

SixSigmaTV.Net
THE NETWORK FOR SIX SIGMA

Process Capability Analysis (Cpk)

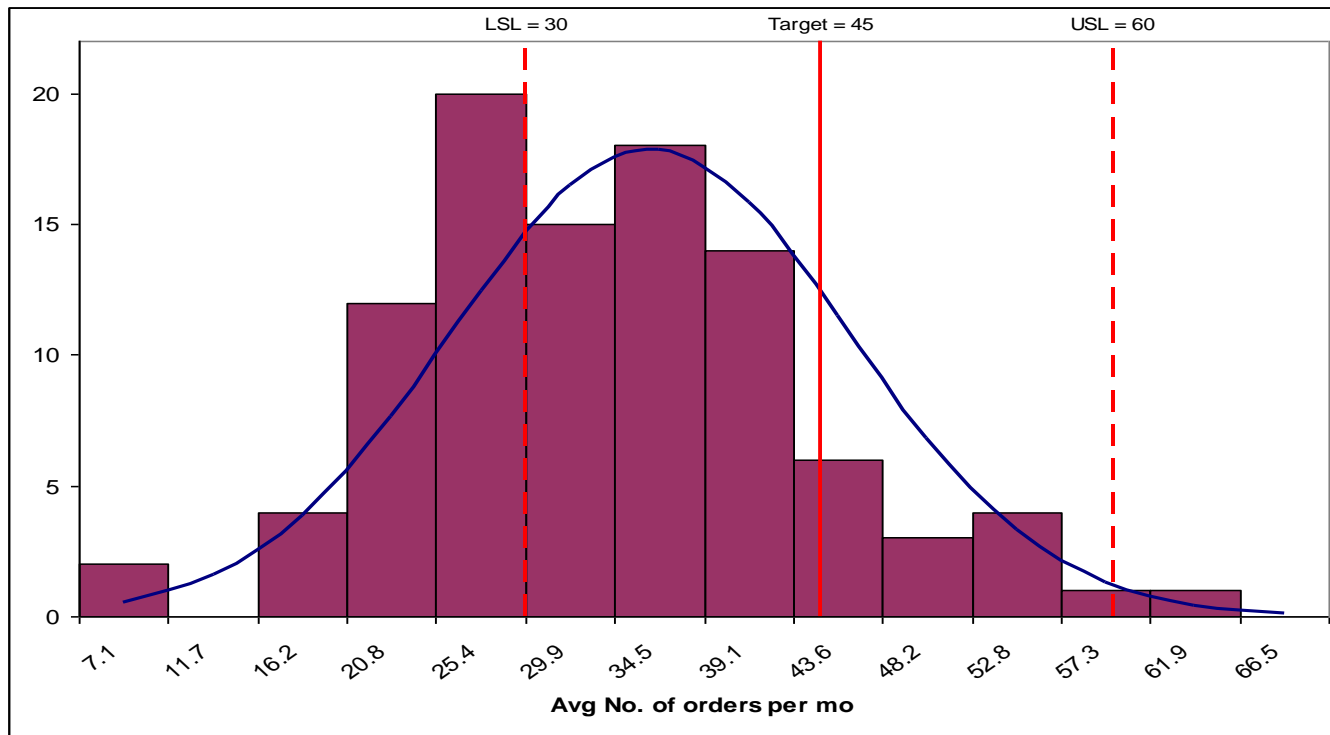
SixSigmaTV.Net

Process Capability Using SigmaXL

- SigmaXL is an easy to use Excel plug-in for Six Sigma graphical and statistical analysis to help with many phases of your DMAIC, DFSS, Lean or any improvement project
- Visit SigmaXL.Com and get your free 30 day trial
- SigmaXL also has Web Demos to show you all of the functions and features and ease of use of their latest products

Is Your Process Capable?

- Process Capability Analysis measures the ability of a process to meet customer requirements
- It compares the process width (spread / distribution) to the customer-defined acceptable amount of variation (the specification limits)



Process Capability

- Uses of Capability Analysis:
 - To establish a baseline of current operations as a gauge for process improvement.
 - To provide a means for periodic process monitoring to identify changes in process.
 - Understand the ability of a process to meet or exceed customer expectations.
- Requires:
 - Established limits of acceptable process performance (spec limits).
 - A capable measuring system.
 - A normal distribution and stable process.
 - Continuous data with a minimum sample size of 30 (50 or more is better).

Capability Analysis Indices

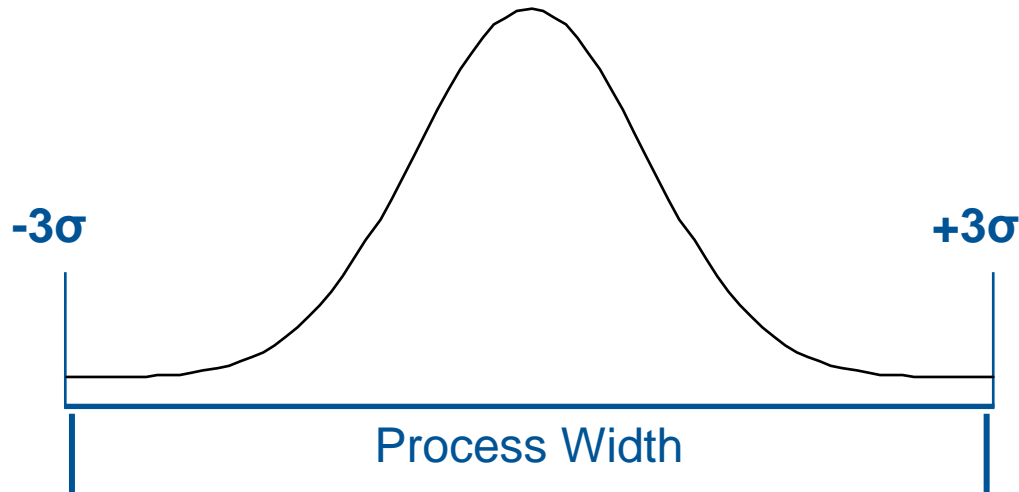
- C_p : Compares the process specification limits to the variation (spread) of the process.
- C_{pu} : Measures process capability and fallout to the upper specification limit.
- C_{pl} : Measures process capability and fallout to the lower specification limit.
- C_{pk} : Measures process variation and fallout against both upper and lower specification limits.
- DPMO: Measures defects per million opportunities.

Process Capability Ratio: Cp

- Ratio of total variation (spread) within the specification limits to the total variation of the process (spread of the spec limits/spread of the process). Does it have the ability to fit?
- Provides a statistical summary of process performance.
- Typical goals for Cp are greater than 1.33 or 1.67 for high risk (medical devices, airplanes).

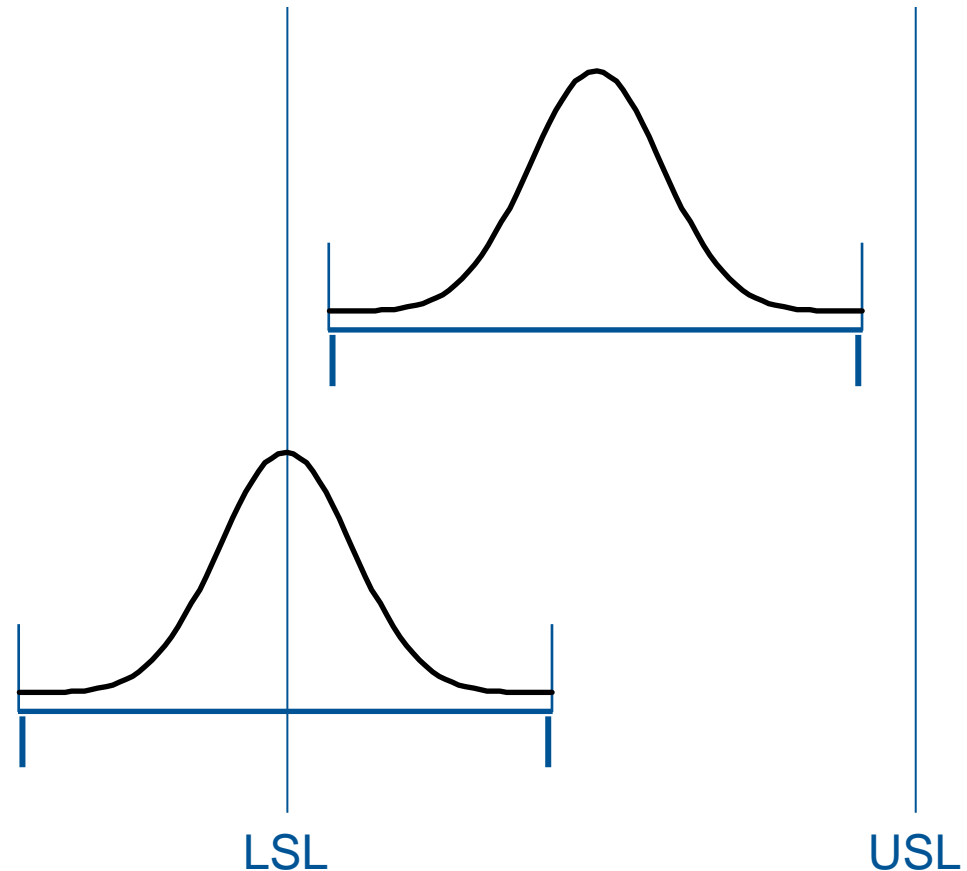
Process Capability Ratio: C_p

$$C_p = \frac{\text{Allowed variation (spec)}}{\text{Normal variation of the process}} = \frac{USL - LSL}{6\sigma}$$



Process Capability Ratio: C_p

- C_p does not account for location of the process relative to the specification limits; it does provide an indication of potential capability.
- In the example on the right, both processes would have identical C_p values, though the one below is producing defects



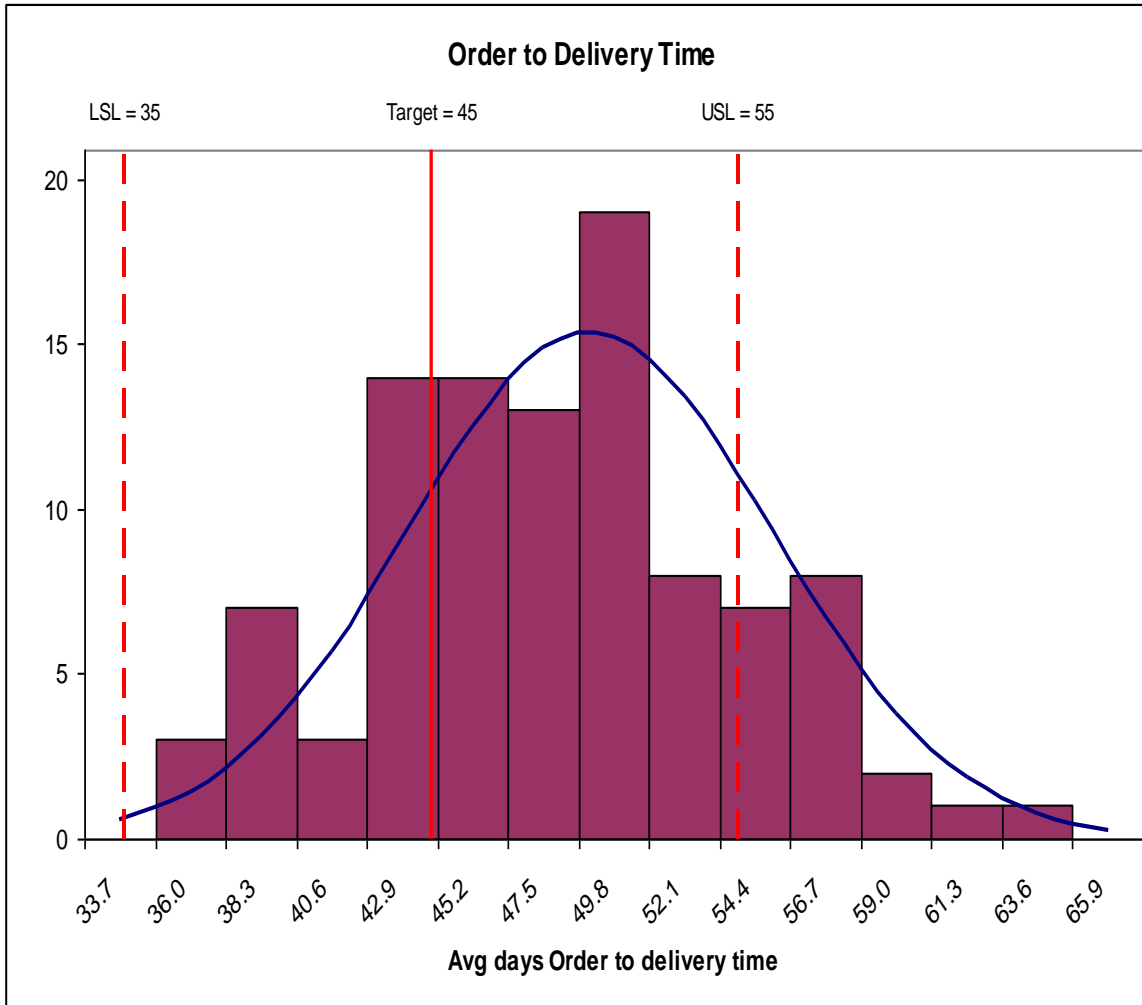
Process Capability Ratios:

C_{pu} , C_{pl} , C_{pk}

- Account for the location of the process in the capability estimate.
- Measures the capability of the process relative to the nearest specification.
- Typical goals for C_{pk} are greater than 1.33 or 1.67 if high risk.
- C_{pk} tells you what spec limit you are off centered towards. It will be the same as the smaller result of the C_{pu} and C_{pl} analysis.

SigmaXL: Process Capability

- What is the process capability?



Count = 100
Mean = 49.020
Stdev (Overall) = 5.9780
USL = 55
Target = 45
LSL = 35

Capability Indices using
Overall Standard Deviation

Cp/Pp = 0.557596
Cpu/Ppu = 0.333443
Cpl/Ppl = 0.781750
Cpk/Ppk = 0.333443
Cpm = 0.462707

Expected Overall Performance

ppm > USL = 158576
ppm < LSL = 9507.2
ppm Total = 168083
% > USL = 15.86%
% < LSL = 0.95%
% Total = 16.81%

Actual (Empirical) Performance

% > USL = 16.00%
% < LSL = 0.00%
% Total = 16.00%

Process Capability: Non-Capable Processes

- Find out what Xs are driving the variation within the process and make plans to improve them. Reducing the variation first will allow you identify and fix the Xs that are keeping you off target.
- Find out what Xs are driving the mean to be off target and implement improvements to center the process on the target.
- Do not tamper with the spec limits if you find out your process is currently not capable.

Capability Analysis: Discrete Data

- Discrete distributions are usually associated with recording the number of defective items (classification), or number of defects per unit (count)
- Examples
 - Pass/fail measurements based on whether a service met expectations or not
 - Error-free/errors
 - Acceptable/defect
 - # total errors/# applications
- Measures typically identify the proportion of the items that fit one classification.

Defects per Million Opportunities (DPMO): Discrete Data

- If each unit only has one opportunity for a defect, calculate the defects as a proportion of the units and multiply by 1,000,000.
- If each unit has multiple opportunities for defects, calculate defects as a proportion of total opportunities.
 - Example: if a loan application has 12 opportunities for defects, then there are 600 opportunities for defects in a sample of 50 applications. If 30 defects are found, then:

$$DPMO = (30/600) * 1000000 = 50,000$$

SigmaXL: Discrete Data DPMO/Sigma

Process Sigma Calculator - Discrete Data

Number of Units Processed	N	1000
Total Number of Defects	D	145
Number of Defect Opportunities per Unit	O	1
Defects per million opportunities	dpmo	145000.0
Defects as percentage		14.50%
Process Sigma Level	Sigma	2.56

Notes:

1. Total number of defects should include defects made and later fixed.
2. Sigma level incorporates 1.5 sigma shift.
3. Sample size should be large enough to observe 5 defects.

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Ready

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Six Sigma Conversion Table

Yield	DPMO	Sigma	Yield	DPMO	Sigma	Yield	DPMO	Sigma
6.6%	934,000	0	69.2%	308,000	2	99.4%	6,210	4
8.0%	920,000	0.1	72.6%	274,000	2.1	99.5%	4,660	4.1
10.0%	900,000	0.2	75.8%	242,000	2.2	99.7%	3,460	4.2
12.0%	880,000	0.3	78.8%	212,000	2.3	99.75%	2,550	4.3
14.0%	860,000	0.4	81.6%	184,000	2.4	99.81%	1,860	4.4
16.0%	840,000	0.5	84.2%	158,000	2.5	99.87%	1,350	4.5
19.0%	810,000	0.6	86.5%	135,000	2.6	99.90%	960	4.6
22.0%	780,000	0.7	88.5%	115,000	2.7	99.93%	680	4.7
25.0%	750,000	0.8	90.3%	96,800	2.8	99.95%	480	4.8
28.0%	720,000	0.9	91.9%	80,800	2.9	99.97%	330	4.9
31.0%	690,000	1	93.3%	66,800	3	99.977%	230	5
35.0%	650,000	1.1	94.5%	54,800	3.1	99.985%	150	5.1
39.0%	610,000	1.2	95.5%	44,600	3.2	99.990%	100	5.2
43.0%	570,000	1.3	96.4%	35,900	3.3	99.993%	70	5.3
46.0%	540,000	1.4	97.1%	28,700	3.4	99.996%	40	5.4
50.0%	500,000	1.5	97.7%	22,700	3.5	99.997%	30	5.5
54.0%	460,000	1.6	98.2%	17,800	3.6	99.9980%	20	5.6
58.0%	420,000	1.7	98.6%	13,900	3.7	99.9990%	10	5.7
61.8%	382,000	1.8	98.9%	10,700	3.8	99.9992%	8	5.8
65.6%	344,000	1.9	99.2%	8,190	3.9	99.9995%	5	5.9
						99.99966%	3.4	6

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