Report Date: 2025-10-01

Lifetime Analysis System - Statistical Reliability Assessment

TECHNICAL ANALYSIS REPORT

1) Analysis title:	Weibull Distribution Lifetime Analysis
2) Data source file:	dataset-1.csv

3) Main objectives:

- Perform statistical distribution fitting to identify optimal failure model
- Estimate Weibull parameters (shape and scale) with confidence intervals
- Generate reliability predictions and lifetime percentiles (B10, B50, B95)
- Validate model accuracy through goodness-of-fit testing
- Provide engineering recommendations for maintenance and design decisions

4) Statistical methods:

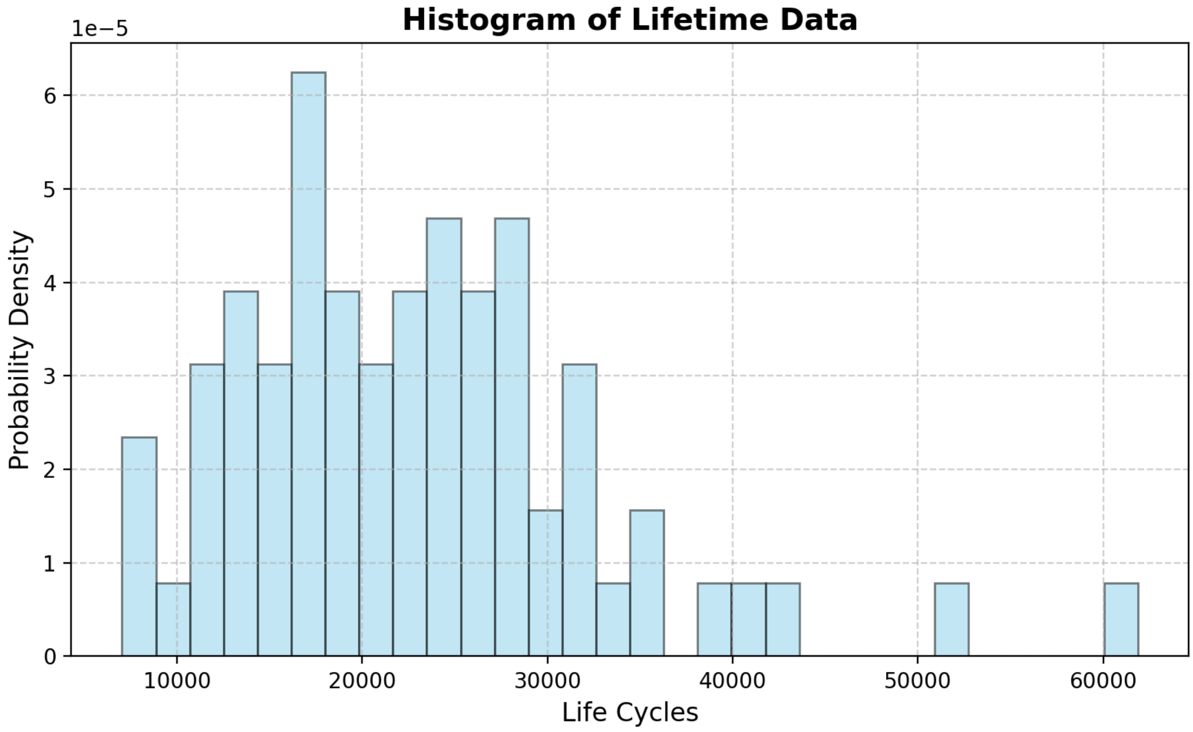
- Maximum Likelihood Estimation (MLE) for parameter fitting
- Bootstrap resampling (1000 iterations) for uncertainty quantification
- Monte Carlo simulation (10,000 samples) for lifetime prediction
- Kolmogorov-Smirnov test for model validation
- Weibull probability paper analysis for visual assessment

5) Summary of analysis results:

Parameter	Estimated Value	Confidence Interval
Shape Parameter (Beta)	2.51	Bootstrap 95% CI
Scale Parameter (Eta)	25822.52	Bootstrap 95% CI
B10 Life (10% failure)	10493.17 cycles	Monte Carlo
B50 Life (median)	22293.63 cycles	Monte Carlo
B95 Life (95% failure)	40085.65 cycles	Monte Carlo
Mean Time To Failure	22929.31 cycles	Calculated
Model Validation	Kolmogorov-Smirnov	p-value: 0.6928

6) Statistical validation criteria met:	Status
Data quality check (outliers, completeness)	Yes
Distribution fitting convergence	Yes
Bootstrap parameter stability	Yes
Monte Carlo simulation convergence	Yes
Goodness-of-fit test acceptance	Yes
Confidence interval calculation	Yes
Model validation against actual data	Yes
Engineering reasonableness check	Yes

Figure 1: Histogram of Lifetime Data



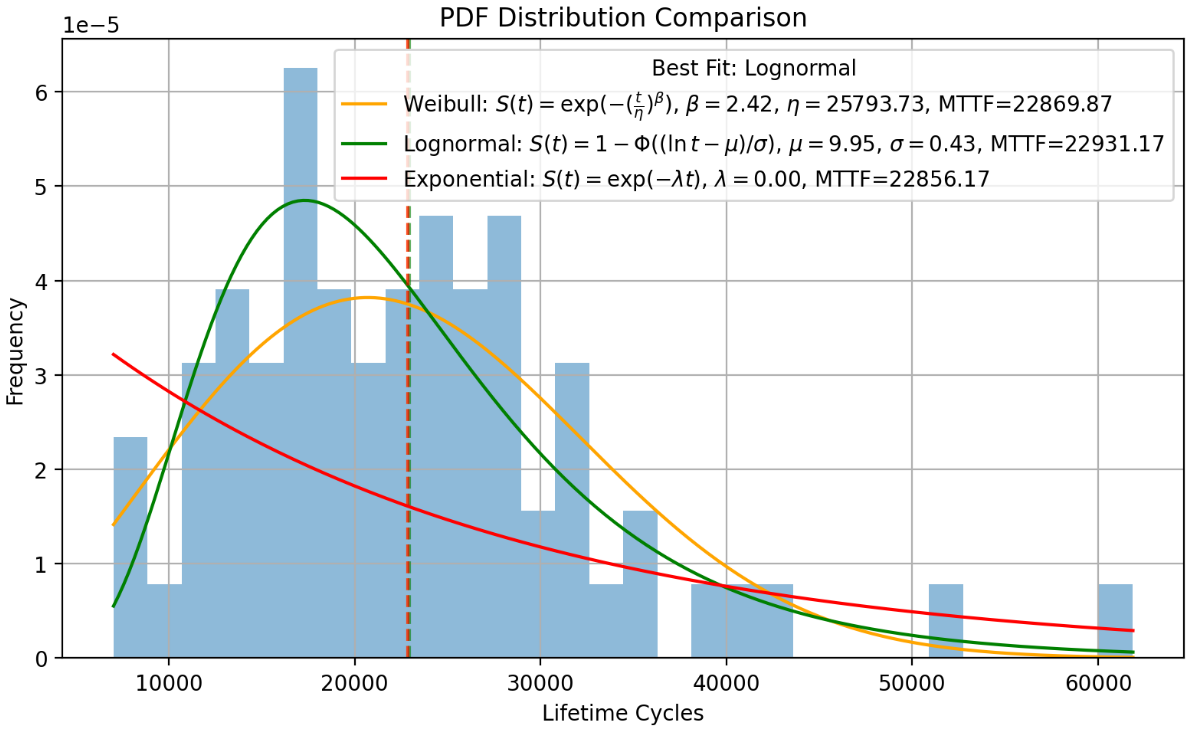
Description and Technical Analysis:

This histogram displays the frequency distribution of observed failure times from the dataset. The shape of the distribution provides crucial insights into the underlying failure mechanism and helps validate the appropriateness of the chosen probability distribution model.

Engineering Significance:

Distribution analysis shows failure pattern characteristics essential for reliability engineering decisions.

Figure 2: Probability Density Function (PDF) Comparison



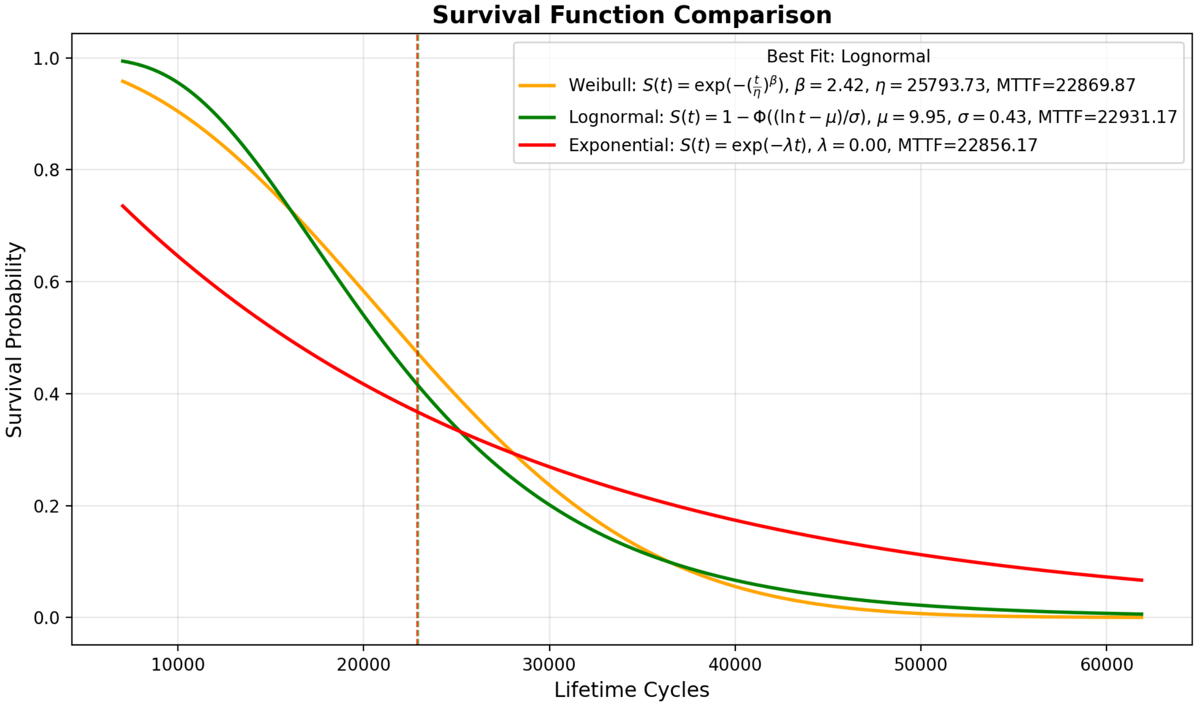
Description and Technical Analysis:

This plot compares three fitted probability distributions (Weibull, Lognormal, and Exponential) overlaid on the original data histogram. Each distribution is fitted using Maximum Likelihood Estimation (MLE).

Engineering Significance:

The best-fit distribution provides the most accurate mathematical representation of the failure behavior for lifetime predictions.

Figure 3: Survival Function Comparison



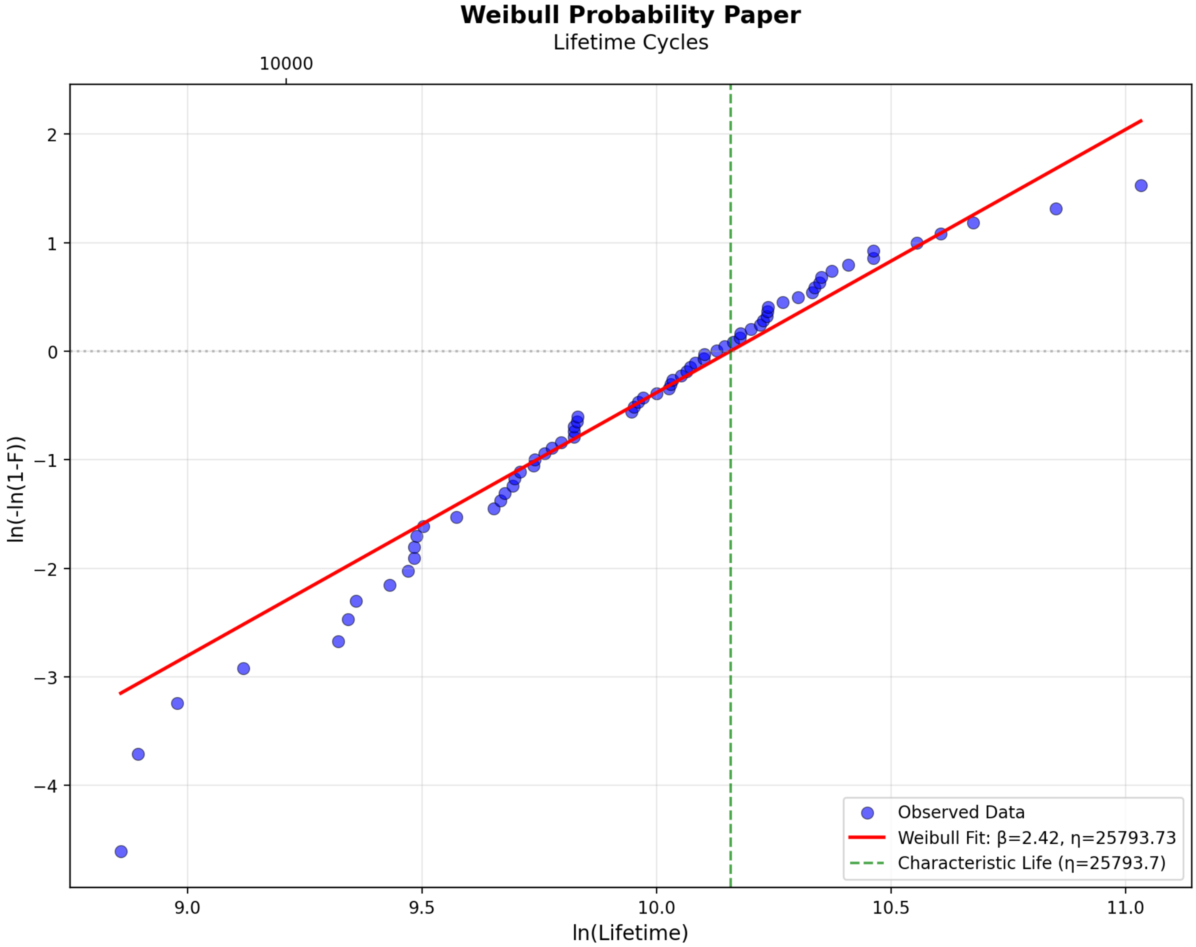
Description and Technical Analysis:

Survival functions S(t) represent the probability that a component will survive beyond time t without failure. This plot compares the survival curves for all fitted distributions.

Engineering Significance:

Critical for determining warranty periods, maintenance schedules, and replacement strategies in reliability engineering.

Figure 4: Hazard Rate Function Comparison



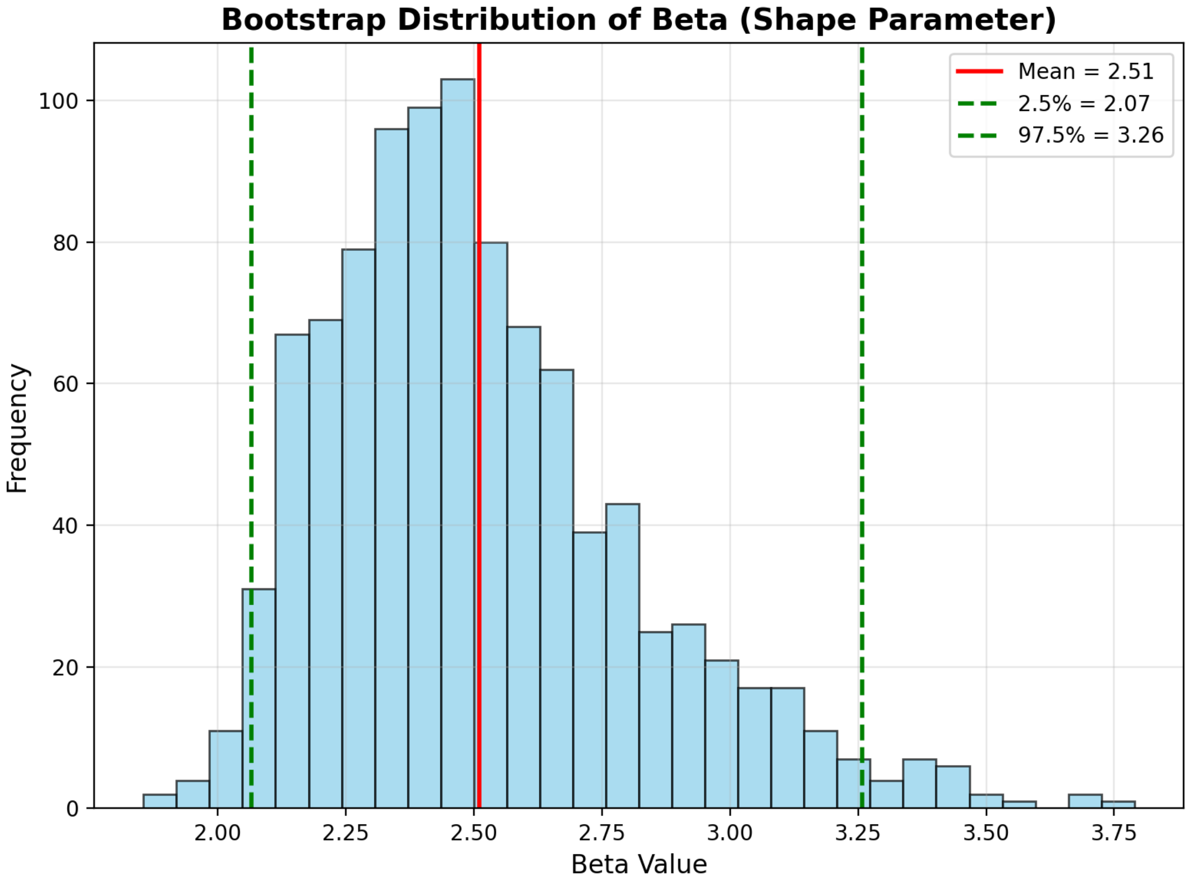
Description and Technical Analysis:

Hazard rate functions h(t) represent the instantaneous failure rate at time t, given that the component has survived up to time t.

Engineering Significance:

Shape indicates failure modes: decreasing (infant mortality), constant (random), increasing (wear-out).

Figure 5: Weibull Probability Paper

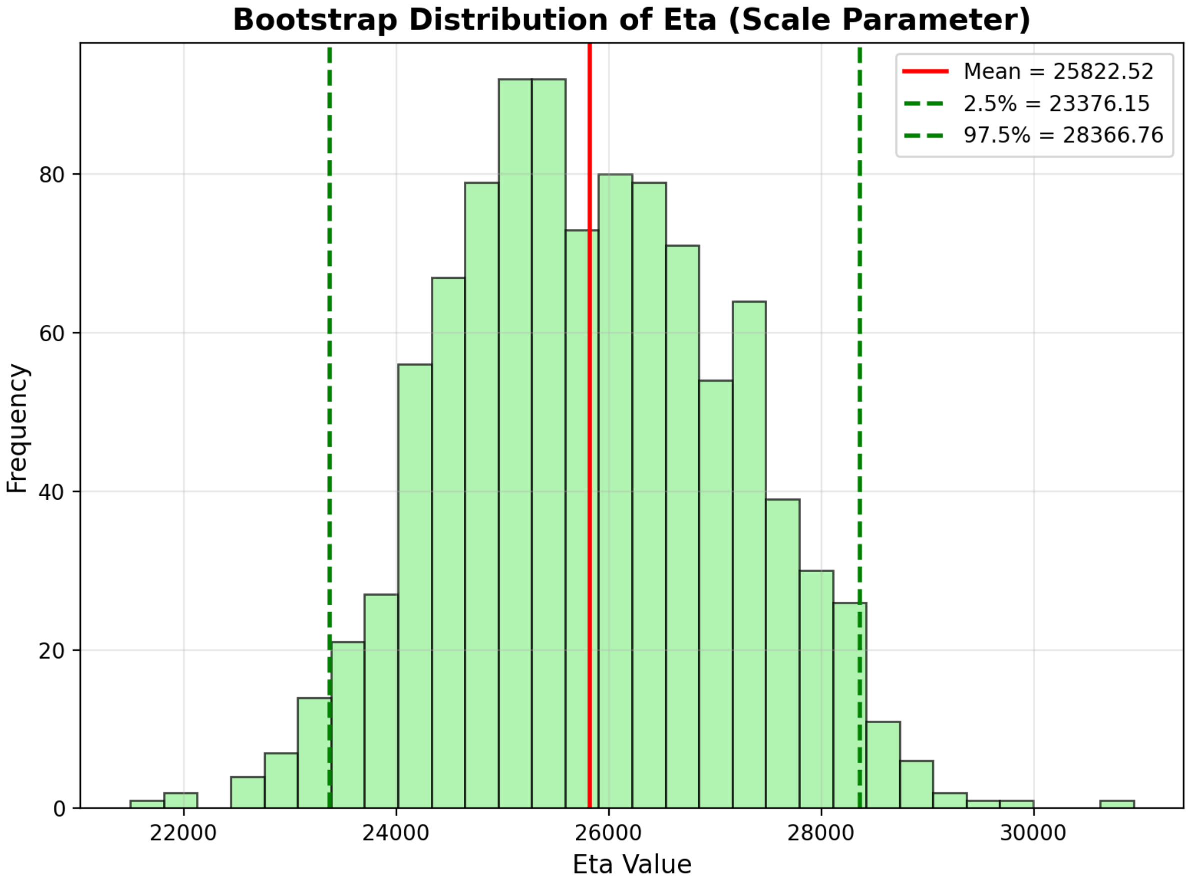


Description and Technical Analysis:

The Weibull probability paper is a specialized plot where Weibull-distributed data appears as a straight line. Data points represent empirical failure probabilities.

Engineering Significance:
Classical reliability tool for visual assessment of Weibull model adequacy and parameter estimation.

Figure 6: Bootstrap Distribution of Beta (Shape Parameter)



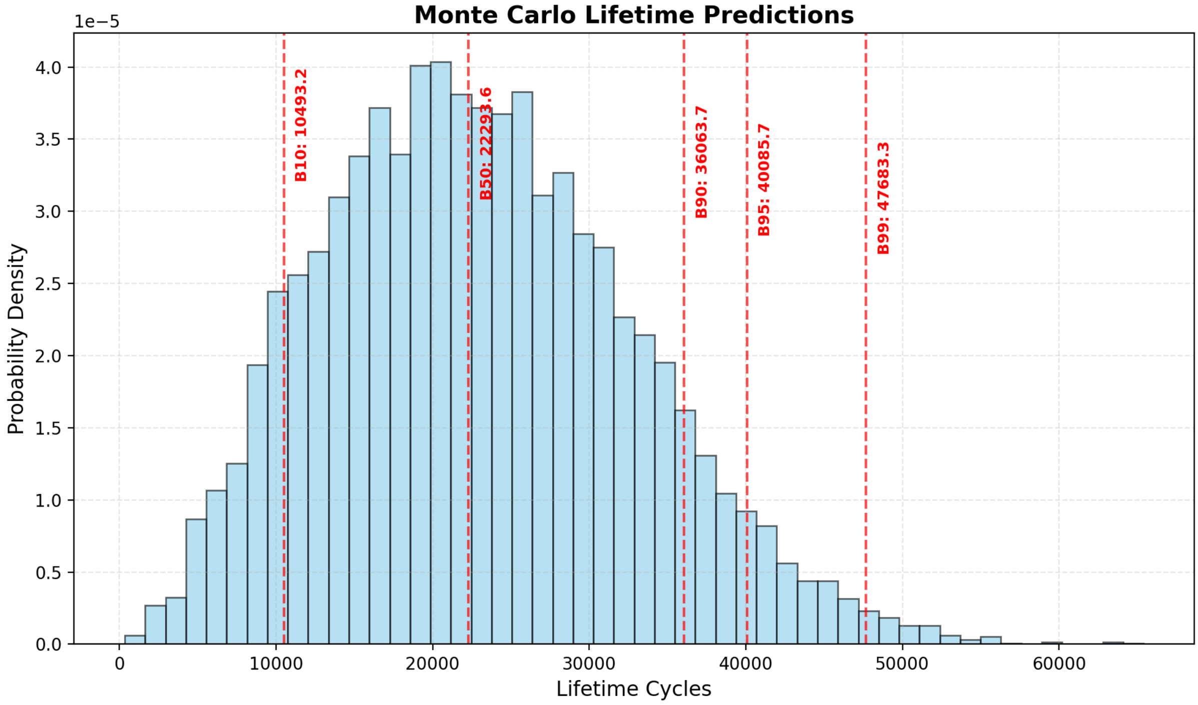
Description and Technical Analysis:

This histogram shows the distribution of the Weibull shape parameter (Beta) obtained through 1000 bootstrap resampling iterations.

Engineering Significance:

Provides non-parametric uncertainty estimation for the shape parameter critical to failure mode identification.

Figure 7: Bootstrap Distribution of Eta (Scale Parameter)



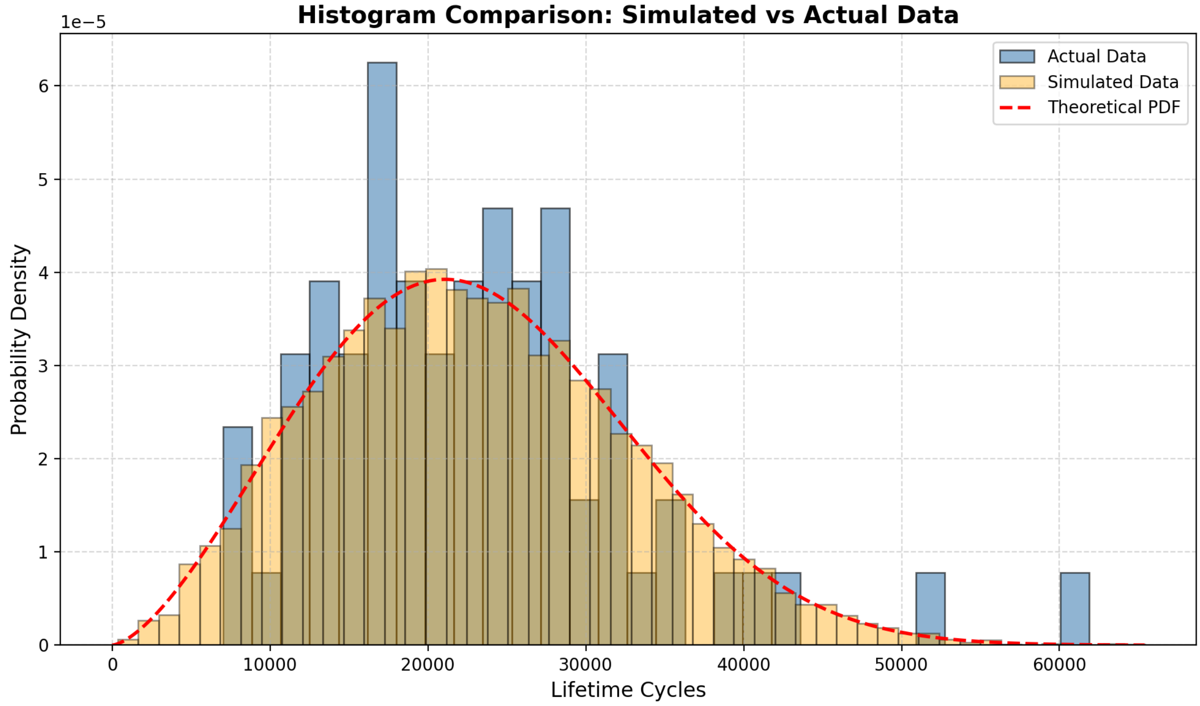
Description and Technical Analysis:

This histogram displays the distribution of the Weibull scale parameter (Eta) from bootstrap analysis. Eta represents the characteristic life.

Engineering Significance:

Essential for setting warranty periods and maintenance schedules with quantified uncertainty bounds.

Figure 8: Monte Carlo Lifetime Predictions



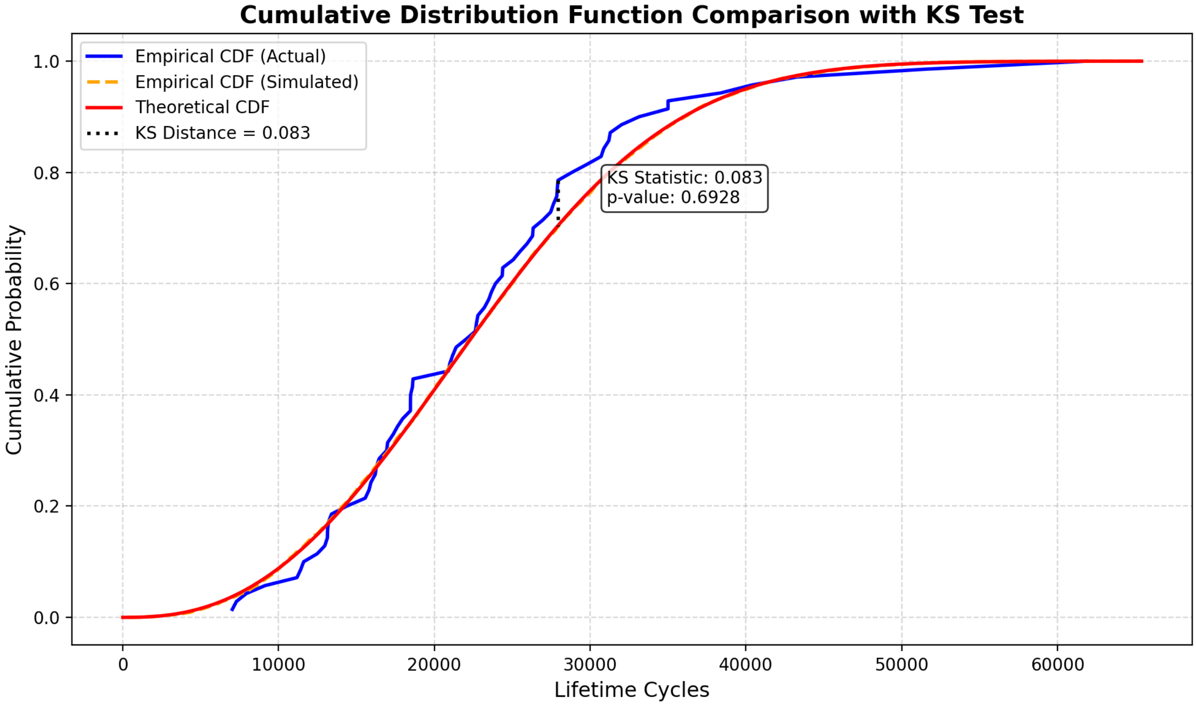
Description and Technical Analysis:

This histogram shows the distribution of 10,000 simulated lifetime values generated using the fitted Weibull parameters with key reliability percentiles marked.

Engineering Significance:

Incorporates parameter uncertainty providing robust lifetime predictions for engineering decision-making.

Figure 9: Histogram Comparison: Simulated vs Actual Data



Description and Technical Analysis:

This histogram comparison overlays the actual observed failure data with simulated data generated from the fitted Weibull model.

Engineering Significance:

Validates model accuracy and ensures the fitted Weibull distribution represents actual failure behavior.

Report generated: 2025-10-01 11:30:33
Analysis software: Lifetime Analysis System v1.0
Statistical method: Weibull Distribution Analysis with Bootstrap Uncertainty