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Process Capability

by Sanjaya Kumar Saxena

The capability of a process is a statistical indicator of how well it is functioning, or, in other words, how successful it is at running within its specified limits.

In the absence of any special or assignable causes of variation, a process will still have some inherent variability. Process capability is a statistical measure of this inherent variability.

Example

Imagine we wish to set up a process for manufacturing ordinary washers, thin disks with holes in the middle, used to support the loads of threaded fasteners.

The requirement is that our washers should have an inner diameter of 1.0 cm. This is the target, or mean. A maximum acceptable variation is ±0.1 cm. Any variation beyond acceptable limits is considered a defect. For example, a washer having an inner diameter of 1.11 cm will be marked as defective.

Formally put, the inner diameter specifications are 1.0 ± 0.1 cm. This means:

1. Specified tolerance or acceptable variation is 0.2 cm (the spread of tolerance).
2. The lower specification limit, referred to as LSL, is 0.9 cm (1.0 - 0.1).
3. The upper specification limit, referred to as USL, is 1.1 cm (1.0 + 0.1).
4. The target, or mean, diameter is 1.0 cm.

Clearly, our manufacturing process will be a “capable” one provided it has a mean equal to the target of 1.0 cm and variation less than the specified tolerance or acceptable variation of 0.2 cm.

In addition, there should not be any special cause of variation. In other words, the process should be under control.

Computing Process Capability

When computing process capability, there is a distinction to be made regarding the current and future ability of the process and its past performance. Here we will focus on the performance of the process.

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Table 1 presents four common mathematical expressions to compute process performance under different contexts.

Table 1 Computing process performance

Pp is a good measure when the process is centered in the middle of USL and LSL.	$P_p = \frac{(USL - LSL)}{6\sigma}$
Ppu is used for processes that have only an upper specification limit. See the 30-minute pizza delivery example in "Delight Your Customers the Six Sigma Way."	$P_{pu} = \frac{(USL - \mu)}{3\sigma}$
Ppl is used for processes that have only a lower specification limit.	$P_{pl} = \frac{(\mu - LSL)}{3\sigma}$
Ppk is a good measure when the process is not exactly centered in the middle of USL and LSL.	$P_{pk} = \min[P_{pl}, P_{pu}]$

For a capable process, these values should be equal to or greater than 1.0. The commonly recommended value is 1.33 or greater.

If **Pp** is equal to 1.0, then only 0.26% of the washers produced will be defective, provided their inner diameters follow the normal distribution. Wondering why?

Simply refer to the Six Sigma Forum beginner article "Delight Your Customers the Six Sigma Way," which explains the following characteristics of a normal distribution:

- 68% of the data points fall within the area of -1σ and +1σ on either side of the mean.
- Approximately 95.5% fall within 2σ on either side.
- 99.7% fall within 3σ on either side (99.74% to be a little more precise).

If Pp = 1.0, only (100 - 99.74)%, or 0.26%, of the washers will have inner diameters beyond USL or LSL.

Examples

Table 2 contains sample inner-diameter data for four different washer-manufacturing processes.

The performance of each process is computed using MINITAB, a statistical software, as illustrated in figure 1 below. Review each chart carefully.

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Table 2 Inner diamaters, in centimeters, of washers produced by four processes

P-I	P-II	P-III	P-IV
0.95	0.93	1.00	0.90
0.96	0.95	1.01	0.91
0.97	0.97	1.02	0.92
0.98	0.98	1.03	0.93
0.99	0.99	1.04	0.94
0.99	0.98	1.04	0.94
1.00	1.13	1.05	0.95
1.01	0.87	1.06	0.96
1.01	1.03	1.06	0.96
1.02	1.02	1.07	0.97
1.03	1.03	1.08	0.98
1.04	1.04	1.09	0.99
1.05	1.05	1.10	1.00
1.00	1.00	1.05	0.95
1.00	1.00	1.05	0.95
1.00	1.00	1.05	0.95
1.00	1.00	1.05	0.95
1.00	1.00	1.05	0.95
0.99	0.99	1.04	0.94
0.99	0.99	1.04	0.94
1.01	1.01	1.06	0.96
1.01	1.01	1.06	0.96
0.98	0.98	1.03	0.93
0.98	0.96	1.03	0.93
1.02	1.02	1.07	0.97
1.02	1.07	1.07	0.97
0.97	0.97	1.02	0.92
1.03	1.05	1.08	0.98
1.04	1.06	1.09	0.99
0.99	0.99	1.04	0.94

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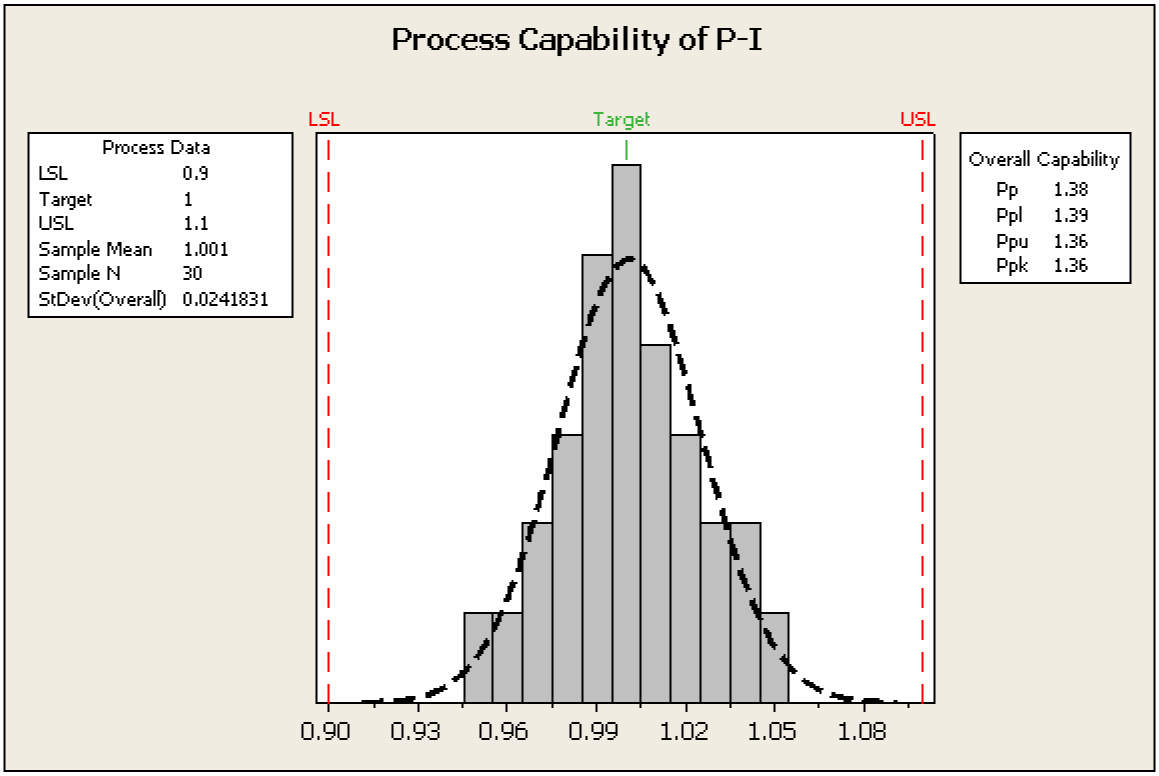
Figure 1 Process performance for four processes



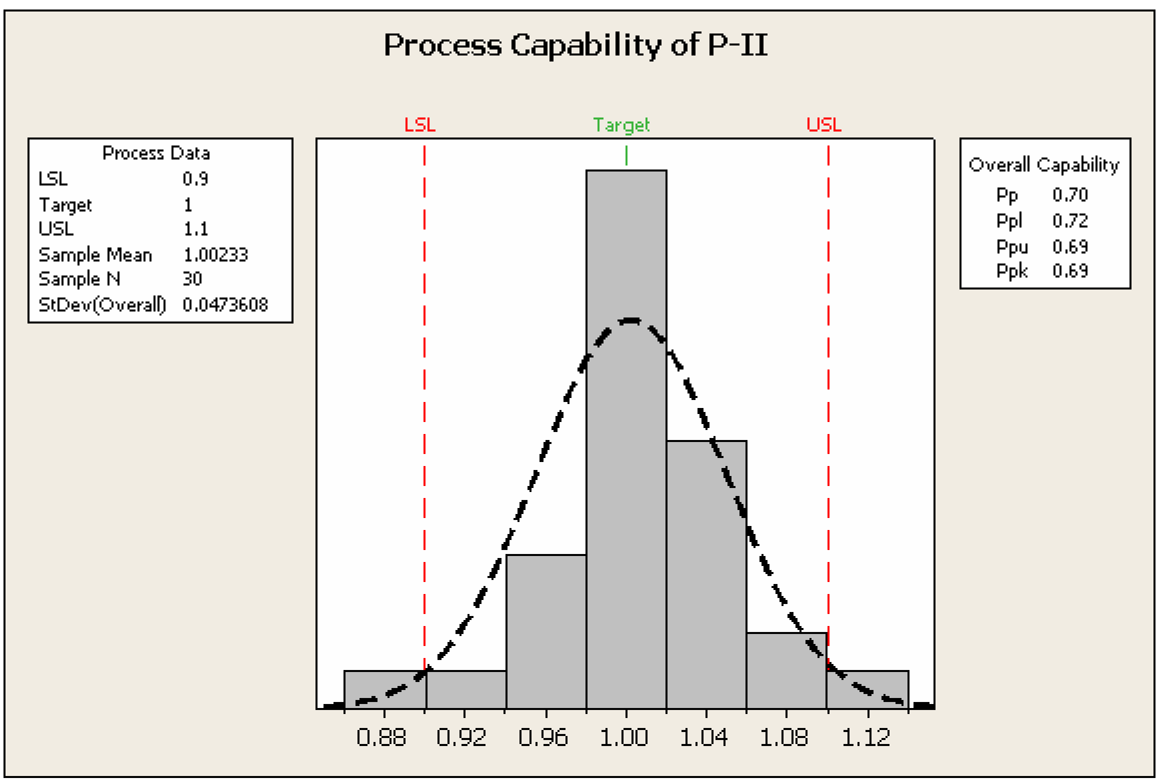


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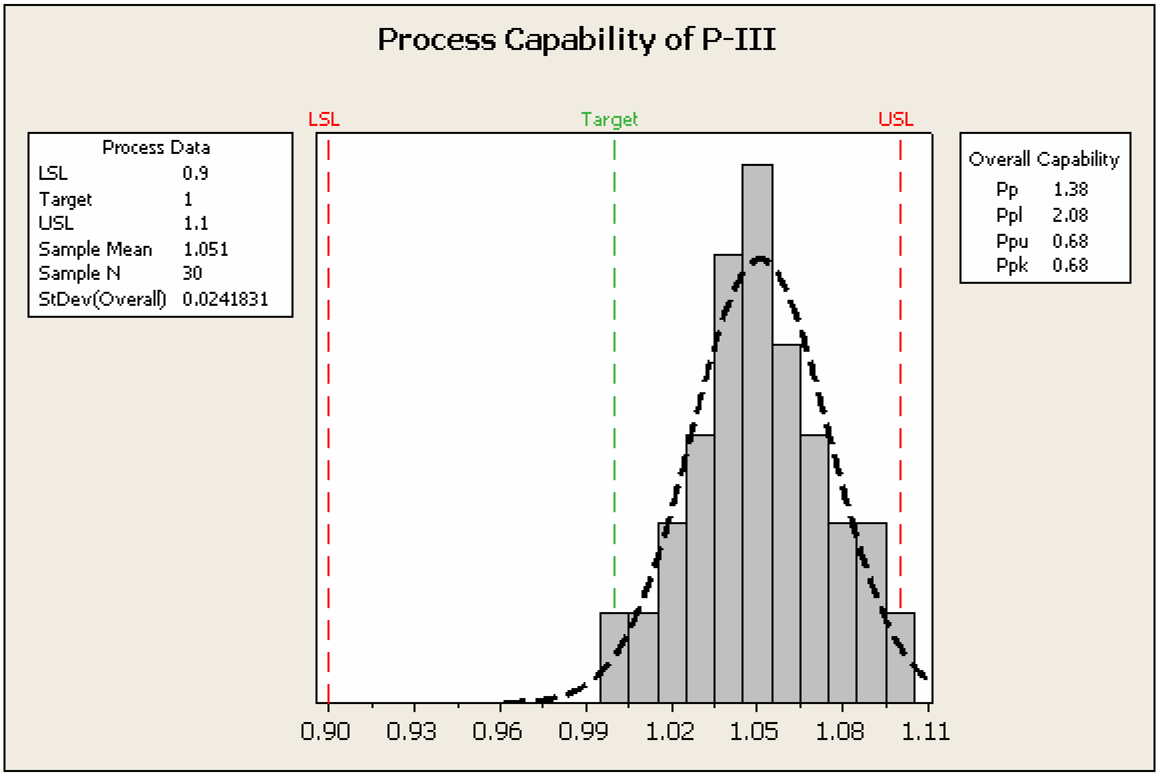
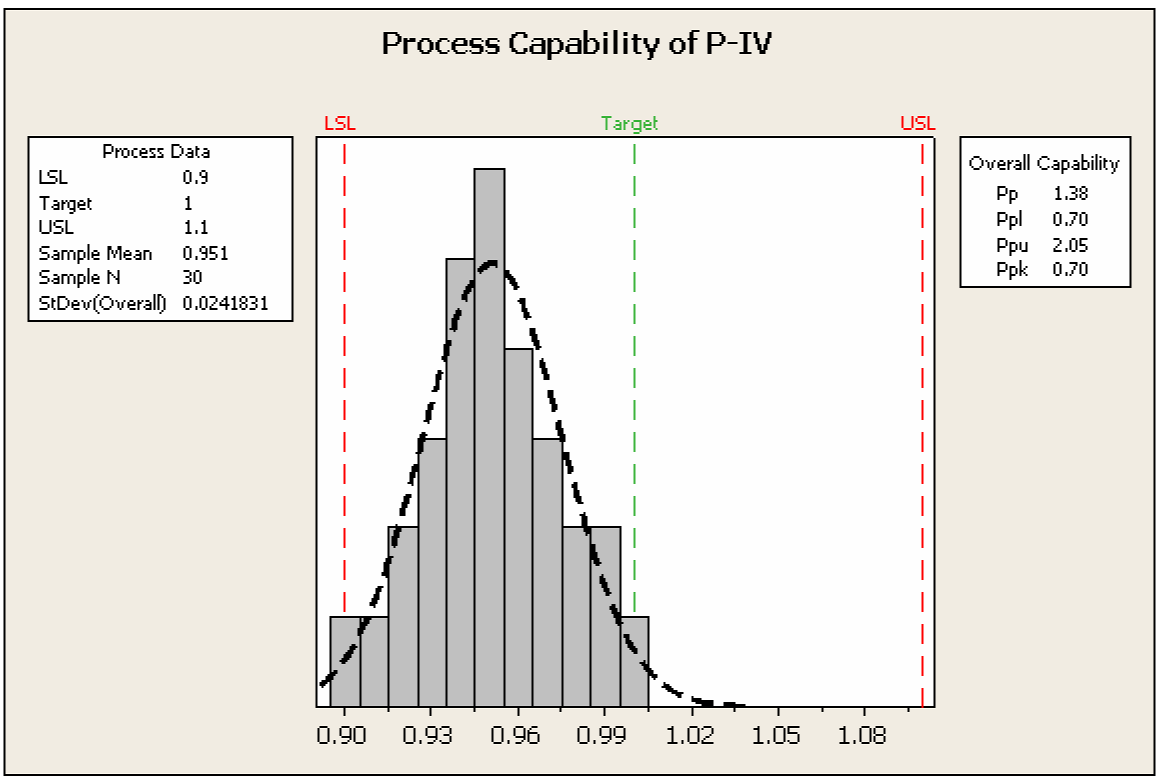
Figure 1 (continued) Process performance for four processes





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Process capability applies to virtually all processes, from traditional manufacturing processes, to software, services, healthcare, and telecom, to insurance. No matter what process is under analysis, it is important to remember that it probably does not operate in isolation. In order to achieve good internal process capability, the capability of processes supplying inputs must also be measured.

About the Author

Sanjaya Kumar Saxena has more than twenty-two years of experience in the software industry, including extensive experience with business process management and information security. He holds a bachelor's of technology in electrical engineering, has served as guest faculty at premier Indian management institutes, and authors *Discover Six Sigma*, a blog to support the application of Six Sigma in different business environments. A member of IEEE, Sanjaya works for Pre-emptive Systems (P) Limited.

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