Assessing Capability with Non-Normal Data – Distribution Fitting

Data Science for Quality Management: Process Capability

with **Wendy Martin**

Learning objective:

Assess capability / performance from a non normal distribution with fitted data

Assess Potential Capability Due to Spread - Cp

```
# Cp Only
cap.gamma[1,1:4] = 0.1112275
```

$$C_p = \frac{USL - LSL}{\sim NT} = \frac{0.8}{7.193} = 0.1112$$

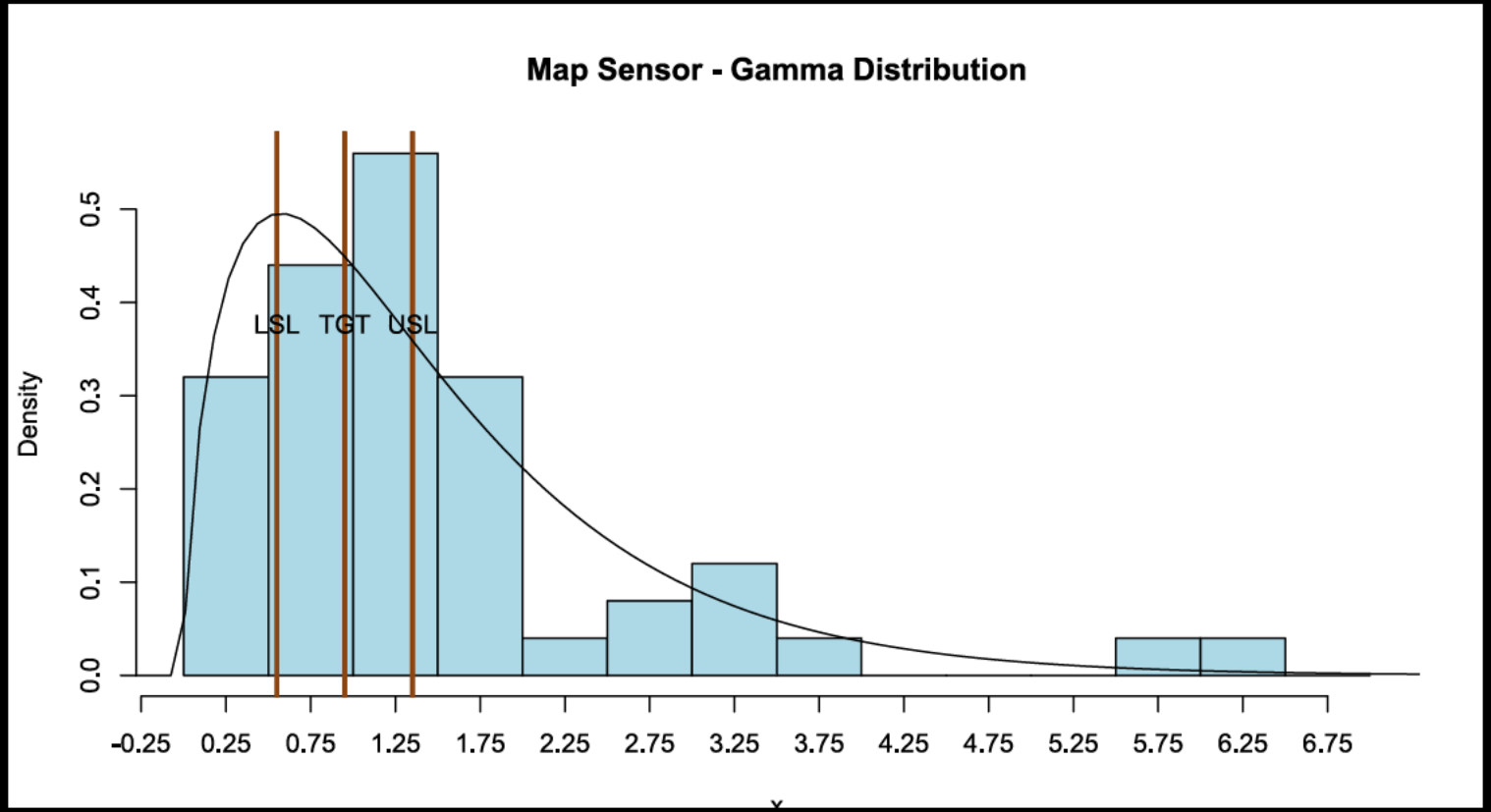
Assess Capability to Produce Within Specification – Cpk

Determine % OOS using the Gamma curve:

```
l.out <- pgamma(q = LSL
,shape = shape
,rate = rate, lower.tail = T) = 0.2115731


u.out <- pgamma(q = USL
,shape = shape
,rate = rate, lower.tail = F) = 0.4344965
```

Make a Visualization



Assess Capability to Produce Within Specification – Cpk

Use the % OOS to calculate a Z Score and divide by 3 to get Cpk (eq)

```
Zu<-qnorm(0.4344965, lower.tail=F)
Cpk.upper<-Zu/3 = 0.054979
```

Assess Capability to Produce Within Specification- Cpk

```
# Cpk Only
cap.gamma[2,1:4] = 0.054979
```

$$C_{pk} = \frac{Z_{EQ}}{3}$$

Assess Capability to Conform to Nominal – Cpm

$$C_{pm} = \frac{USL - LSL}{6\sqrt{\left(\frac{NT}{6}\right)^2 + (\text{Median} - \text{Nominal})^2}}$$

Assess Capability to Conform to Nominal – Cpm

Using Gamma Distribution

$$C_{pm} = \frac{0.8}{6\sqrt{\left(\frac{7.193}{6}\right)^2 + (1.144 - 0.95)^2}}$$

$$C_{pm} = 0.1098$$

Process Performance Measures

If the process is ***not*** in control, use the estimate of the standard deviation based on the overall raw data (ignoring underlying distribution)

```
# Calculate the natural tolerance
s<-sd(mapsensor$z_axis) = 1.263153
nt_s<-6*s = 7.578919
```

Performance Measures – Pp

```
# Pp only
cap.gamma[4,1:4] = 0.1055559
```

$$P_p = \frac{USL - LSL}{6\hat{\sigma}}$$

Performance Measures – Ppk

```
# Ppk only
cap.gamma[5,1:4] = 0.02891283
```

$$P_{pk}U = \frac{USL - \mu}{3\sigma} = 0.0289$$

$$P_{pk}L = \frac{\mu - LSL}{3\sigma} = 0.2400$$

Performance Measures – Ppm

```
# Ppm only
cap.gamma[6,1:4] = 0.09789083
```

$$P_{pm} = \frac{USL - LSL}{6\sqrt{\hat{\sigma}^2 + (\mu - Nominal)^2}}$$

Capability & Performance Summary

statistic	eq	n	value
Cp	=		0.1112
Cpk	=		0.0550
Cpm	=		0.1098
Pp	=		0.1056
Ppk	=		0.0289
Ppm	=		0.0979
Obs. n / PPM (lower)	=	9	180000.0000
Obs. n / PPM (upper)	=	20	400000.0000
Obs. n / PPM (total)	=	20	400000.0000
Pot. PPM (lower)	=		211573.0000
Pot. PPM (upper)	=		434496.0000
Pot. PPM (total)	=		646069.0000

Sources

The material used in the PowerPoint presentations associated with this course was drawn from a number of sources. Specifically, much of the content included was adopted or adapted from the following previously-published material:

- Luftig, J. An Introduction to Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1982
- Luftig, J. Advanced Statistical Process Control & Capability. Luftig & Associates, Inc. Farmington Hills, MI, 1984.
- Luftig, J. A Quality Improvement Strategy for Critical Product and Process Characteristics. Luftig & Associates, Inc. Farmington Hills, MI, 1991
- Luftig, J. Guidelines for Reporting the Capability of Critical Product Characteristics. Anheuser-Busch Companies, St. Louis, MO. 1994
- Spooner-Jordan, V. Understanding Variation. Luftig & Warren International, Southfield, MI 1996
- Luftig, J. and Petrovich, M. Quality with Confidence in Manufacturing. SPSS, Inc. Chicago, IL 1997
- Littlejohn, R., Ouellette, S., & Petrovich, M. Black Belt Business Improvement Specialist Training, Luftig & Warren International, 2000
- Ouellette, S. Six Sigma Champion Training, ROI Alliance, LLC & Luftig & Warren, International, Southfield, MI 2005