LOPA Case Study – What to Do With Rare Events?

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Problem

• Your LOPA team members tell you that the initiating event of concern has never happened in the history of the process unit. No bad events in 20 years. What do you do?
• Ignore the event and move on – It can never happen
• What else?
Available Methods to Handle Problem

• Assume event has happened once, \( M_1 = \frac{1}{N} \)

• Assume event has almost happened \( M_2 = \frac{1}{2N} \)

• Bayesian Results
  \( M_3 = \frac{1}{3N} \)
  \( M_4 = \frac{1}{4N} \)
Methods (cont)

• Poisson Arrivals of Failures
  At 90% limit
  \[ M5 = \frac{0.105}{N} = \frac{1}{10N} \]

• At 10% limit
  \[ M6 = \frac{2.303}{N} \]
Methods (cont.)

• Chi Square Confidence Limit (95%)
  \[ M7 = \lambda = \frac{\chi_{\alpha;2}}{2n} = \frac{5.991}{2n} \]

• Chi Square Confidence Limit (50%)
  \[ M8 = \lambda = \frac{\chi_{\alpha;2}}{2n} = \frac{1.3863}{2n} \]
Methods (cont.)

• Binomial Distribution

\[ M9 = 1 - [0.9]^{1/n} \]
Methods (cont.)

• Uniform Distribution Bayes Estimator

\[ M_{10} = \frac{1}{N+2} \]
Methods (cont.)

• Hypothesis Test – Normal distribution with 95% confidence

$$M11 = \frac{Z^2_\alpha}{n + Z^2_\alpha}$$

$$Z_\alpha = 1.6445$$
Methods (cont.)

• Explosive Initiation Test

\[ M12 = 1 - [0.5]^{1/N} \]
Best Guess Methods

Legend
- M1
- M2
- M3
- M4
- M8
- M9
- M10

Failure Rate, fail/yr

Number of Trials, N

27 Oct 2010
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Confidence Limit Methods

Legend
- M5
- M6
- M7
- M11
- M12

Number of Trials, N
Failure Rate, fail/Yr

M11
M12
M5
M6
M7

Confidence Limit Methods
Recommendations for Basic LOPA

- Determine if the event of concern is physically possible. If not physically possible, delete from LOPA analysis.
- Make sure you have a minimum of 10 years of data. If not use values from LOPA book.
- Use $M1 = 1/N$ for events found to be physically possible.
Recommendations for Beyond Basic LOPA Reviews

• Use estimators M3, M8 or M12.

• M3 (Rule of 1/3N) is easier to remember and calculate.
Conclusions

• There is no single “correct answer”
• Use an estimator that is consistent with the other assumptions in your LOPA study
Does the Audience Know of Another Estimator??
QUESTIONS