



# ***Answering the Question of Likelihood***

***Joe Ricke***

***Nov 14, 2013***

# Risk Reporting Matrix

- Consequences well defined (cost, schedule, performance)
- Likelihood mostly subjective judgment

Likelihood	5	5	10	15	20	25
	4	4	8	12	16	20
	3	3	6	9	12	15
	2	2	4	6	8	10
	1	1	2	3	4	5
		1	2	3	4	5
		Consequence				

# Risk Reporting Matrix

- It depends...

## Dept. of Energy Example

5	Very High	> 90%
4	High	75 - 90%
3	Moderate	26 - 74%
2	Low	10 - 25%
1	Very Low	< 10%

## Dept. of Defense Example

5	Near Certainty	~ 90%
4	Highly Likely	~ 70%
3	Likely	~ 50%
2	Low Likelihood	~30%
1	Not Likely	~ 10%

# Likelihood Guidance

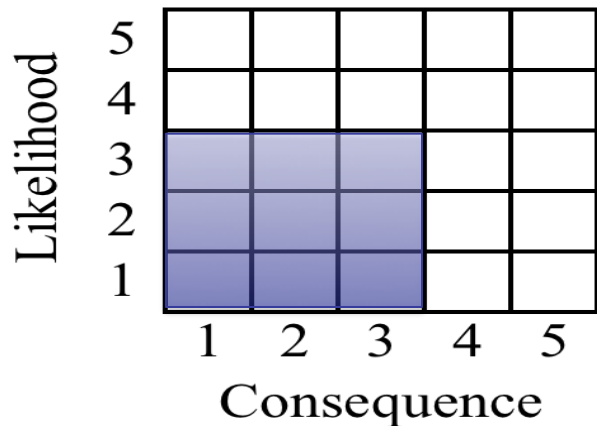
## *Percentage of what?*

“Many, after careful consideration, are convinced that such statements about probability to a person mean precisely nothing, or at any rate that they mean nothing precisely.”

- *L. J. Savage, The Foundations of Statistics*

# Risk Reporting Matrix

- When percentages are displayed numerically (0 – 100%) in a risk cube, the perception of linearity is conveyed
- When percentages are displayed exponentially, their logarithmic nature is revealed

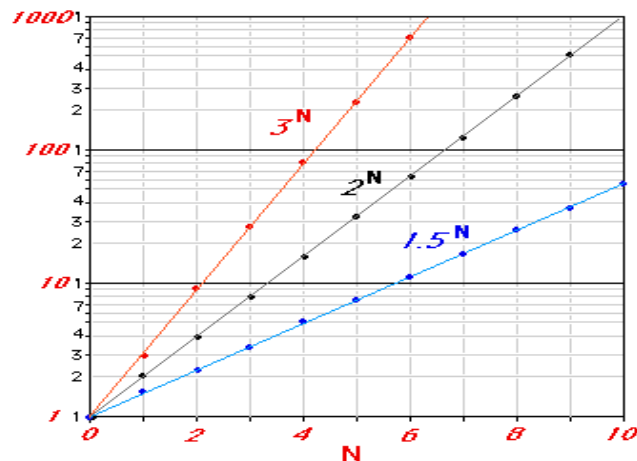


$$100\% = 10^2$$

$$10\% = 10^1$$

$$1\% = 10^0$$

==



# Case Study

- 50-year life span
- Likelihood based upon
  - How often the activity occurs
  - Chance of observing a failure during the activity
- Divide into periods (frequencies) understood by the user

Frequency of Task	Daily	Weekly	Monthly	Quarterly	Semi-Annually	Annually	Lifetime
Outcomes ( $x_i$ )	18,250	2,607	600	200	100	50	1
$\text{Log}_{7.12}(x_i)$	5.0	4.0	3.3	2.7	2.3	2.0	0.0

## Failure probability modulation

			Probability of Failure ( $P_f$ )				
Frequency of Event or Task	$x_i$	$\text{Log}_{7.12}(x_i)$	90%	70%	50%	30%	10%
Daily	18,250	5	4.9	4.8	4.6	4.4	3.8
Weekly	2,607	4	4.0	3.8	3.7	3.4	2.8
Monthly	600	3.3	3.2	3.1	2.9	2.6	2.1
Quarterly	200	2.7	2.6	2.5	2.3	2.1	1.5
Semi-Annually	100	2.3	2.3	2.2	2	1.7	1.2
Annually	50	2	1.9	1.8	1.6	1.4	0.8

## Look-up table

Frequency of Event or Task	Probability of Failure ( $P_f(x_i)$ )				
	90%	70%	50%	30%	10%
Daily	5	5	5	4	4
Weekly	4	4	4	3	3
Monthly	3	3	3	3	2
Quarterly	3	3	2	2	2
Semi-Annually	2	2	2	2	1
Annually	2	2	2	1	1



# General Equation

$$P(x_i) = \log_{\sqrt[T]{I}}(x_i \cdot P_f(x_i))$$

Where:

$T$  = Number of decision tiers (i.e., scale)

$I$  = Highest number of event/task repetitions that occur within the time frame examined

$x_i$  = The number of times an event/task occurs within the time frame examined

$P_f(x_i)$  = Probability of a failure during an event/task

# Capabilities and Limitations

- Use any units of measure
  - Flight hours, run time
- Calculates relative likelihoods
  - Frame of reference matters (tiers and span)
- Can produce off-scale results
  - Likelihoods  $< 0$ 
    - Likelihood so low it could be ignored based on consequence
  - Likelihoods  $> \text{Scale}$ 
    - Likelihood is so high it could be considered as realized
- User-defined analysis tool
  - Scalable
  - Infinitely adjustable
- Combine with reliability growth management methods

- Inputs
  - Time frame (SUT life span)
  - Risk reporting matrix tiers (5 is common)
  - Periodicity of event/task
    - Training proficiency requirements
    - Periodic maintenance requirements
  - Probability of observing a failure ( $P_f(x_i)$ )
    - Estimated or observed RMA data
  - Life Cycle Employment (affects  $x_i$ )
    - Operational time / (Operational Time + Maintenance Time)
  - Operational TEMPO (affects  $x_i$ )
    - Typical for SUT



- Basic factors
  - Span, reporting scale, event frequency, event failure rate estimate
- Tailored factors
  - Employment factors (Maintenance periods, Operational Tempo, etc...)

Risk Likelihood Calculator	
Q1: Over what time frame (in years) do you want to evaluate the likelihood of a risk? _____	50
Q2: How many tiers of likelihood are there in your risk reporting matrix? _____	5
Q3: What is the interval (in days) between occurrences of the event/task you are evaluating? _____	7
Q4: What is the estimated failure rate (in %) of the event/task you are evaluating? _____	15
Q5: What is the percent of time the SUT will be employed over its expected life span? _____	77
Q6: What is the expected operational tempo (in percent) for the SUT when employed? _____	90
On a scale of 1 to <b>5</b> the likelihood of your risk occurring is:	<b>2.85</b>
Based on your answers to Q1 and Q2, the likelihood scaling factor for your risk reporting matrix is: 7.12	
Your event will occur <b>1,807</b> times over the time frame you selected in Q1.	
Notes: <ol style="list-style-type: none"> <li>1. Risk likelihood comparisons cannot be made unless they are observed over the same time period (Q1) and on the same scale (Q2).</li> <li>2. The evaluation frame of reference is established by the response to Q1.</li> <li>3. Likelihood is scaled to the number of decision tiers by the response to Q2.</li> <li>4. The answer to Q4 cannot be zero. Extremely low failure rates can be estimated.</li> </ol>	

# Interpretation

- Precise estimate
  - Tie breaker for equal-consequence risks
- Off-scale high results:
  - Risk may be considered realized
- Off-scale low results:
  - Risk may be considered negligible



# Interpretation

<b>Inputs</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>
<b>Time Frame (Years)</b>	50		
<b>Tiers</b>	5		
<b>Interval (Days)</b>	7		
<b>Failure Rate (%)</b>	15		
<b>Life Cycle (%)</b>	100		
<b>Op Tempo (%)</b>	100		
<b>Likelihood</b>	3.04		

# Interpretation

<b>Inputs</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>
<b>Time Frame (Years)</b>	50	50	
<b>Tiers</b>	5	5	
<b>Interval (Days)</b>	7	7	
<b>Failure Rate (%)</b>	15	15	
<b>Life Cycle (%)</b>	100	77	
<b>Op Tempo (%)</b>	100	100	
<b>Likelihood</b>	<b>3.04</b>	<b>2.91</b>	

# Interpretation

<b>Inputs</b>	<b>Case 1</b>	<b>Case 2</b>	<b>Case 3</b>
<b>Time Frame (Years)</b>	50	50	50
<b>Tiers</b>	5	5	5
<b>Interval (Days)</b>	7	7	7
<b>Failure Rate (%)</b>	15	15	15
<b>Life Cycle (%)</b>	100	77	77
<b>Op Tempo (%)</b>	100	100	90
<b>Likelihood</b>	<b>3.04</b>	<b>2.91</b>	<b>2.85</b>



# Implications

- Consistent with risk management guidance
  - Avoid (eliminate number of occurrences ( $x_i = 0$ ))
  - Mitigate (reduce failure rate  $P_f(x_i)$  and/or  $x_i$ )
  - Accept (do nothing)
  - Transfer (someone else's problem)
- Common Frame of reference
  - Must be the same span of events (years, hours, etc.)
  - Otherwise risk comparison / reporting will be degraded
- Order of magnitude between tiers
  - Order of magnitude reduction to report lower likelihood/exposure
  - Risk exposure “burn down” harder to justify

- Objective vice subjective estimate
  - Calculation
  - Consistent
  - Logical
  - Asks better questions than “What do you think?”
- Scalable, adaptable and adjustable
- Rumb line to focus the likelihood debate



# Contact Information

**700 Independence Parkway  
Suite 300**

**Chesapeake, VA 23320**

**(757) 361-9581**

**FAX (757) 361-9585**

**<http://www.avwtech.com>**

**[ricke@avwtech.com](mailto:ricke@avwtech.com)**