



# Reliability Distributions and Their Use

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# Accendo Reliability

**Illuminated Reliability Engineering Knowledge**

# Reliability Distributions?



# What is Life Data?

How do you define failure?

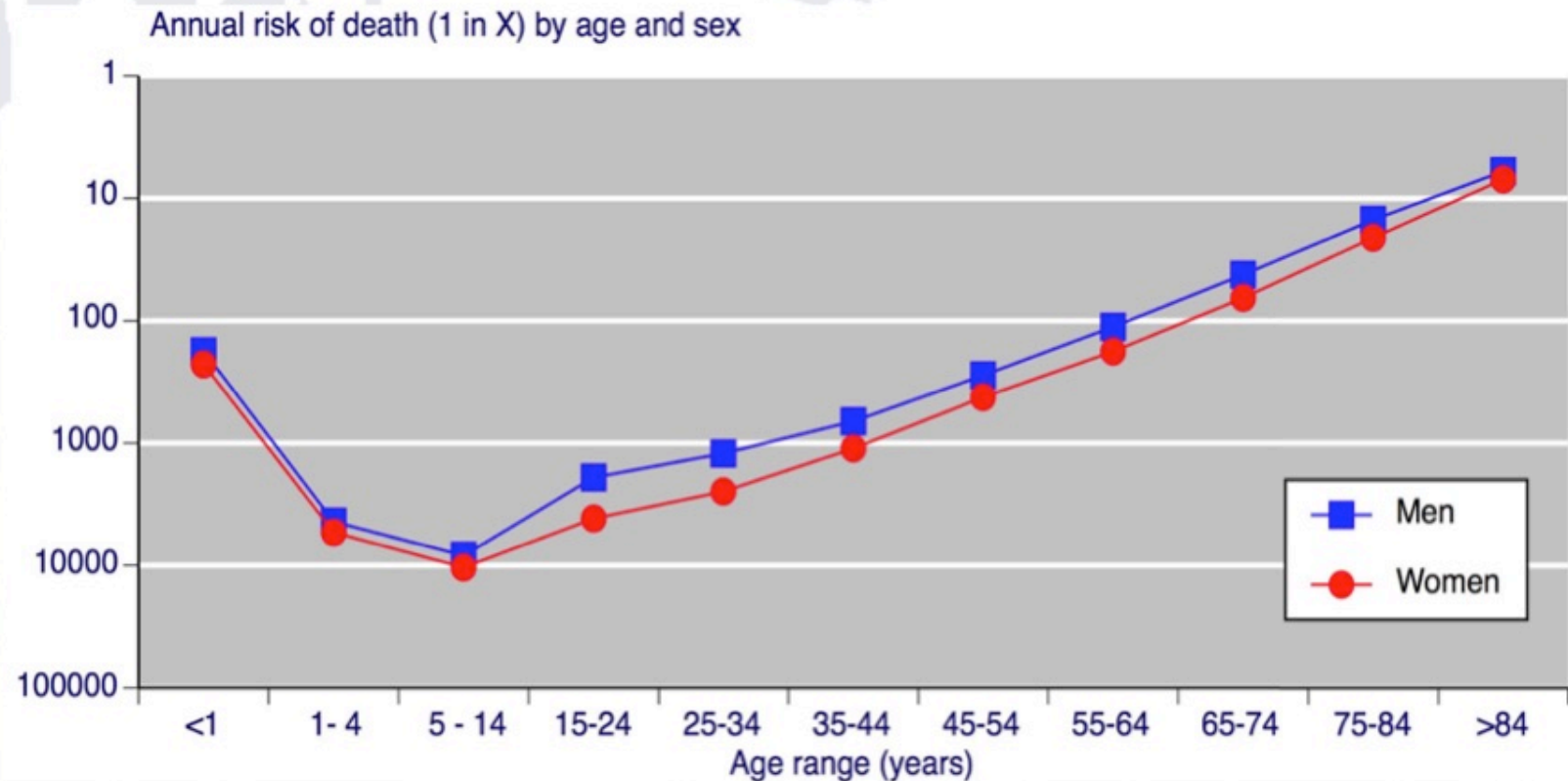


# Lifetimes Vary




# Human Mortality

Figure 1: Annual risk of death by age and sex in the UK



From <http://www.medicine.ox.ac.uk/bandolier/booth/Risk/dyingage.html>



# Types of data

What is wrong  
with the data you  
have available?



# What do we need to know?

Common questions asked of the data.

**Good Enough?**







Better Than?

# Number Spares/Replacements





How can you get  
the data you  
need?



# Data to Histogram

Let's take our first look at the data

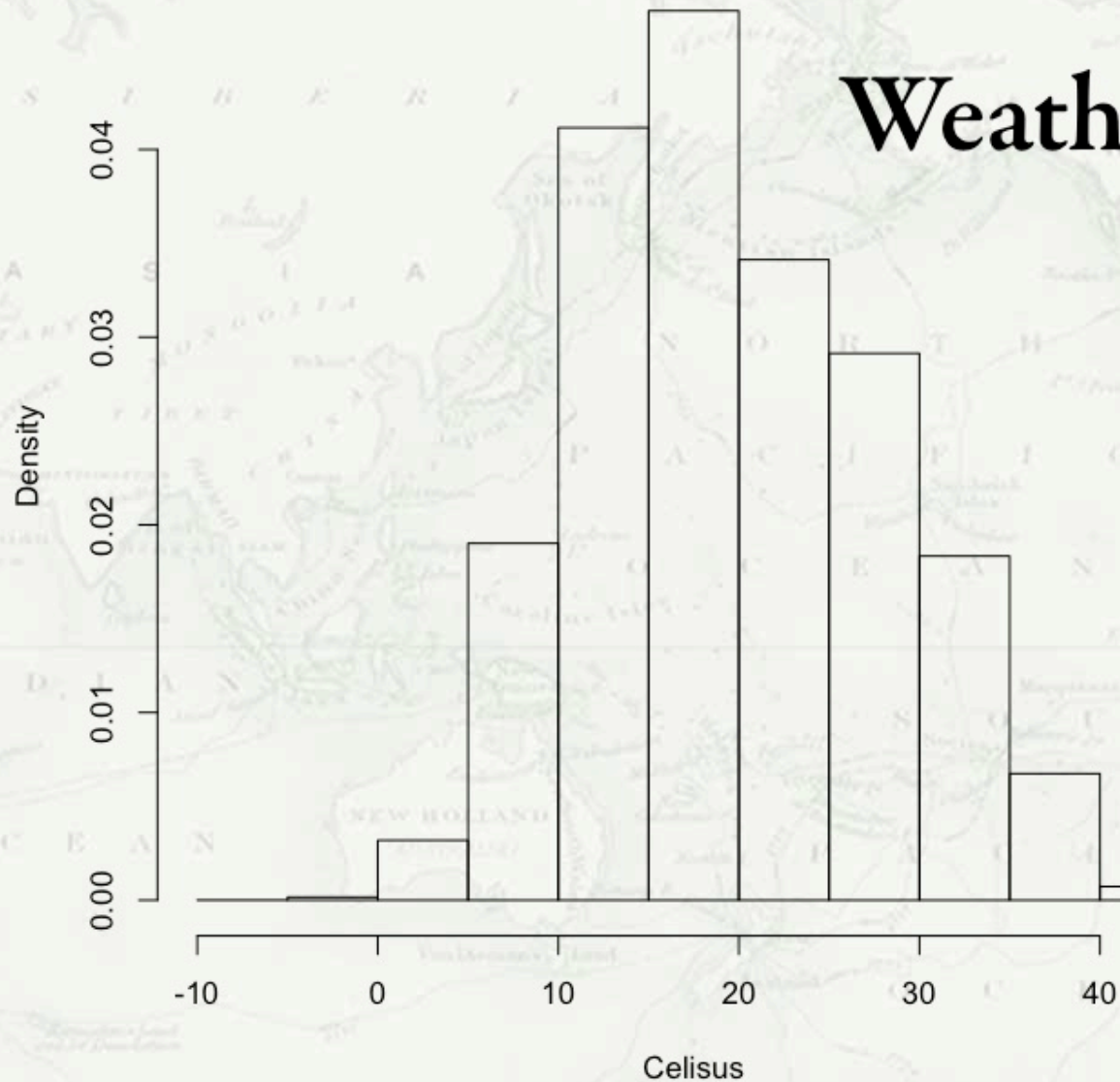


# A Big Pile of Numbers



## 1990 - 2010 California Temperatures (°C)

# Weather Data

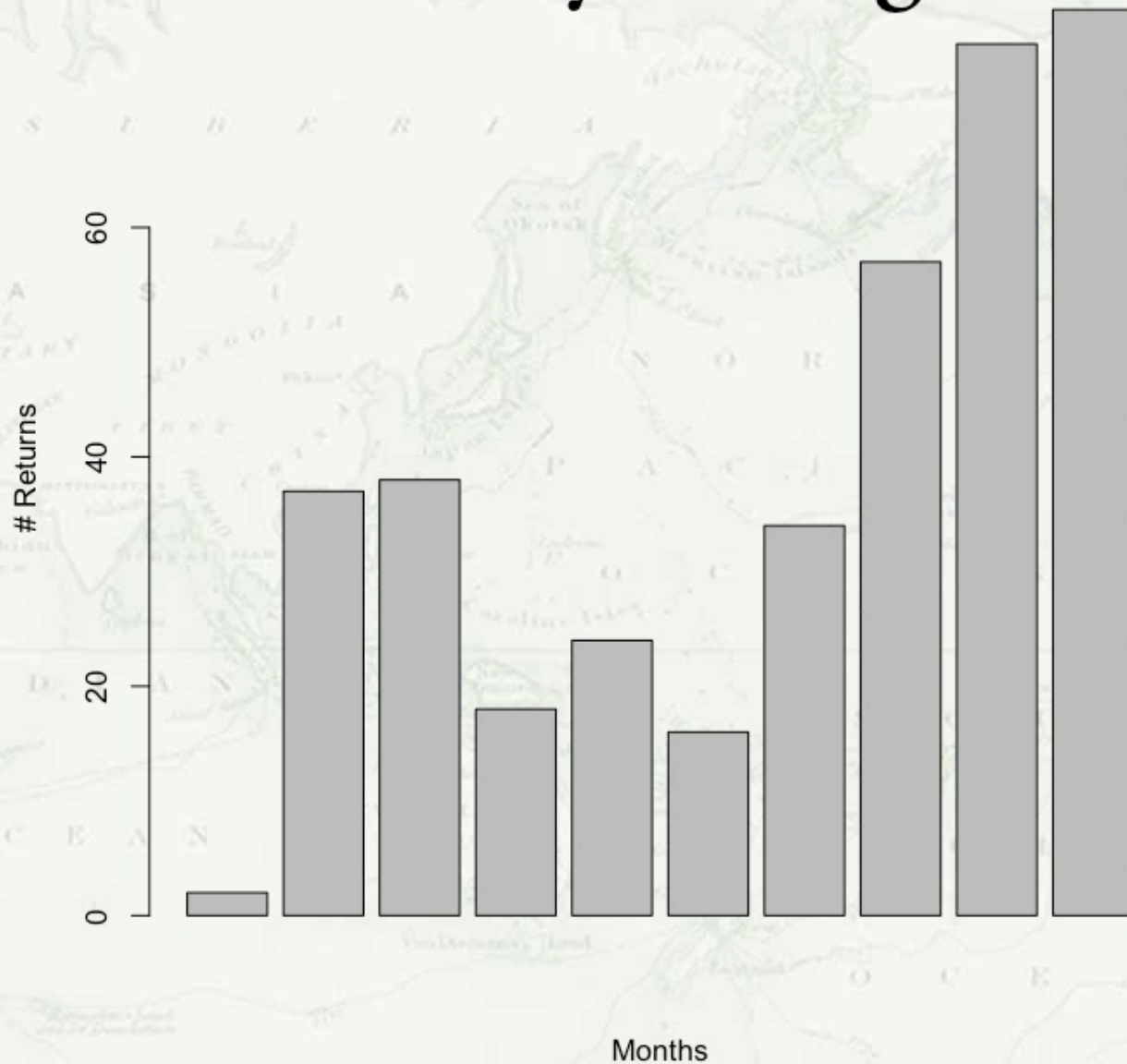




# Warranty Returns Data



# Warranty Histogram



What are your  
favorite data  
plots?

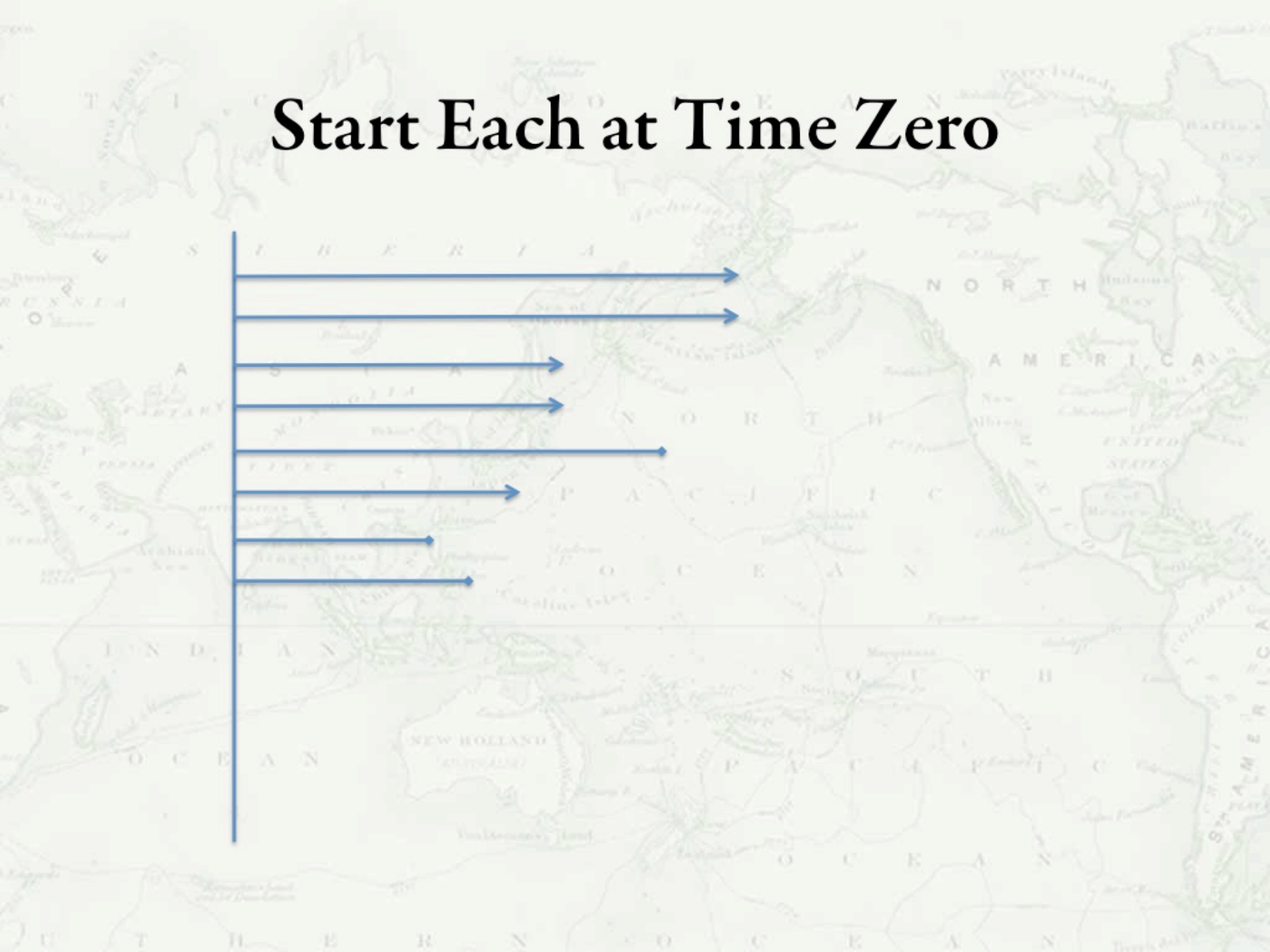


# Data to Weibull CDF

Cumulative Distribution Function.



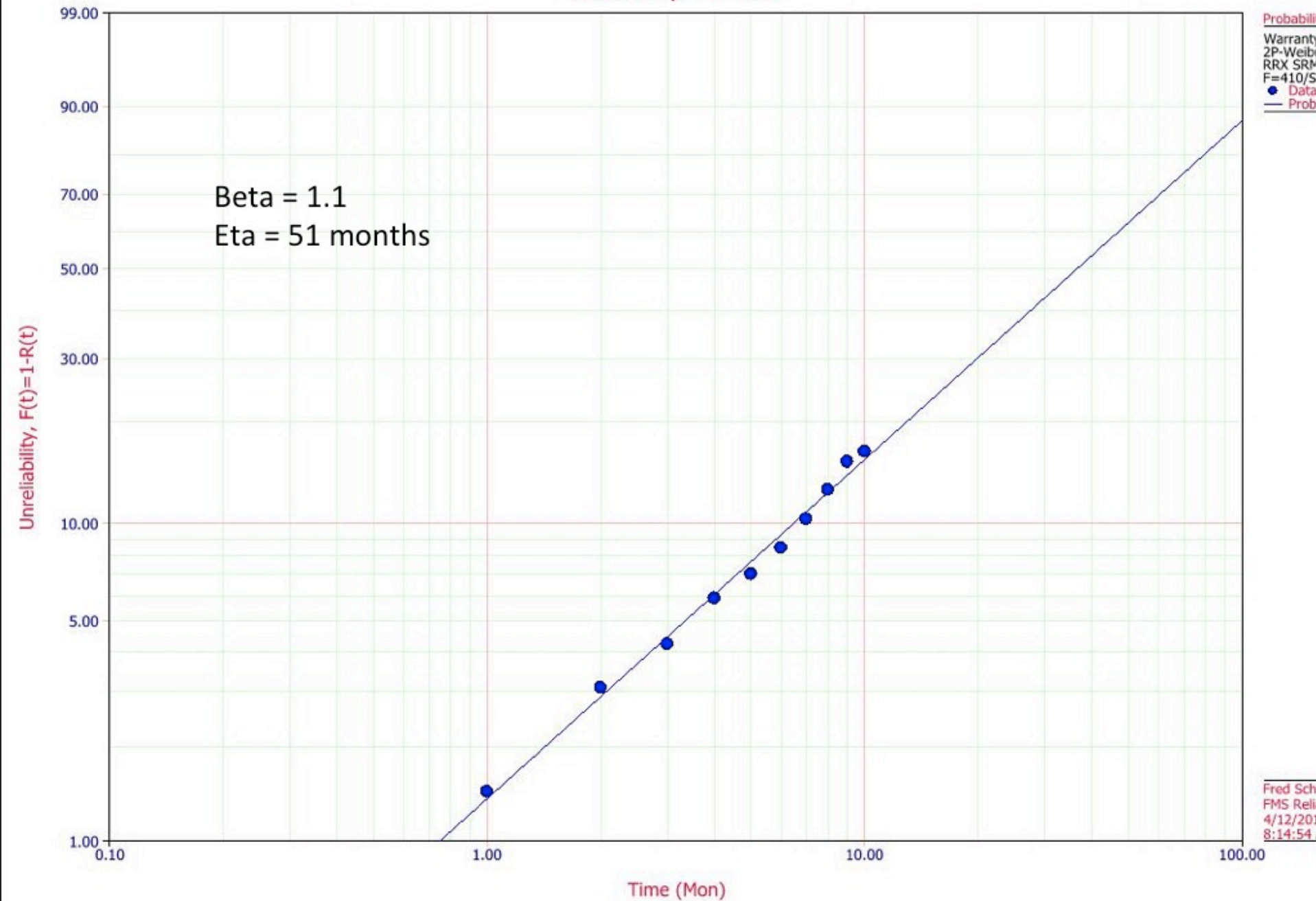
# Start Each at Time Zero



# Track Time to Failure & Number Not Failed Yet

[illegible]

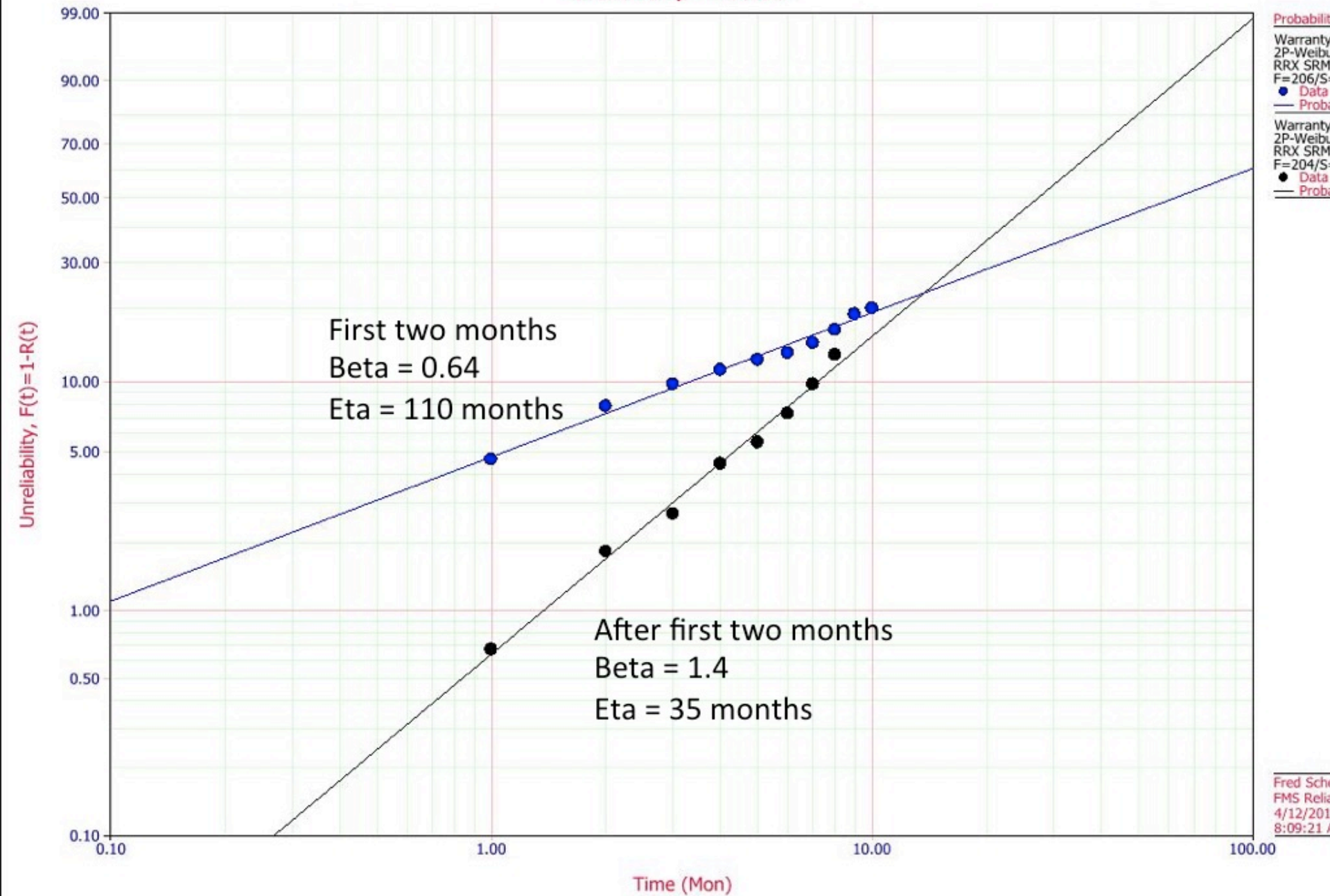
# Probability - Weibull



Probability  
Warranty  
2P-Weibull  
RRX SRM  
F=410/S  
● Data  
— Prob

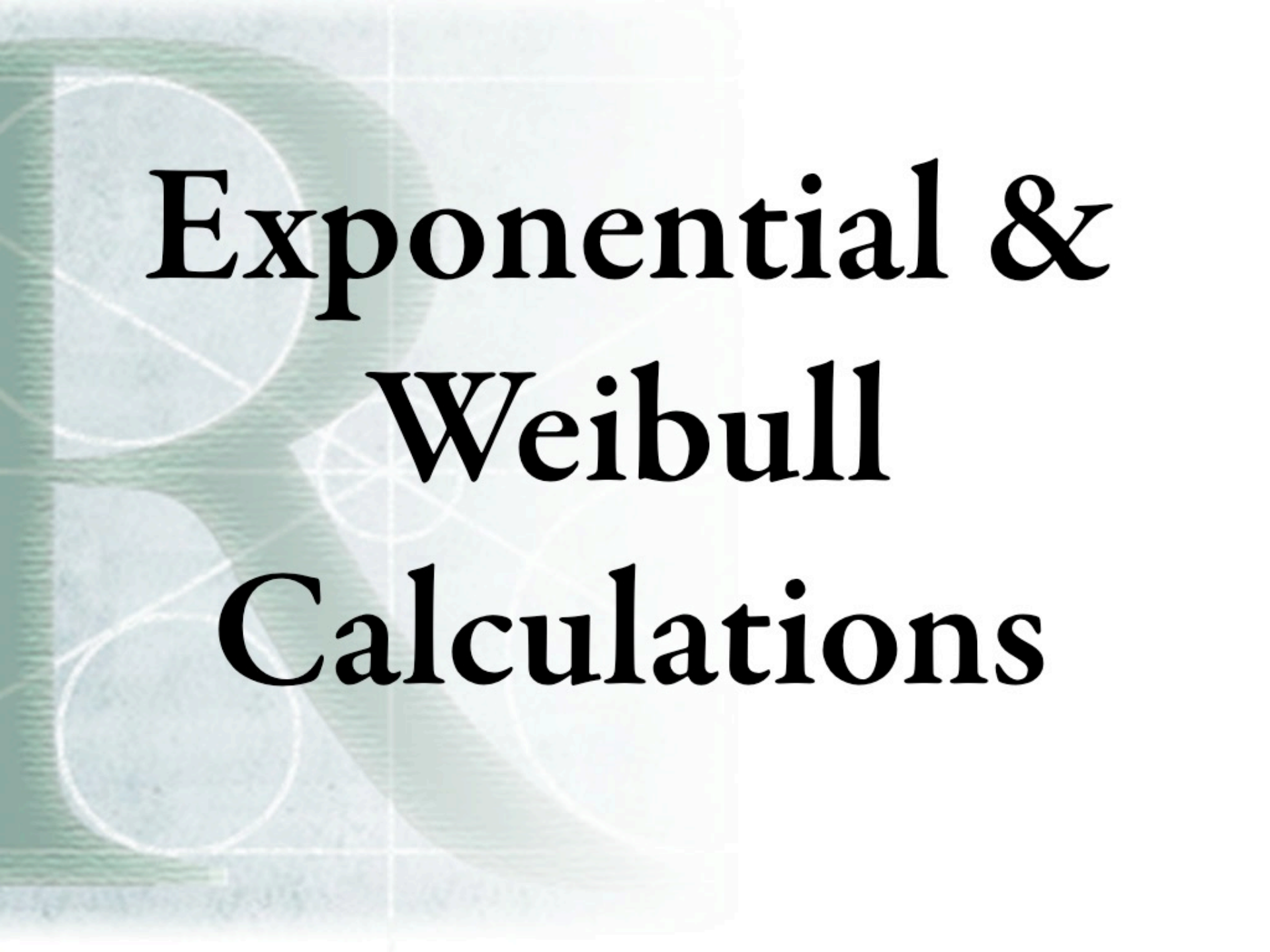
Fred Sch  
FMS Relia  
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8:14:54

# Probability - Weibull



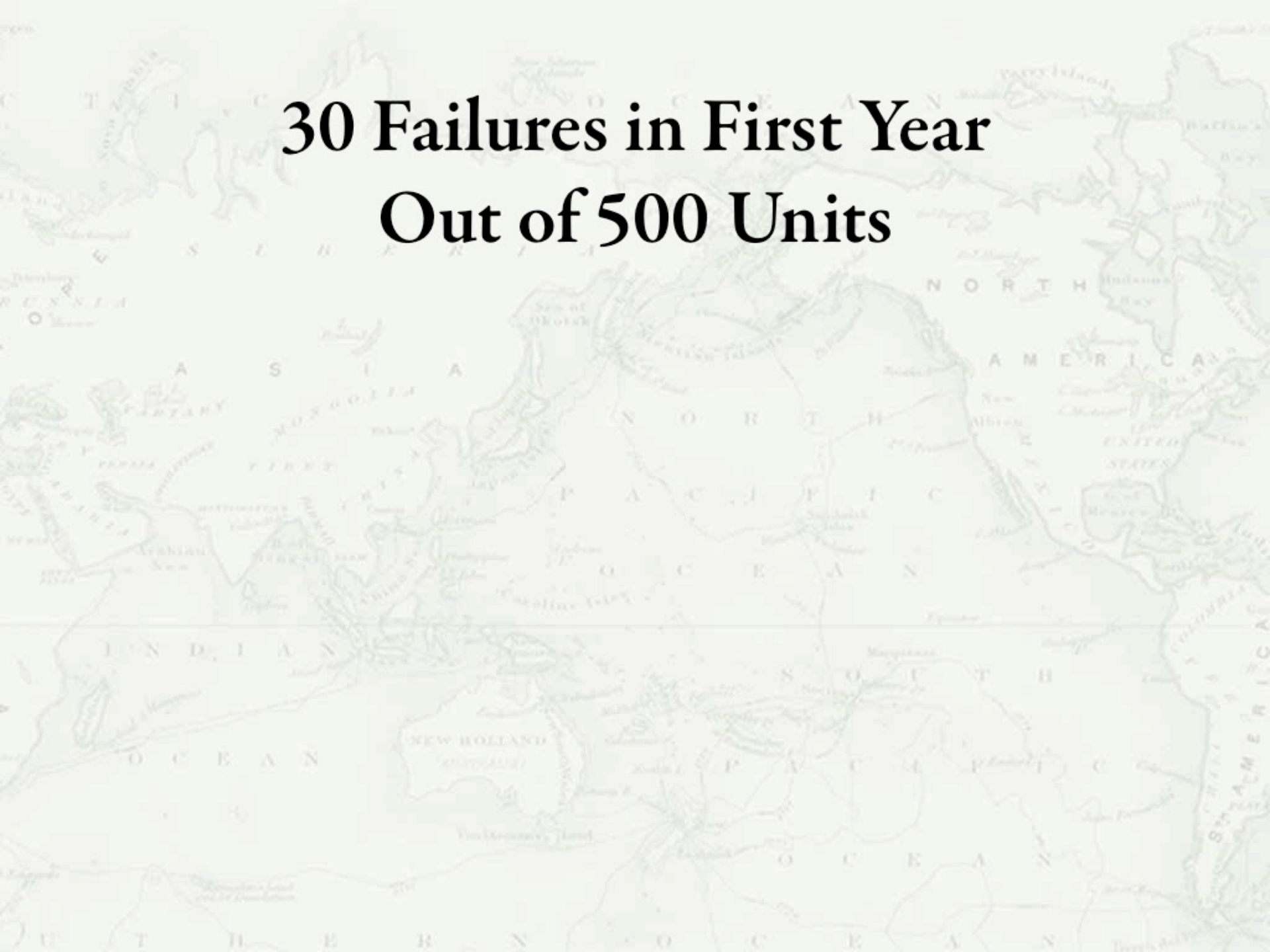


Do you  
Weibull?



# Exponential & Weibull Calculations

# 30 Failures in First Year Out of 500 Units





# Exponential Calculation for # Failures in Second Year

1year = 8760 hours

$$500 \times 8760 = 4,380,000$$

$$\theta = 4,380,000 / 30 = 146,000$$

$$F(t) = 1 - e^{-(t/\theta)}$$

$$F(8760) = 1 - e^{-(8760/146,000)} = 29.11$$

# Weibull Calculation for # Failures in Second Year

Fit a Weibull Distribution

$$\beta = 0.5 \quad \eta = 2,290,000$$

$$F(t) = 1 - e^{-\left(t/\eta\right)^\beta}$$

$$500 \times F(2 \times 8760) = 500 \times \left[ 1 - e^{-\left(2 \times 8760 / 2,290,000\right)^\beta} \right] = 42$$

$$42 - 30 = 12$$

# Weibull Calculation for # Failures in Second Year

Fit a Weibull Distribution

$$\beta = 2 \quad \eta = 35,200$$

$$F(t) = 1 - e^{-\left(\frac{t}{\eta}\right)^\beta}$$

$$500 \times F(2 \times 8760) = 500 \times \left[ 1 - e^{-\left(\frac{2 \times 8760}{35,200}\right)^2} \right] = 110$$

$$110 - 30 = 80$$



Friends don't let  
friends use  
MTBF

# Binomial and Sample Size

Success testing basic formula.



# The magic of 77 Samples





# Success Testing

$$n = \frac{\ln(1 - C)}{m^{\beta} \times \ln(R)}$$

$$77 = \frac{\ln(1 - 0.95)}{1 \times \ln(0.96)}$$

**My Favorite - 60% Confidence**



Time to check the  
qual packages from  
your vendors

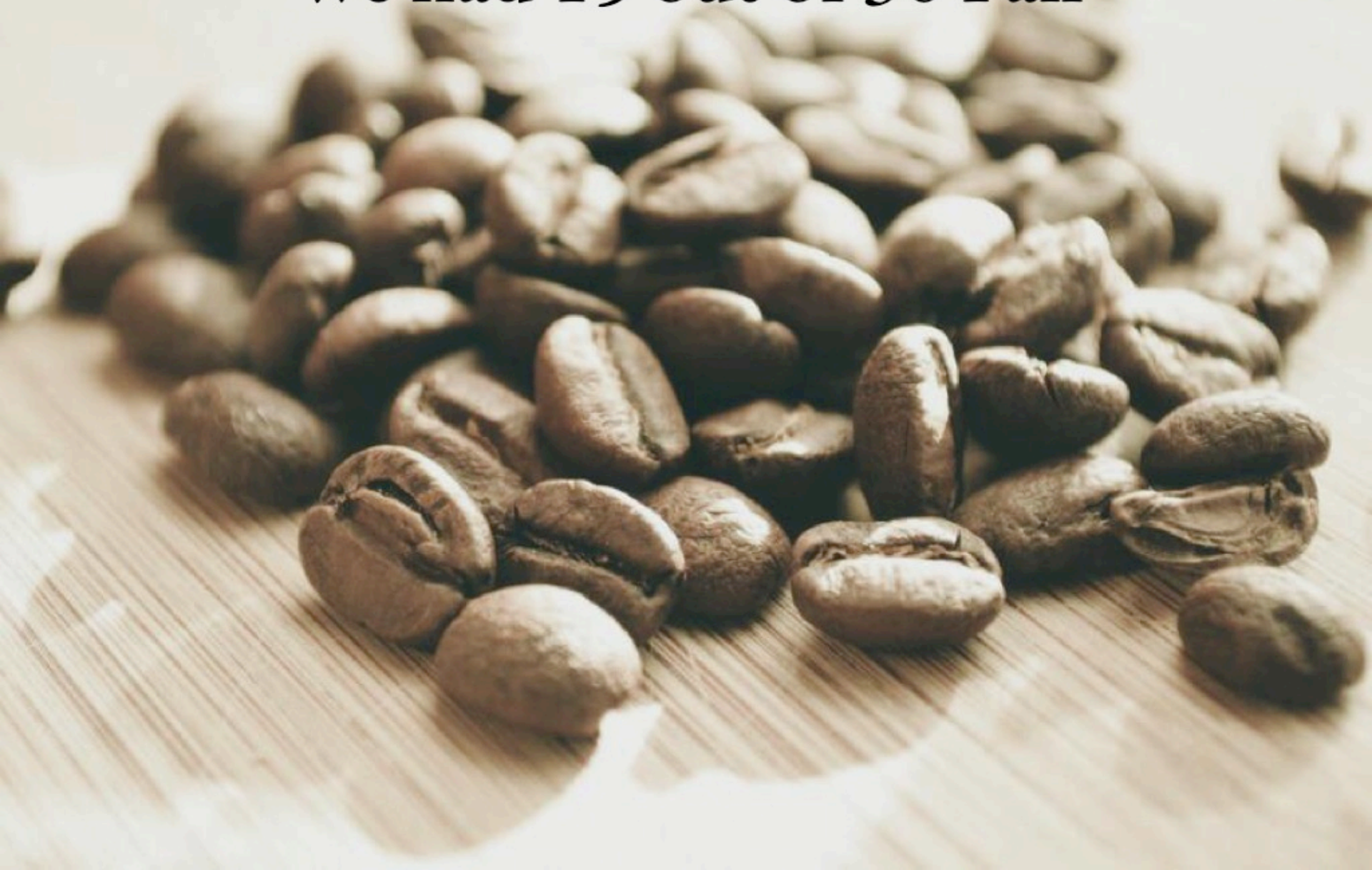




# Hypergeometric

A fun use of this distribution.

**We had 15 out of 30 Fail**





# They Claim a 100 FIT Rate





**It could be random chance...**

$$P(X = k) = \frac{\binom{K}{k} \binom{N-K}{n-k}}{\binom{N}{n}}$$

$$P(X = 15) = \frac{\binom{100}{15} \binom{10^9 - 100}{30 - 15}}{\binom{10^9}{30}} = 8.48 \times 10^{-98}$$


What are other  
uses of a life  
distribution?



# Dare To Know

**Interviews with Quality and Reliability Thought Leaders**





# What are your Questions?

Thanks for participating.