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

Step 6 — Assess Process Control

- We will use the Map Sensor data to demonstrate calculating process capability using distribution fitting.

Process Capability Distribution Fitting

The MAP Sensor Problem:

- A major automobile manufacturer produces a Manifold Absolute Pressure Sensor (MAP) Sensor, an electronic device that links the Powertrain Control Module with the engine in all its automobiles.

Process Capability Distribution Fitting

- Inside this sensor is a ceramic substrate, with surface mounted components.
- The placement of these components is critical, and their location is measured from datum reference points in the X, Y, and Z axes.

Process Capability Distribution Fitting

- The data file mapsensor.dat contains the z-axis values for one of the critical components; from 50 consecutive production lots.
- The specification for this component is 0.9500+/-0.4000 (coded data in thousandths of an inch)

Best Distribution Fit

- Best fit from available distributions is the distribution with:
    - Lowest AIC value
    - Best fit in the tail regions in plots

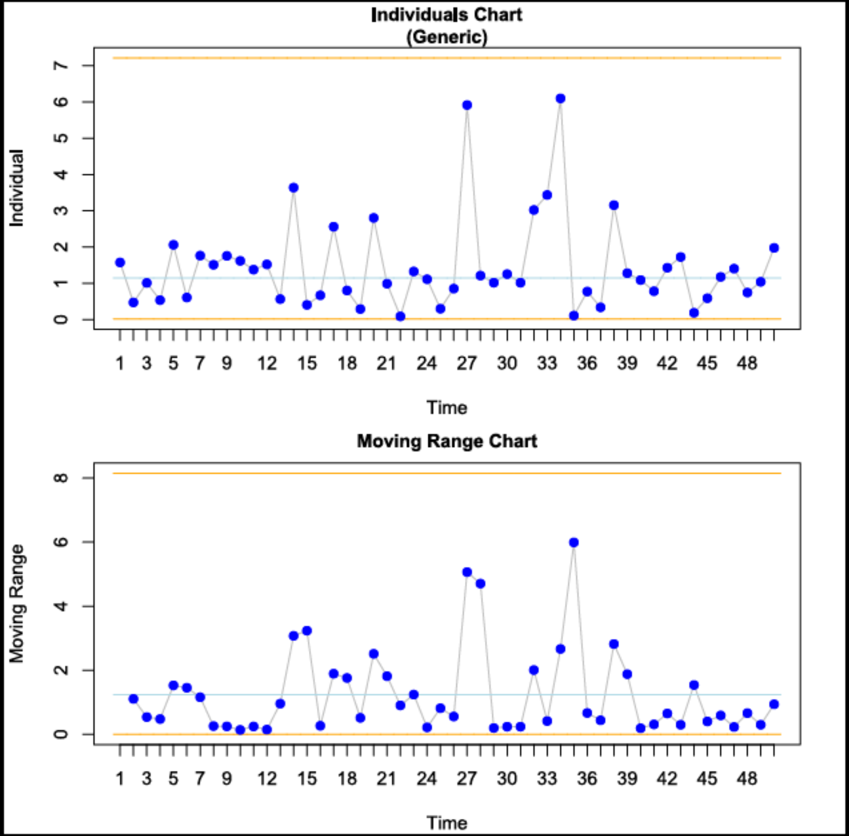
Best Distribution Fit

Distribution	LPL	UPL	AIC	Other
Exponential	0.002	9.644	139.81	
Weibull	0.009	6.913	136.89	
Gamma	**0.021**	**7.213**	**135.31**	
Log Normal	0.076	14.418	136.99	
Johnson	-1.908	12.687	147.71	

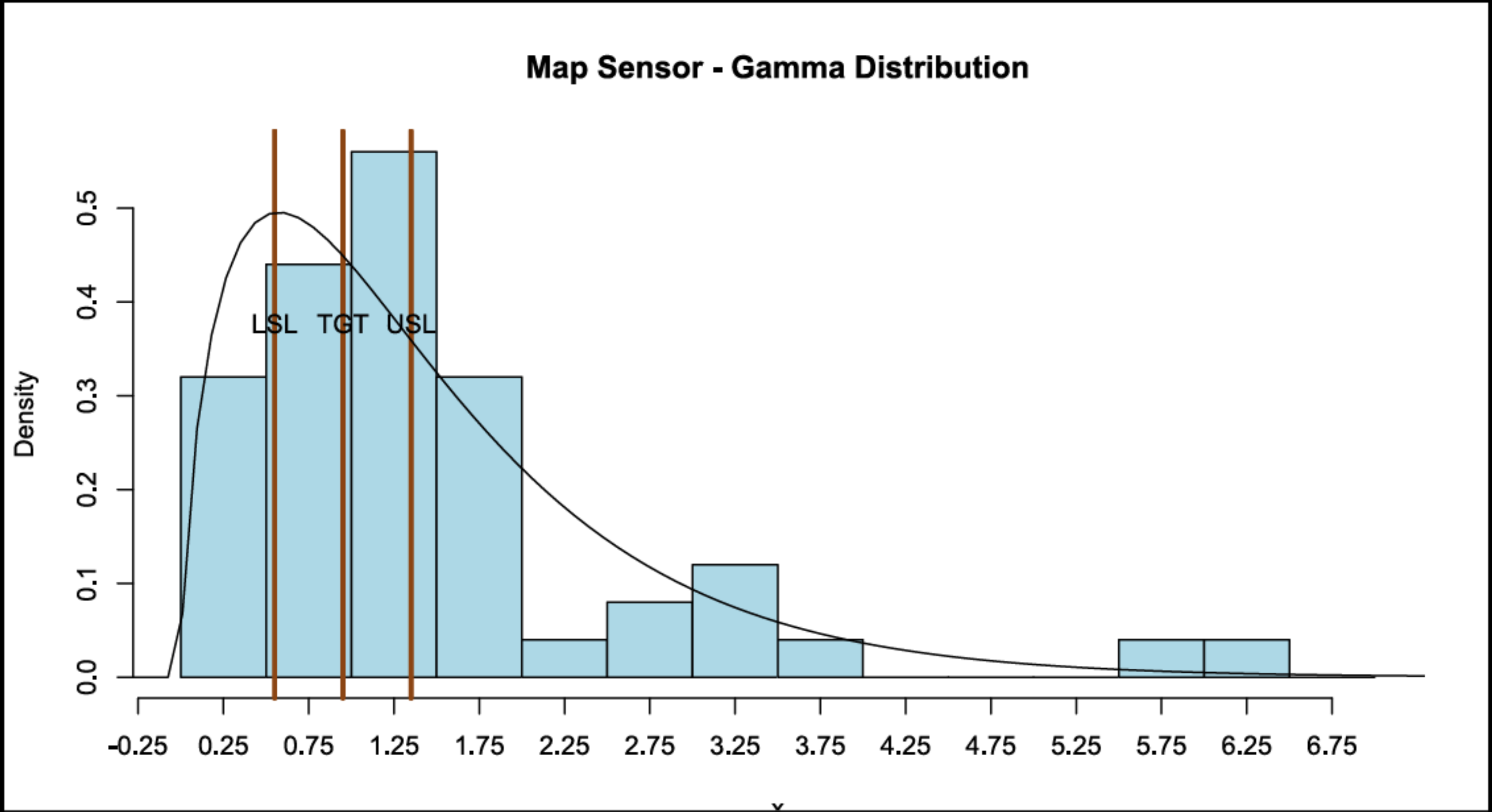
Step 6 — Assess Process Control

Control Chart with Gamma distribution for the individuals, Exponential distribution for moving range

```
spc.chart.variables.individual.and.movingrange.
generic.simple(individuals = mapsensor$z_axis
,chart1.center.line = median(mapsensor$z_axis)
,chart1.control.limits.lcl = LNPL.gamma
,chart1.control.limits.ucl = UNPL.gamma
,chart2.control.limits.lcl = LNPL.mr.exp
,chart2.control.limits.ucl = UNPL.mr.exp)
```



Gamma Distribution



Step 7 — Assess Potential Capability

```
# Send data to an object named “data”
data<-mapsensor$z_axis
```

Step 7 — Assess Potential Capability

```
# Goodness of fit for the Gamma

fit.g<-fitdist(data = mapsensor$z_axis, distr
= "gamma“)

shape<-fit.g$estimate[1]

rate<-fit.g$estimate[2]
```

Step 7 — Assess Potential Capability

```
# Get natural tolerance for the Gamma
Distribution for the individual values

f<-function(p,lower.tail)

{qgamma(p, shape = shape, rate = rate,
lower.tail = lower.tail)

}

nt.gamma<-natural.tolerance(f)
```

Step 7 — Assess Potential Capability

```
# Define inputs
LSL       <- 0.55
Target    <- 0.95
USL       <- 1.35
```

Step 7 — Assess Potential Capability

```
# Define inputs – proportion out of spec
l.out <- pgamma(q = LSL, shape = shape, rate
= rate, lower.tail = T)
u.out <- pgamma(q = USL, shape = shape, rate
= rate, lower.tail = F)
total.out <- l.out + u.out
```

Step 7 — Assess Potential Capability

```
# Define inputs – center, variability, NT’
median     <- median(data)
mean       <- mean(data)
nt_est     <- nt.gamma$natural.tolerance
s          <- sd(data)
```

Step 7 — Assess Potential Capability

```
# Define inputs – Actual out of spec
obs.above.spec <- sum(data > USL)
obs.below.spec <- sum(data < LSL)
totaln         <- length(data)
```

Step 7 — Assess Potential Capability

```
spc.capability.summary.ungrouped.nonnormal.simple.R()
```

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
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- Ouellette, S. Six Sigma Champion Training, ROI Alliance, LLC & Luftig & Warren, International, Southfield, MI 2005