

PredictionProbe

Benefits of Using Probabilistic Approach

- Cost Reduction
- Reliability Prediction and Improvement
- Weight Savings
- Life Extension
- Root-Cause Identification
- Uncertainty / Risk / Safety Quantification
- Probabilistic Risk-Based Design
- Test Reduction
- Sensitivity Analysis

Success

Story 1

Weight Reduction – Jet Engine Turbine Disk

Problem: Designers at a major aerospace corporation wanted to try to reduce the weight of a turbine disk design, which they felt was unnecessarily heavy. The disk was being life limited because of Low Cycle Fatigue (LCF).



Probabilistic Solution: The distribution of LCF life was calculated at various critical disk locations as a function of variations in temperature, rotor speed, pressure, material properties, blade loads, snap fits, and dimensions. Based on the distributions of LCF life, even for the most limiting location, the lower percentiles of life still exceeded life requirements by a wide margin.

Result: The designers redesigned this disk taking advantage of this excessive margin. 8 lbs. of weight were removed, and the resulting design had just the appropriate margin. Over the life of a fleet of engines, the cost savings in raw material and performance was \$90M.

Success Story 2 Life Extension— Power Generator Fan Fan Disk

Problem: A major manufacturing company which makes power generators gave a warranty on its generator for a specified lifetime and replaced major components in the generator to ensure that the life would be met. They felt they were replacing the Fan Disk far too early, which was at one half the warranty period.



Probabilistic Solution: The distribution of Fan Disk life was calculated based on variations in rotor speed, material properties, and geometric tolerances. Based on the distribution of Fan Disk life, there was a minimal failure probability prior to the end of the warranty period.

Result: The Fan Disk's life was doubled resulting in the removal of the requirement to replace the Fan Disk halfway through the warranty period while still having a minimal Fan Disk failure probability. The cost savings were \$58M.

Success Story 3 Test Elimination – Shuttle / Mir

Problem: Needed to determine how to best predict Docking Capture to the first successful Shuttle/Mir Mission. Traditionally done with extensive testing.



Probabilistic Solution: Probabilistic analyses were conducted for uncertainty modeling of initial capture contact conditions, capture failure modes modeling, reliability analysis of capture phase structural loads, probabilistic design sensitivity analysis, and capture design envelope simulation.

Result: Based on extensive amount of information that was learned, the tests required for qualification were reduced resulting in a \$450K cost savings.

Success Story 4 Weight Savings – Boeing EELV

Problem: Wanted to improve the design and minimize the overall weight of the EELV (Evolved Expendable Launch Vehicle) Upper Stage Vehicle Design.



Probabilistic Solution: The probabilistic analyses considered manufacturing process alternatives, stock size alternatives, all major failure modes, and design features for cost-effective manufacturing. The probabilistic analyses computed the reliability of the design, computed probabilistic sensitivity factors to identify key design drivers for special attention, and computed design weight.

Result: The reliability goals were achieved, and the weight was reduced by more than 20% compared to the initial designs using the deterministic approach.