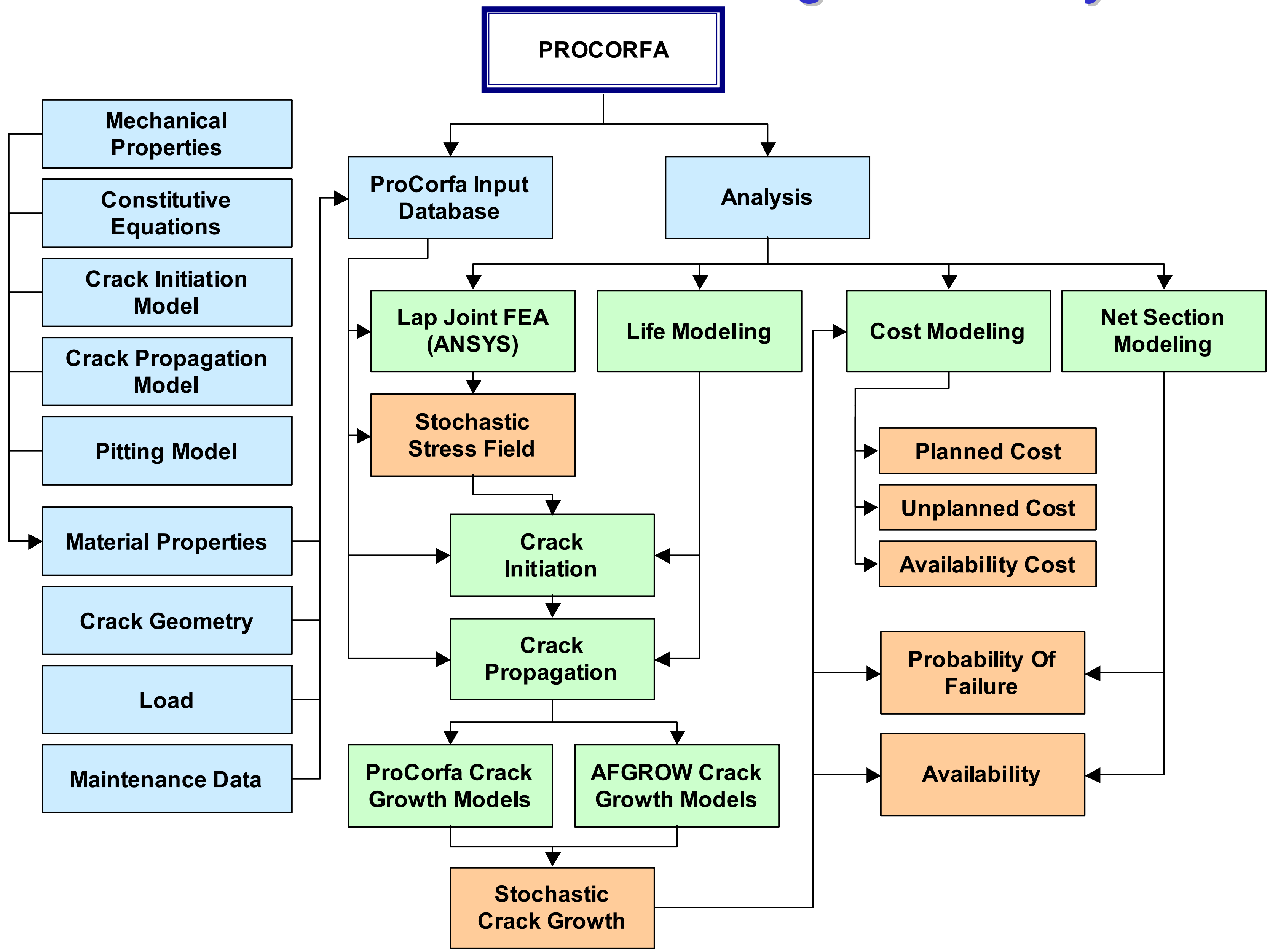
ProCORFA GUI: Main Window Dialog

ProCORFA Main Window

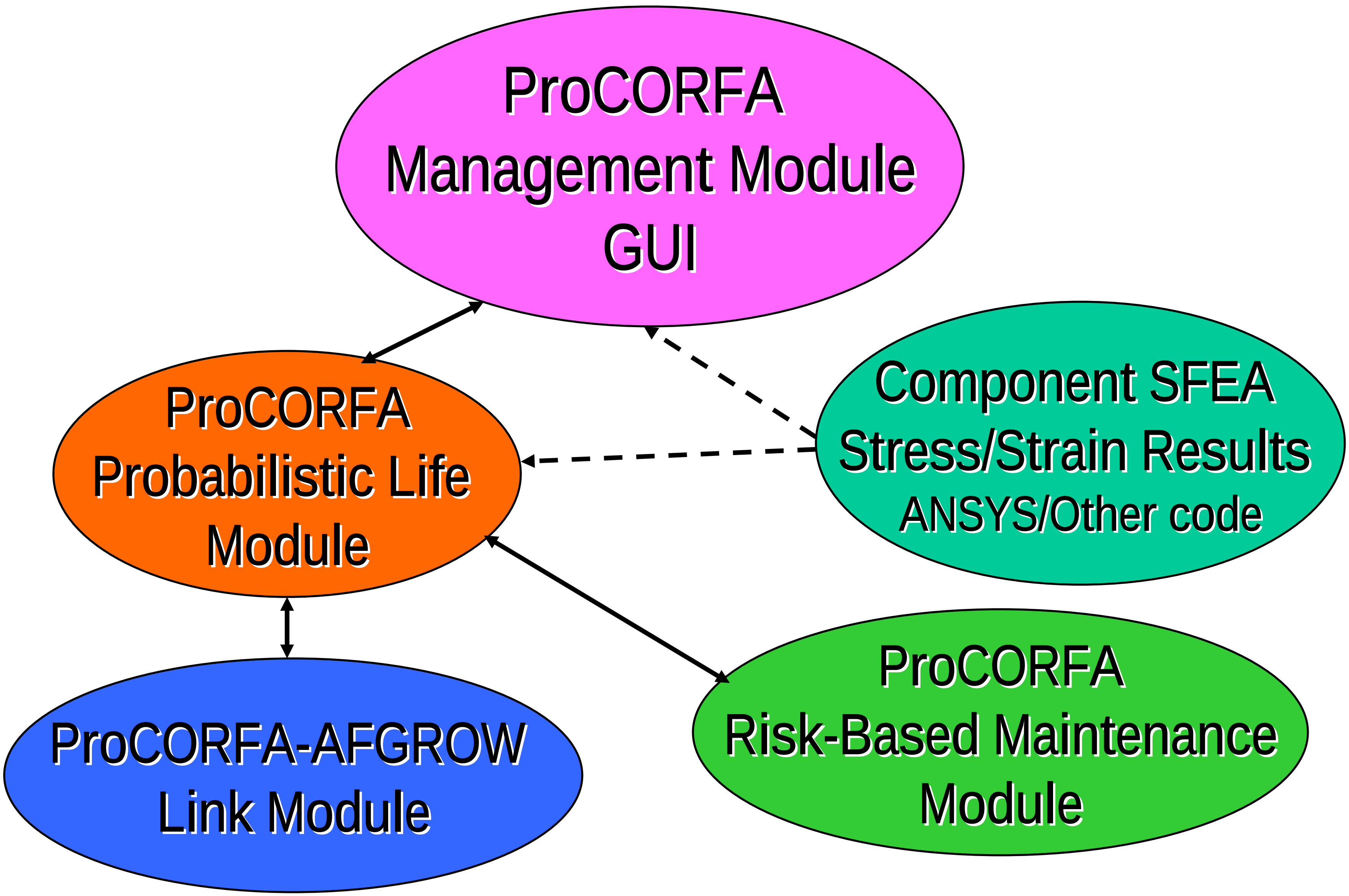
Main Menu Items:

- File
- Input Data
- Component Model
- Analysis Options
- Review Results
- Graphics
- Setting
- Help

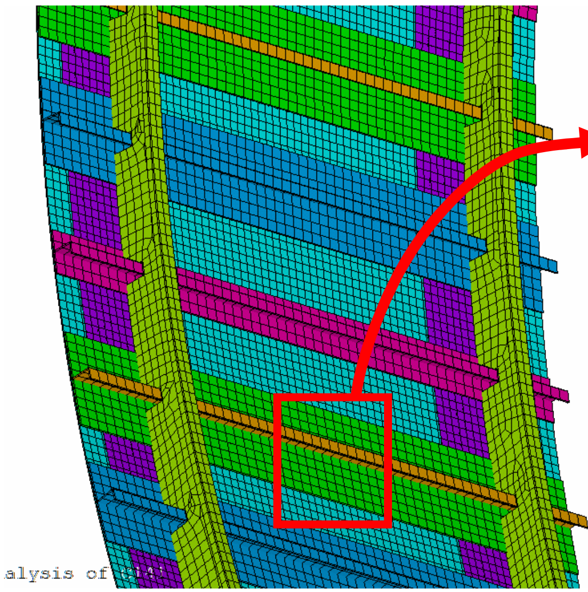
ProCORFA Software Configuration Layout

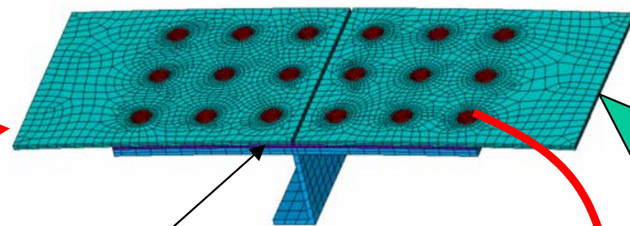


ProCORFA Modular Configuration



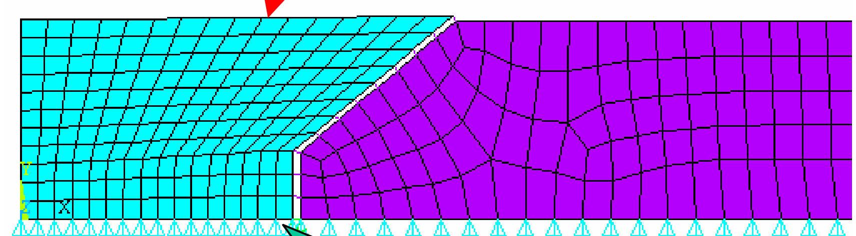
Multi-Scale Stochastic FE Approach





Displacement constrains of boundary nodes are interpolated from global model using sub-modeling technique

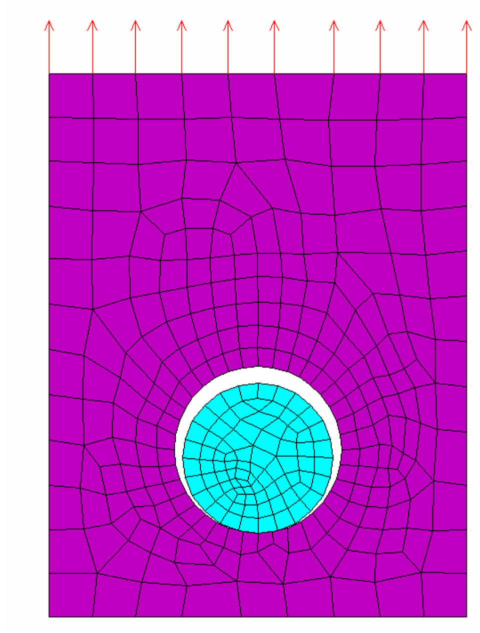
Local Model:
- Solid elements
- Includes contacts
- Obtain BC from global model
- Consider stochastic parameters
- Detailed local stresses



Global Model:
- Shell and beam elements
- "Weld" stringers and frames with skin panel
- Linear analysis
- Find critical locations

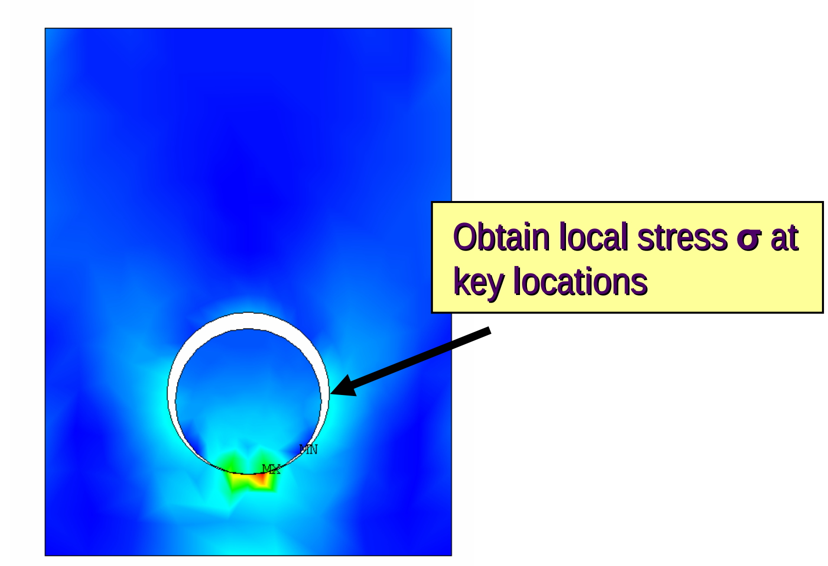
Very Local Model:
- Axi-symmetric elements
- Material and full contact nonlinearity
- Residual stress and interference analysis

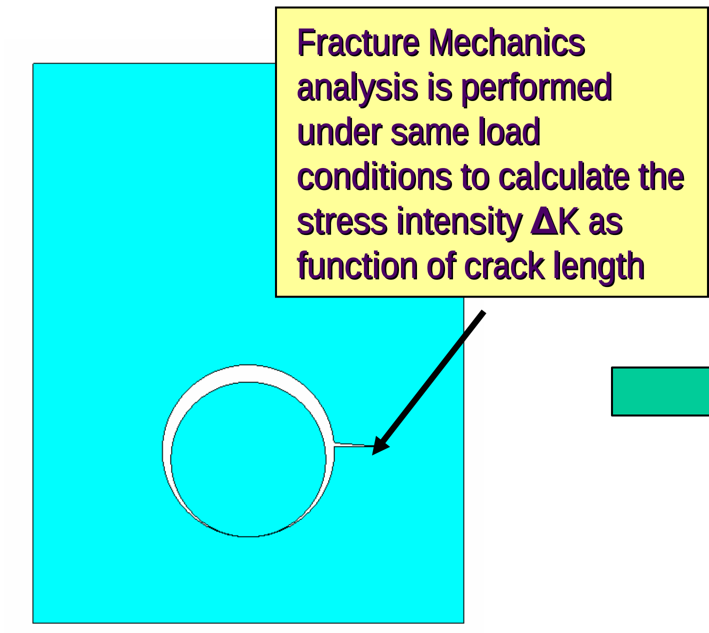
(collaboration with STI Technologies Inc.)

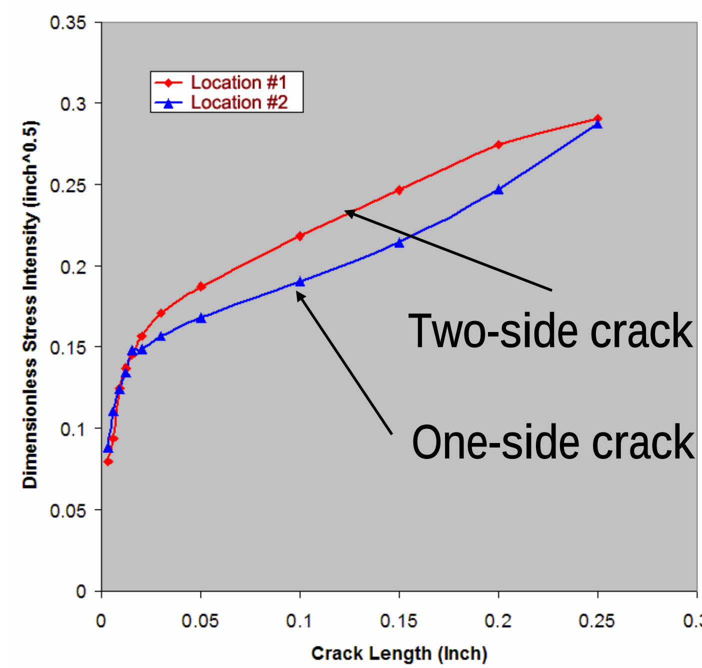


Single hole plate-rivet model

Contact FEA

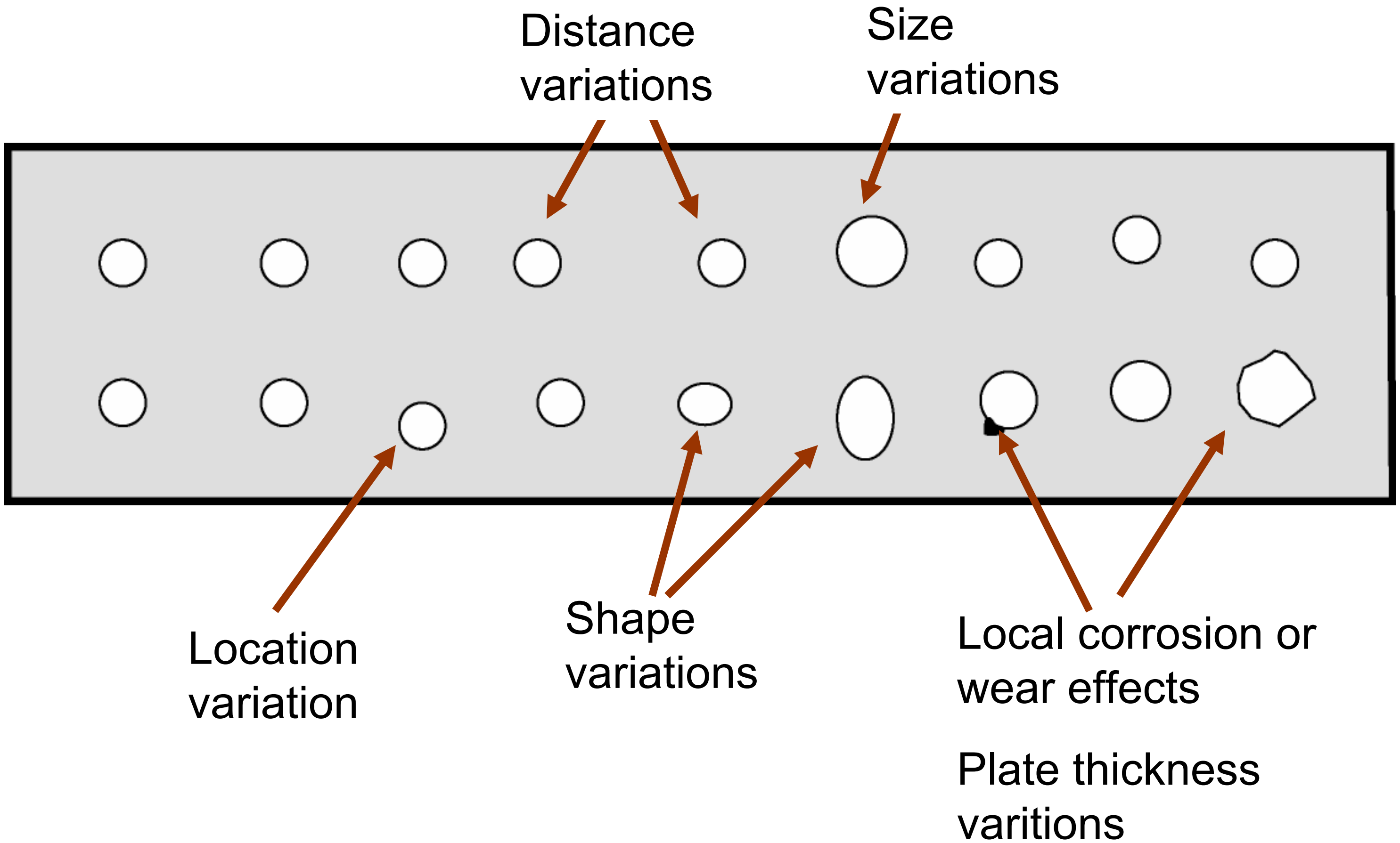






Dimension less stress intensity $\beta(a) = \frac{K}{\sigma\sqrt{\pi a}}$

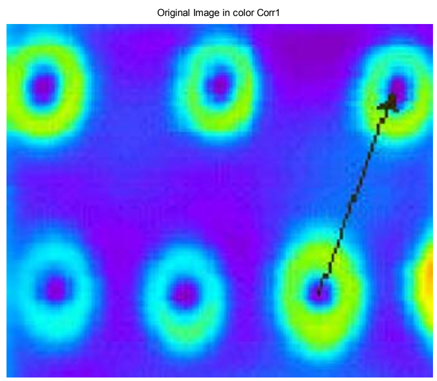
Stochastic FE Analysis for Local Stress Distribution



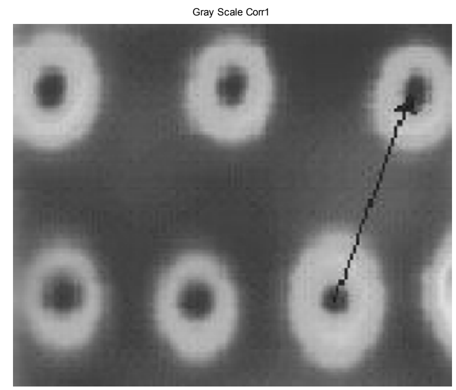
- Obtain the local stress distribution considering all the random variabilities.

- Perform fatigue analysis assuming the same dimensionless stress intensity β obtained from the single-hole model shown in the previous slide

Stochastic Corrosion Surface Topographies

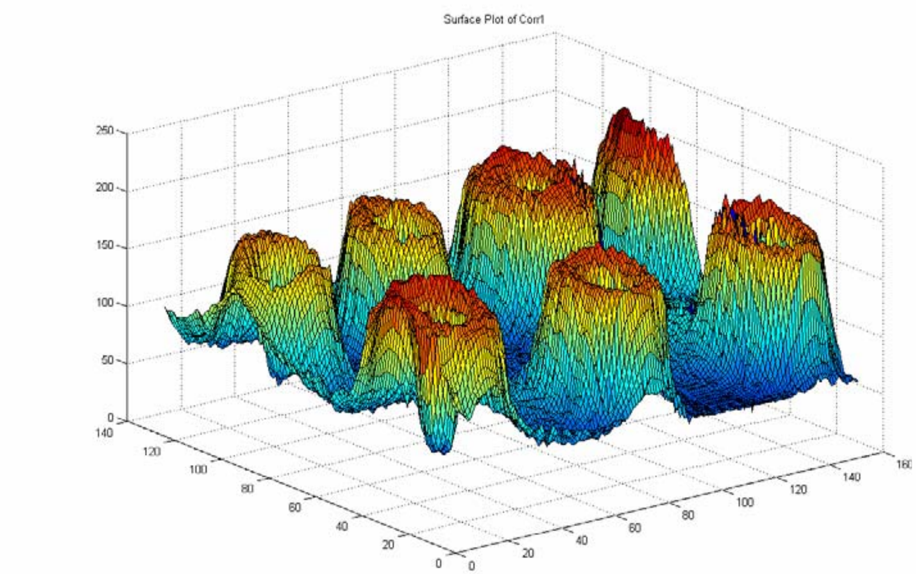


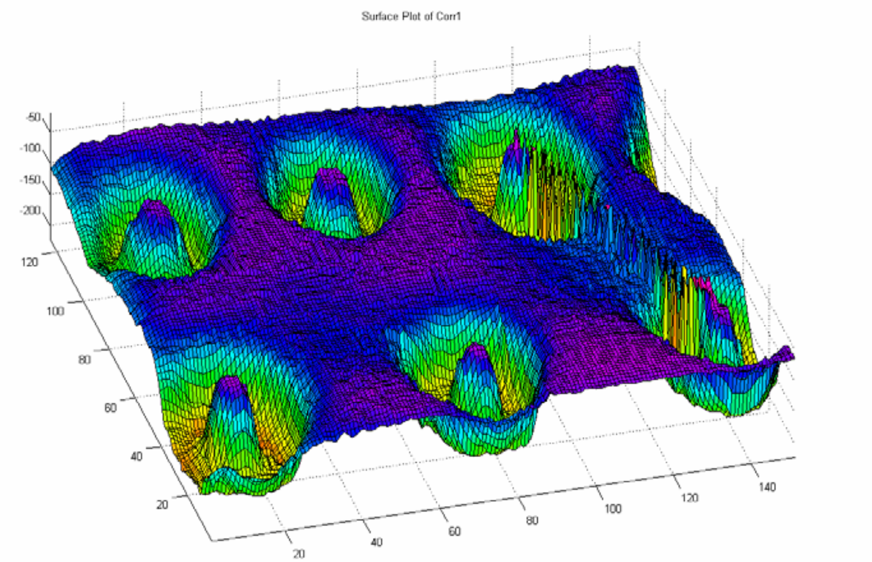
Original RGB Image



Grayscale Image

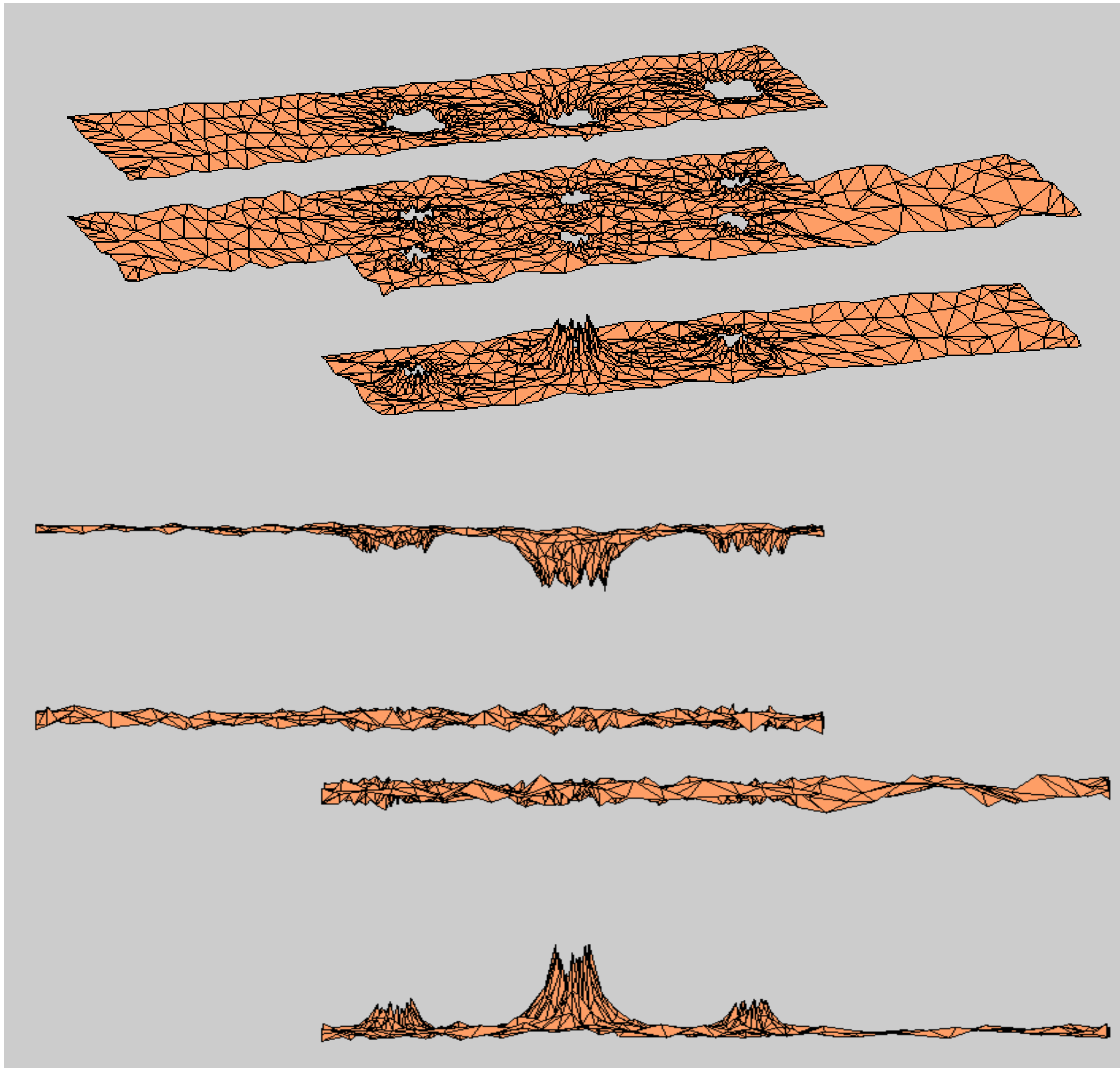
Corrosion Sample # 1



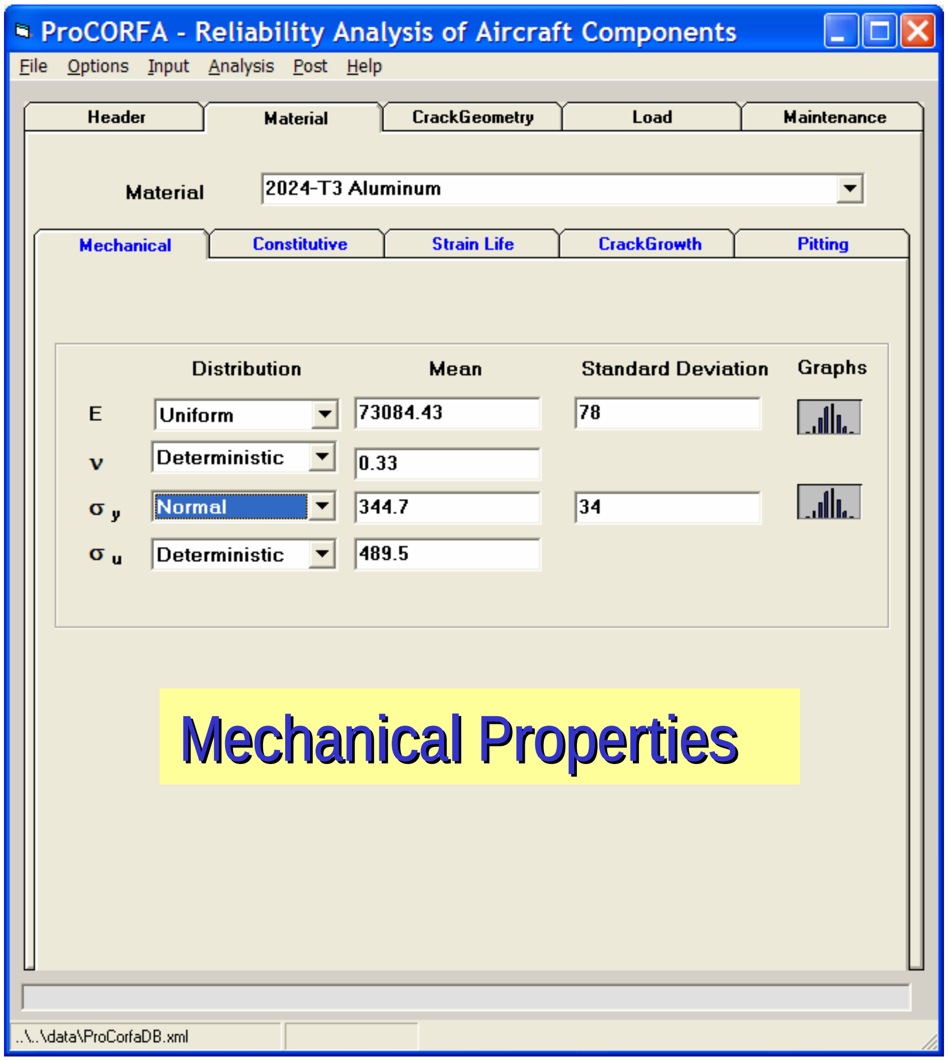


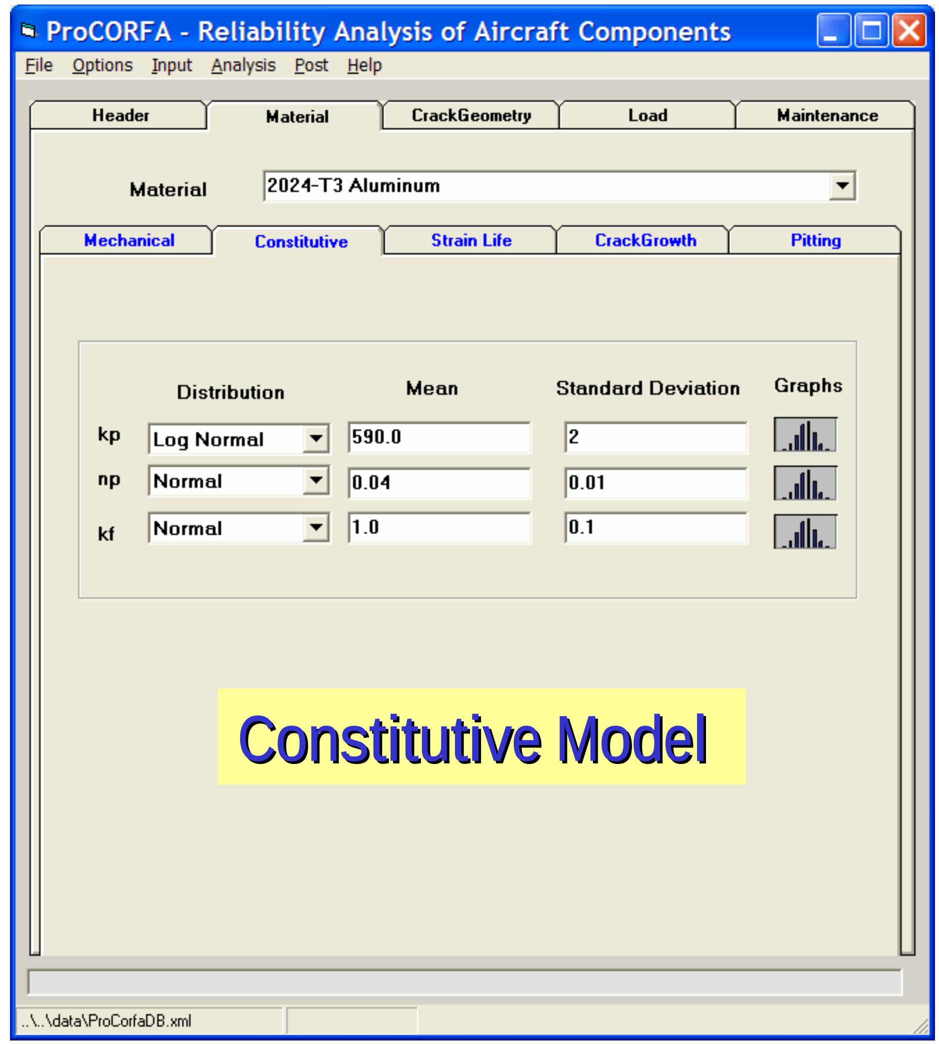
Surface Plots from different Views

Simulated Stochastic Corroded Surfaces for FE Model

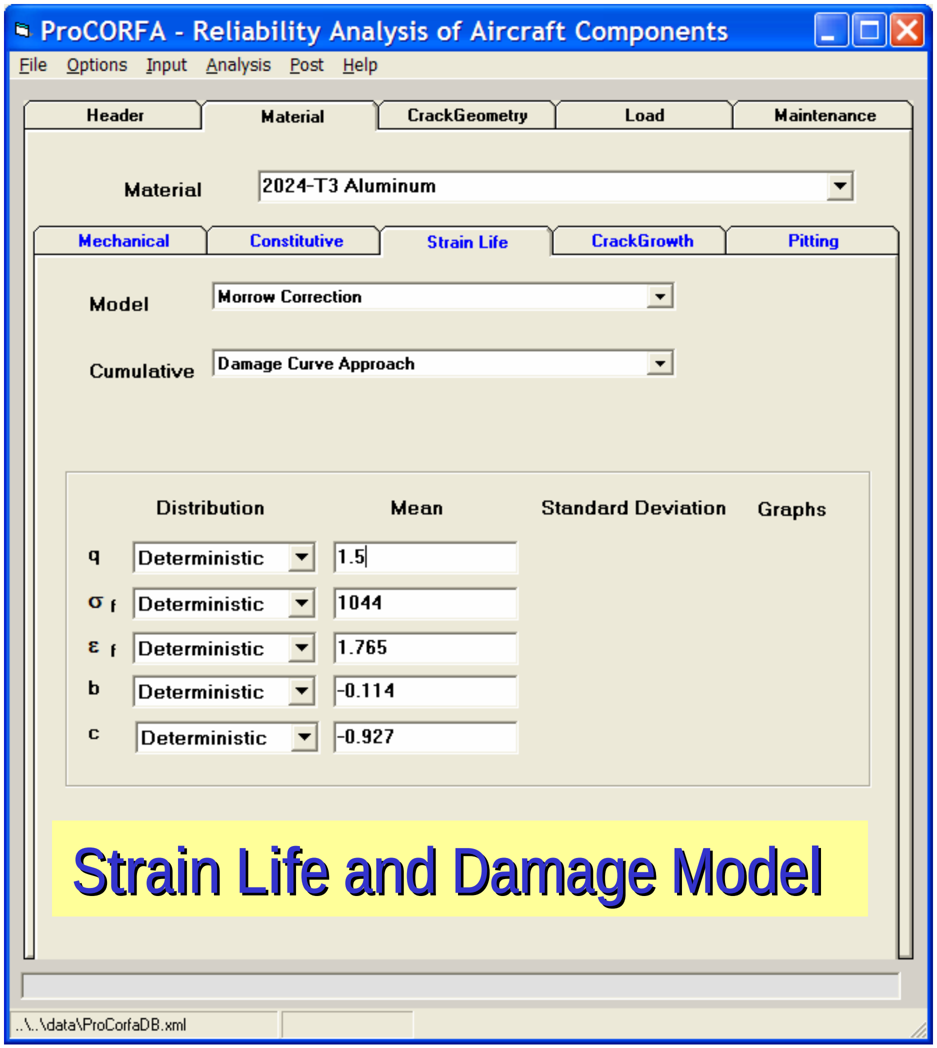


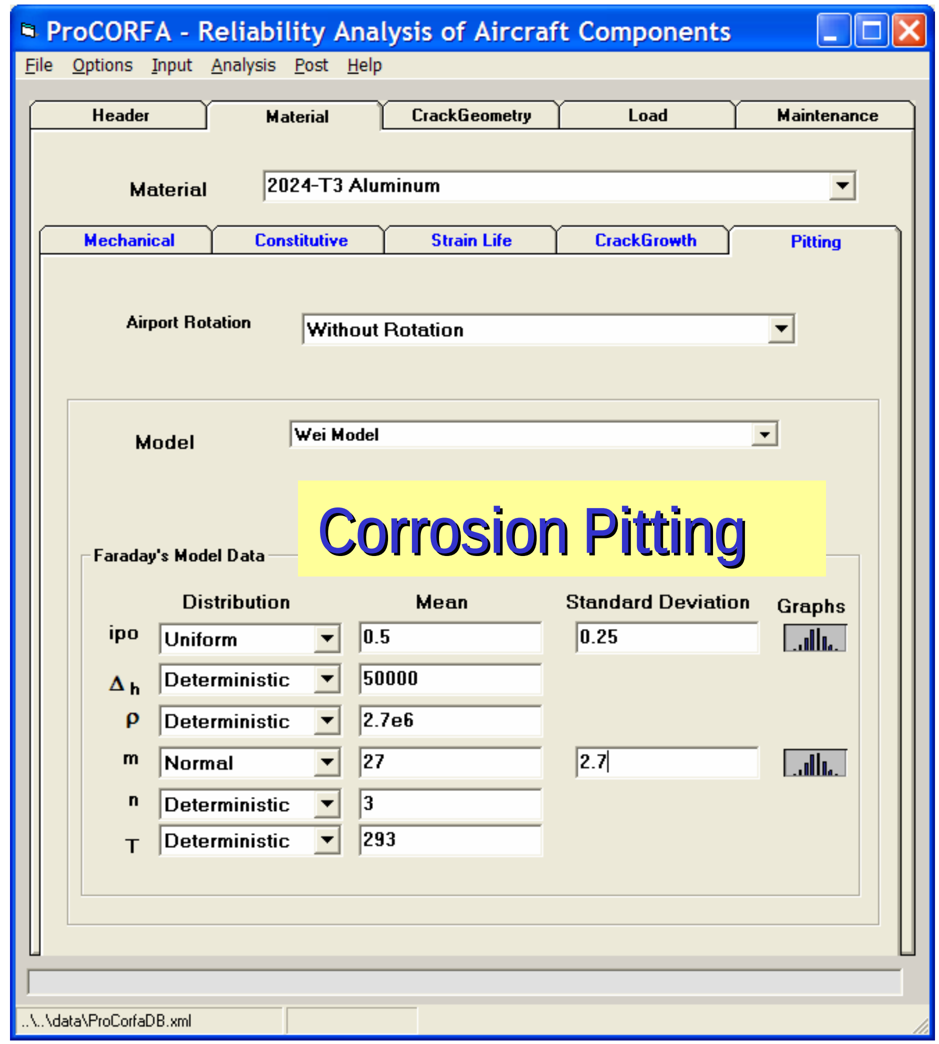
Mechanical Properties & Constitutive Model



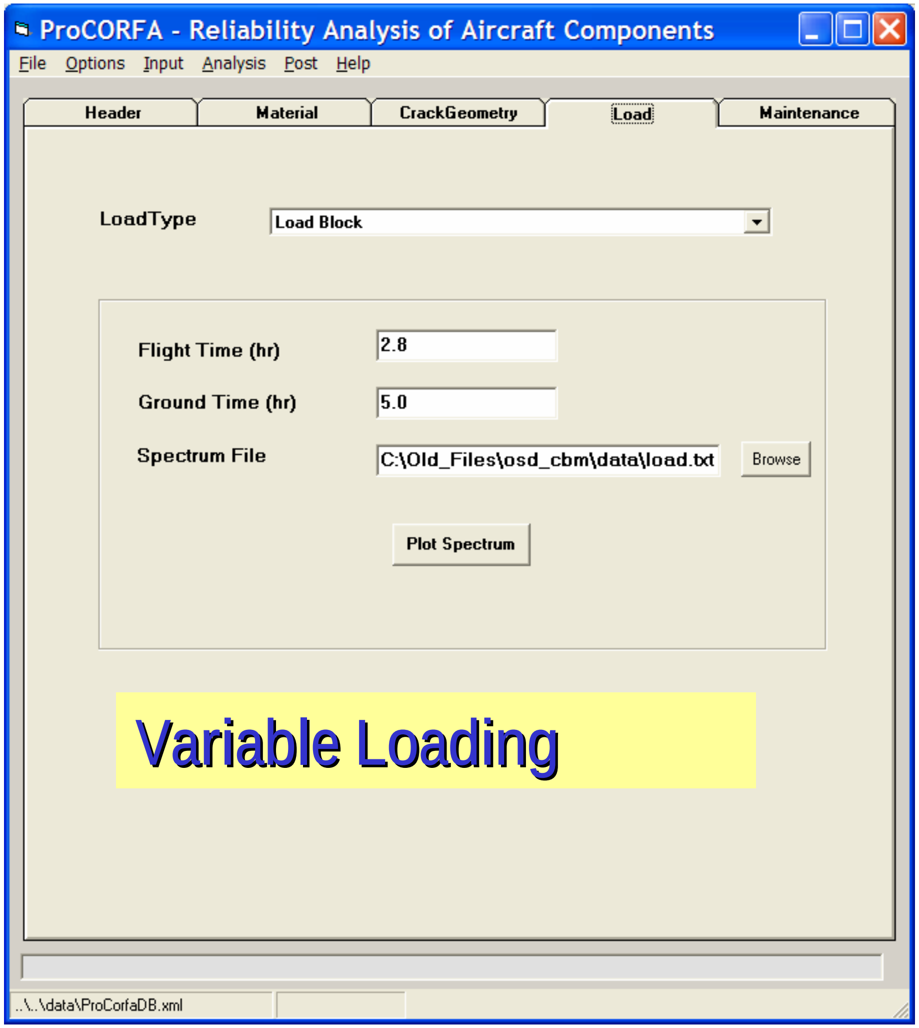


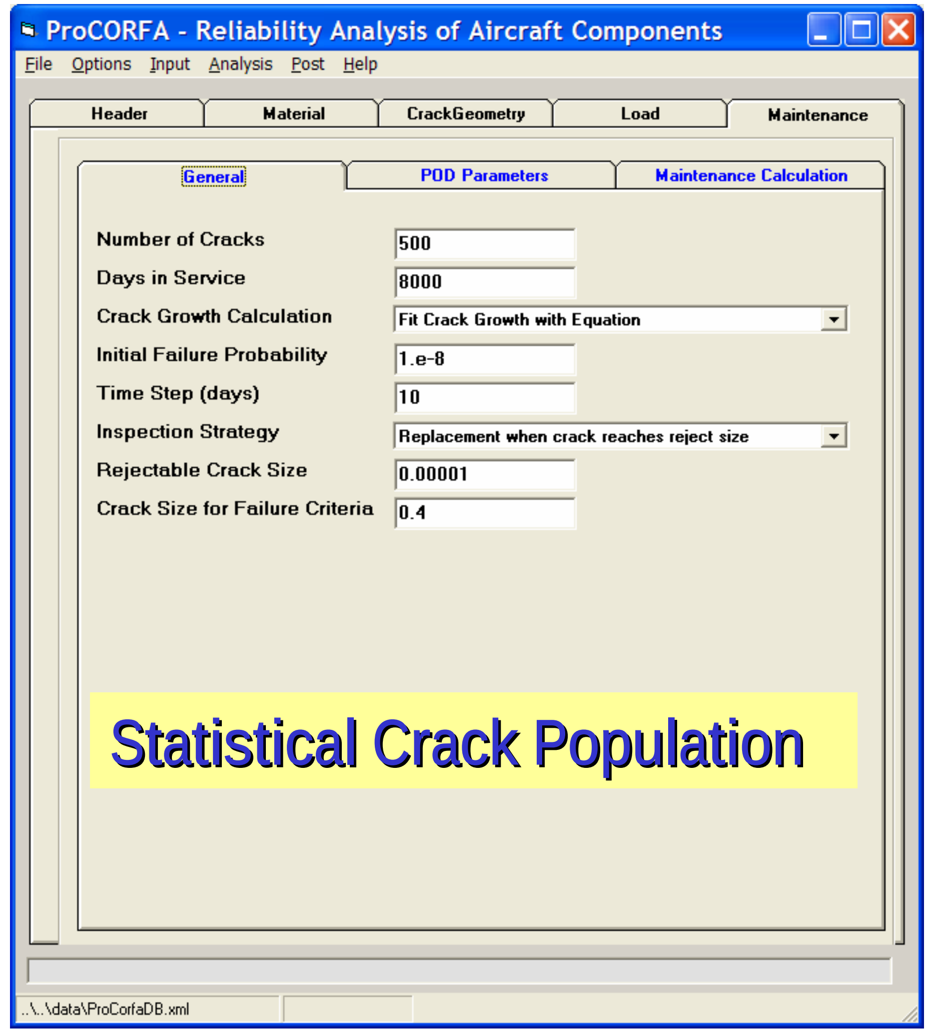
Strain Life, Fatigue Damage Model and Pitting



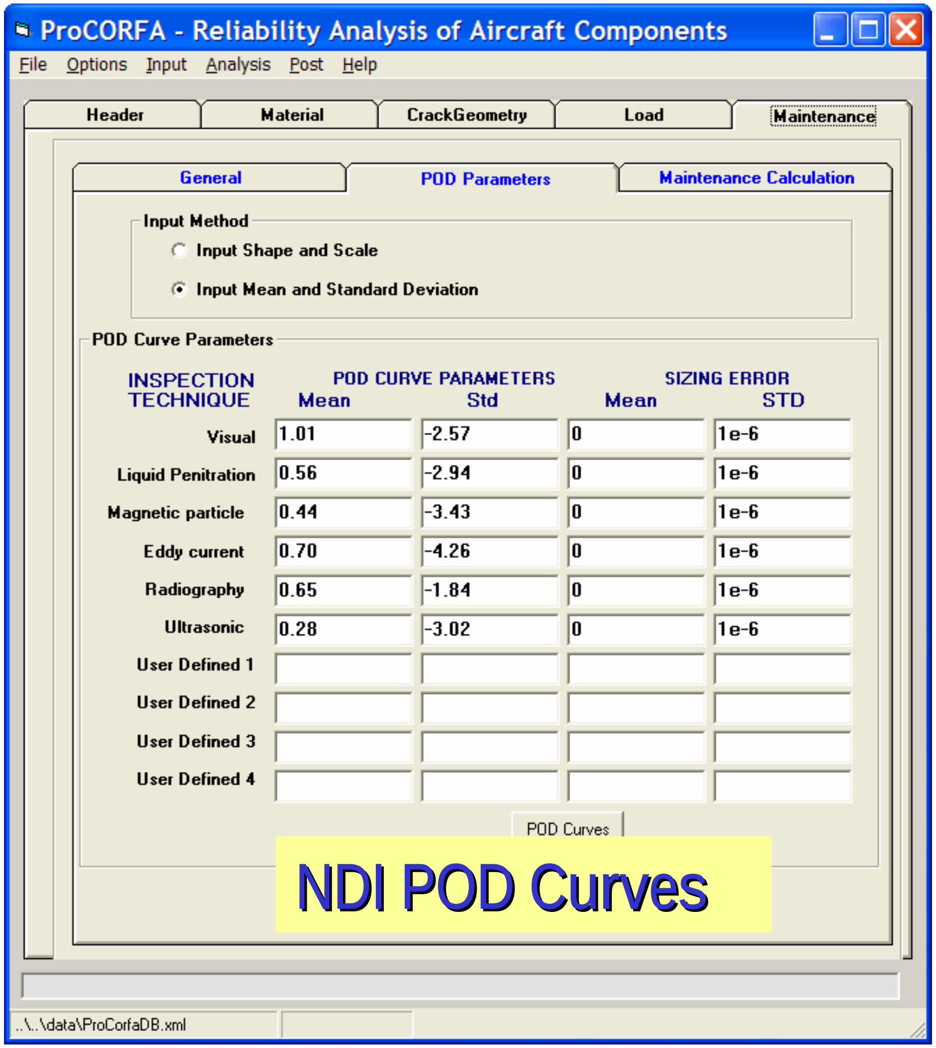


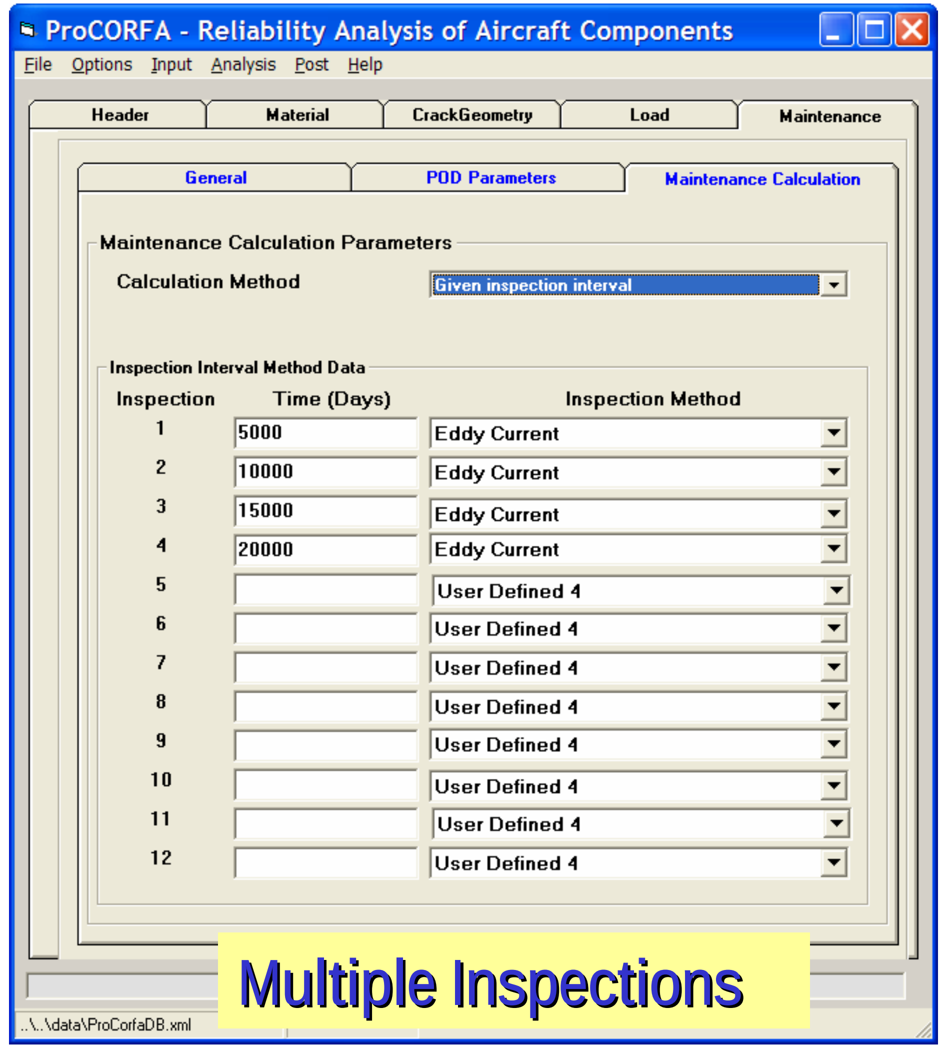
Variable Loading and Statistical Crack Population



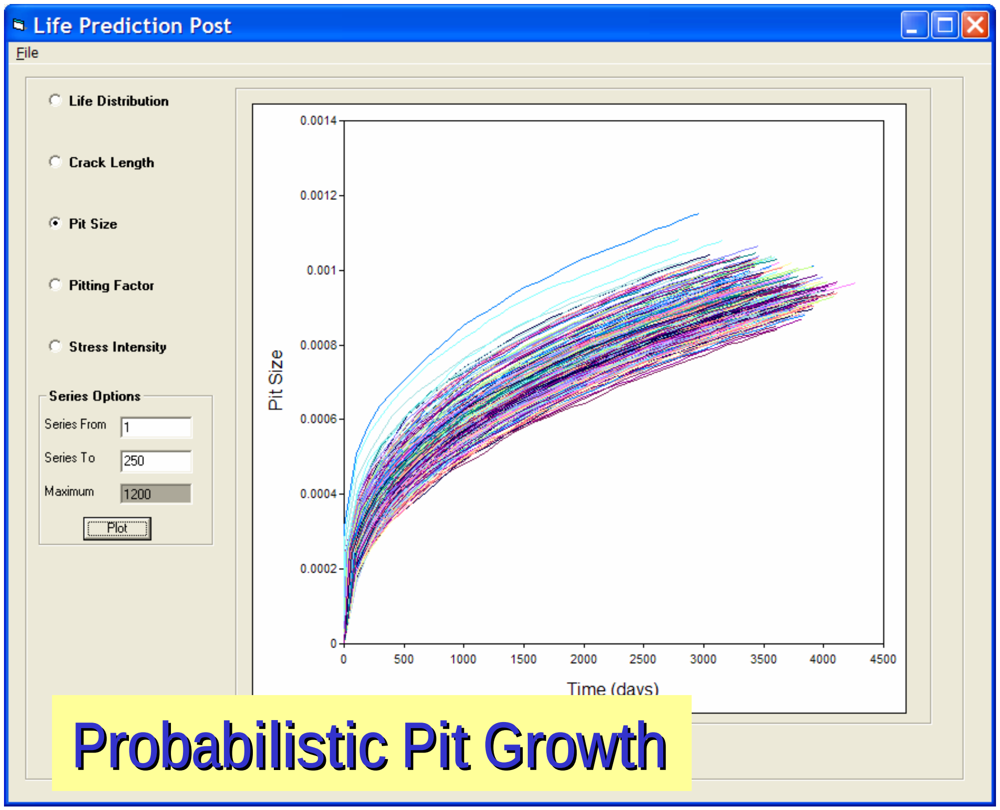


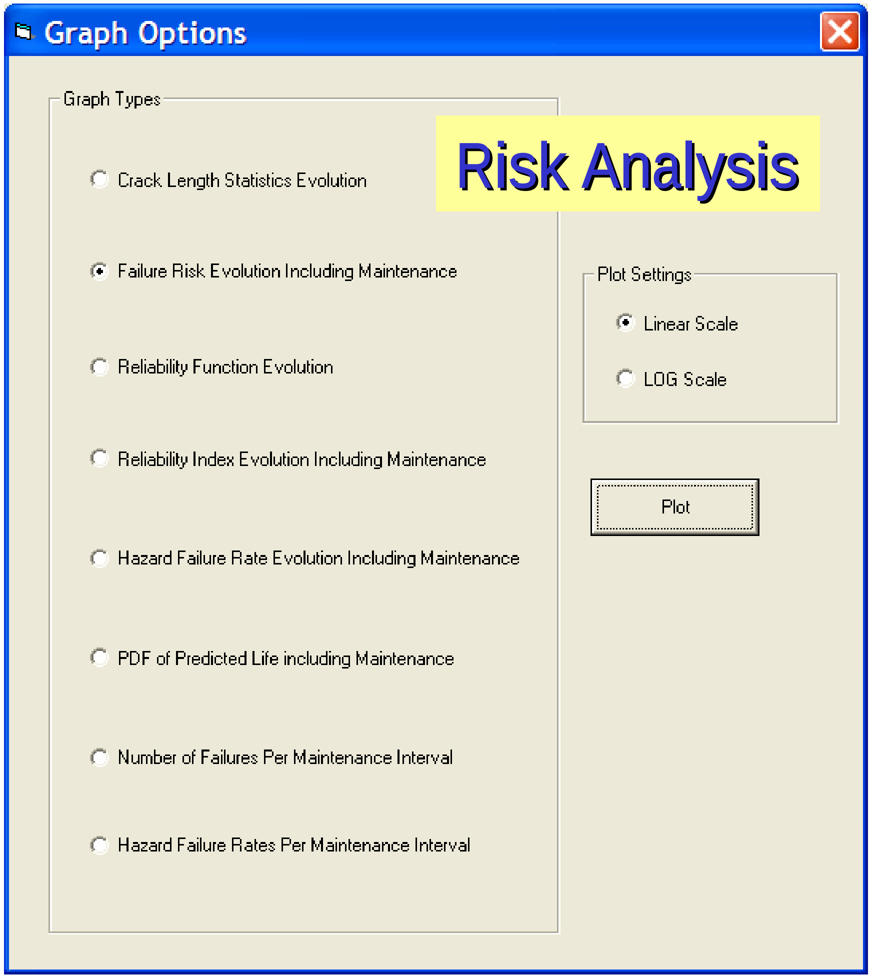
Maintenance Info: POD Curves, Inspection Times



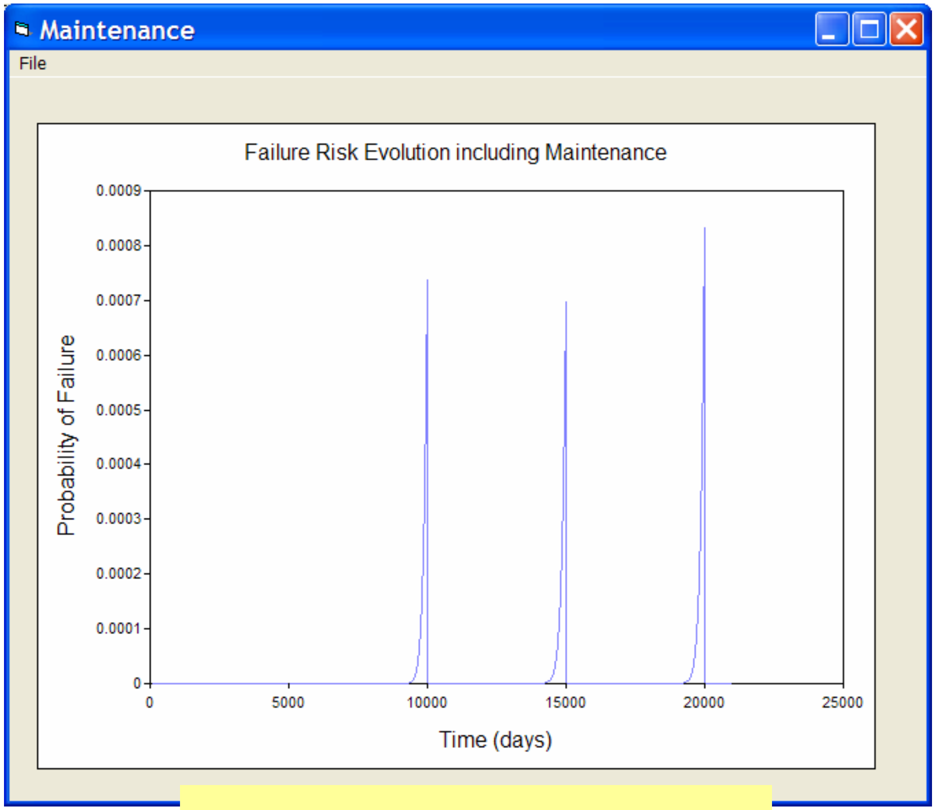


Life Prediction and Risk-Based Condition Assessment

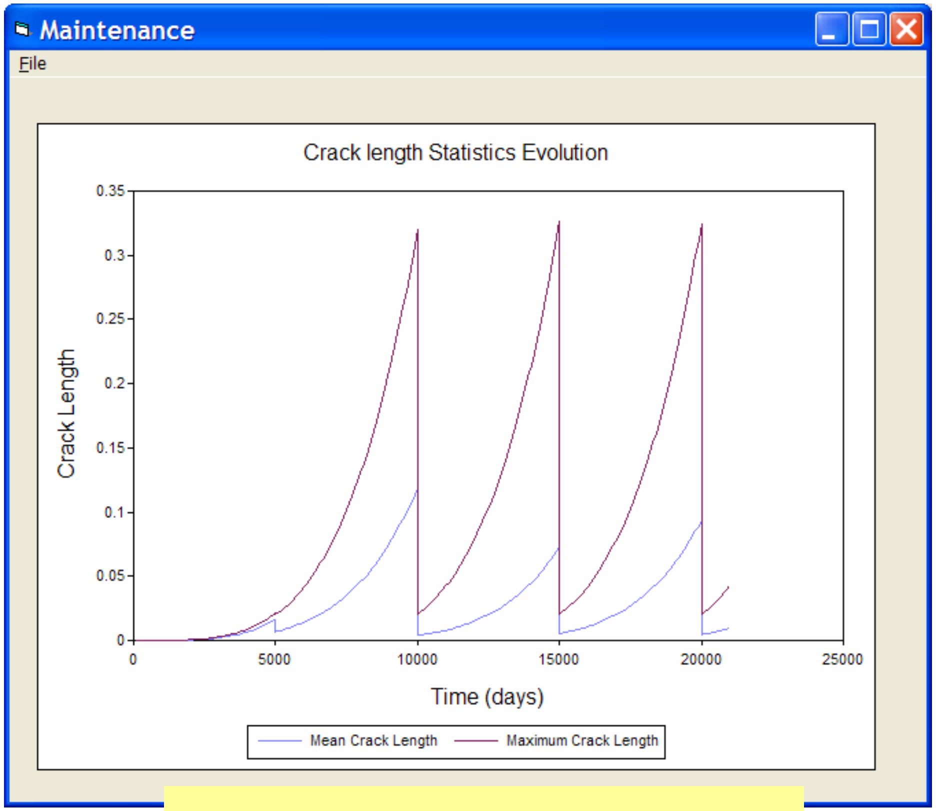




Crack Statistics & Risk-Based Condition Assessment



Failure Risk Evolution



Crack Growth Statistics

Probabilistic Optimal Life-Cycle Cost Analysis

- **Objective:** Develop an optimal inspection program that minimizes cost under reliability constraints

- Assumptions:

- Crack growth model:

$A(t)=A_0 \exp(\Lambda t),\ t > 0$ (A_0 and Λ are random)

- Cracks with length

. $A(t) > a_{cr}$ => replaced (failure)

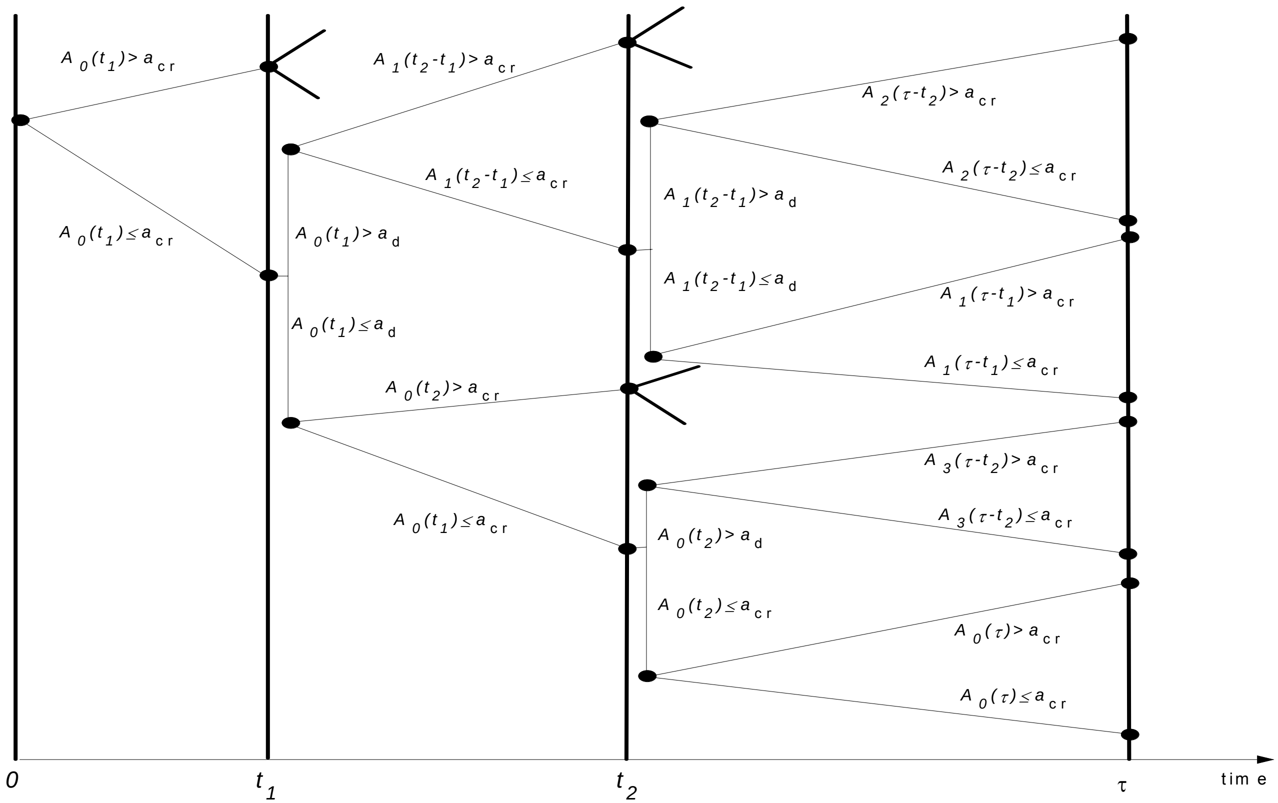
. $a_d < A(t) \leq a_{cr}$ => repaired

. $A(t) \leq a_d$ => undetected

- System failure probability $P_f(t) > p_{f,0}$ at all times

(collaboration with Professor M. Grigoriu, Cornell University)

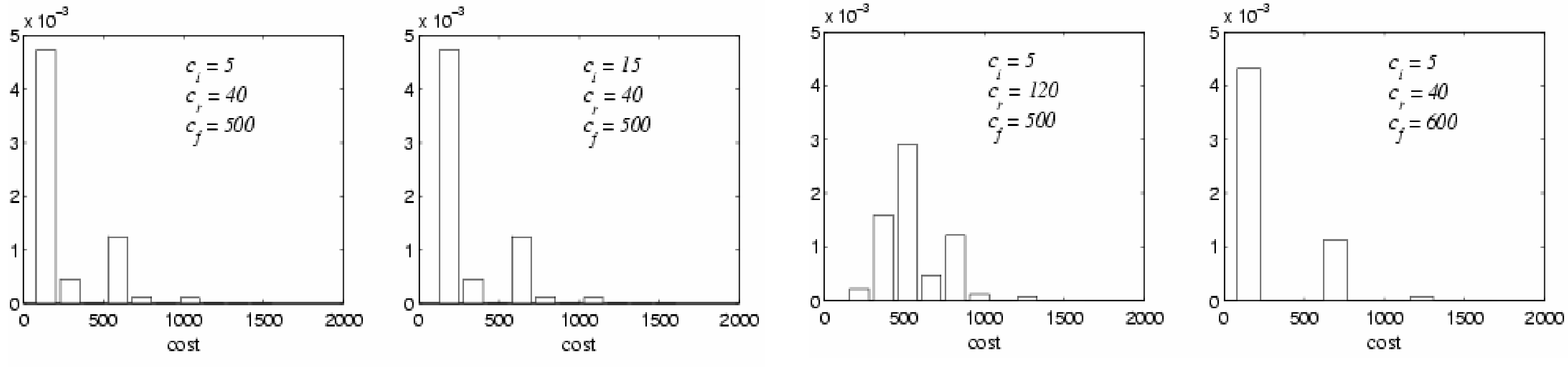
- Inspection and Maintenance Policy:



- Model parameters:
  - Cost: c_i, c_r and c_f = inspection, repair, failure costs
  - System life: $\tau > 0$
  - Inspection schedule: $(t_1,\ldots,t_n)$ = inspection times

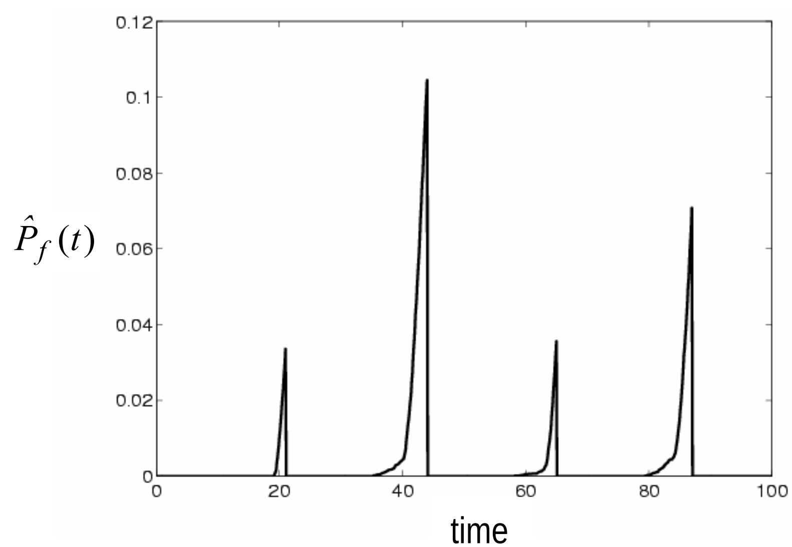
Total Cost and Failure Probabilities:

- Total cost at $t = \tau$:



- Failure probabilities:

$$\hat{P}_f(t) = \frac{\#\ \{A(t) > a_{cr}\}}{\#\ \{\text{samples}\}}$$



- Optimization algorithm:

  - Problem statement:

$$\min_{t_1,\ldots,t_n}\{q_n(c^*;t_1,\ldots,t_n)\}\ \text{ under}$$

$$P_f(0) \le p_{f,0},\, P_f(t_1) \le p_{f,0}, \ldots, P_f(t_n) \le p_{f,0},\, P_f(\tau) \le p_{f,0}$$

$$\text{and}\quad 0 \le t_1 \le t_2 \le \ldots \le t_n \le \tau$$

$$(\text{where } q_n(c^*;t_1,\ldots,t_n) = \text{probability that total cost at } t=\tau > c^*)$$

  - Feasible region for *n*=2: