Assessing Capability from X and MR Chart – Normal

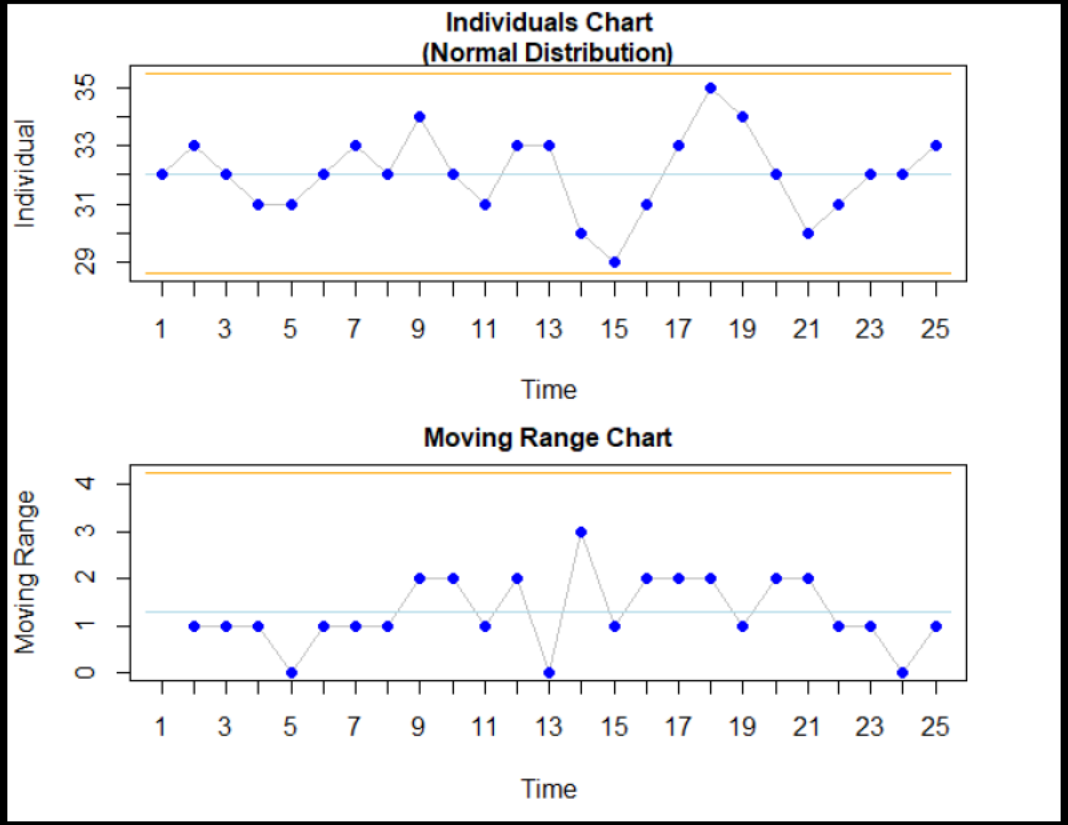
Data Science for Quality Management: Process Capability

with **Wendy Martin**

Learning objective:

Assess capability / performance from an X and MR chart for data that is normally distributed

Step 6 — Assess Process Control



Calculate estimate of sigma from chart

```
mrbar<-mean(abs(diff(Tank6$Concentration)))
d2<-spc.constant.calculation.d2(2)
(sig_est.mr<-mrbar/d2) = 1.14471
```

Calculate Natural Tolerance

```
# Calculate the natural tolerance
# If normally distributed, this is 6*sig_est
(nt_est<-6*sig_est.mr)
= 6.868259
```

Assess Potential Capability Due to Spread - Cp

```
# Cp only
spcx.mr$capability[1,1:4] = 0.8735839
```

$$C_{p(pot.)} = \frac{USL - LSL}{6\hat{\sigma}} = \frac{35 - 29}{6(1.145)} = 0.874$$

Assess Capability to Produce Within Specification - Cpk

$$C_{pk}U = \frac{Z_U}{3} = 0.862$$

$$C_{pk}L = \frac{Z_L}{3} = 0.885$$

$$C_{pk} = \min(C_{pk}U, C_{pk}L)$$

$$\text{Cpk} = 0.862$$

```
xbar<-mean(tank6$Concentration)

spc.capability.cpU.simple(upper.specification =
USL,process.center = xbar, process.variability
= sig_est.mr^2, n.sigma = 6) = 0.8619361

spc.capability.cpL.simple(lower.specification =
LSL,process.center = xbar, process.variability
= sig_est.mr^2, n.sigma = 6) = 0.8852317

Cpk<-
spc.capability.cpk.simple(lower.specification =
LSL, upper.specification =
USL,process.variability = sig_est.mr^2,
process.center = xbar, n.sigma = 6)
= 0.8619361
```

Assess Capability to Produce Within Specification - Cpk

```
# Cpk only
spcx.mr$capability[2,1:4] = 0.8619361
```

Assess Capability to Conform to Nominal – Cpm

```
# Cpm only
spcx.mr$capability[3,1:4] = 0.873051
```

$$C_{pm} = \frac{USL - LSL}{6\sqrt{\hat{\sigma}^2 + (\mu - Nominal)^2}} = 0.873$$

Performance Measures

```
# Calculate overall standard deviation
s<-sd(tank6$Concentration)
= 1.368698

# Calculate the natural tolerance
# If normally distributed, this is 6*s
nt_s<-6*s
= 8.212186
```

Performance Measures – Pp

```
# Pp only
spcx.mr$capability[4,1:4] = 0.7306215
```

Performance Measures – Ppk

```
# Ppk only
spcx.mr$capability[5,1:4] = 0.7208799
```

Performance Measures – Ppm

```
# Ppm only
spcx.mr$capability[6,1:4] = 0.7303097
```

Capability & Performance Results

statistic	eq	n	value
Cp	=		0.8736
Cpk	=		0.8619
Cpm	=		0.8731
Pp	=		0.7306
Ppk	=		0.7209
Ppm	=		0.7303
Obs. n / PPM (lower)	=	0	0.0000
Obs. n / PPM (upper)	=	0	0.0000
Obs. n / PPM (total)	=	0	0.0000
Pot. PPM (lower)	=		3957.0000
Pot. PPM (upper)	=		4858.0000
Pot. PPM (total)	=		8815.0000

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