Squeezing Variation for Profit

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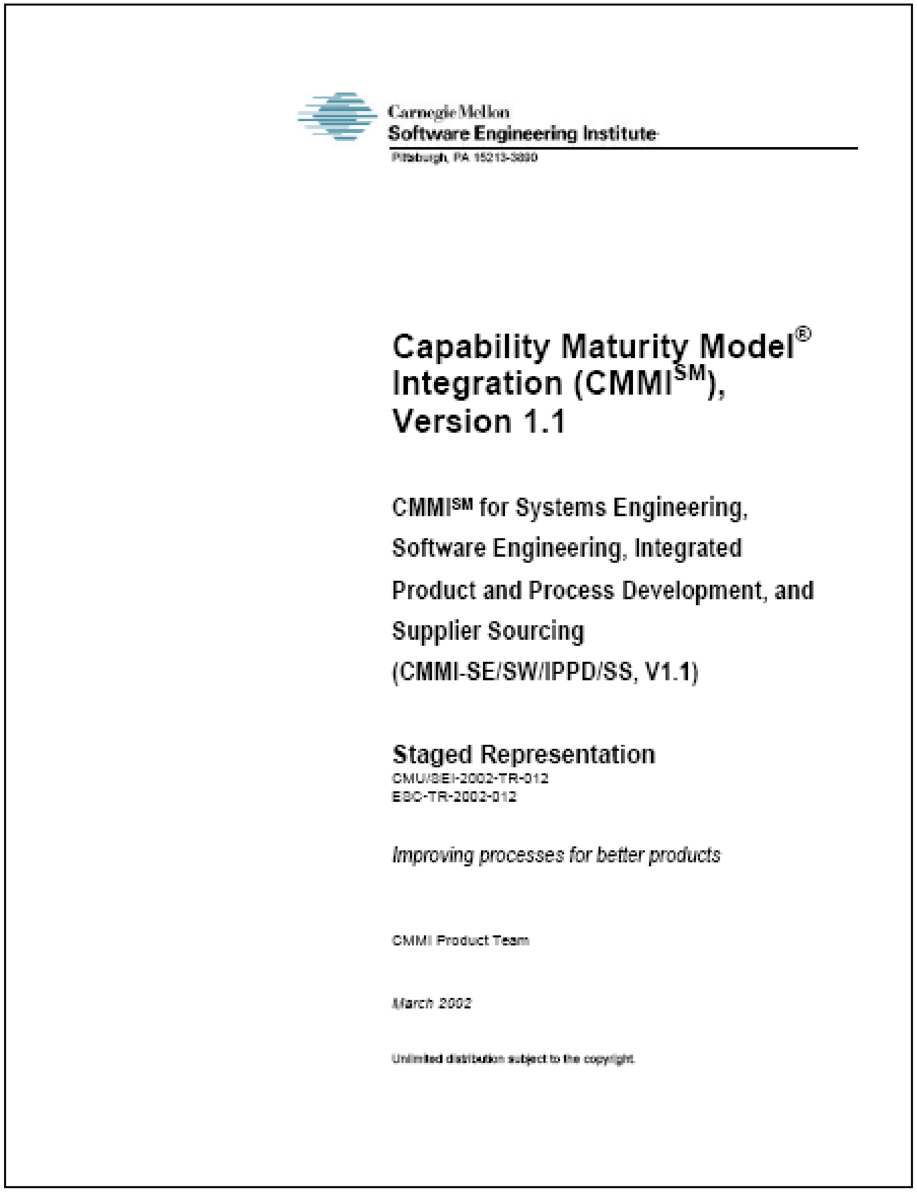
Background...



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Capability Maturity Model®
Integration (CMMI SM),
Version 1.1

CMMI SM for Systems Engineering, Software Engineering, Integrated Product and Process Development, and Supplier Sourcing
(CMMI-SE/SW/IPPD/SS, V1.1)

Staged Representation
CMU/SEI-2002-TR-012
ESC-TR-2002-012

Improving processes for better products

CMMI Product Team

March 2002

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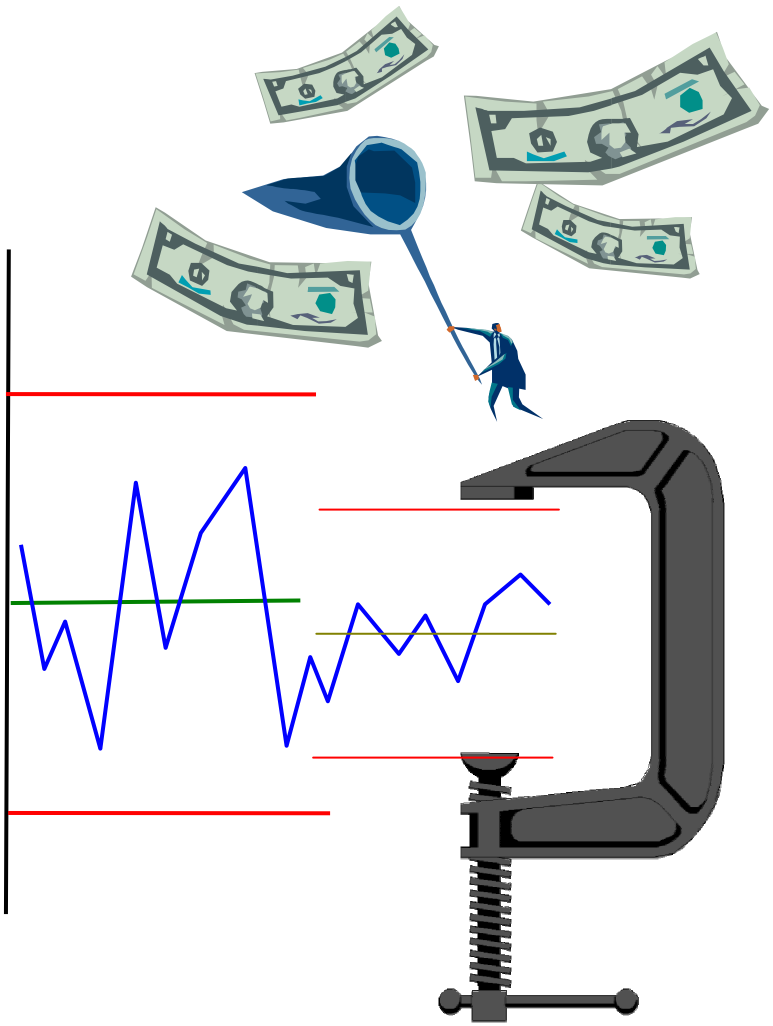
- CMMI Level 4, ***Quantitatively Managed*** covers both the organizational and project aspects of process stability and capability
- *Stability* and *Capability* are not just noble concepts, they have economic value and are about managing variation

The problem…



- The economic value of rendering processes stable and capable is often incalculable
- And, the return on investment of placing *more* processes under quantitative management likewise is indeterminable
- So, how to quantify the benefit?

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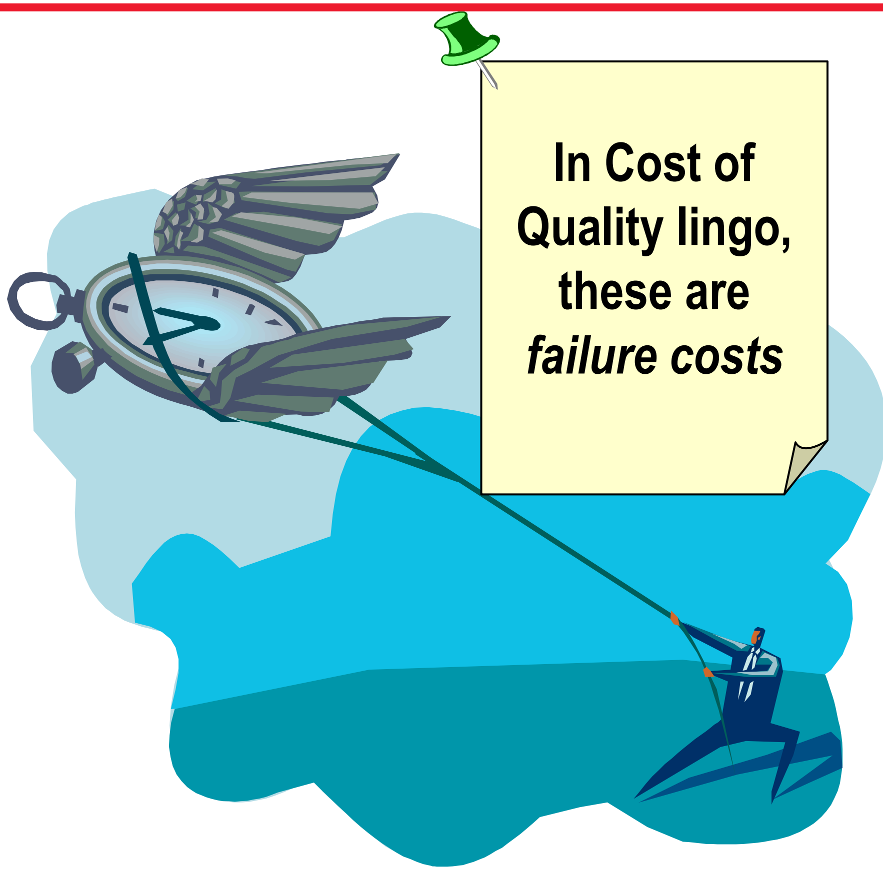
Situations where variation manifests as schedule misses is a problem..



Schedule often is a major concern of Customers

- Projects miss committed delivery dates due to systematic underestimates of the effort to perform tasks
- Projects miss committed delivery dates due to poor execution and control of project tasks
- Missed delivery dates often have dire consequences

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The concept of failure costs…

Internal Failure Cost are the costs that result from a failure to…

“Do it right the first time.”

- Defect correction
- Budget misses
- Processing discrepancy reports (DR’s)
- Retesting
- Unscheduled downtime
- Inventory shrinkage
- Schedule misses
- Invoice errors
- Payroll errors
- Erroneous status reporting
- Lost data

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Example…

- The *Build Scheduling* subprocess was put under Quantitative Management
- Same process used across several projects to determine schedule performance

Data were collected for 30 samples…

Build	±Days Early or Late	Build	± Days Early or Late	Build	± Days Early or Late
Build 1	28	Build 11	23	Build 21	89
Build 2	1	Build 12	20	Build 22	11
Build 3	-1	Build 13	19	Build 23	15
Build 4	10	Build 14	337	Build 24	12
Build 5	19	Build 15	58	Build 25	20
Build 6	5	Build 16	2	Build 26	4
Build 7	90	Build 17	53	Build 27	4
Build 8	2	Build 18	8	Build 28	13
Build 9	87	Build 19	10	Build 29	31
Build 10	11	Build 20	62	Build 30	95

Fairly clear that schedule performance is an issue

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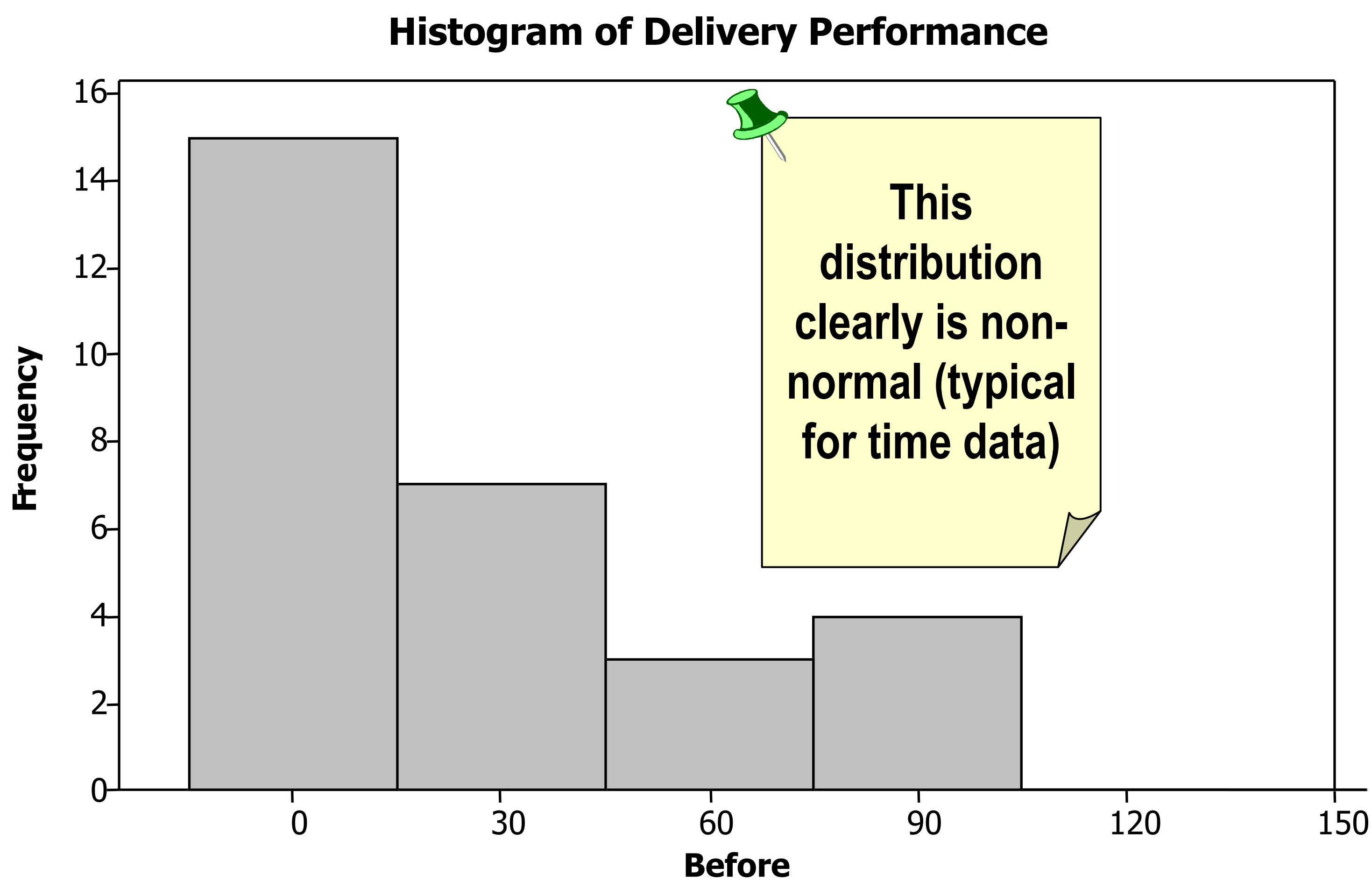
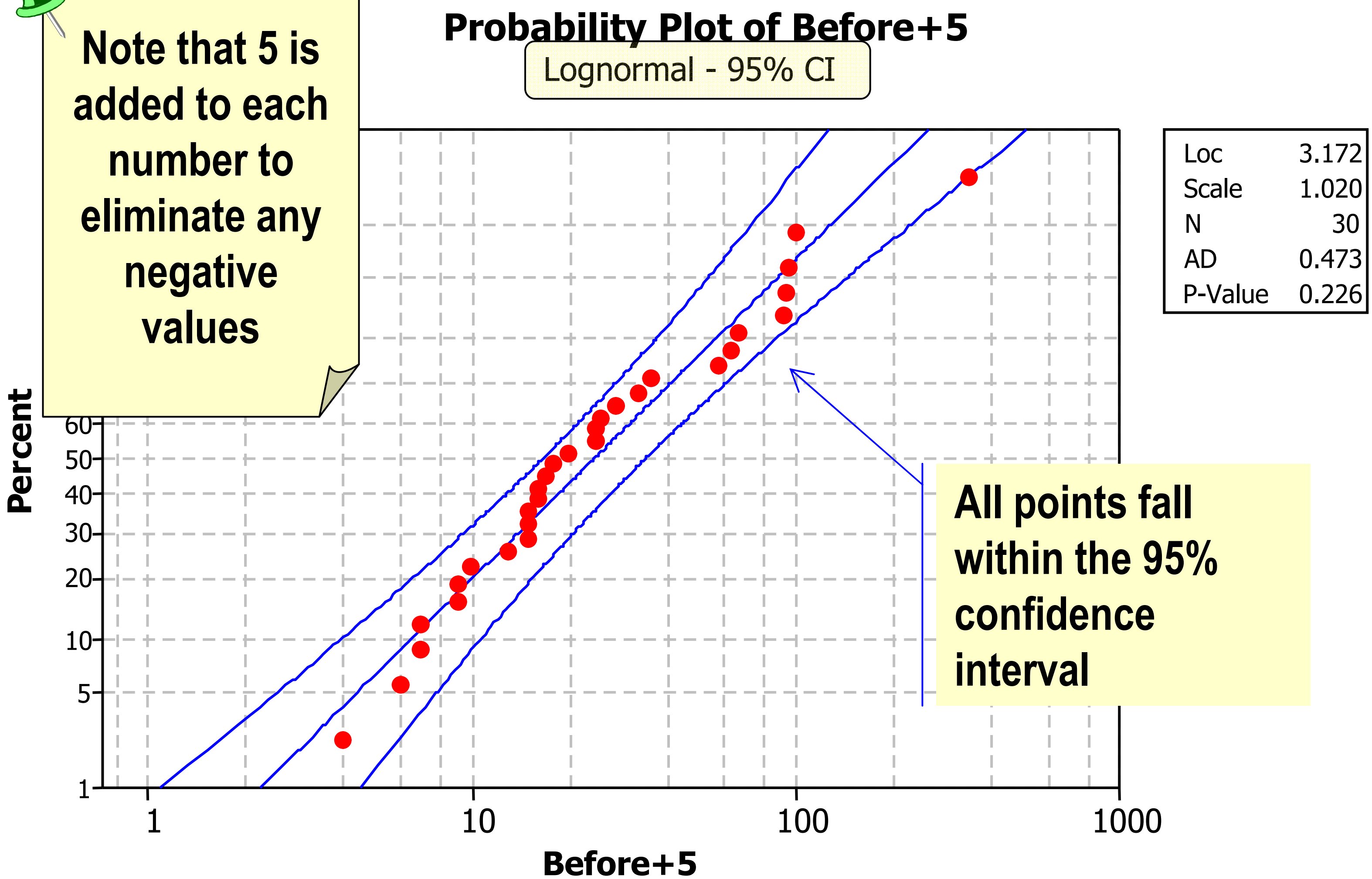
Histogram reveals the shape of the data…



Data that are not normal present analytic challenges

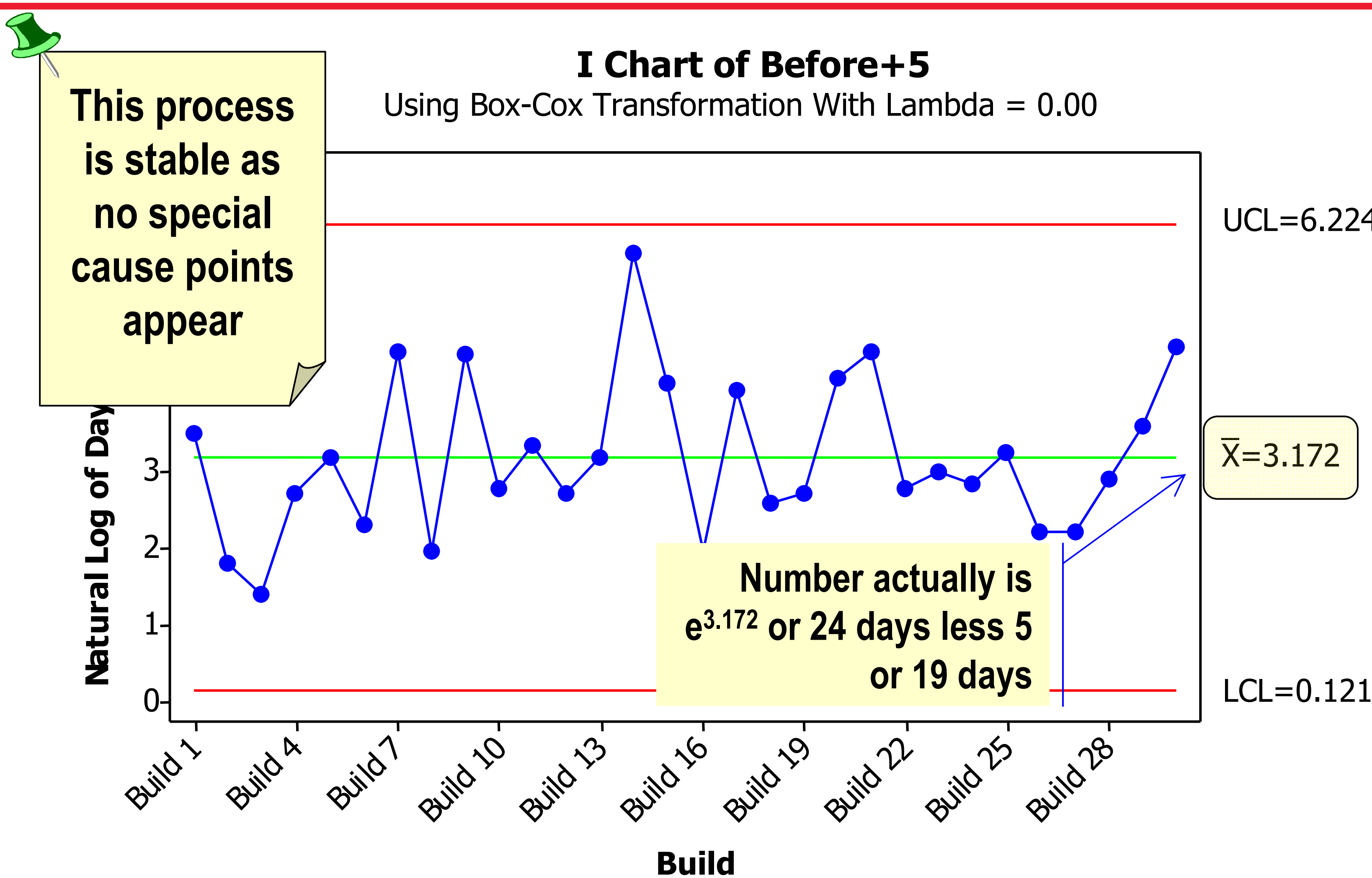
Further analysis shows the data to be a lognormal distribution…

Note that 5 is added to each number to eliminate any negative values



All points fall within the 95% confidence interval

Charting the data shows the process to be stable…



Stable processes lend themselves to improvement

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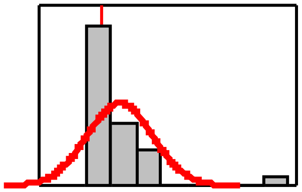
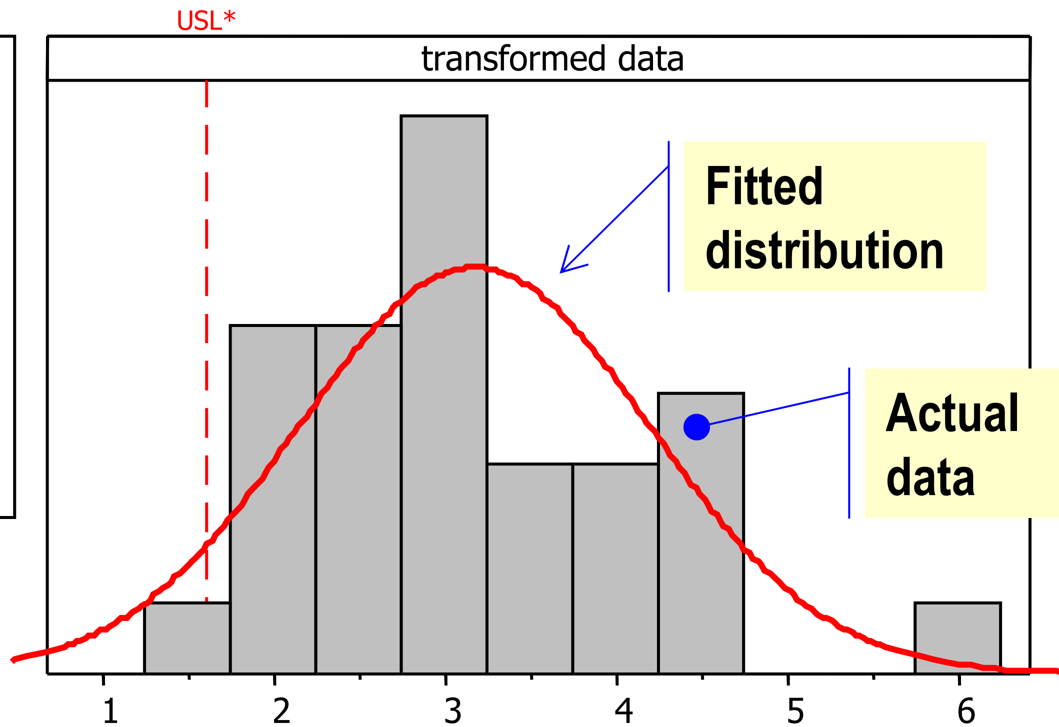
The process is *not* capable…



Process Capability of Before+5

Using Box-Cox Transformation With Lambda = 0

Process Data	
LSL	*
Target	*
USL	5
Sample Mean	42.6
Sample N	30
StDev(Overall)	64.4483
After Transformation	
LSL*	*
Target*	*
USL*	1.60944
Sample Mean*	3.1725
StDev(Overall)*	1.02886



Fitted distribution

Actual data

Overall Capability	
Z.Bench	-1.52
Z.LSL	*
Z.USL	-1.52
Ppk	-0.51
Cpm	*

Observed Performance	
% < LSL	*
% > USL	96.67
% Total	96.67

Exp. Overall Performance	
% < LSL*	*
% > USL*	93.56
% Total	93.56

Can expect the process to be late 94% of the time

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An improvement team went to work…

- The team conducted a thorough Causal Analysis and Resolution
- They implemented a new Build Scheduling process

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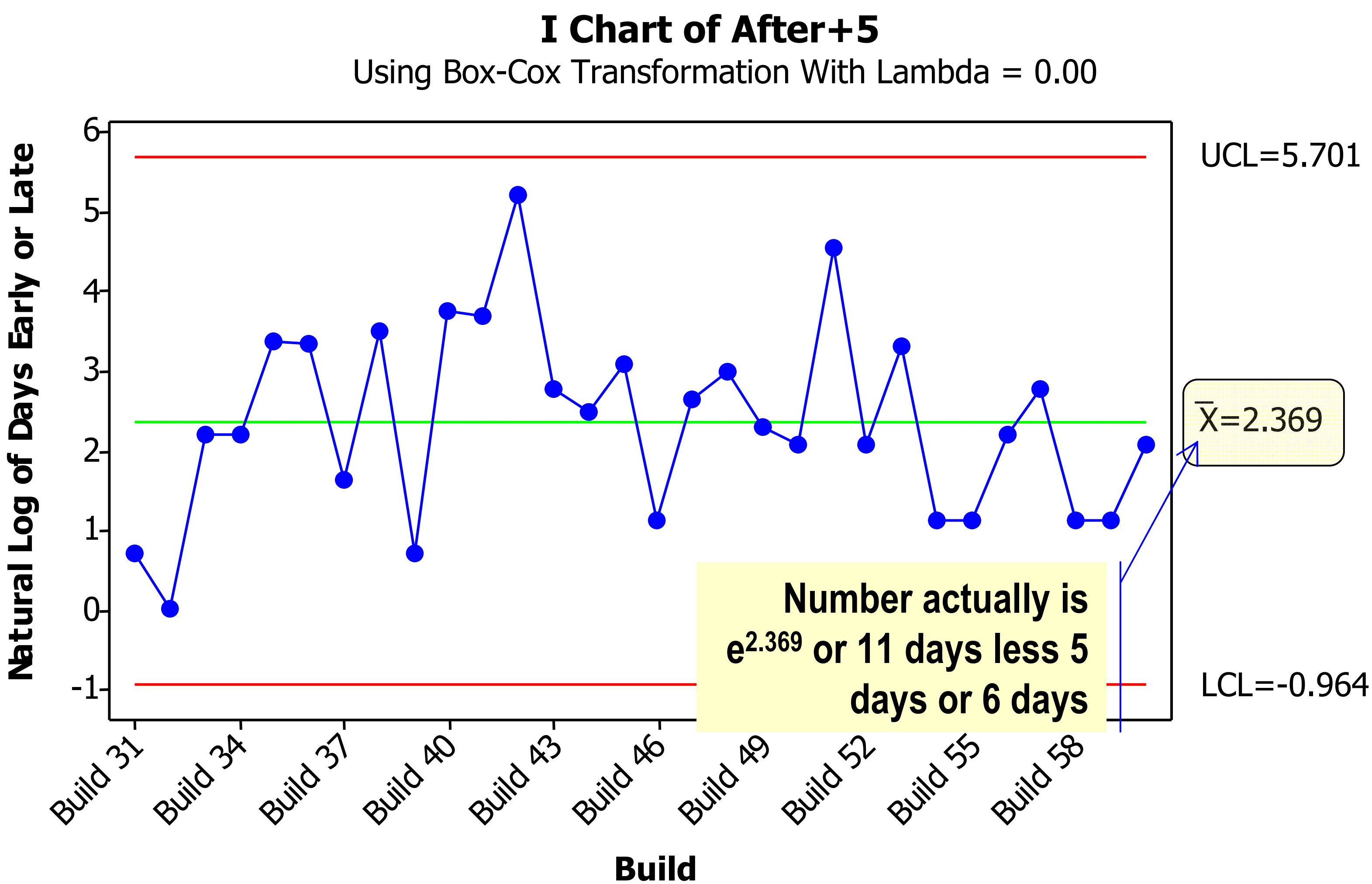
Data were collected for 30 new samples…

Build	± Days Early or Late	Build	± Days Early or Late	Build	± Days Early or Late
Build 31	-3	Build 41	35	Build 51	88
Build 32	-4	Build 42	177	Build 52	3
Build 33	4	Build 43	11	Build 53	22
Build 34	4	Build 44	7	Build 54	-2
Build 35	24	Build 45	17	Build 55	-2
Build 36	23	Build 46	-2	Build 56	4
Build 37	0	Build 47	9	Build 57	11
Build 38	28	Build 48	15	Build 58	-2
Build 39	-3	Build 49	5	Build 59	-2
Build 40	38	Build 50	3	Build 60	3

The performance looks better. But, by how much, and what dollar benefit?

The "After" process is still stable…



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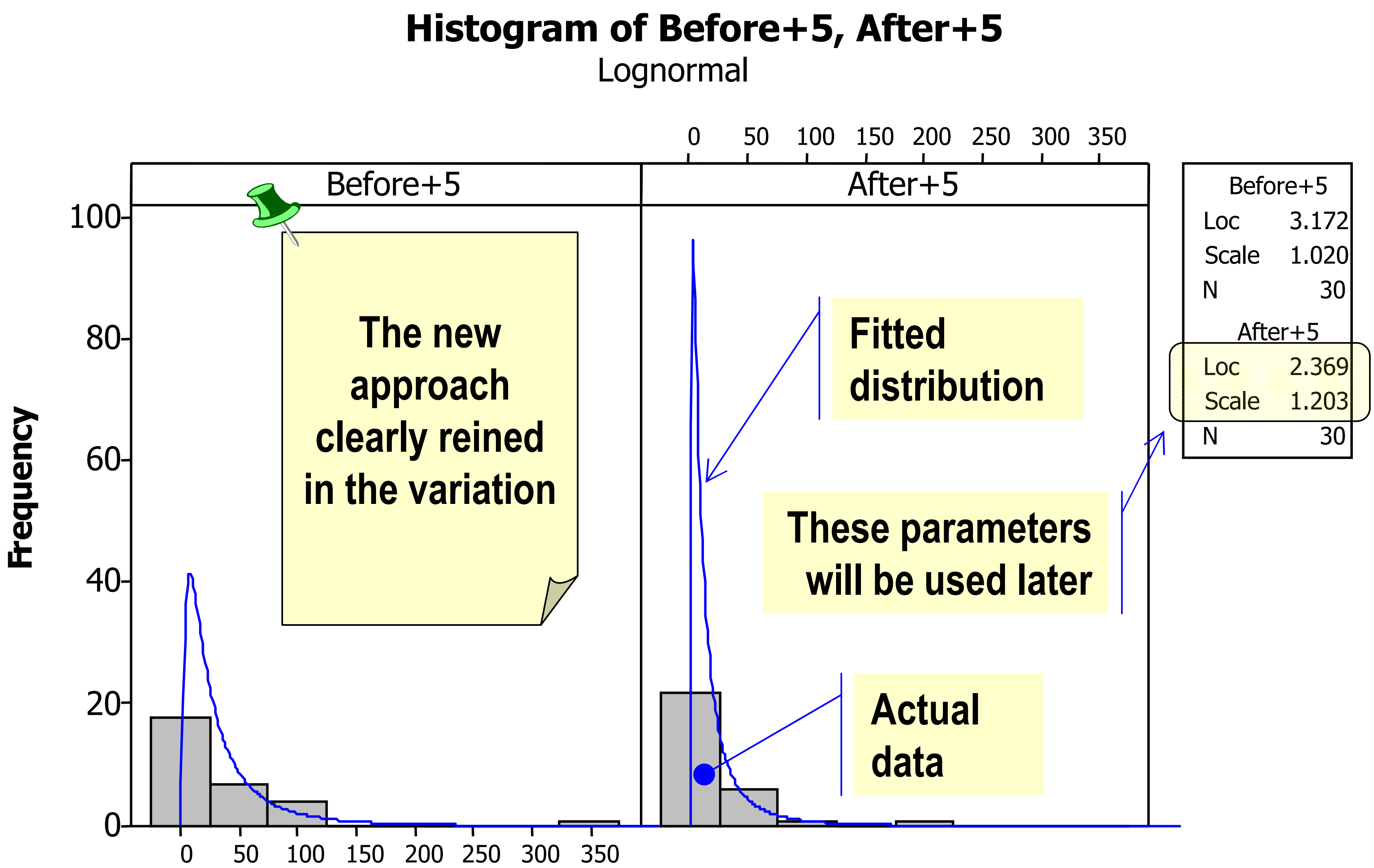
Comparing the "Before" to the "After" shows a change in the data distribution…



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And, a hypothesis test shows that difference is indeed real…

A Mann Whitney test is similar to a *t*-test but can be applied to non-normal data

Mann-Whitney Test and CI: Before, After

```
         N  Median
Before  30   14.00
After   30    4.50

Point estimate for ETA1-ETA2 is 8.00
95.2 Percent CI for ETA1-ETA2 is (2.01,17.00)
W = 1082.0
Test of ETA1 = ETA2 vs ETA1 not = ETA2 is significant at 0.0138
The test is significant at 0.0137 (adjusted for ties)
```

95% confidence interval does not contain zero

P-Value > .05; not significant

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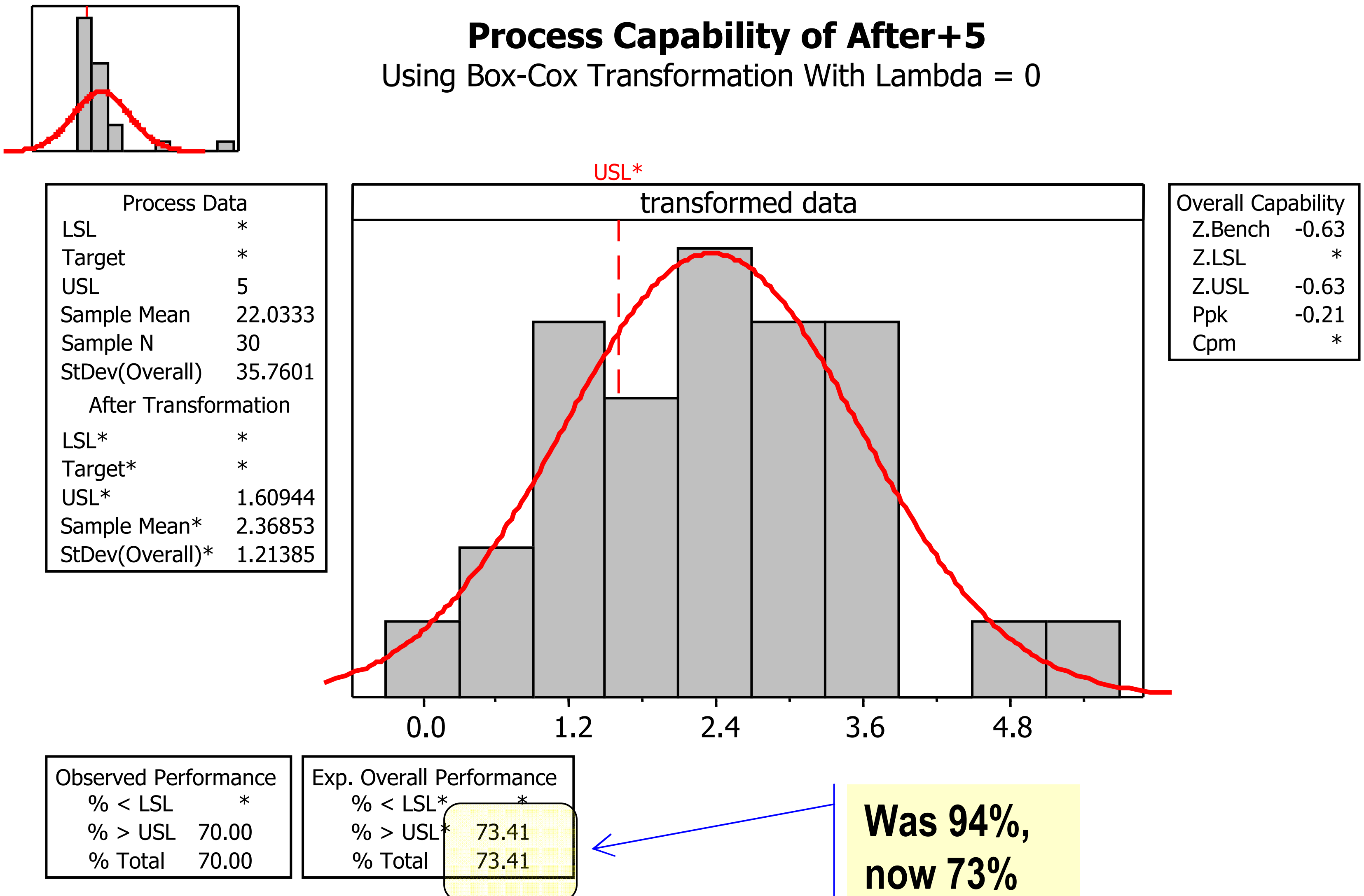
And more the process is more capable…



Was 94%, now 73%

Next, compute the failure costs...

Days Late	Resources per Day	Labor Cost per Hour	probability	Failure Cost (Before)
1	40 hrs.	$50	1.0%	$124
2	40 hrs.	$50	1.7%	$816
:	:	:	:	:
140	40 hrs.	$50	1.8%	$15,523

- Compute the probability of each possible day late using the parameters from the fitted distributions
- Compute the daily failure cost: resource hours × labor rate
- Weight the daily failure costs by the probability
- Sum all the daily failure costs

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The revised process cuts failure cost almost in half…

Days Late	Resources per Day	Labor Cost per Hour	p(Before)	Overrun (Before)	p(After)	Overrun (After)
1	40 hrs.	$50	1.0%	$124	4.8%	$1,908
2	40 hrs.	$50	1.7%	$816	6.3%	$5,027
:	:	:	:	:	:	:
20	40 hrs.	$50	1.8%	$15,523	1.4%	$11,581
:	:	:	:	:	:	:
140	40 hrs.	$50	0.1%	$3,473	0.0%	$1,347
Cumulative Failure Cost				$1,226K		$728K

A net benefit of $500K

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Summary...

- The specific benefit from squeezing variation out of a process can be calculated using Cost of Quality principles and Six Sigma techniques
- Knowing the payoff makes further quantitative management compelling

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