Adventures in Reliability: Heavily Censored Data

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Approved for public release; distribution is unlimited.
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# Adventures in Reliability: Heavily Censored Data

## 14. ABSTRACT

At times reliability data are recorded as exact failure times on systems. This is a trivial case that is handled usually by simple textbook analysis approaches. Many times, especially in the T&E community, all that is known regarding failures is that a certain number of events have been observed during a flight. These type of data are called ‘interval data’ and do not equate with exact failure times. Trivial analysis approaches can severely bias MTBF estimates and ‘paint a pretty picture’. In this presentation statistical techniques for handling this data are discussed.

## 16. SECURITY CLASSIFICATION OF:

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## 17. LIMITATION OF ABSTRACT

None

## 18. NUMBER OF PAGES

10

## 19. NAME OF RESPONSIBLE PERSON

412 TENG/EN (Tech Pubs)

## 19b. TELEPHONE NUMBER

661-277-8615

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Adventures in Reliability: Heavily Censored Data

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Flight Test Failure Data

- Best case is to observe right, left or interval censored data
  - Fails during a flight...that’s all we know.

- Right:
  \[ T = 0 \]

- Left:
  \[ T = 0 \]

- Interval:
  \[ T = 0 \]

- Interval data happens when multiple flights occur before a failure is observed.

- We will ignore intervals this time...maybe next time.
Rehash of Rocket Motor Data
Catastrophic Missle Failures During Launch

- 20,000 missiles in inventory.
- 1,940 field firings of the missile.
- From June 1997 to March 1998 there were 3 catastrophic failures of the motor.
- Estimated service life = 20 years.
- Saw catastrophic failures at:
  - $T = 8.5, 14.2,$ and $16.5$ years.

Possible Failure Causes
How do we analyze this?...

- Believed Failure Mechanism (acc. to NSWC-IH):
  - Thermal cycling—caused propellant-to-case bondline AND/OR propellant-to-propellant bondline to fail.
  - Causes the surface area to increase and explosive ignition of propellant.

Motor Crosssection
...With one of many models.
Choose your Adventure

- Probability Models:
  - Exponential
  - Lognormal
  - Weibull
  - Logistic
  - Log Logistic
  - Rayleigh
  - Frechet
  - Normal
  - SEV
  - LEV
  - ...

- All have descriptions of why they are useful.
- Censoring ⇒ Model Fitting Difficulty
  - Use likelihood methods...
- Which one should we use?
- Does it matter?
Fitted Life Models \{Best is MIN(AIC)\}

\[ AIC_c = 36.488 \]

Censor Type
- Left
- Right

Distribution Model
- Log Normal
- Weibull
- Log-Logistic
- Gamma

\[ AIC_c = 35.514 \]

\[ AIC_c = 35.488 \]

\[ AIC_c = 36.203 \]
Which model would you choose?
Based on Reliability Estimation and CI’s

Pr(Survival > 20 Years)

Likelihood Ratios
W:LLG = 1.04
W:G = 1.41
W:LN = 1.63
Summary

- Stake holders on both sides of the fence may choose different models based on interests.
  - Uncertainty in decisions, or indecision.
  - Implies model selection uncertainty.
  - Somebody has to choose…unbiasedly.
  - What tool or method will they use?
- Who can justify their choice?
- MORE QUANTITATIVE RIGOR
  - More to come on this in the future…