Individuals and Moving Range Charts – Known Mathematical Model

Data Science for Quality Management: X and Moving Range Charts for Non-Normally Distributed Data

with **Wendy Martin**

Learning objectives:

Calculate Control Limits for data that is distributed exponentially

Generate the X and MR chart using R software for exponential data

X and MR Charts Non-Normal Distributions

- The difficulty associated with mathematical distributions as skewed as the Exponential function relates not so much to the X chart, but to the control limits to be employed for the Moving Ranges.

X and MR Charts Non-Normal Distributions

- The constants associated with the Moving Range chart simply do not accommodate the expected distribution of Moving Ranges at n=2 that one would anticipate from an Exponential function.

X and MR Charts Non-Normal Distributions

- Review the following distribution of Moving Ranges generated from a Monte Carlo simulation of values anticipated from a standard exponential function with an Omicron of 6.76 and a mean of 15.84:

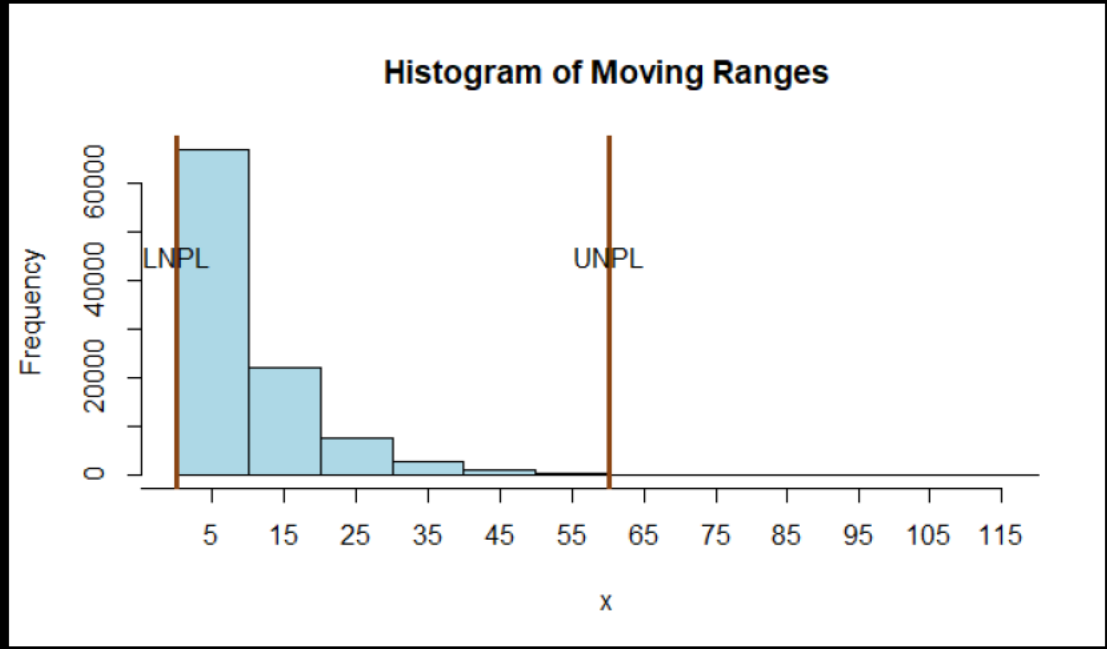
X and MR Charts Non-Normal Distributions

```
rexp.low(n = 100000, low = 6.76, mean =
mean(RFP_Response_Time$Time))
mr.exp.low<- c(abs(diff(mc)))
```

Shape Test indicates the data are distributed exponentially

X and MR Charts - Expected Moving Range Values

```
nqtr(natural.tolerance.exp(x =
mr.exp.low),5)
natural.tolerance  60.2142
lower.limit        0.01231
upper.limit        60.22655
lower.area         0.00135
upper.area         0.00135
```



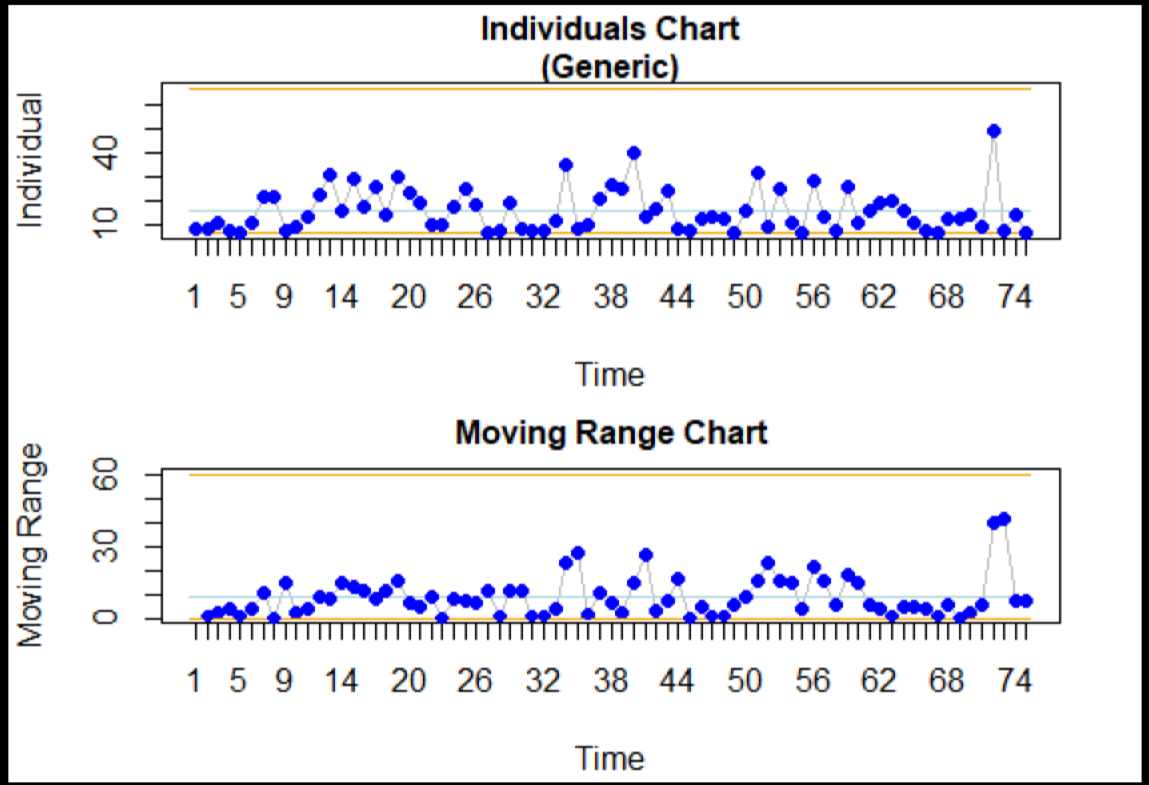
X and MR Charts

Standard Exponential Formula-Based MR Chart

- Using the estimates of control limits generated for the X chart from the Exponential distribution, but with the standard exponential Moving Range values, we would obtain:

X and MR Charts

Standard Exponential Formula-Based MR Chart



X and MR Charts Non-Normal Distributions

- What would you use as a centerline?
  - Mean?
  - Gives you real information from all points
  - Need to recalculate the run rules
  - How would you do this?

X and MR Charts Non-Normal Distributions

- $0.6321^x = 0.0027$ below the mean
  - The lowest value is the mode – you expect to see it a lot!
  - Run below $= \frac{\ln .0027}{\ln .6321} = 12.894$ and

- $0.3679^x = 0.0027$ above the mean
  - Run above$= \frac{\ln .0027}{\ln .3679} = 5.914$

X and MR Charts Non-Normal Distributions

Define new rules

```
# Changing rules
rules <-
spc.rulesets.nelson.1984.test.1.2.3.4()


# Turn off the lower control limit rule
rules$outside.limits <-
spc.controlviolation.nelson.1984.test1.outsid
e.zone.a.upper
```

X and MR Charts Non-Normal Distributions

Define new rules

```
# If using the mean for the X chart, adjust the run rules

rules$runs       <- NULL

rules$runs.above <- spc.controlviolation.nelson.1984.test2.runs.above.create(point.count = 6)

rules$runs.below <- spc.controlviolation.nelson.1984.test2.runs.below.create(point.count = 13)
```

X and MR Charts Non-Normal Distributions

Define new rules

```
# Test for run rules

runs.overall <-
unique(exp.chart$chart1.is.control.violation$
rule.results$runs.above |
exp.chart$chart1.is.control.violation$rule.re
sults$runs.below)
```

X and MR Charts Non-Normal Distributions

- Median?
  - Allows you to use the traditional run rules of 8 above or below
  - Less precise estimate of the location

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.
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- 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