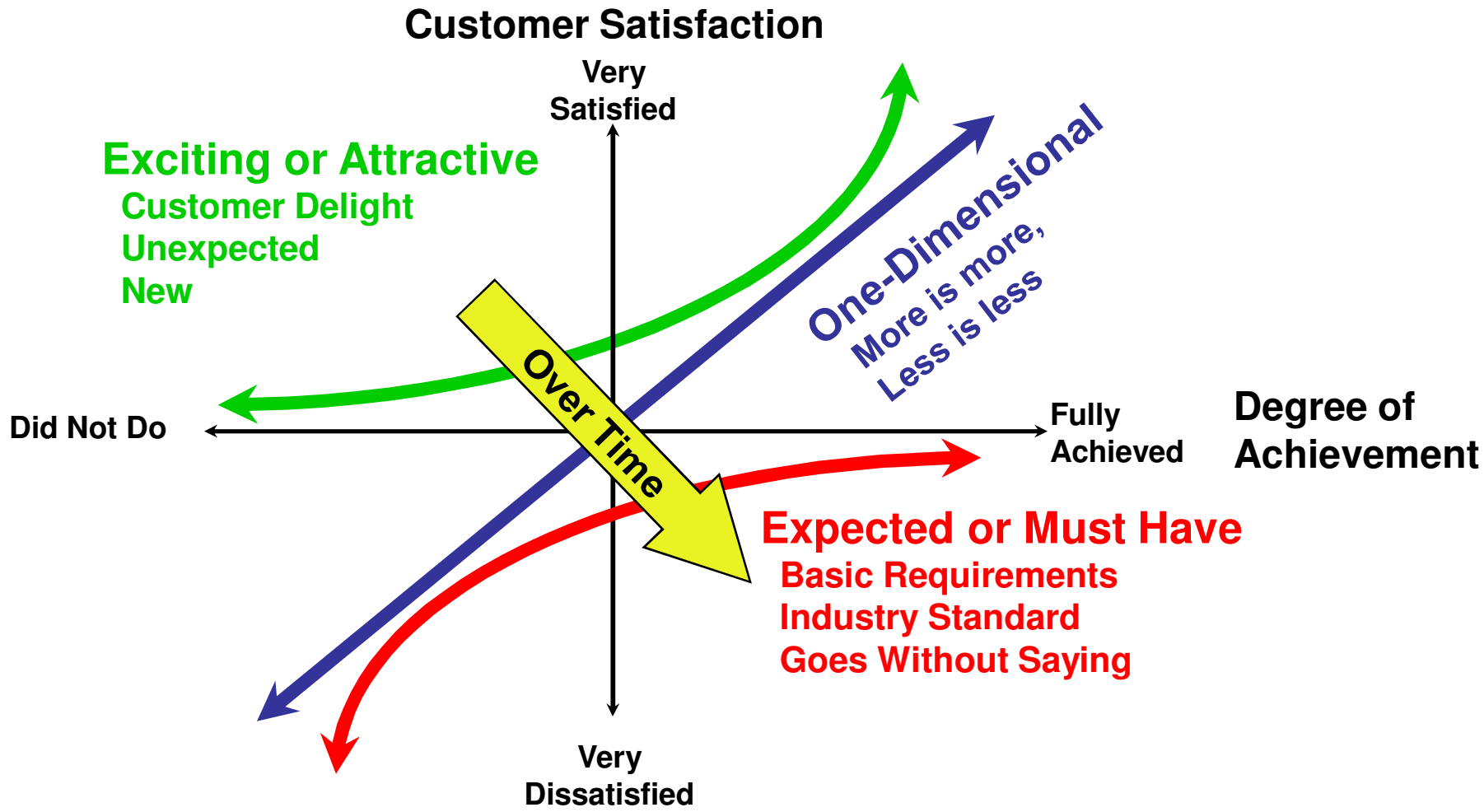
Reliability Measurement

Agenda

- **Presenter**
  - Dan Burrows, Panduit Corporate Reliability Engineer
  - CRE, CSSBB
  - E-mail: Dan.Burrows@panduit.com
  - Extension: 708-532-1800 ext. 1894
- **Reliability Measurement**
  - A Little About Reliability
  - Design Phase
  - Testing Phase
  - Operational Phase

Definition of Excellence

Kano Model – Where Is Reliability?



Definition vs. the "Real World"

- **Reliability** is the probability that an item can perform its intended function for a specified interval under stated conditions following prescribed procedures

- ***There are "Real World" conflicts with this textbook definition that we need to keep in mind…***
  - **Probability** – Customers expect a probability of 1, "It Works"
  - **Intended Function** – The product may be used in unintended ways and still be expected to work
  - **Under Stated Conditions** – The product may be operated outside of the stated conditions and still be expected to work
  - **Prescribed Procedures** – Customers may not have the required tools or skill level and may not follow procedures and still expect the product to work

➔ ***Customers are looking for Quality over Time***

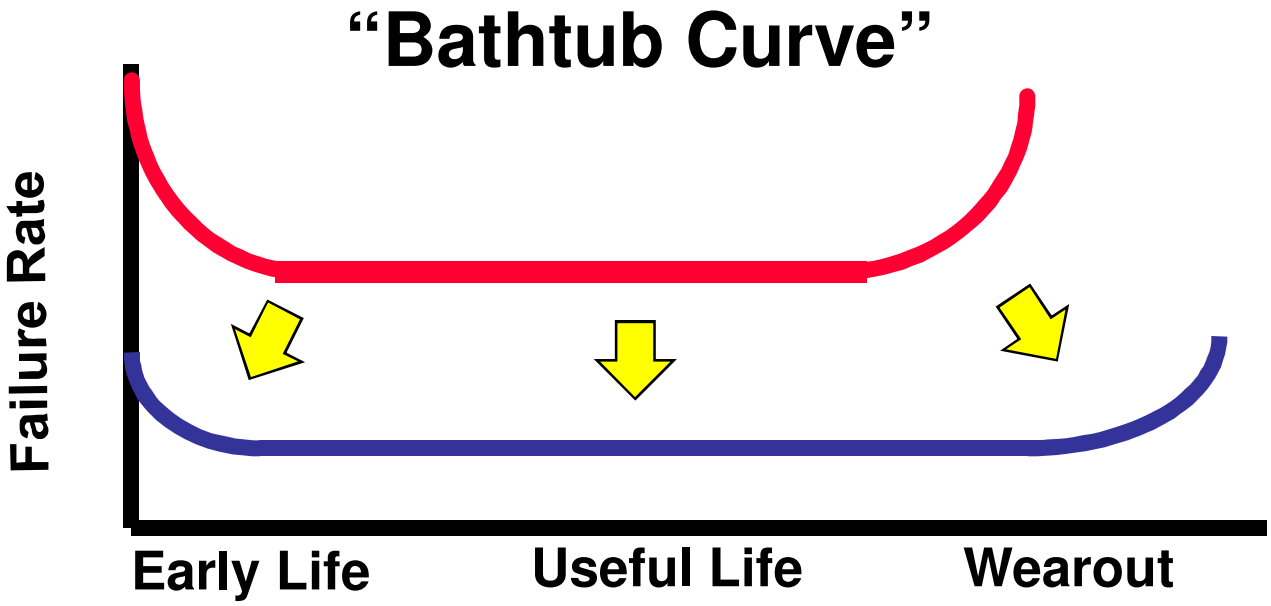
The Right Tool at the Right Time Throughout the Development Cycle

STAGE GATE PRODUCT DEVELOPMENT					
New Business Opportunity	Preliminary Investigation	Concept Generation	Business Case Development	Product Design	Product Release
•Field Data Collection and Analysis	•Field Data Collection and Analysis	•Reliability Analysis •Failure Mode and Effects Analysis	•Reliability Plan •Reliability Analysis •Failure Mode and Effects Analysis	•Reliability Analysis •Failure Mode and Effects Analysis •Reliability Test	•Failure Mode and Effects Analysis •Reliability Test •Field Data Collection and Analysis

Managing Reliability

- **Reliability Engineering**

  A systems approach to planning for, designing in, verifying, and tracking the reliability of products throughout their life to achieve reliability goals.



In Unison

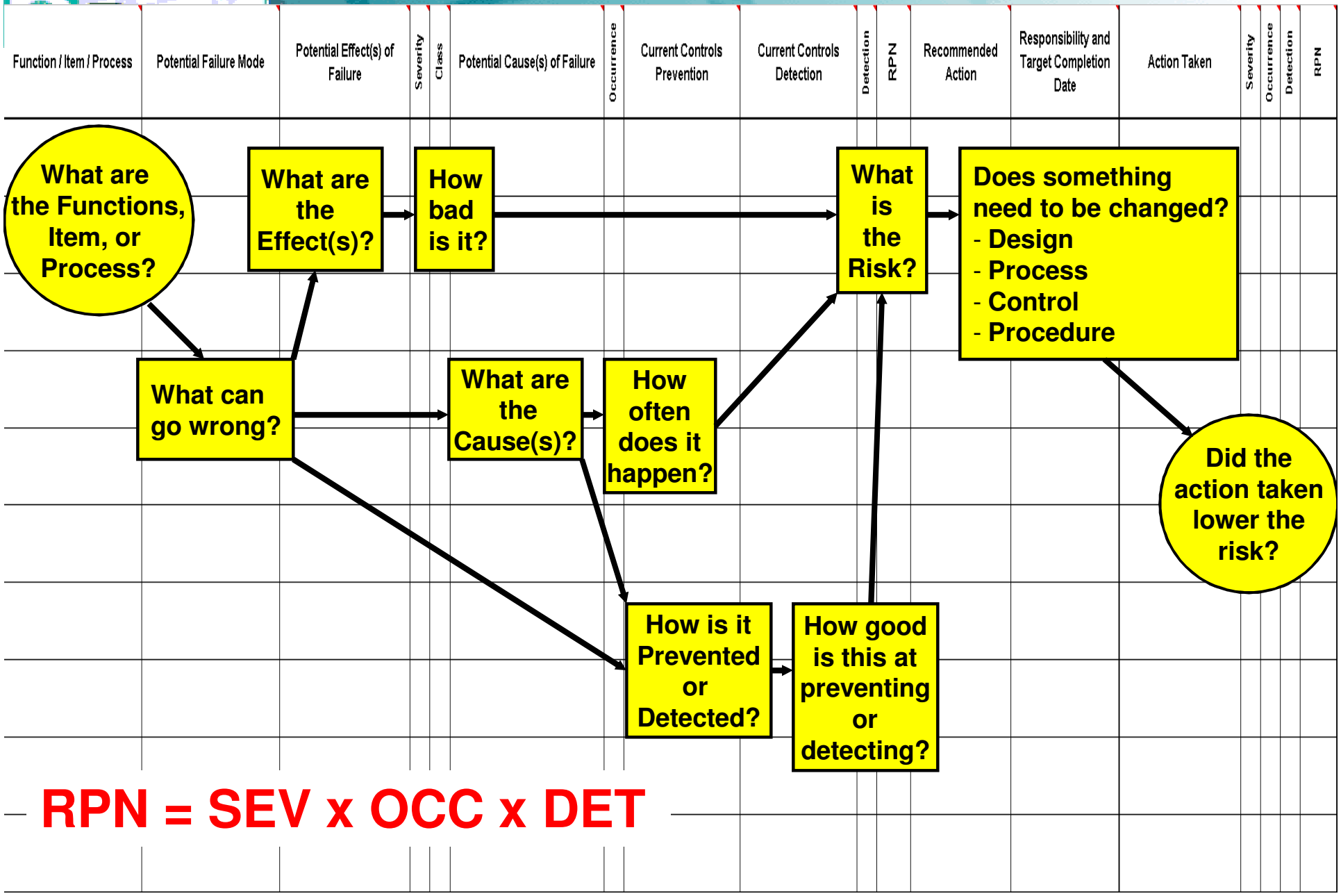
“Drain the bathtub.”

Design Measurement – Reliability Predictions

Using Telcordia/Bellcore SR-332 prediction techniques…

Part	Qty	Base Failure Rate Per 10^9 hours	Qual Factor	Env Factor	Temp Factor	Elec Stress Factor	Total Device Failure Rate Per 10^9 hours
IC, Bipolar	17	26	1.0	1.0	1.0		442
IC, NMOS	14	58	1.0	1.0	1.0		812
Transistor	5	6	1.0	1.0	1.0	1.0	30
Capacitor	5	2	2.5	1.0	1.0	1.0	25
LED	1	4	3.0	1.0	1.0		12
Total Design							**1321**

Design Measurement – FMEA Risk



RPN = SEV x OCC x DET

Test Measurement – Reliability Probability

Reliability Demonstration

Number of Units	30	***Enter***
Number of Failures	2	***Enter***
Confidence Level Desired	0.95	***Enter***
Reliability	***0.810***	***Look up from Table***

Beta Table

			Confidence Level Columns			
Sample Size	**Successes**	**Failures**	**0.75**	**0.90**	**0.95**	**0.99**
5	3	2	0.447	0.333	0.271	0.173
	4	1	0.610	0.490	0.418	0.294
	5	0	0.794	0.681	0.607	0.464
10	7	3	0.580	0.489	0.436	0.340
	8	2	0.674	0.585	0.530	0.428
	9	1	0.773	0.690	0.636	0.530
	10	0	0.882	0.811	0.762	0.658
15	12	3	0.702	0.629	0.583	0.497
	13	2	0.769	0.700	0.656	0.570
	14	1	0.840	0.778	0.736	0.651
	15	0	0.917	0.866	0.829	0.750
20	17	3	0.769	0.709	0.671	0.596
	18	2	0.822	0.766	0.729	0.656
	19	1	0.877	0.827	0.793	0.723
	20	0	0.936	0.896	0.867	0.803
25	22	3	0.811	0.761	0.728	0.663
	23	2	0.855	0.808	0.777	0.714
	24	1	0.900	0.858	0.830	0.771
	25	0	0.948	0.915	0.891	0.838
30	27	3	0.841	0.797	0.768	0.711
	28	2	0.877	0.837	0.810	0.755
	29	1	0.916	0.880	0.856	0.804
	30	0	0.956	0.928	0.908	0.862

Test Measurement – MTTF or Failure Rate

MTTF and Failure Rate Demonstration

Failure Free

						MTTF	Failure Rate
Time per Unit	100	*Enter*	**Point Estimate**			*5000*	*0.000200000*
Number of Units	50	*Enter*	***Confidence Intervals***				
Confidence Level Desired	0.90	*Enter*		One-Sided	Lower	*2171*	*0.000460517*
				Two-Sided	Lower	*1669*	*0.000599146*
				Two-Sided	Upper	*97479*	*0.000010259*
MTTF Desired to be Demonstrated	2000	*Enter*	**Required Time per Unit**	*92*			
Number of Units	50	*Enter*					
Confidence Level Desired	0.90	*Enter*					
MTTF Desired to be Demonstrated	2000	*Enter*	**Required Number of Units**	*46*			
Time per Unit	100	*Enter*					
Confidence Level Desired	0.90	*Enter*					

Failures Occur

						MTTF	Failure Rate
Total Time on All Units	5000	*Enter*	**Point Estimate**			*1250*	*0.000800000*
Total Number of Failures	4	*Enter*	***Confidence Intervals***				
Confidence Level Desired	0.90	*Enter*	**Stop after Predetermined # of Failures**				
				One-Sided	Lower	*748*	*0.001336156*
				Two-Sided	Lower	*645*	*0.001550731*
				Two-Sided	Upper	*3659*	*0.000273263*
			Stop after a Predetermined Time				
				One-Sided	Lower	*626*	*0.001598717*
				Two-Sided	Lower	*546*	*0.001830703*
				Two-Sided	Upper	*3659*	*0.000273263*

Production System Measurement – System Effectiveness

System Effectiveness = Availability x Efficiency x Yield

90% x 95% x 99% = 85%

➢ ***How is the total system performing?***

Availability = Uptime / (Uptime + Downtime)

432 min / (432 min + 48 min) = 90%

➢ ***Is it running?***

Efficiency = Design Cycle Time / Actual Cycle Time

(4 min/cycle x 103 cycles) / 432 min = 95%

➢ ***At design rate?***

Yield = Good Parts / Total Parts

102 / 103 = 99%

➢ ***Are the parts good?***

System Effectiveness – What Would You Try To Improve?

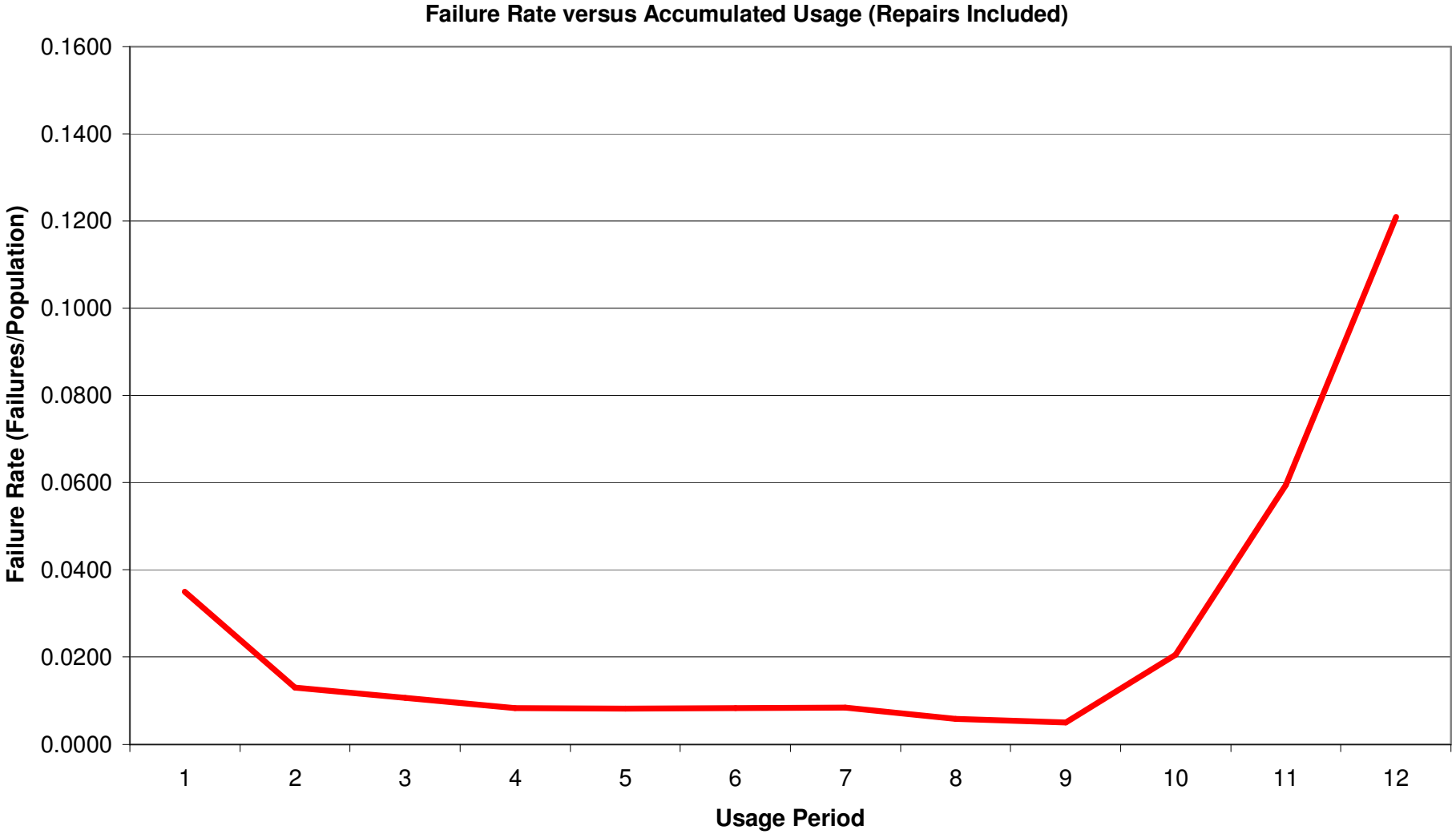
System Effectiveness	Availability	Efficiency	Yield
85% =	90%	95%	98%
70% =	75%	95%	98%
66% =	90%	75%	98%
64% =	90%	95%	75%

Operational Measurement – Usage and Calendar Time

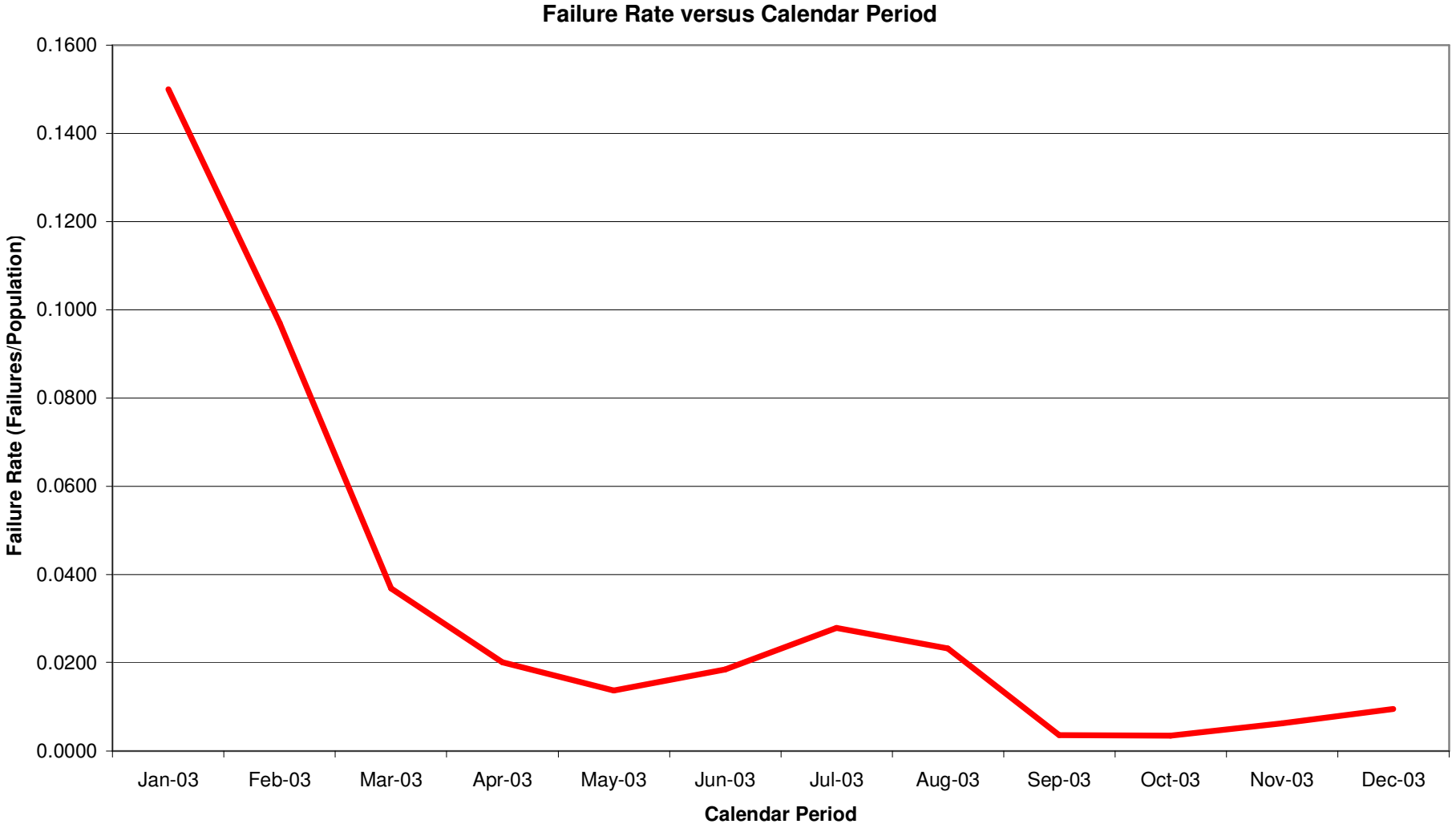
- **Usage Time Pattern?**
- **Calendar Time Pattern?**

		Total Quantity Failed or Recalled During Period											
Ship Period	Ship Qty	Jan-03	Feb-03	Mar-03	Apr-03	May-03	Jun-03	Jul-03	Aug-03	Sep-03	Oct-03	Nov-03	Dec-03
Jan-03	500	75	20	10		5	10	30	25	10	15	30	55
Feb-03	1000		125	25	10		10	25	30		5	30	55
Mar-03	1500			75	20		25	50	45			5	15
Apr-03	2000				70	15	30	45	30		10	5	5
May-03	2000					75	25	55	35			5	10
Jun-03	2000						65	45	50		5	5	
Jul-03	2000							55	45	5			5
Aug-03	2000								40	10	5	10	5
Sep-03	1500									25	5		5
Oct-03	1500										10	5	5
Nov-03	1000											10	5
Dec-03	1000												5

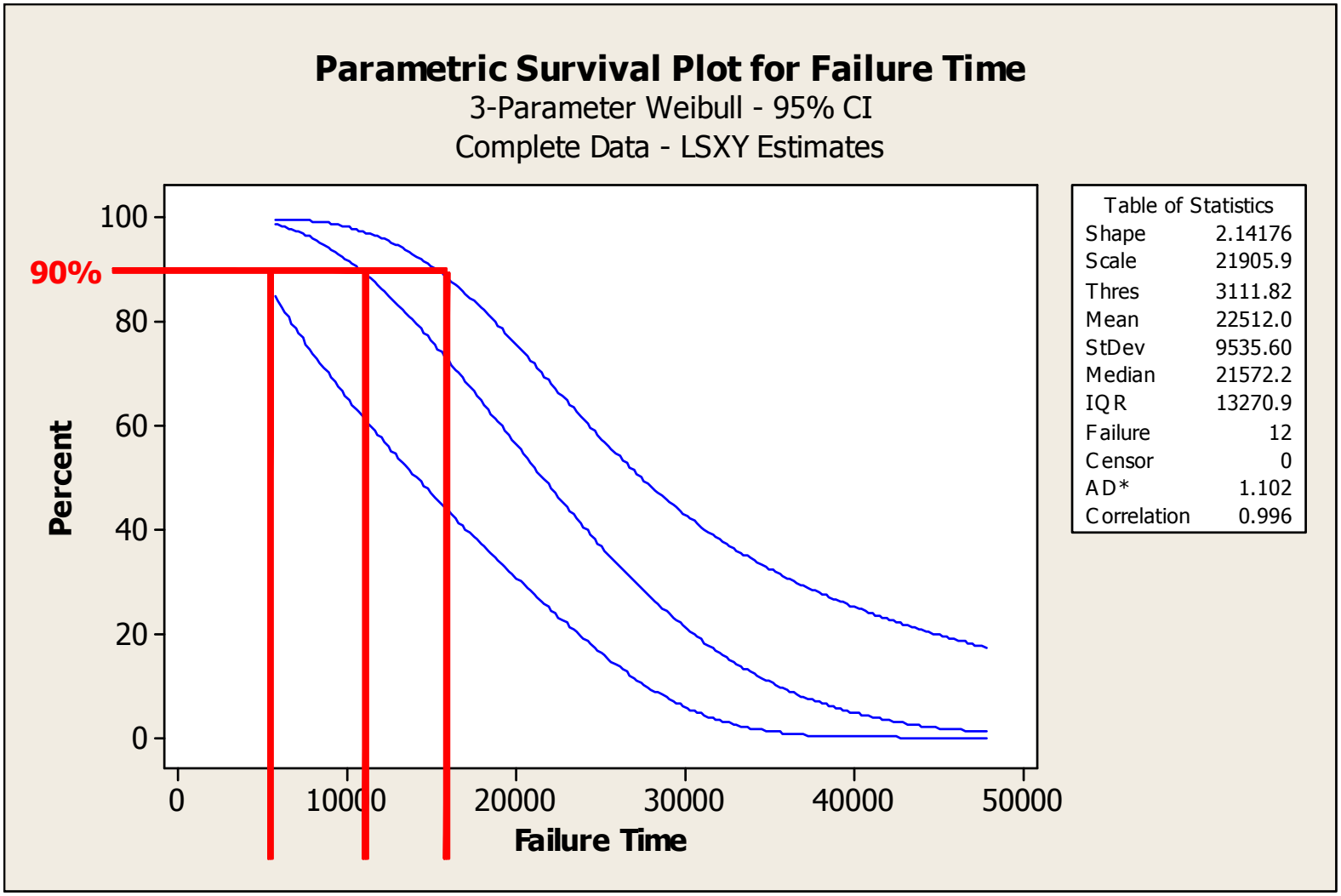
Usage Time Analysis



Calendar Time Analysis



Statistical Measurement – Distribution Analysis Survival Plot



One Last Time…

“Drain the bathtub.”

Wrap-Up

- **Questions / Comments**
- **Thanks**