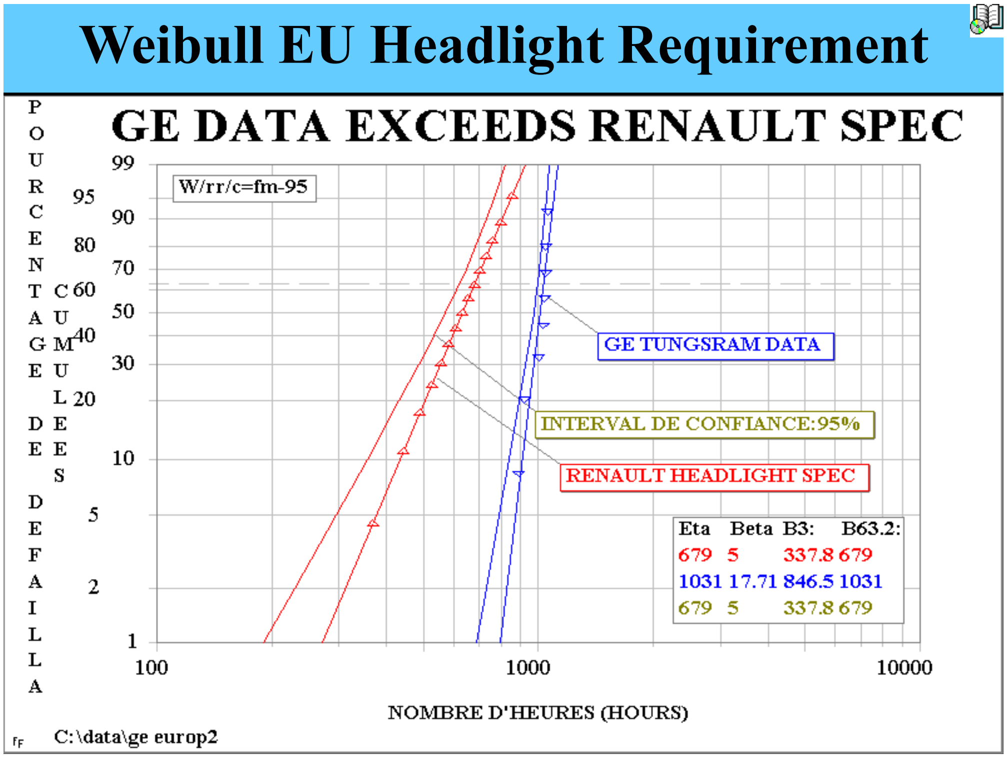
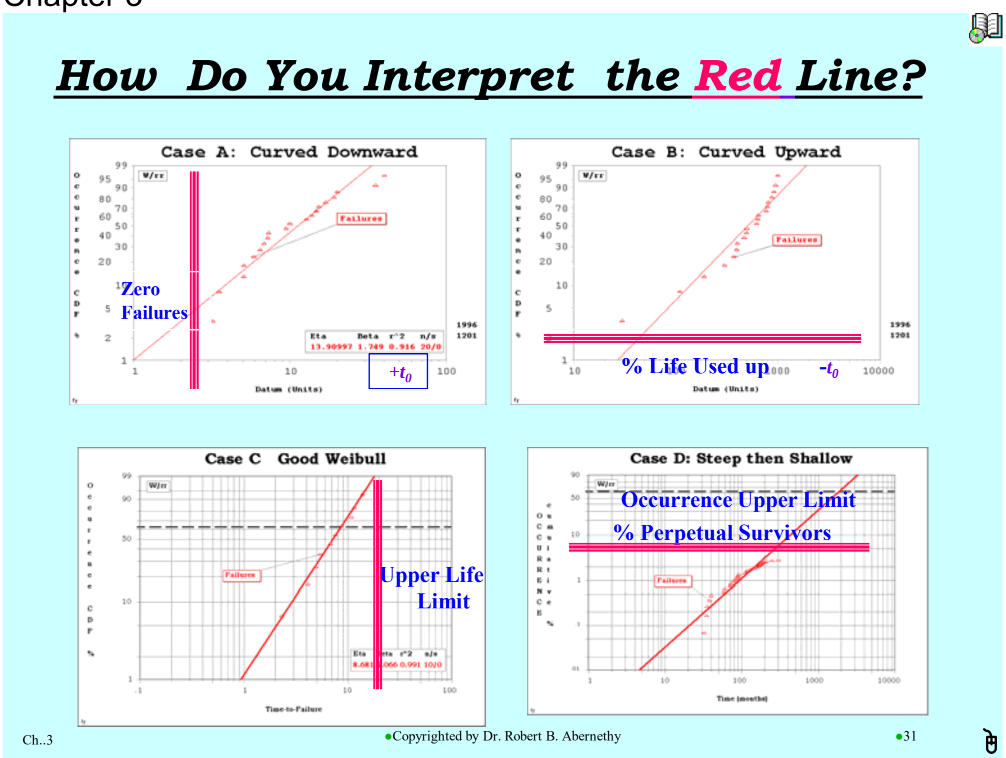
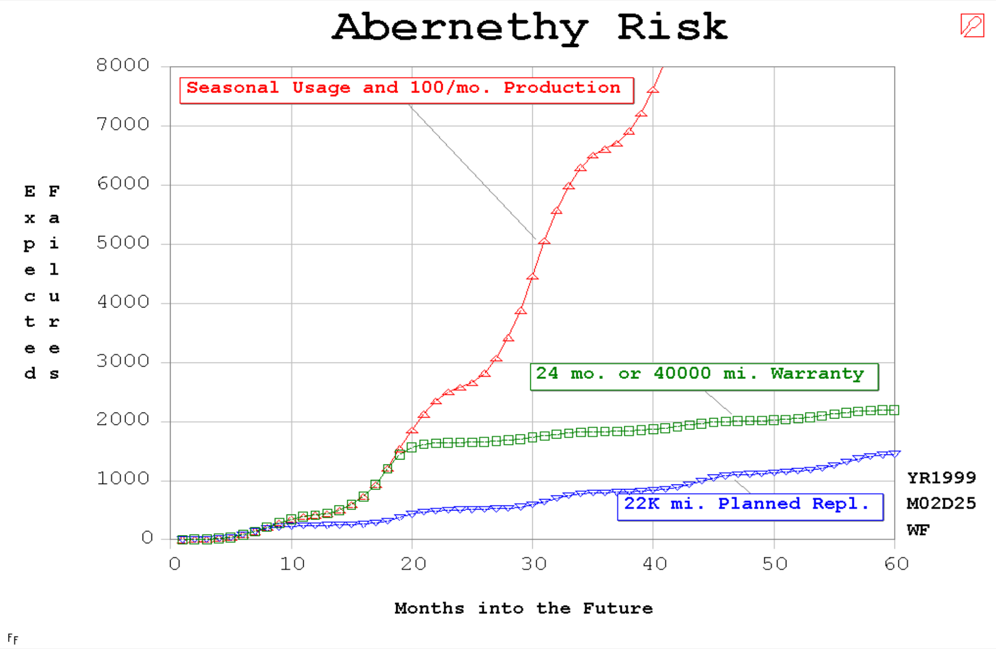
Chapter 2



Chapter 3



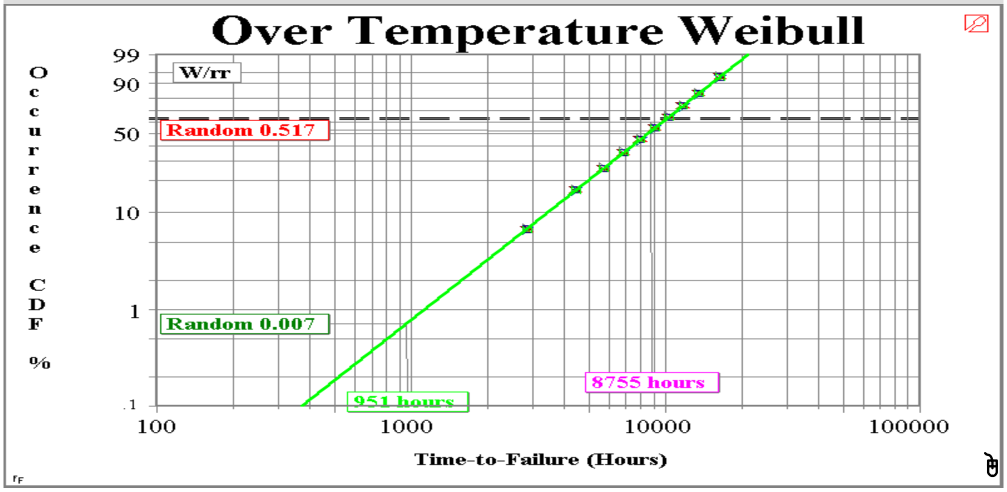
Predictions with Seasonal Usage & Production, Warranty Limits, & Parts Replacements.



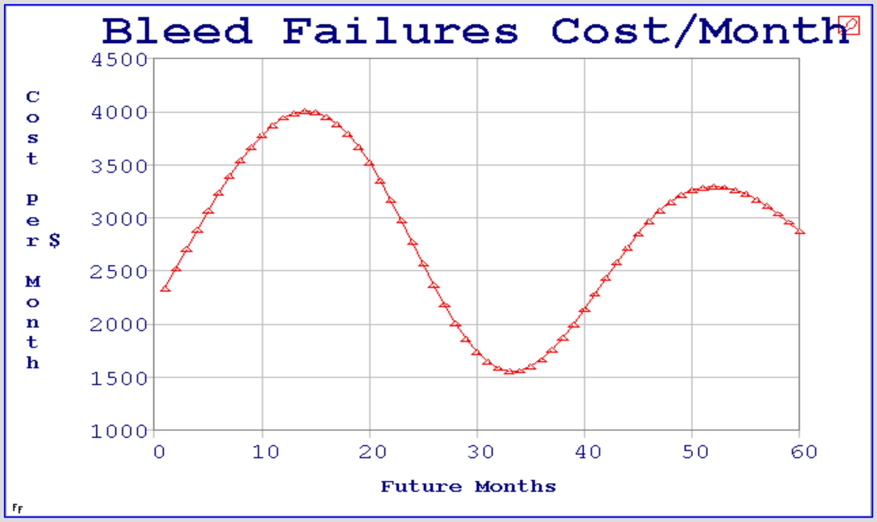
4.7.1* Monte Carlo Simulation

•Monte Carlo simulations use random numbers and convert them into random events like time-to-failure.

•We convert random numbers into random events like time-to-failure. There are many ways but the most popular used the CDF inversely.



4.5.2 Maintainability Rhythm Converted to Cost

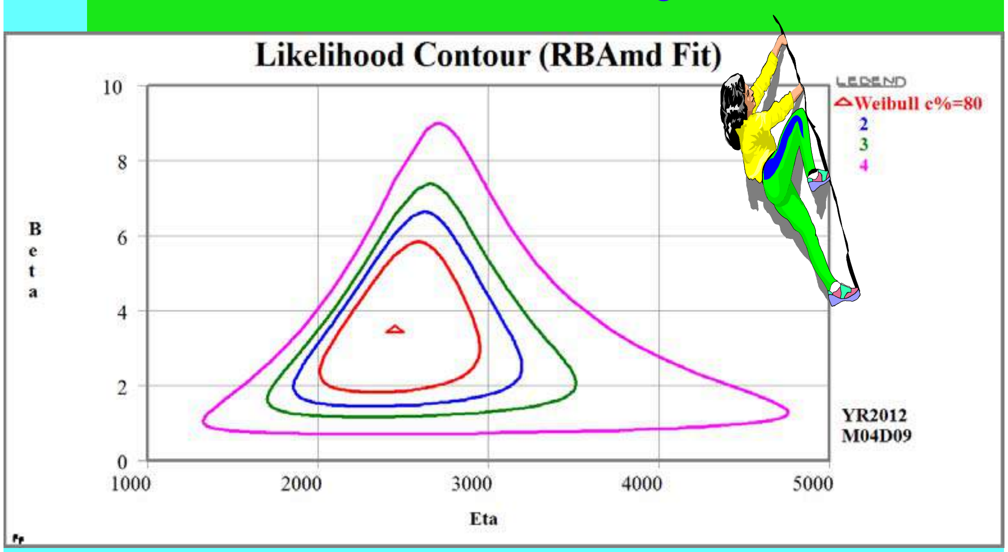


Ch. 4 Copyrighted by Dr. Robert Abernethy 23

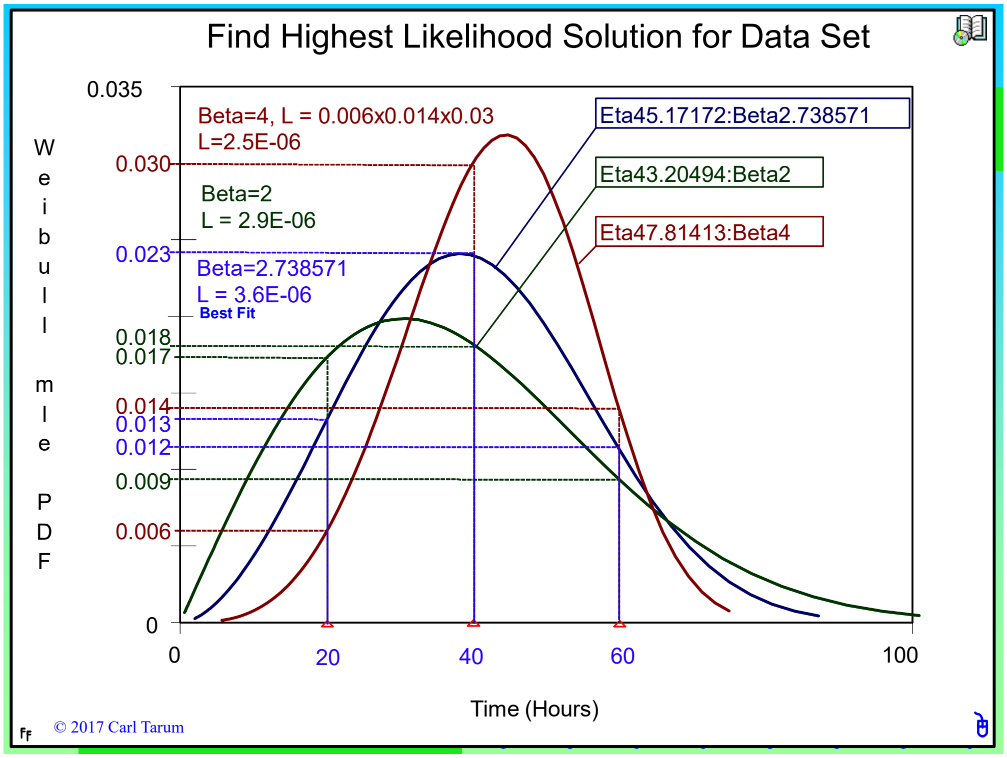
Chapter 5

5.2 Likelihood Contours

Climbing the Likelihood



Ch. 5 Copyrighted by Dr. Robert B. Abernethy 10



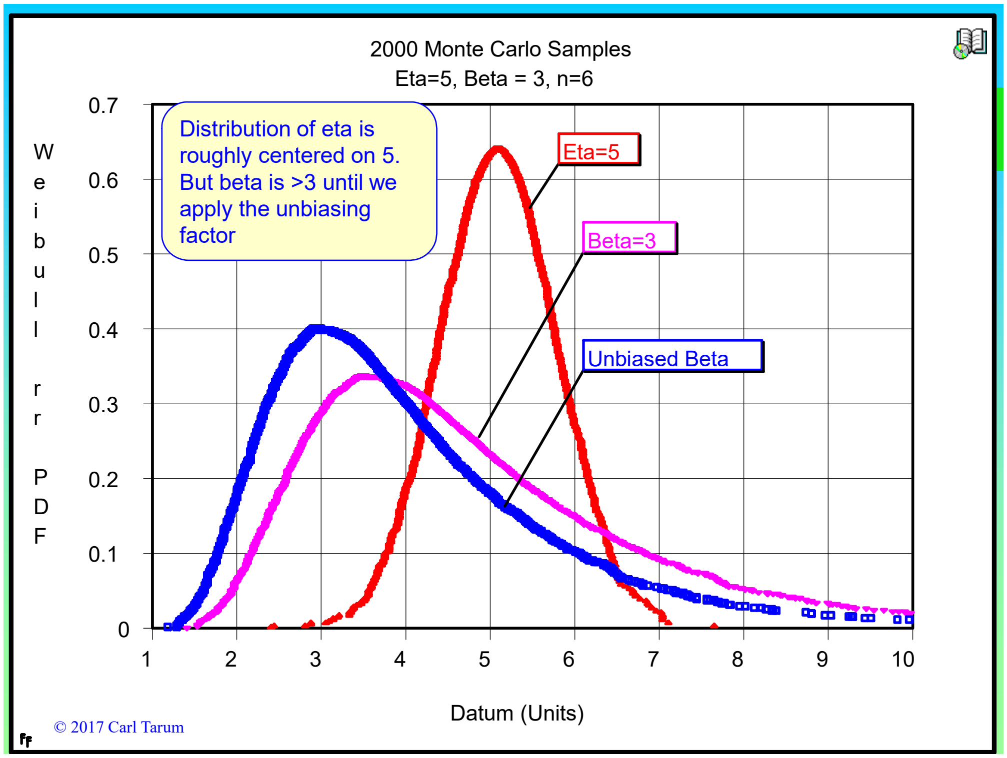
Numbers

Precise Plot Reading

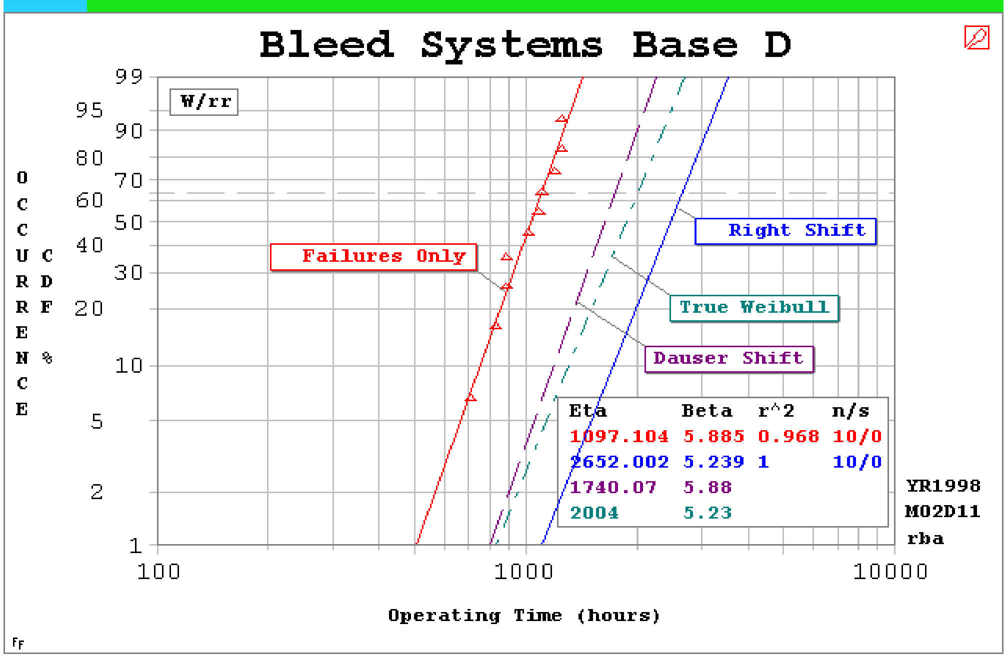
Set3 - Eta43.20494:Beta2
 X = 20, Y = 0.0172892
 X = 40, Y = 0.01818602
 X = 60, Y = 0.009347564
Likelihood = 0.0172*0.0181* 0.0093
           = 2.93908E-06
Log(L)   = -12.7374

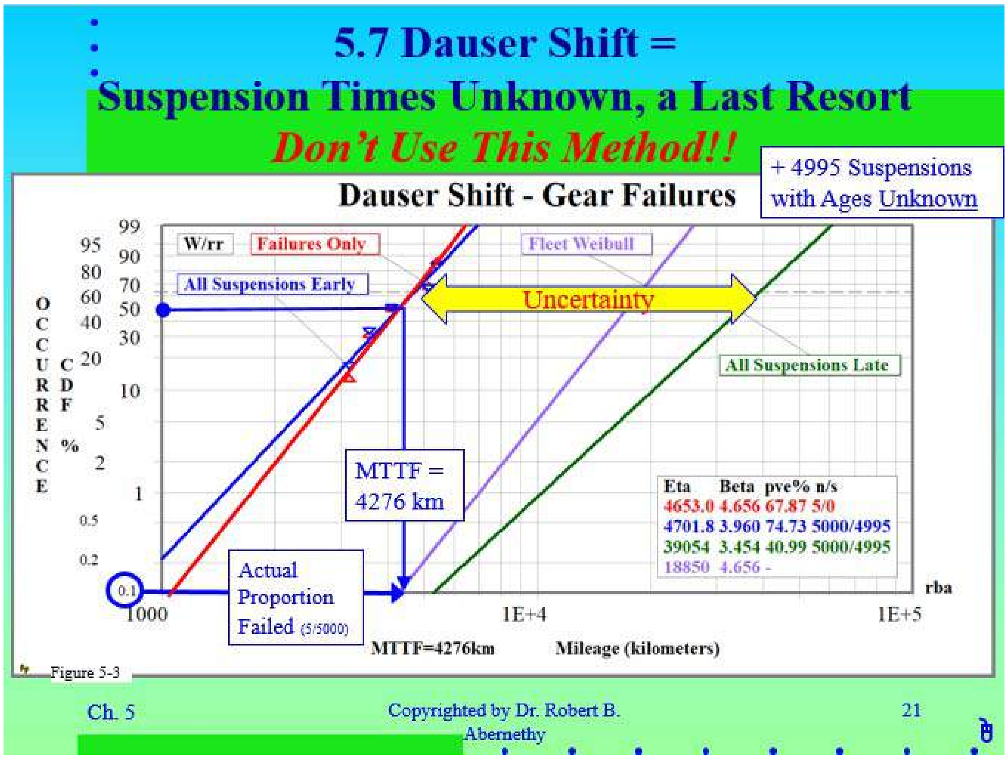
Set4 - Eta47.81413:Beta4
 X = 20, Y = 0.005939972
 X = 40, Y = 0.02999379
 X = 60, Y = 0.01386538
Likelihood = 0.0059*0.0299* 0.0138
           = 2.47029E-06
Log(L)   = -12.9112

Set2 - Eta45.17172:Beta2.738571
 X = 20, Y = 0.0132081
 X = 40, Y = 0.02394593
 X = 60, Y = 0.0127673
Likelihood = 0.0132* 0.0239*0.0112
           = 3.56661E-06
Log(L)   = -12.5439 (best)

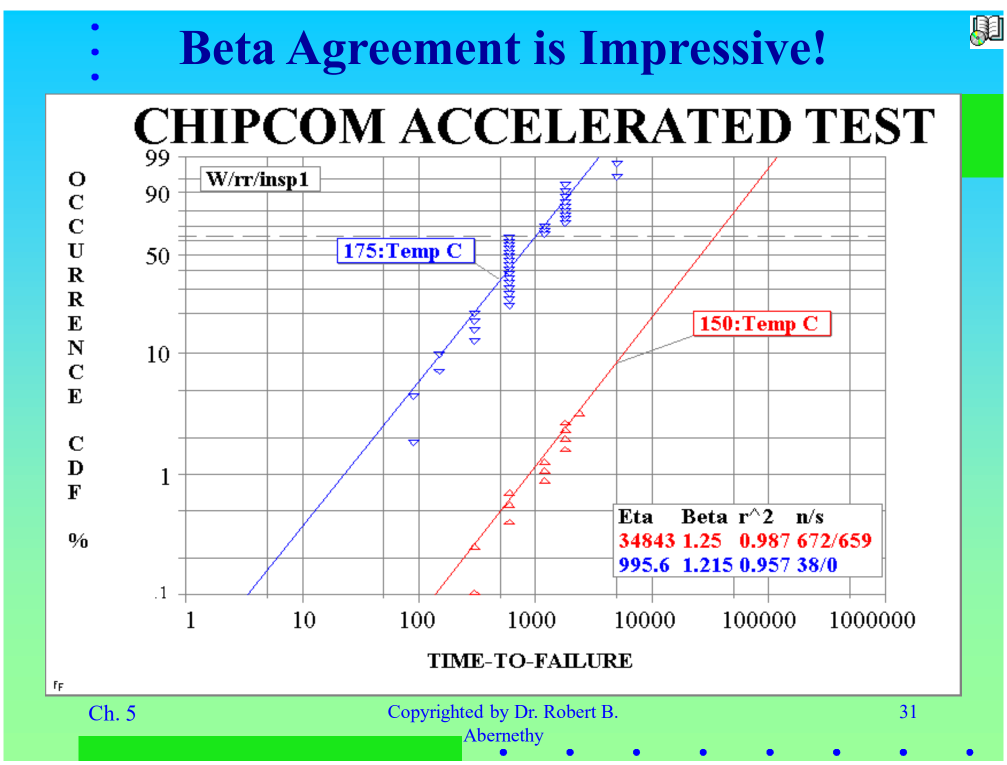


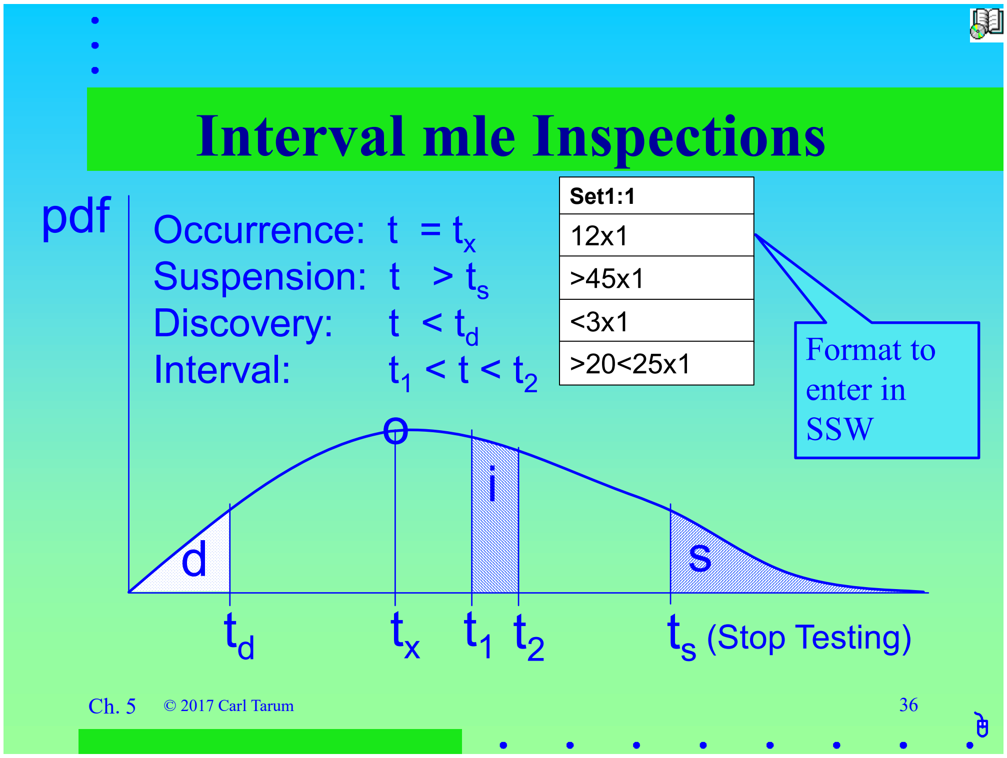
Dauser Shift Works Well…In This Case..



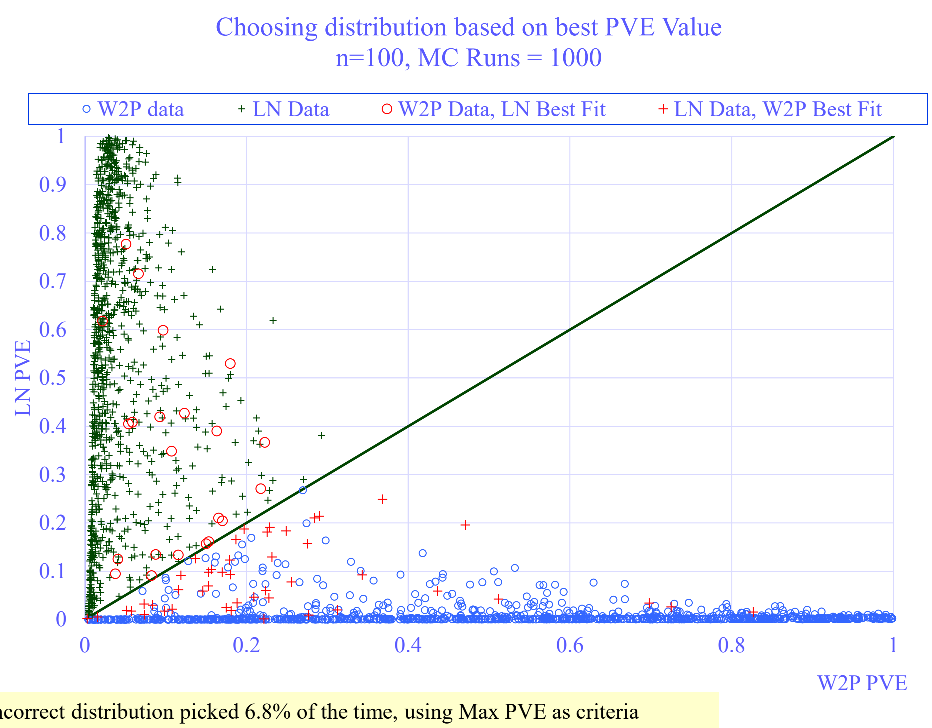


- Plot failures only (Red line)
- Do the Dauser Shift (Purple)
- Blue is if all suspensions were before the first Failure.
- Right shift is if all of the suspensions were at the last failure. This will be the graphical solution, so is the maximum we could get.

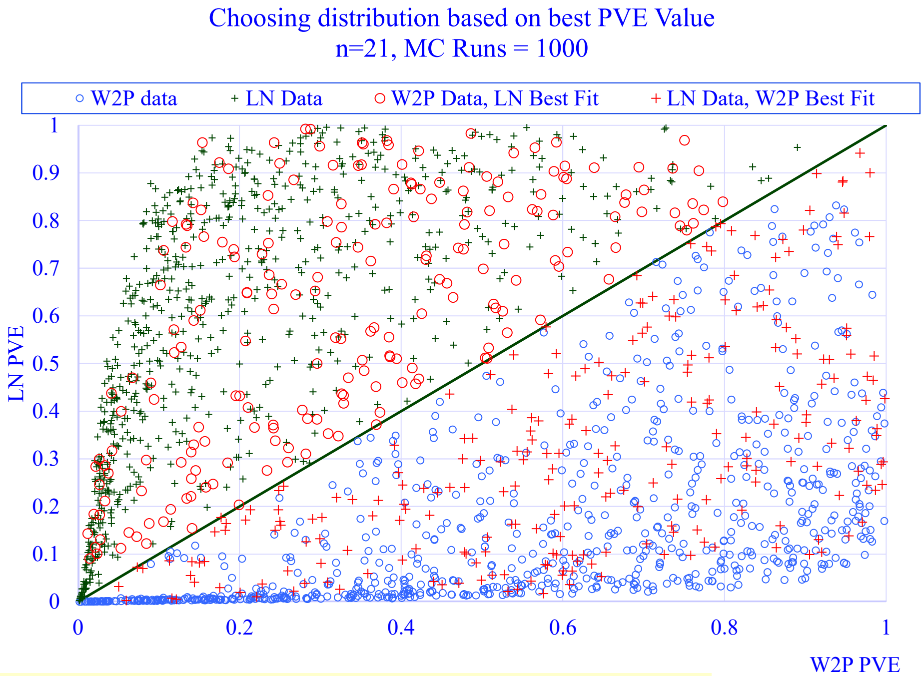




Risks of just jusing the Best PVE as sole criteria to pick a model.
1000 Monte Carlo runs were made with 100 failures. The random numbers were first used to generate LogNormal curves, and the same random numbers used to generate Weibull 2 Parameter curves. Then the PVE was calculated for each model on each set. This is the result:



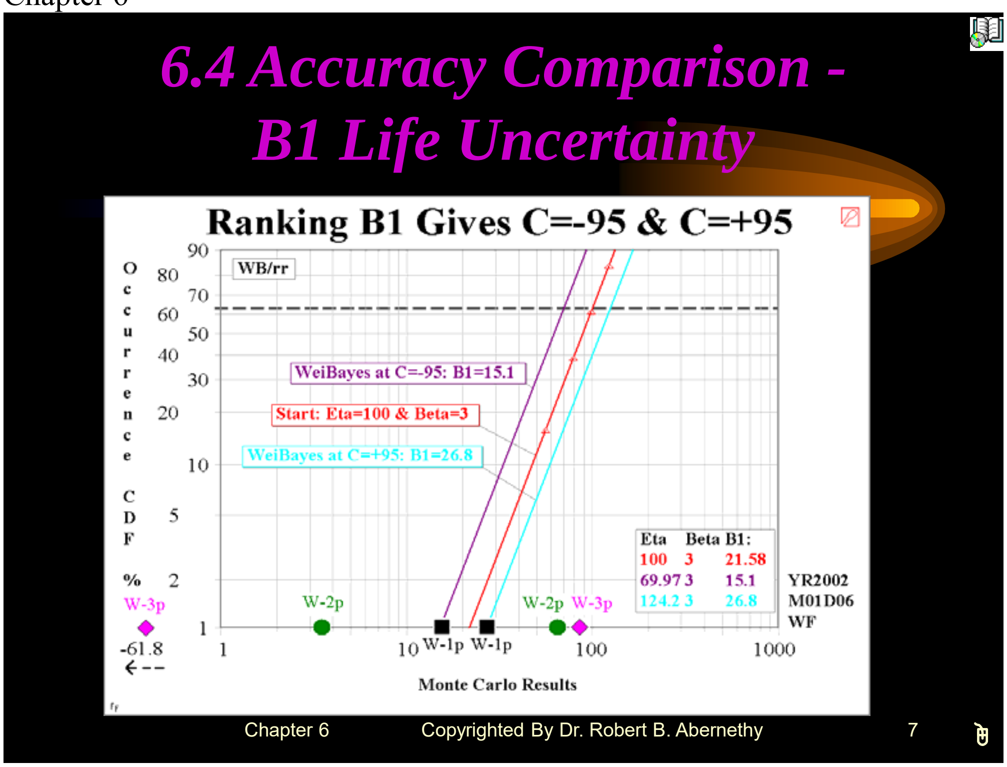
For sets with 100 occurrences, Using the best PVE picked the correct model 93.2% of the time. Then this was repeated with only 21 failures

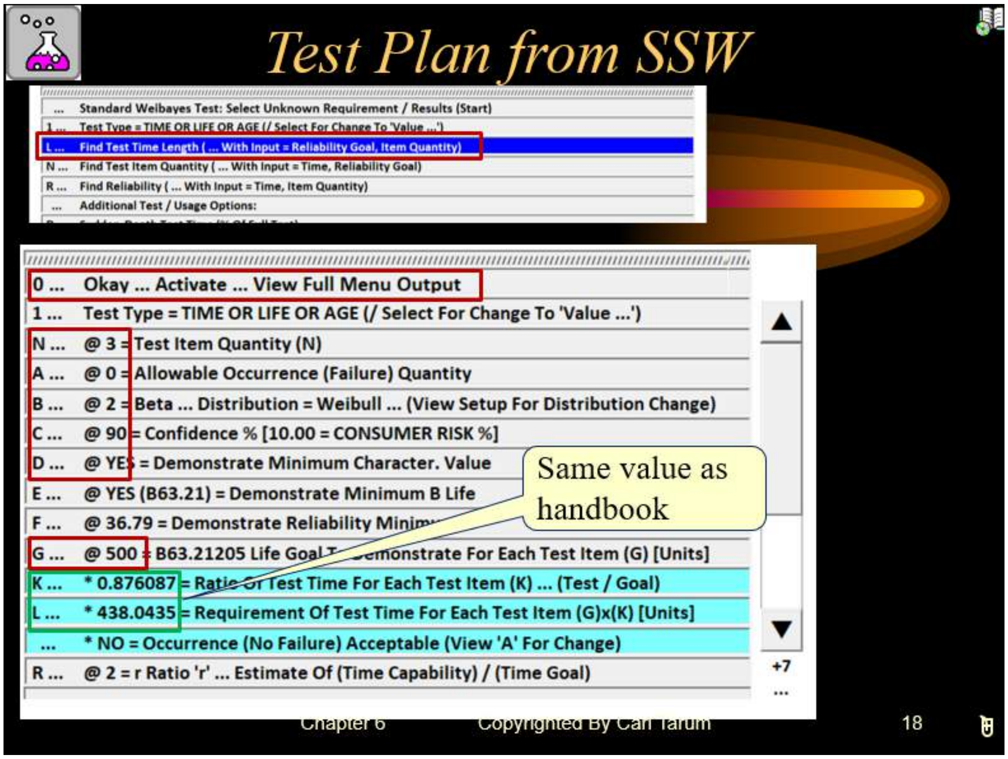


Incorrect distribution picked 45.1% of the time, using Max PVE as criteria

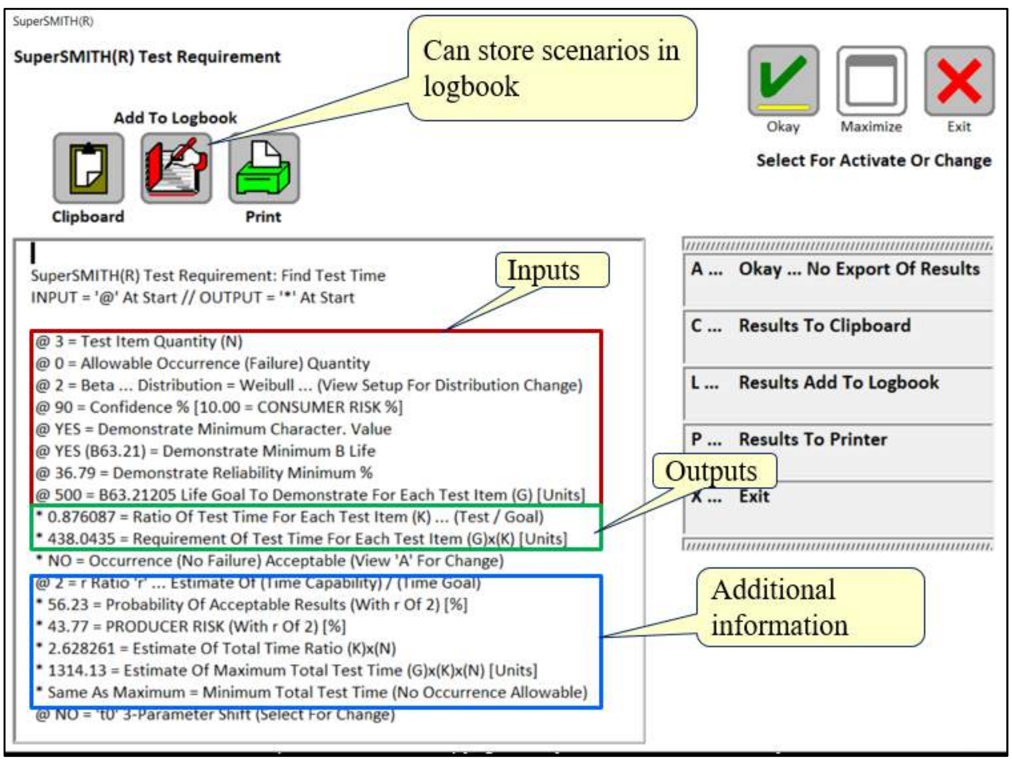
Using the best PVE picked the correct model only 55% of the time. If you wanted to use PVE and be 90% sure of picking the best model, you would have to have one PVE be at least 50% better (e.g. LN is 10%, W2P is 60%) to be 90% sure that W2P is the better fit. With this criteria, on the samples, the correct pick was done 25% of the time, an incorrect pick was done 10% of the time, and 65% of the time the best distribution could not be determined (That is, the two PVEs varied, but not by 50%)

Chapter 6

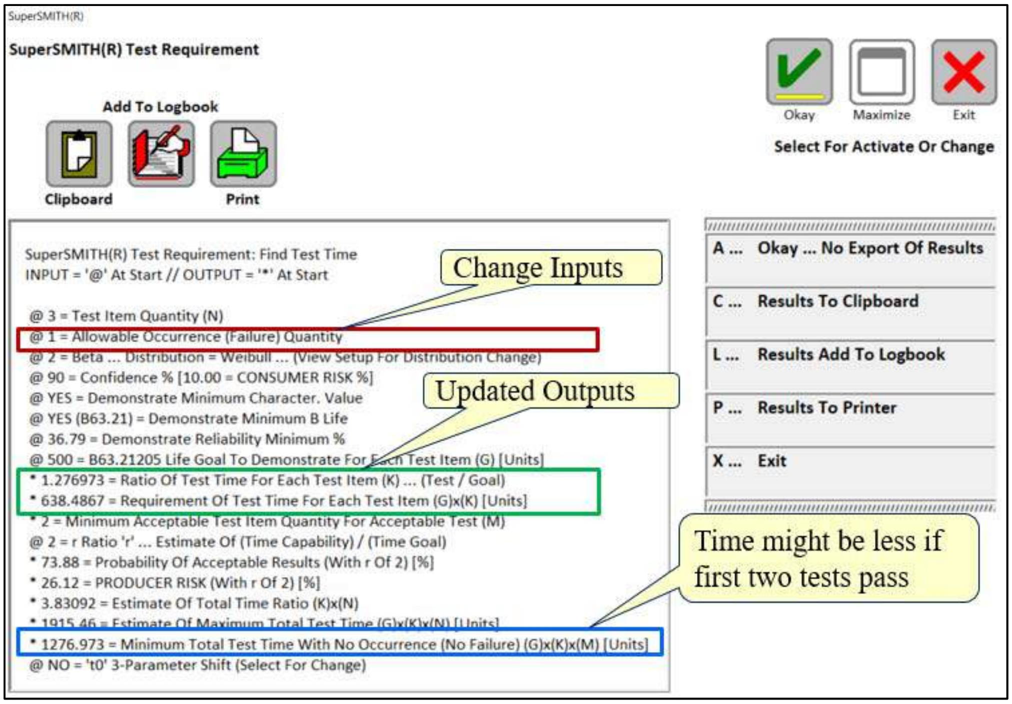


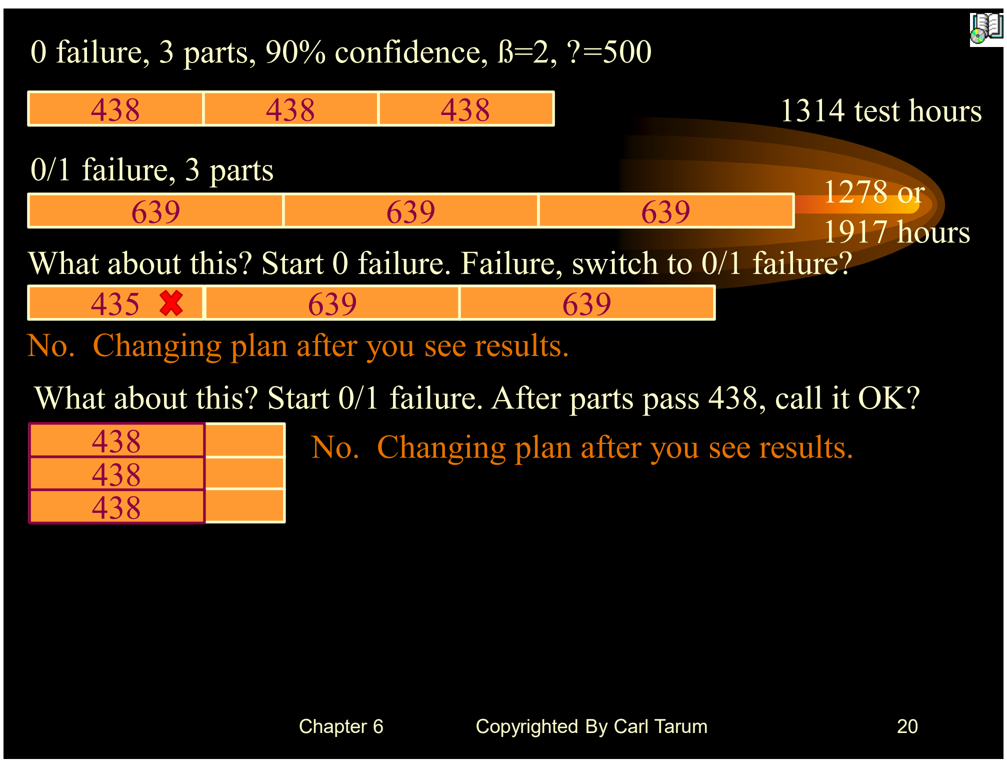


Test Plan from SSW
... Standard Weibayes Test: Select Unknown Requirement / Results (Start)
1 ... Test Type = TIME OR LIFE OR AGE (/ Select For Change To 'Value ...')
L ... Find Test Time Length (... With Input = Reliability Goal, Item Quantity)
N ... Find Test Item Quantity (... With Input = Time, Reliability Goal)
R ... Find Reliability (... With Input = Time, Item Quantity)
... Additional Test / Usage Options:
0 ... Okay ... Activate ... View Full Menu Output
1 ... Test Type = TIME OR LIFE OR AGE (/ Select For Change To 'Value ...')
N ... @ 3 = Test Item Quantity (N)
A ... @ 0 = Allowable Occurrence (Failure) Quantity
B ... @ 2 = Beta ... Distribution = Weibull ... (View Setup For Distribution Change)
C ... @ 90 = Confidence % [10.00 = CONSUMER RISK %]
D ... @ YES = Demonstrate Minimum Character. Value
E ... @ YES (B63.21) = Demonstrate Minimum B Life
F ... @ 36.79 = Demonstrate Reliability Minimum
G ... @ 500 = B63.21205 Life Goal To Demonstrate For Each Test Item (G) [Units]
K ... * 0.876087 = Ratio Of Test Time For Each Test Item (K) ... (Test / Goal)
L ... * 438.0435 = Requirement Of Test Time For Each Test Item (G)x(K) [Units]
... * NO = Occurrence (No Failure) Acceptable (View 'A' For Change)
R ... @ 2 = r Ratio 'r' ... Estimate Of (Time Capability) / (Time Goal)
+7
...
Same value as handbook
Chapter 6
Copyrighted By Can Tarum
18



SuperSMITH(R)
SuperSMITH(R) Test Requirement
Can store scenarios in logbook
Add To Logbook
Clipboard
Print
Okay
Maximize
Exit
Select For Activate Or Change
SuperSMITH(R) Test Requirement: Find Test Time
INPUT = '@' At Start // OUTPUT = '*' At Start
Inputs
@ 3 = Test Item Quantity (N)
@ 0 = Allowable Occurrence (Failure) Quantity
@ 2 = Beta ... Distribution = Weibull ... (View Setup For Distribution Change)
@ 90 = Confidence % [10.00 = CONSUMER RISK %]
@ YES = Demonstrate Minimum Character. Value
@ YES (B63.21) = Demonstrate Minimum B Life
@ 36.79 = Demonstrate Reliability Minimum %
@ 500 = B63.21205 Life Goal To Demonstrate For Each Test Item (G) [Units]
* 0.876087 = Ratio Of Test Time For Each Test Item (K) ... (Test / Goal)
* 438.0435 = Requirement Of Test Time For Each Test Item (G)x(K) [Units]
* NO = Occurrence (No Failure) Acceptable (View 'A' For Change)
@ 2 = r Ratio 'r' ... Estimate Of (Time Capability) / (Time Goal)
* 56.23 = Probability Of Acceptable Results (With r Of 2) [%]
* 43.77 = PRODUCER RISK (With r Of 2) [%]
* 2.628261 = Estimate Of Total Time Ratio (K)x(N)
* 1314.13 = Estimate Of Maximum Total Test Time (G)x(K)x(N) [Units]
* Same As Maximum = Minimum Total Test Time (No Occurrence Allowable)
@ NO = 't0' 3-Parameter Shift (Select For Change)
A ... Okay ... No Export Of Results
C ... Results To Clipboard
L ... Results Add To Logbook
P ... Results To Printer
X ... Exit
Outputs
Additional information


SuperSMITH(R)
SuperSMITH(R) Test Requirement
Add To Logbook
Clipboard
Print
Okay
Maximize
Exit
Select For Activate Or Change
SuperSMITH(R) Test Requirement: Find Test Time
INPUT = '@' At Start // OUTPUT = '*' At Start
@ 3 = Test Item Quantity (N)
@ 1 = Allowable Occurrence (Failure) Quantity
@ 2 = Beta ... Distribution = Weibull ... (View Setup For Distribution Change)
@ 90 = Confidence % [10.00 = CONSUMER RISK %]
@ YES = Demonstrate Minimum Character. Value
@ YES (B63.21) = Demonstrate Minimum B Life
@ 36.79 = Demonstrate Reliability Minimum %
@ 500 = B63.21205 Life Goal To Demonstrate For Each Test Item (G) [Units]
* 1.276973 = Ratio Of Test Time For Each Test Item (K) ... (Test / Goal)
* 638.4867 = Requirement Of Test Time For Each Test Item (G)x(K) [Units]
* 2 = Minimum Acceptable Test Item Quantity For Acceptable Test (M)
@ 2 = r Ratio 'r' ... Estimate Of (Time Capability) / (Time Goal)
* 73.88 = Probability Of Acceptable Results (With r Of 2) [%]
* 26.12 = PRODUCER RISK (With r Of 2) [%]
* 3.83092 = Estimate Of Total Time Ratio (K)x(N)
* 1915.46 = Estimate Of Maximum Total Test Time (G)x(K)x(N) [Units]
* 1276.973 = Minimum Total Test Time With No Occurrence (No Failure) (G)x(K)x(M) [Units]
@ NO = 't0' 3-Parameter Shift (Select For Change)
Change Inputs
Updated Outputs
Time might be less if first two tests pass
A ... Okay ... No Export Of Results
C ... Results To Clipboard
L ... Results Add To Logbook
P ... Results To Printer
X ... Exit


0 failure, 3 parts, 90% confidence, ß=2, ?=500
438 438 438
1314 test hours
0/1 failure, 3 parts
639 639 639
1278 or
1917 hours
What about this? Start 0 failure. Failure, switch to 0/1 failure?
435 639 639
No. Changing plan after you see results.
What about this? Start 0/1 failure. After parts pass 438, call it OK?
438
438
438
No. Changing plan after you see results.
Chapter 6
Copyrighted By Carl Tarum
20

0 failure, 3 parts, 90% confidence, ß=2, ?=500

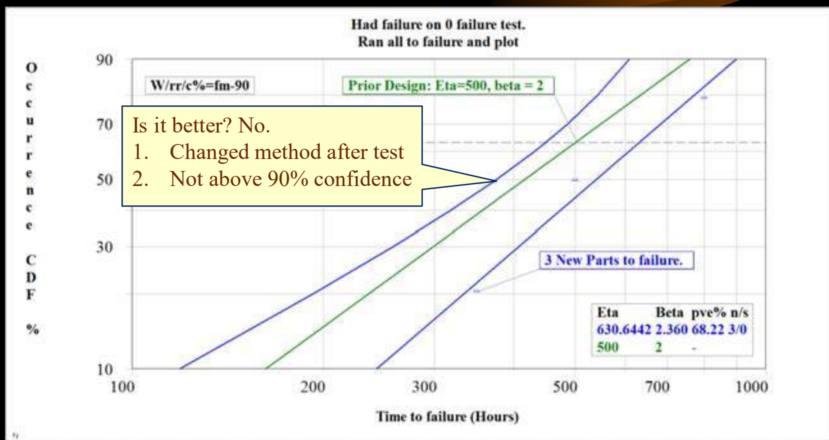
438	438	438

1314 test hours

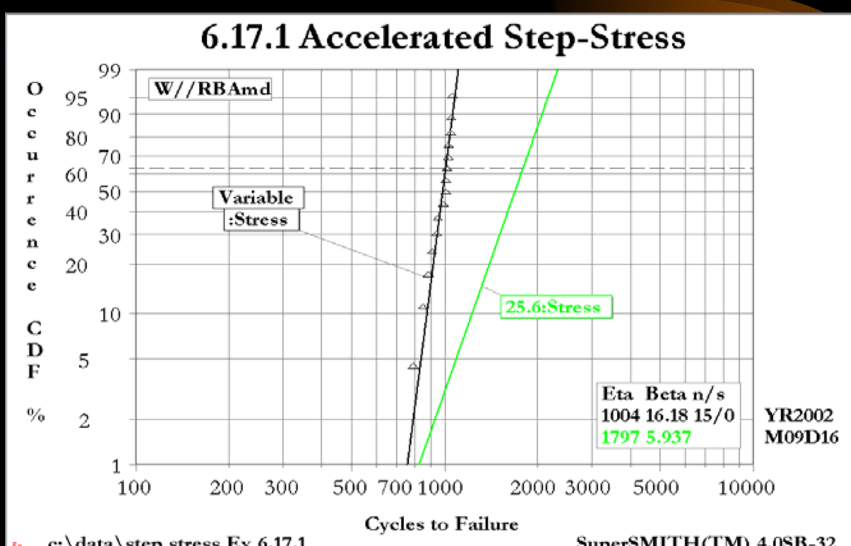
Actual results. Run all to failure to check failure mode

350 ✖	550 ✖	800 ✖

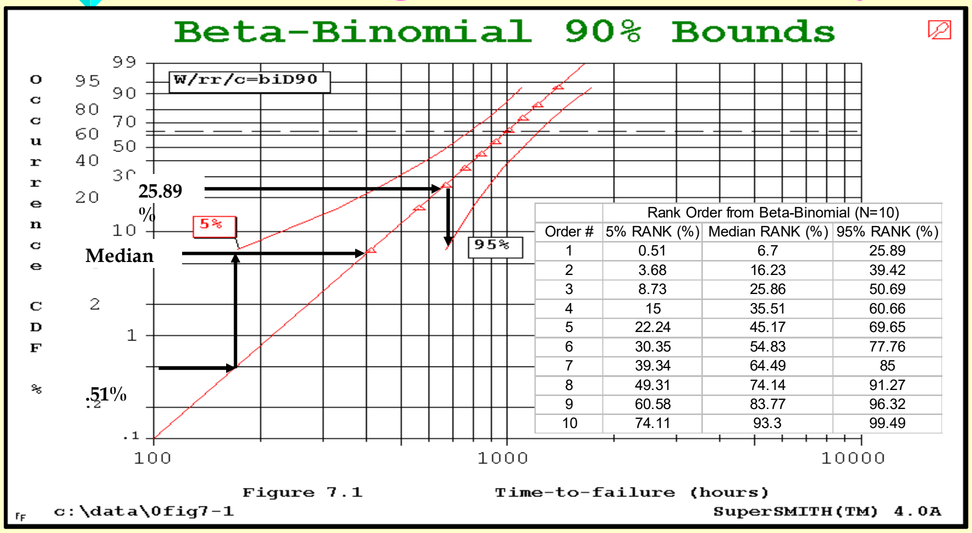
1700 hours



Normal Stress = 25.6 ksi



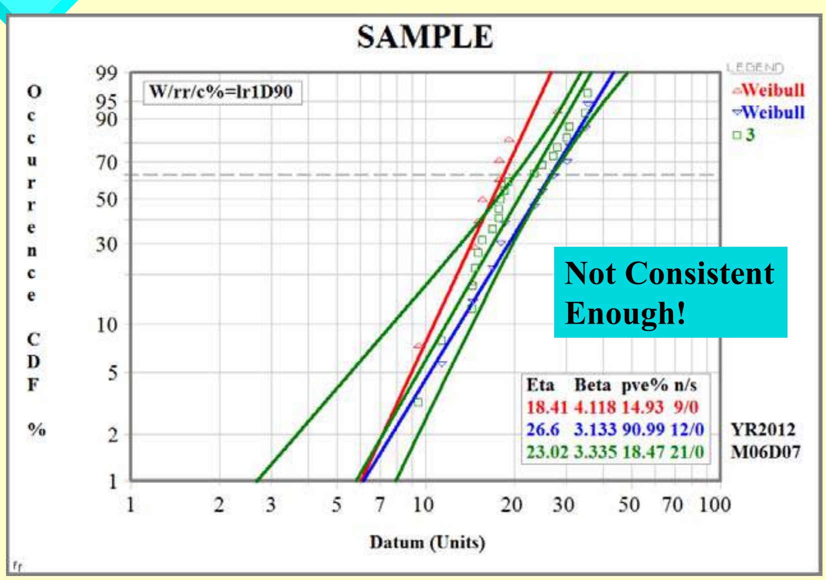
7.3.1 Beta-Binomial Bounds Plotting Them Correctly

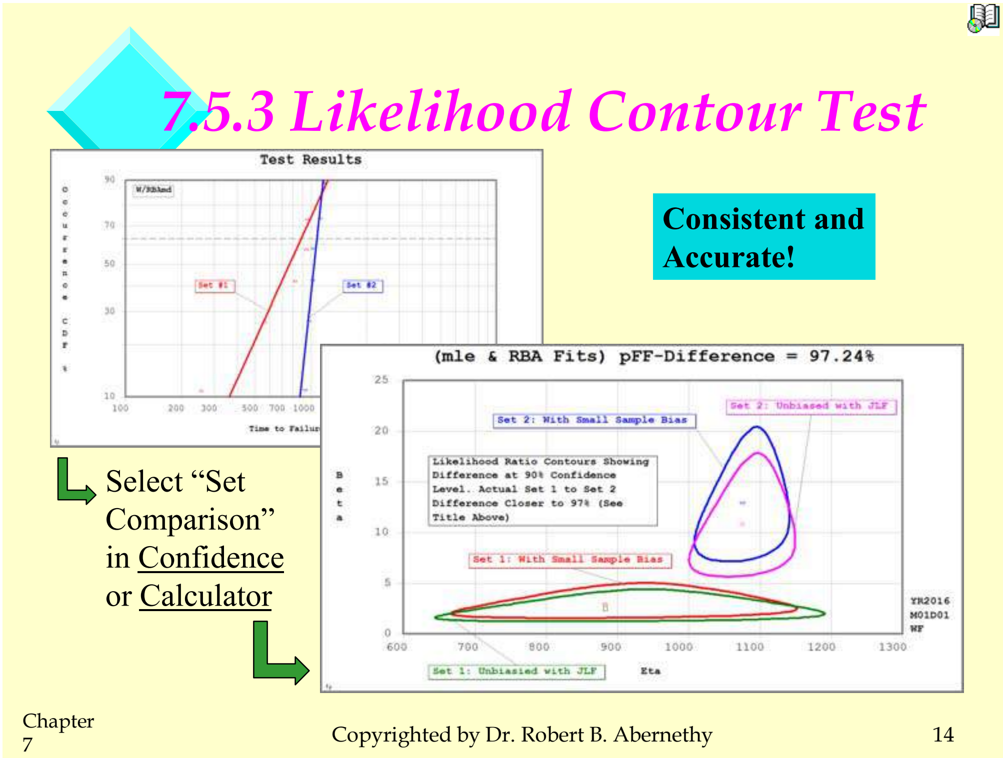


Rank Order from Beta-Binomial (N=10)

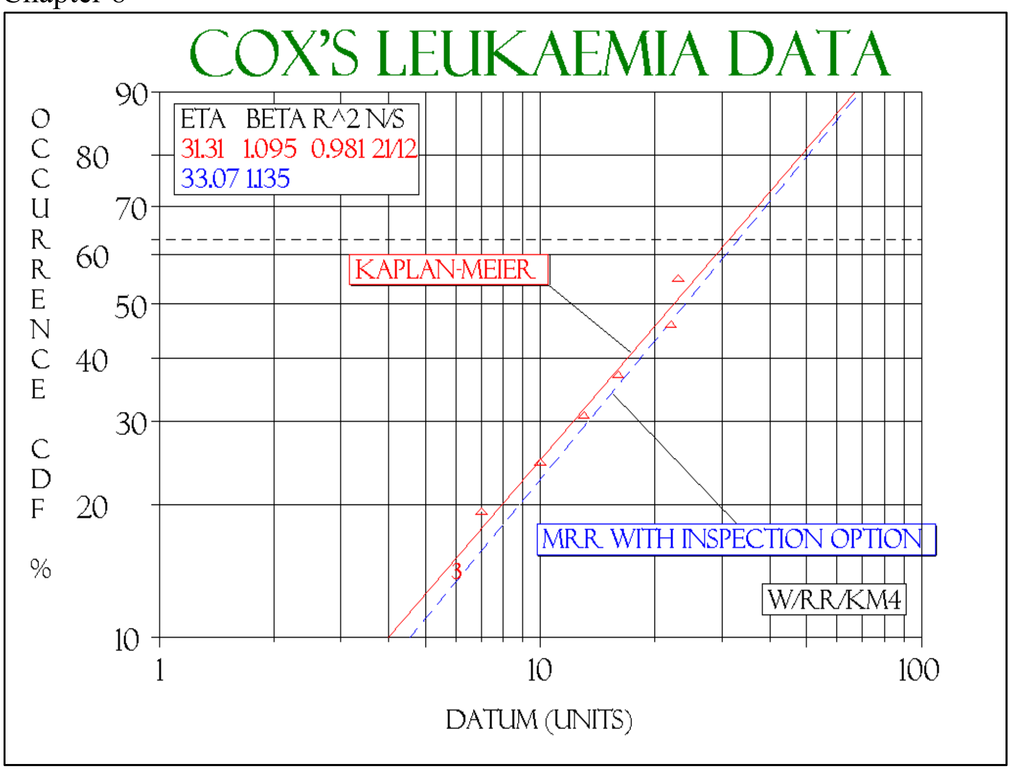
Order #	5% RANK (%)	Median RANK (%)	95% RANK (%)
1	0.51	6.7	25.89
2	3.68	16.23	39.42
3	8.73	25.86	50.69
4	15	35.51	60.66
5	22.24	45.17	69.65
6	30.35	54.83	77.76
7	39.34	64.49	85
8	49.31	74.14	91.27
9	60.58	83.77	96.32
10	74.11	93.3	99.49

1) Put Double-Sided Confidence Around Merged Set
2) Significant Difference If Individual Fit Lines Outside

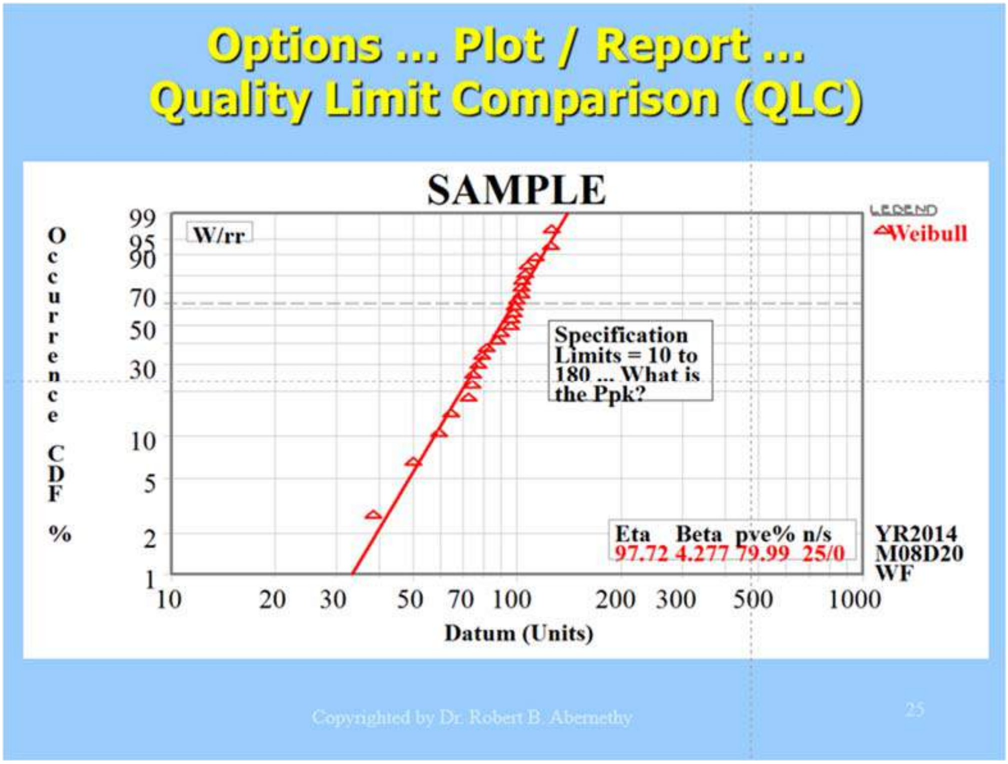


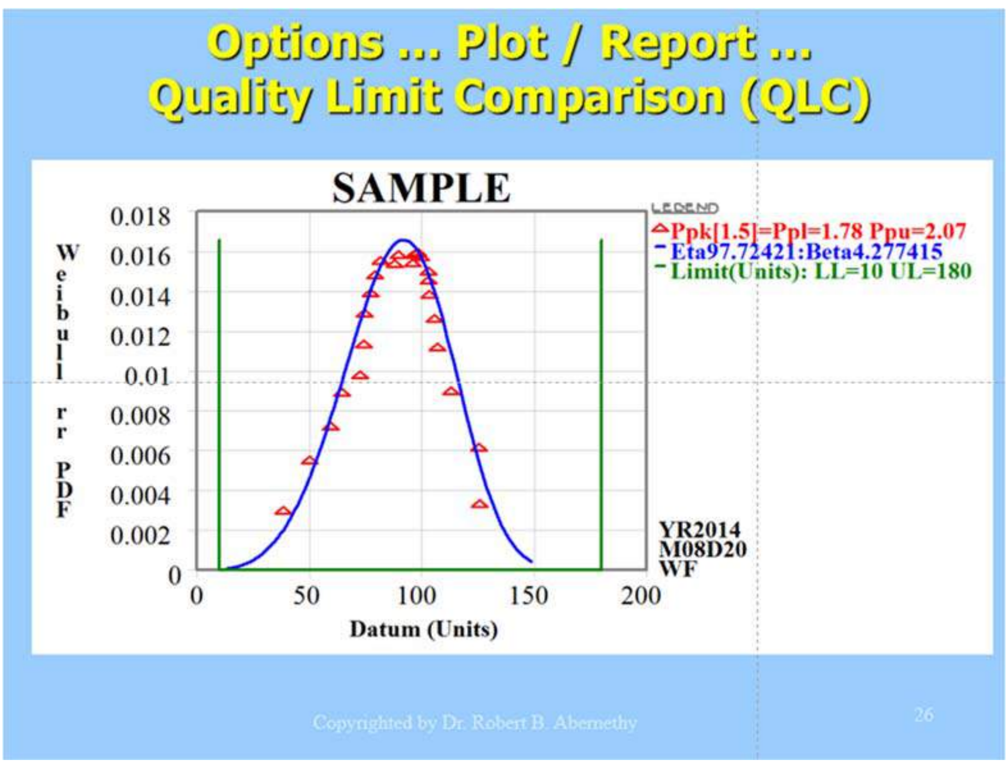


Chapter 8

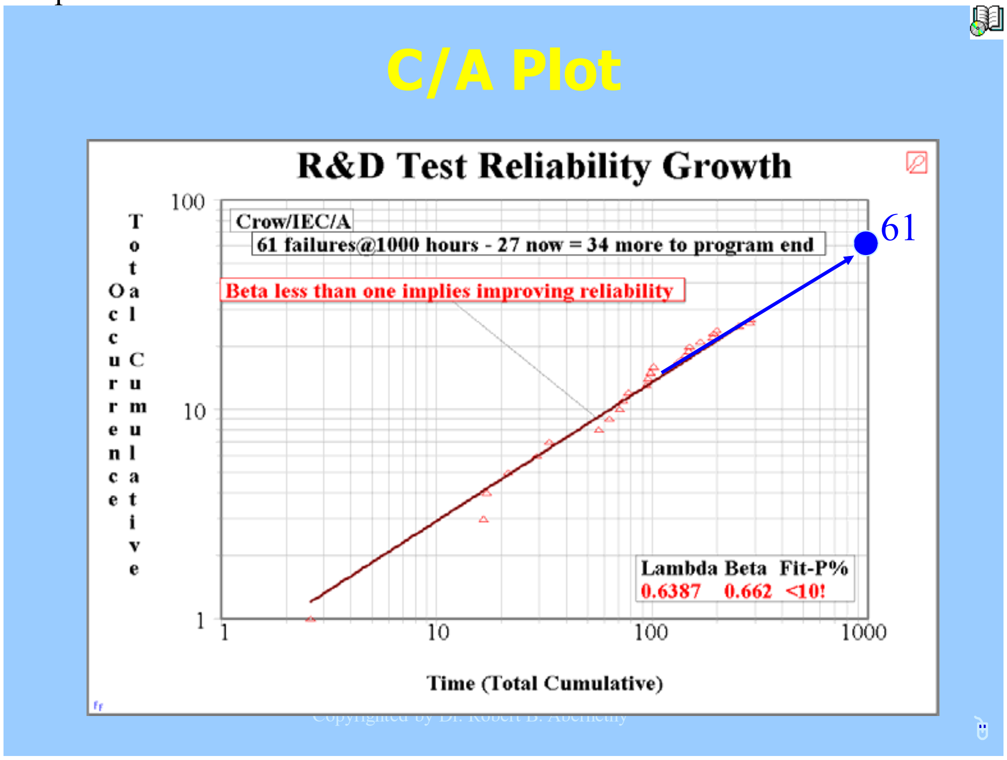


Note: This data set is available under the dice icon in SSW as a special data set.



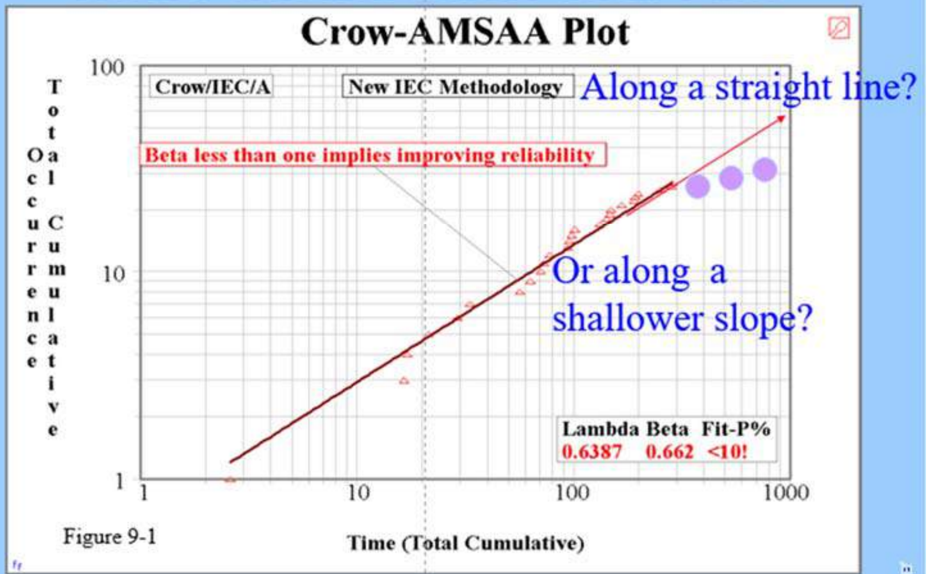


Note: SuperSMITH(r) is the only Weibull software that can plot the data points on the pdf curve like this.

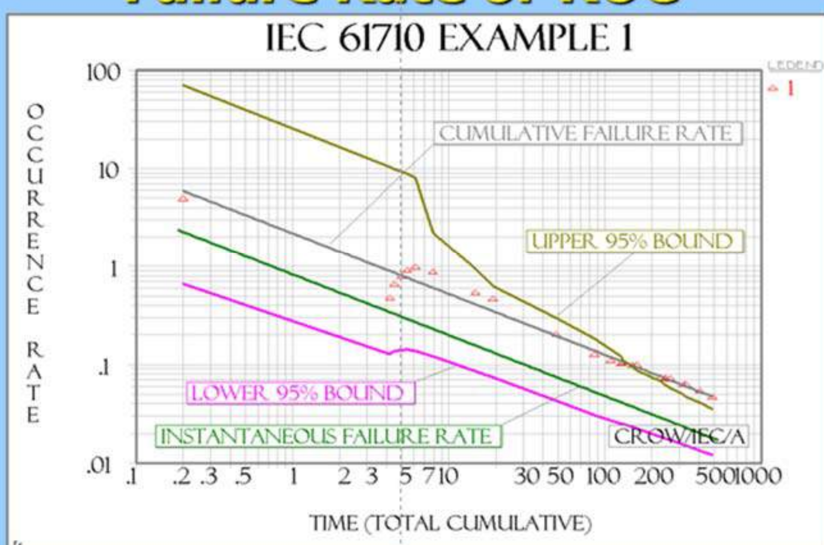

C/A Plot
R&D Test Reliability Growth
Crow/IEC/A
61 failures@1000 hours - 27 now = 34 more to program end
Beta less than one implies improving reliability
61
Lambda Beta Fit-P%
0.6387 0.662 <10!
Total Cumulative Occurrence
Time (Total Cumulative)
100
10
1
1
10
100
1000


Will We Make It?
R&D Test Reliability Growth
Lambda Beta Fit-P%
0.6387 0.662 <10!
Msg for Management :
We Won't Make It!
Need Corrective Action!
Predicted Rate at 1000 hours = 0.04
Contractual Requirement 0.02 @ 1000 Hours
Crow/IEC/A
Occurrence RATE
Time (Total Cumulative)
1
.1
.01
1
10
100
1000
Copyrighted by Dr. Robert B. Abernethy

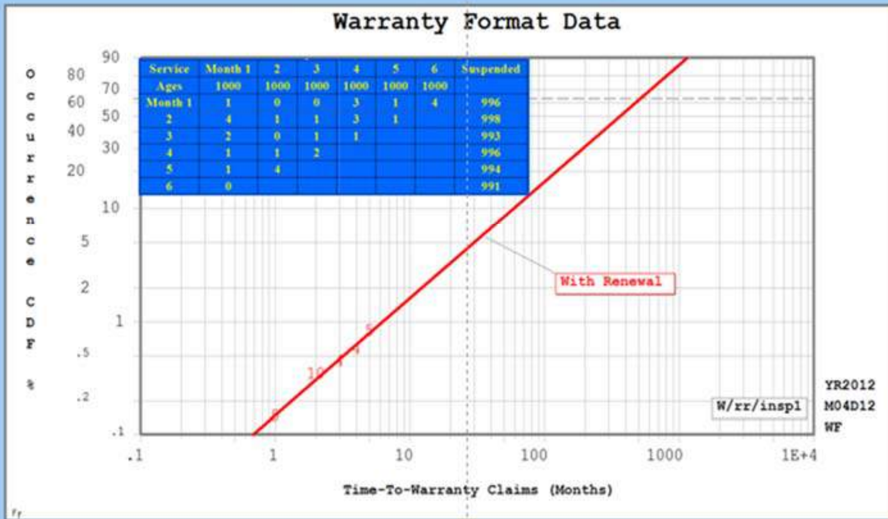
Management Corrective Action is Effective. Where will the Next Points Fall?



90% Confidence Bounds on Failure Rate or ROC



9.10 Warranty Claims Weibull Plot



Service	Month 1	2	3	4	5	6	Suspended
Ages	1000	1000	1000	1000	1000	1000	
Month 1	1	0	0	3	1	4	996
2	4	1	1	3	1		998
3	2	0	1	1			993
4	1	1	2				996
5	1	4					994
6	0						991

C-A is Best Practice for Predicting Warranty Claims by Calendar month