**Brion Hurley**
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**Business Performance Improvement LLC**

Community Consulting Lead
**Lean Portland**

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# Six Sigma Primer Workshop

# Housekeeping

Glasses
Bathrooms
Exit


- Volunteer group of Lean consultants working with nonprofits
- Provide networking events, happy hours, free workshops and volunteer opportunities
- LeanPortland.com


- Helping businesses and organizations achieve “triple bottom line” performance using Lean and Six Sigma
- Classes, workshops, consulting and mentoring
- BIZ-PI.com


- Nonprofit social enterprise innovation lab and co-working space since 2004
- Assist with capital access that is compatible for businesses and the communities they serve
- HatchTheFuture.org

# Agenda

- Intros
- History
- Variation
- Sigma Levels
- DMAIC
- Data
- Gage R&R
- Gage R&R Exercise
- SPC
- Capability
- Minitab/Excel
- Charts and Graphs
- ANOVA
- Electricity Reduction Project
- Regression
- DOE
- DOE Exercise
- Belt System
- Examples (Suppliers, Healthcare)
- Q&A and Next Steps

# 0:10

Your name?

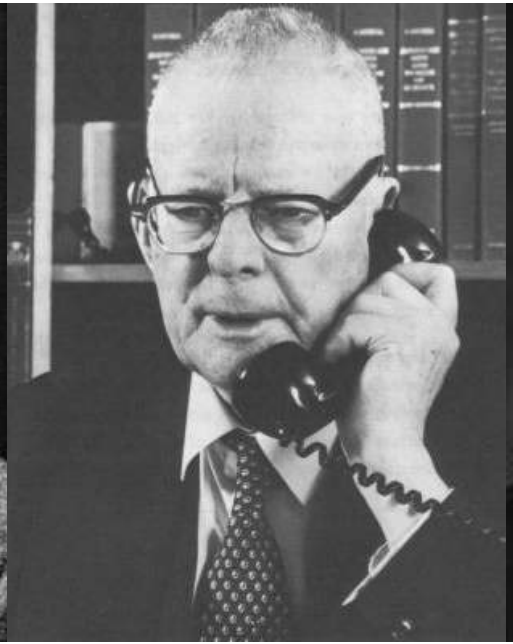
Company?

Your position?

Why are you here?

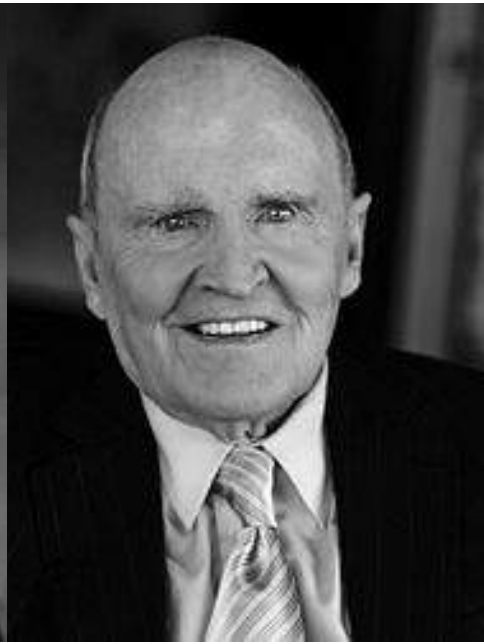
# a brief history…

**Walter Shewhart**
“Father of SPC”, PDCA
Engineer, statistician
Bell Labs, Western Electric
*1891-1967 (1924)*



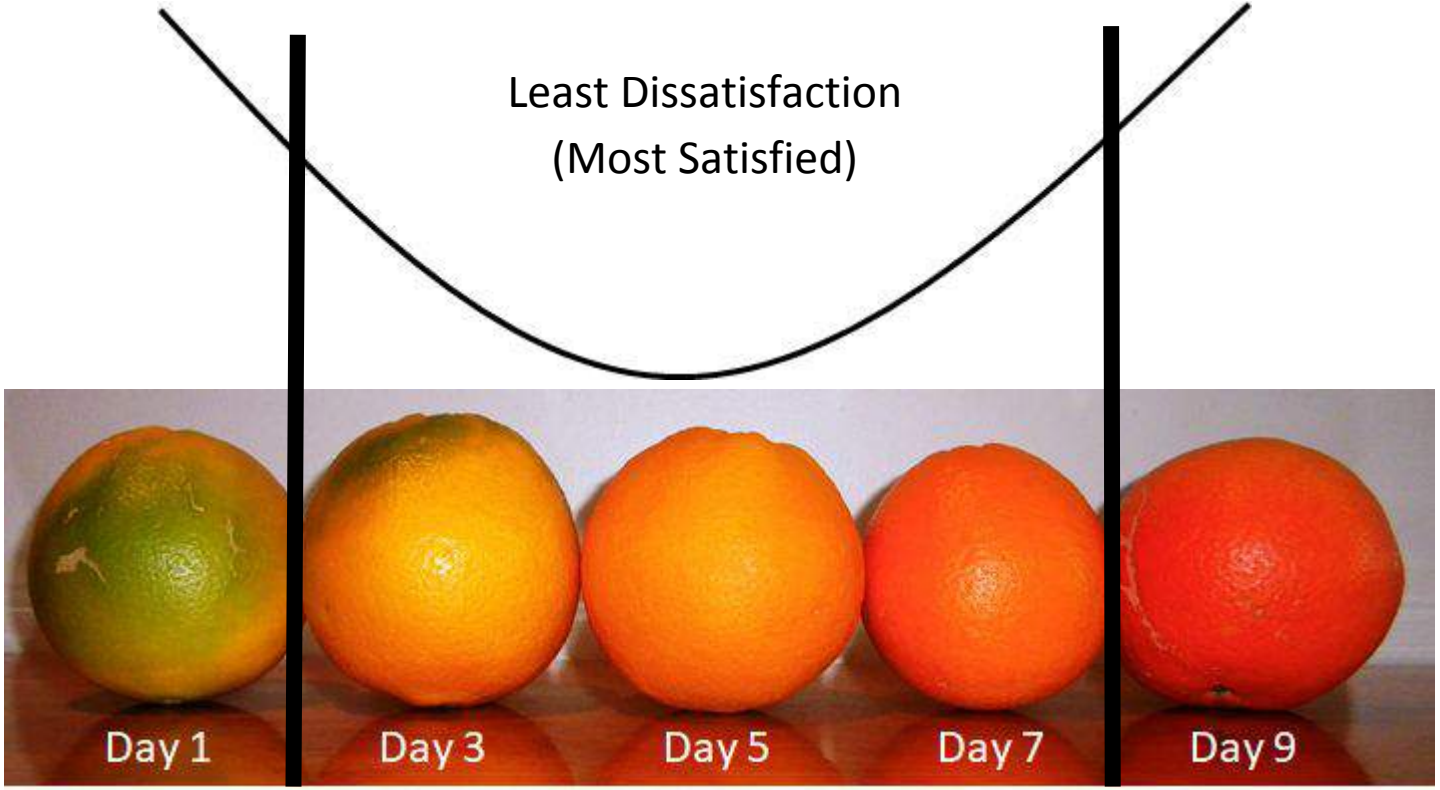
**W. Edwards Deming**
Engineer, statistician & consultant
Championed work of Shewhart in US and Japan, key connection to Lean and Six Sigma
*1900-1993 (1950)*

**Bill Smith**
"Father of Six Sigma”
Engineer, Motorola
*1929–1993 (1986)*



**Jack Welch**
CEO, General Electric
Six Sigma culture
*1981-2001 (1995)*

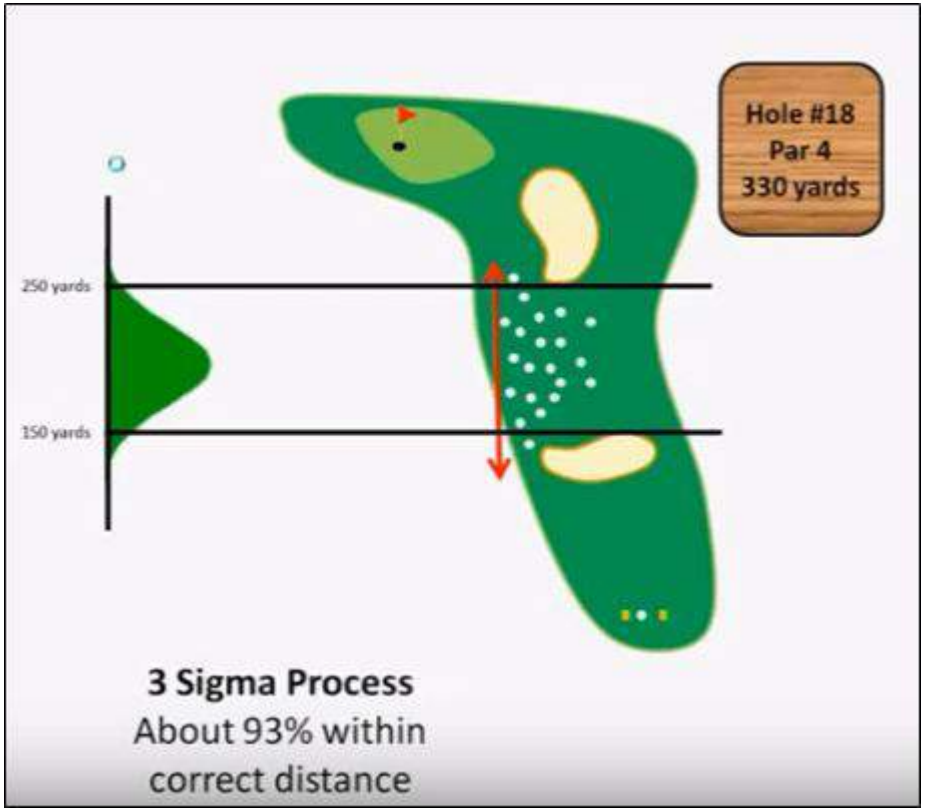
# Does variation matter? Not black and white



# What is Six Sigma?

## Six Sigma Golfing

https://www.youtube.com/watch?v=AUP50Ahk5oI



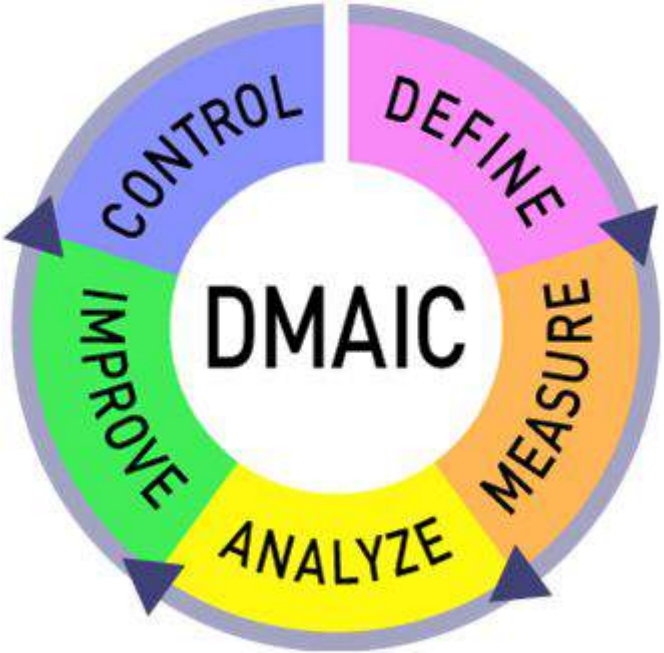
# Sigma Levels

| Sigma Level | Defects Per Million | Yield | Cost (% Sales) |
|---|---|---|---|
| 6.0 | 3.4 | 99.99966% | Very Low (< 1%) |
| 5.5 | 32 | 99.9968% | |
| 5.0 | 233 | 99.977% | Low (1-5%) |
| 4.5 | 1,350 | 99.87% | |
| | | | |
| 3.5 | 22,750 | 97.7% | |
| 3.0 | 66,807 | 93.3% | High (10-20%) |
| 2.5 | 158,655 | 84.1% | |
| 2.0 | 308,537 | 69.1% | Very High (20-30%) |
| 1.5 | 500,000 | 50.0% | |
| 1.0 | 691,462 | 30.9% | Excessive ( > 30%) |

What sigma level are your processes?

# DMAIC

- Successful methodology that uses data to confirm extent of problem, get to root cause, link solutions to causes, and maintain improvements
- Increases chance of project success than not following model



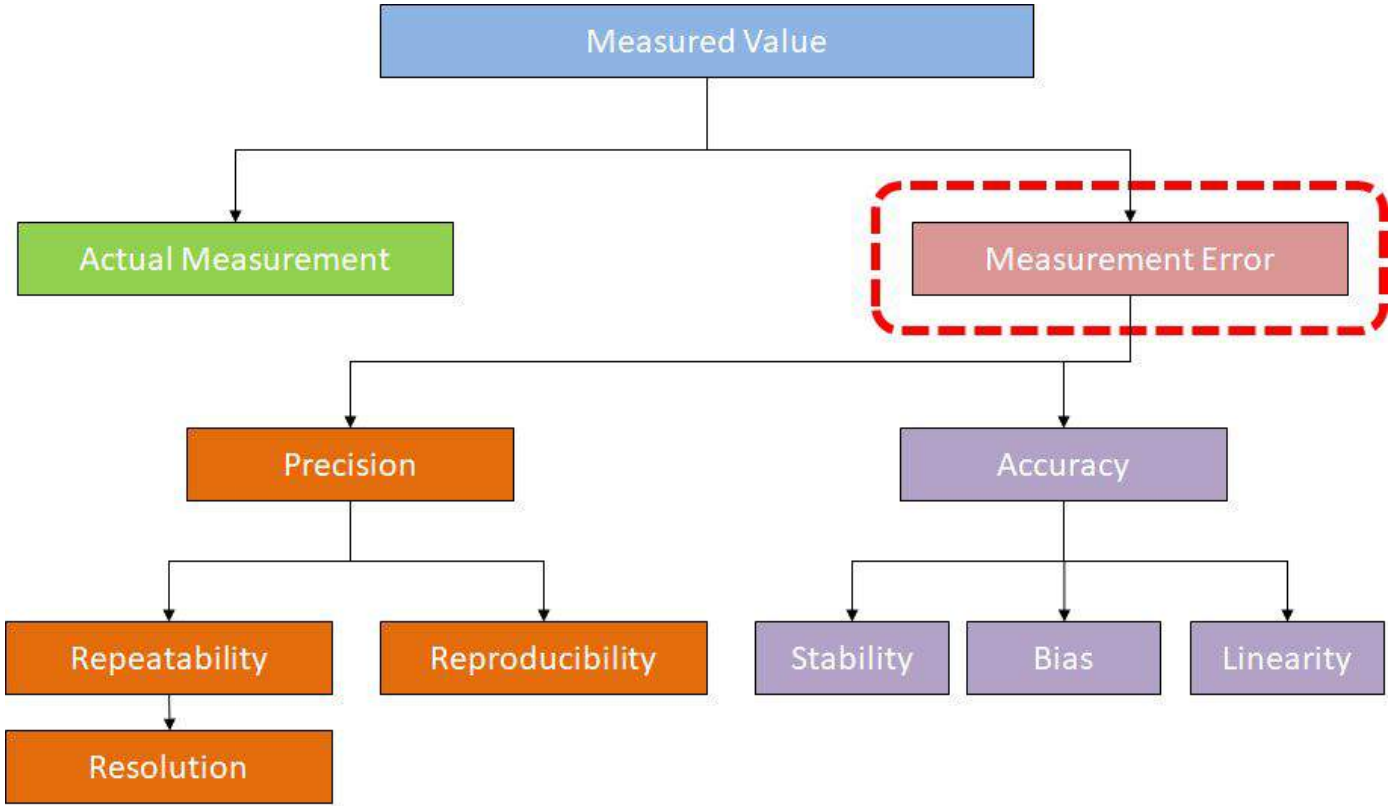
# All about the data!

- Data is at the heart of Six Sigma
- Without data, there can be no assurance of improvement
  - Just educated guessing
  - Not a reliable method for improving
- Focus is on separating true improvement from random chance (luck)
- Take time to gather data, to help support and sell others on your ideas
- Data takes the emotion out of a situation
- Data can be incorrect or misleading, so ensure data collection methods are trusted
  - **“Garbage in, garbage out”**

# The Big 3

- Gage Repeatability and Reproducibility (R&R)
- Statistical Process Control (SPC)
- Capability Analysis

# Measured Value = Actual Value + Measurement Error



# Gage R&R

- R&R stands for Repeatability and Reproducibility
  - Repeatability
    - The variation in measurements taken by a single person or instrument on the same item and under the same conditions
  - Reproducibility
    - The variation induced when different operators, instruments, or laboratories measure the same or replicate items

# Repeatability

REPEATABLE

0.0036
0.0037
0.0035
0.0036
0.0036
0.0037
0.0036
0.0035

GOOD


NOT REPEATABLE

0.0046
0.0057
0.0033
0.0039
0.0050
0.0030
0.0036
0.0055

BAD

# Reproducibility

## REPRODUCIBLE

| PERSON #1 | PERSON #2 |
|---|---|
| 0.0046 | 0.0048 |
| 0.0057 | 0.0050 |
| 0.0032 | 0.0034 |
| 0.0039 | 0.0051 |
| 0.0050 | 0.0037 |
| 0.0030 | 0.0032 |
| 0.0036 | 0.0046 |
| 0.0056 | 0.0044 |
| AVERAGE | AVERAGE |
| **0.0043** | **0.0043** |


## NOT REPRODUCIBLE

| PERSON #1 | PERSON #2 |
|---|---|
| 0.0043 | 0.0034 |
| 0.0052 | 0.0022 |
| 0.0031 | 0.0021 |
| 0.0033 | 0.0023 |
| 0.0045 | 0.0035 |
| 0.0034 | 0.0024 |
| 0.0039 | 0.0029 |
| 0.0052 | 0.0047 |
| AVERAGE | AVERAGE |
| **0.0041** | **0.0029** |

# Exercise

Measure how well you can estimate 10 seconds

1. Find a partner
2. Partner says “start” and starts stopwatch on your phone, tell partner “stop” when you think 10 seconds has elapsed. Make sure partner cannot see their results and don’t provide feedback
3. **Repeat** 6 times, then **reproduce** the study with the other partner
4. Record all results, estimate average and range (max and min) using handout
5. Who is more consistent? Who averages closer to 10 seconds? Who went first vs second?

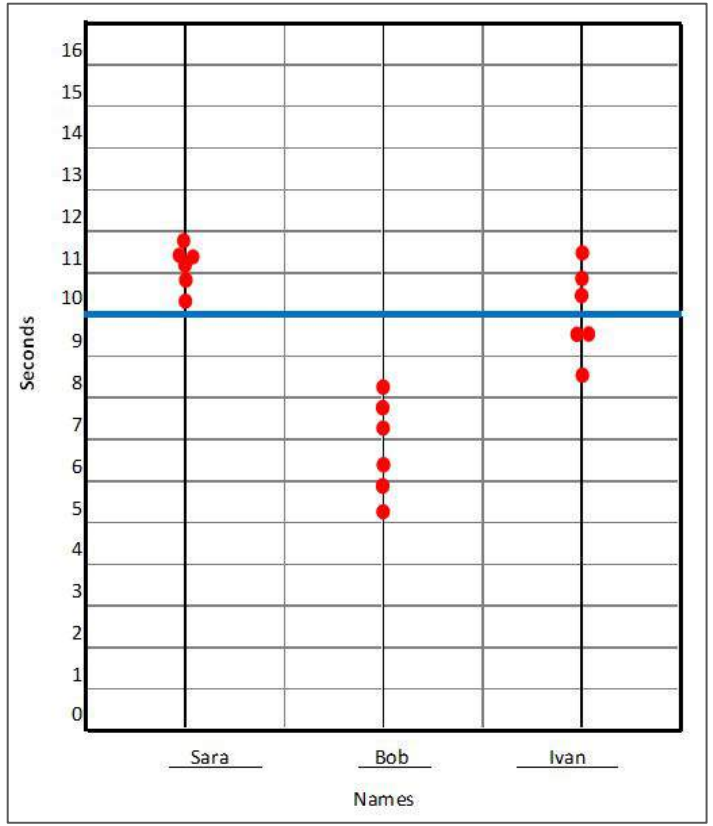
# Fill out form

10 Second Timer Gage R&R

| | Name #1 | Name #2 | Name #3 |
|---|---|---|---|
| | Sara | Bob | Ivan |
| Obs | | | |
| 1 | 11.3 | 5.3 | 8.6 |
| 2 | 10.9 | 7.8 | 10.9 |
| 3 | 11.2 | 6.4 | 9.5 |
| 4 | 11.8 | 7.2 | 10.4 |
| 5 | 10.3 | 8.2 | 11.5 |
| 6 | 11.3 | 5.9 | 9.6 |
| **Avg** | 11.13 | 6.80 | 10.08 |
| **Range (Max - Min)** | 1.5 | 2.9 | 2.9 |

Accuracy: Which person has an average closer to 10 seconds? Ivan

Precision: Which person has a smaller range? Sara



# Attribute Gage R&R: Can you taste the difference?


Fiji©


Zephyrhills©


7-11© Generic

Filtered Tap Water

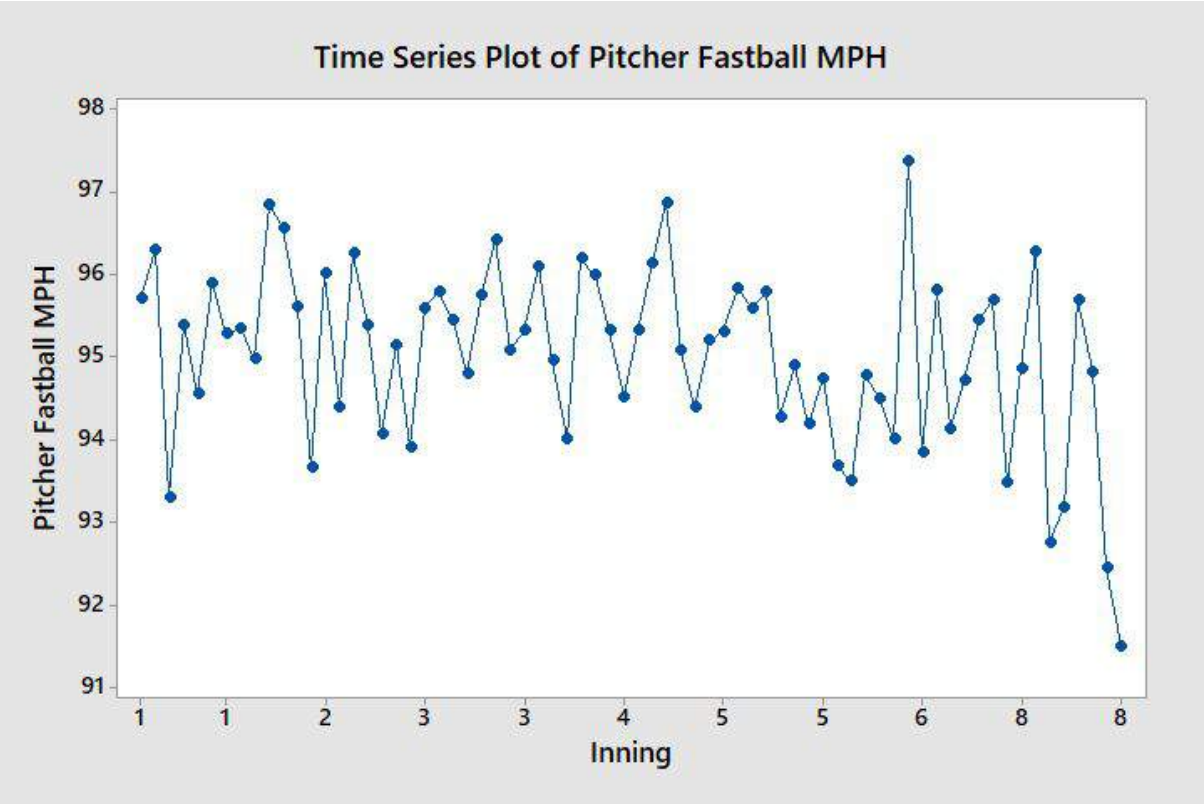
http://leansixsigmaenvironment.org/index.php/does-bottled-water-actually-taste-better-attribute-agreement-analysis/

# Results of Blind Taste Test

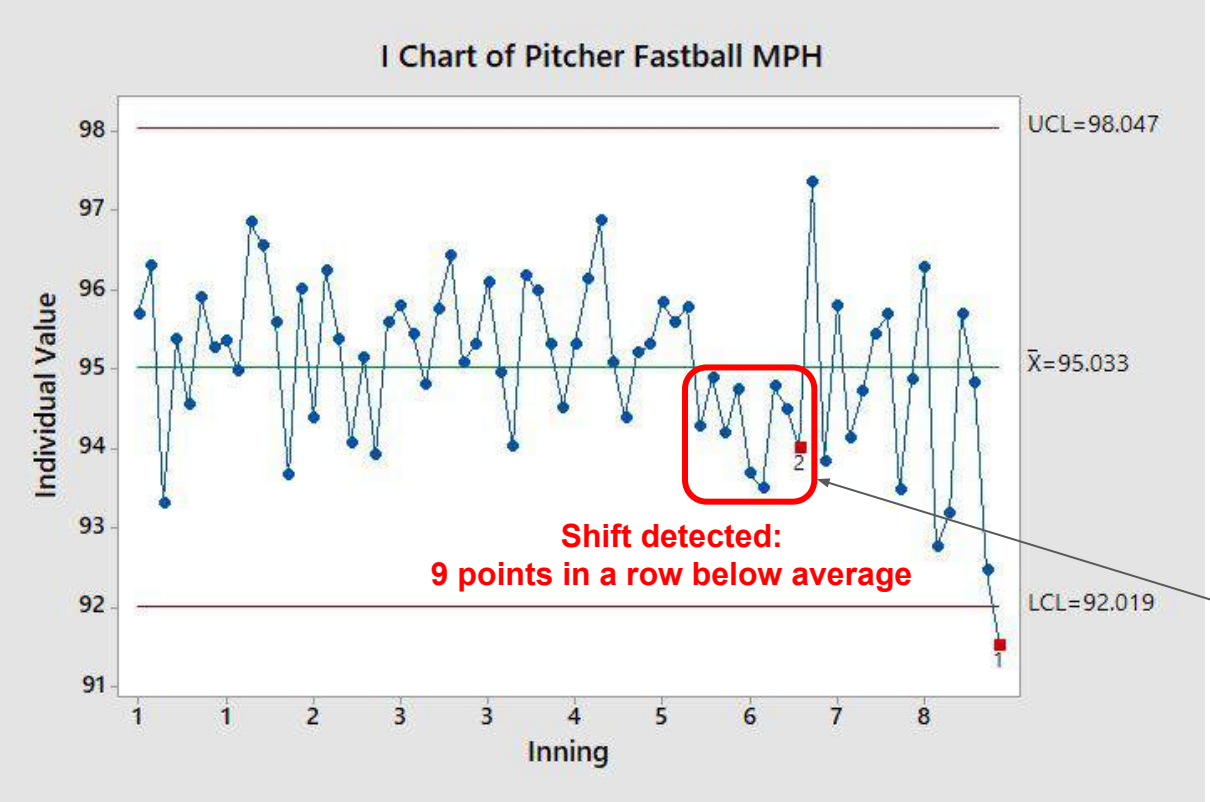
| Cup # | Actual | Tester #1 | Tester #2 | Tester #3 | % Correct |
|---|---|---|---|---|---|
| 1 | Generic | Generic | Tap | Fiji | 33% |
| 2 | Tap | Zephyrhills | Generic | Tap | 33% |
| 3 | Fiji | Fiji | Fiji | Generic | 67% |
| 4 | Zephyrhills | Fiji | | Generic | 0% |
| 5 | Fiji | Tap | Tap | Zephyrhills | 0% |
| 6 | Tap | Z lls | Zephyrhi | Tap | 33% |
| 7 | Generic | ji | Fiji | Zephyrhills | 0% |
| 8 | Zephyrhills | | Generic | Fiji | 0% |
| 9 | Tap | Ta | Tap | Zephyrhills | 67% |
| 10 | Generic | Gene ic | Generic | Generic | 100% |
| 11 | Fiji | Generic | Zephyrhills | Zephyrhills | 0% |
| 12 | Zephyrhills | Fiji | Fiji | Zephyrhills | 33% |
| Overall | | 42% (4) | 33% (3) | 42% (4) | 8% (1) |

NO!

# Statistical Process Control (SPC)

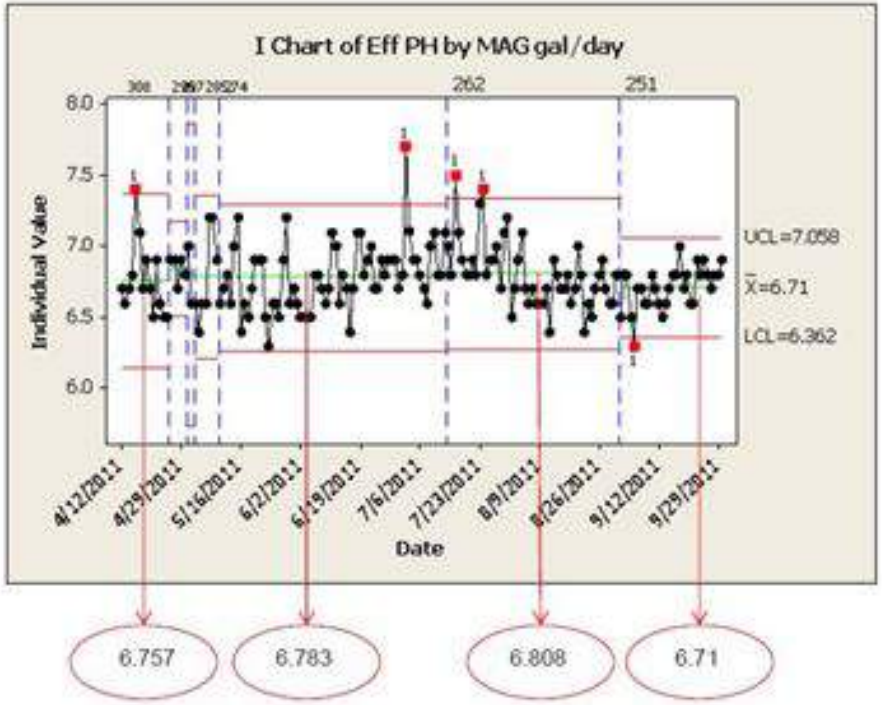


# Now when do you take out the pitcher?



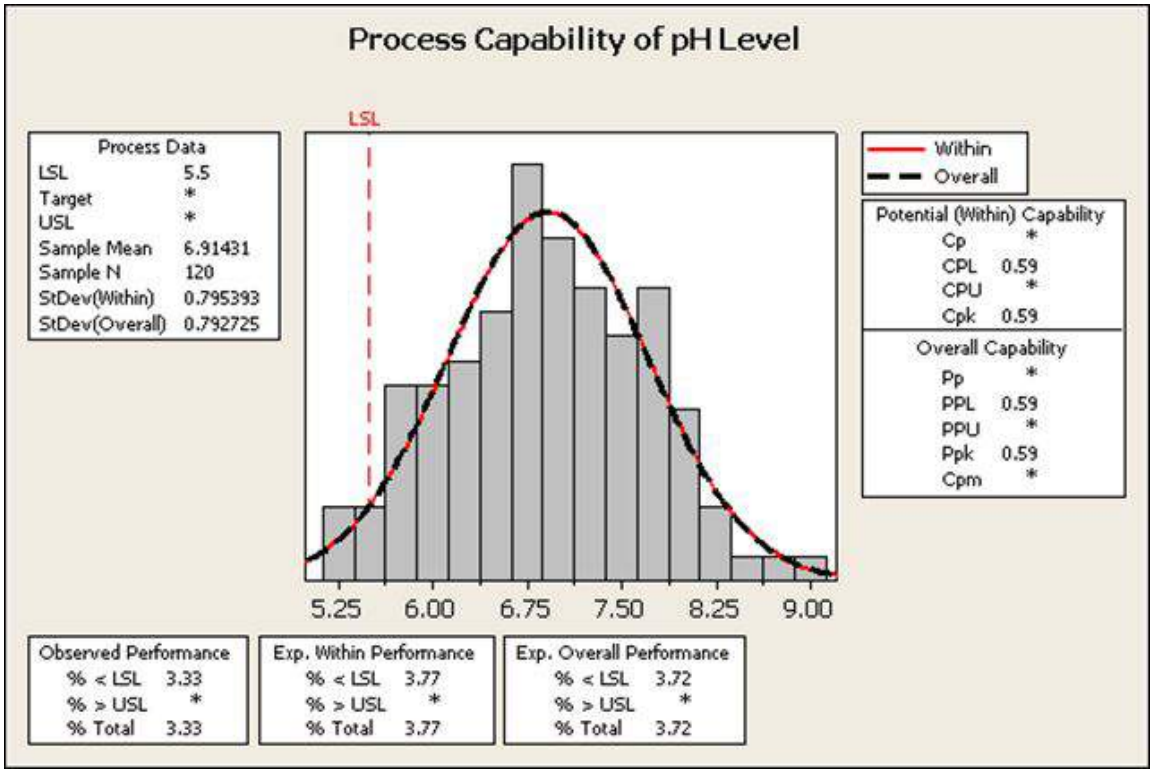
# Case Study: City of Tyler

- Wastewater department stabilized magnesium hydroxide dosages and cut costs with confidence from statistical analysis showing that they will still comply with state regulations, resulting in $80K in savings to date.
- They also established standard operating procedures, which ensured the continued efficiency of their process and savings for the city and taxpayers.



# Capability

- pH level for wastewater discharge
- 4% risk of discharge violation



# Excel and Minitab

## Excel

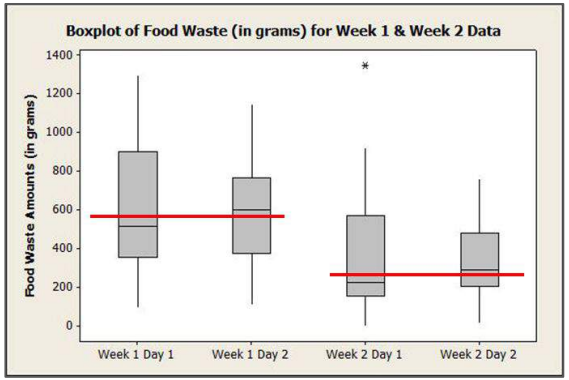
- Easier to use
- Easier to access
- Easier to share
- Flexible, multi-purposes
- Low cost or free

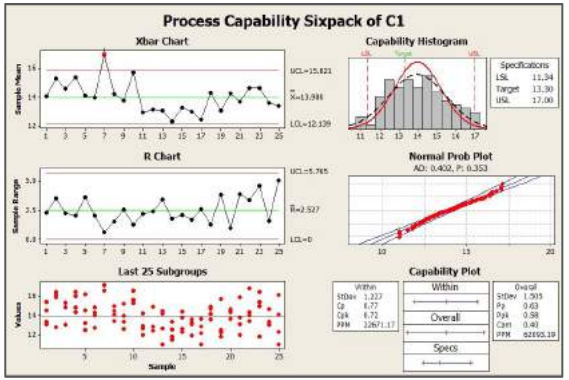
## Minitab

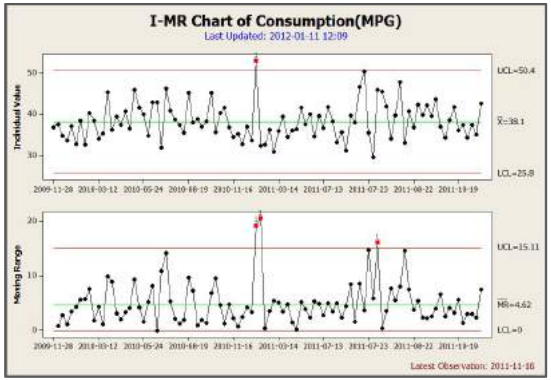
- Better charts and graphs
- Better statistical analysis

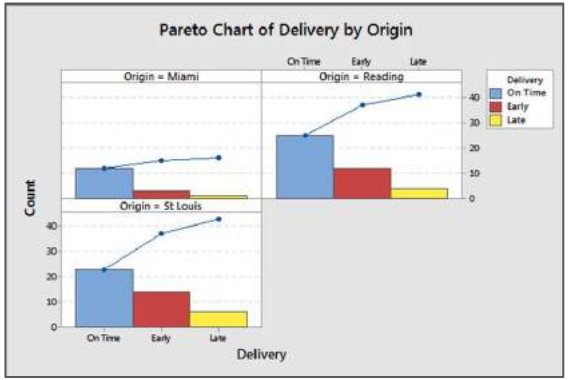
Other packages available: SigmaXL, QI Macros, JMP, R, etc

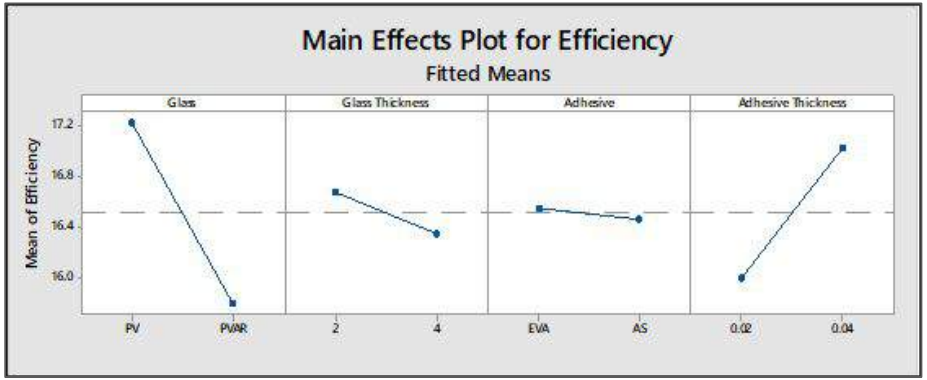
# Minitab Charts and Graphs



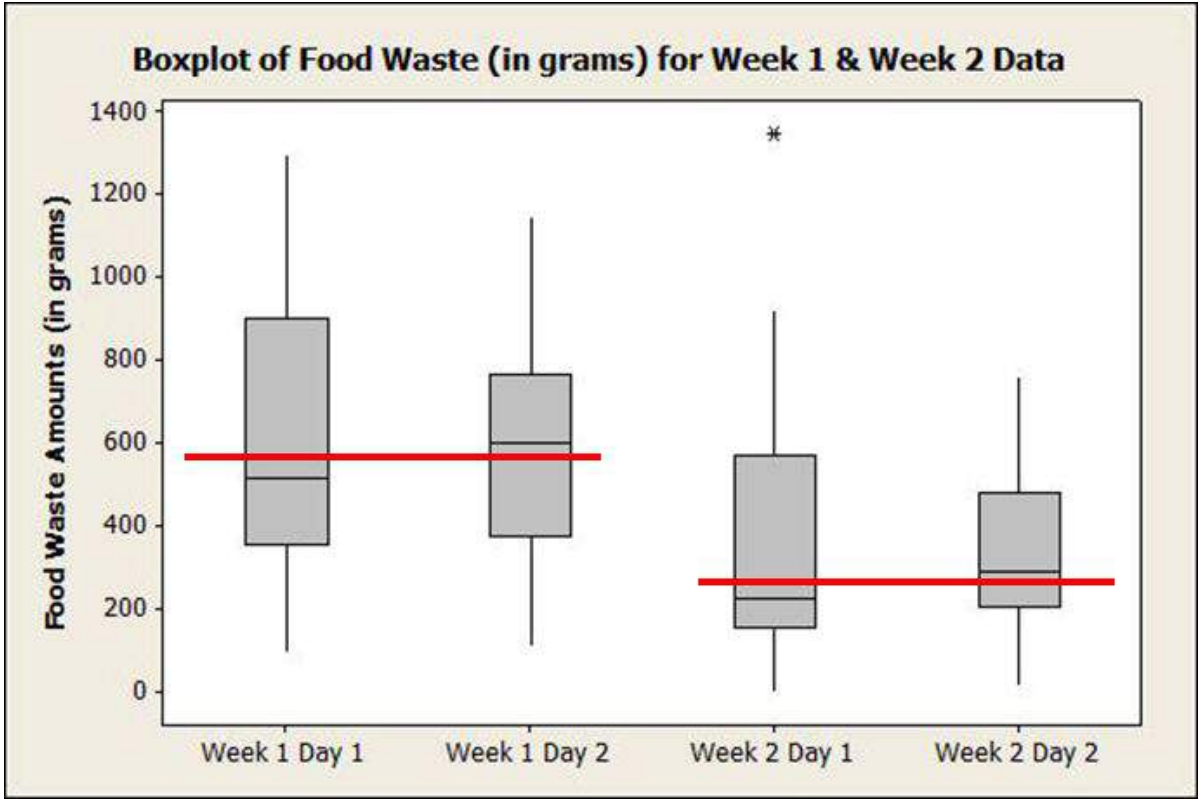



# Analysis of Variance (ANOVA): Is there a difference?



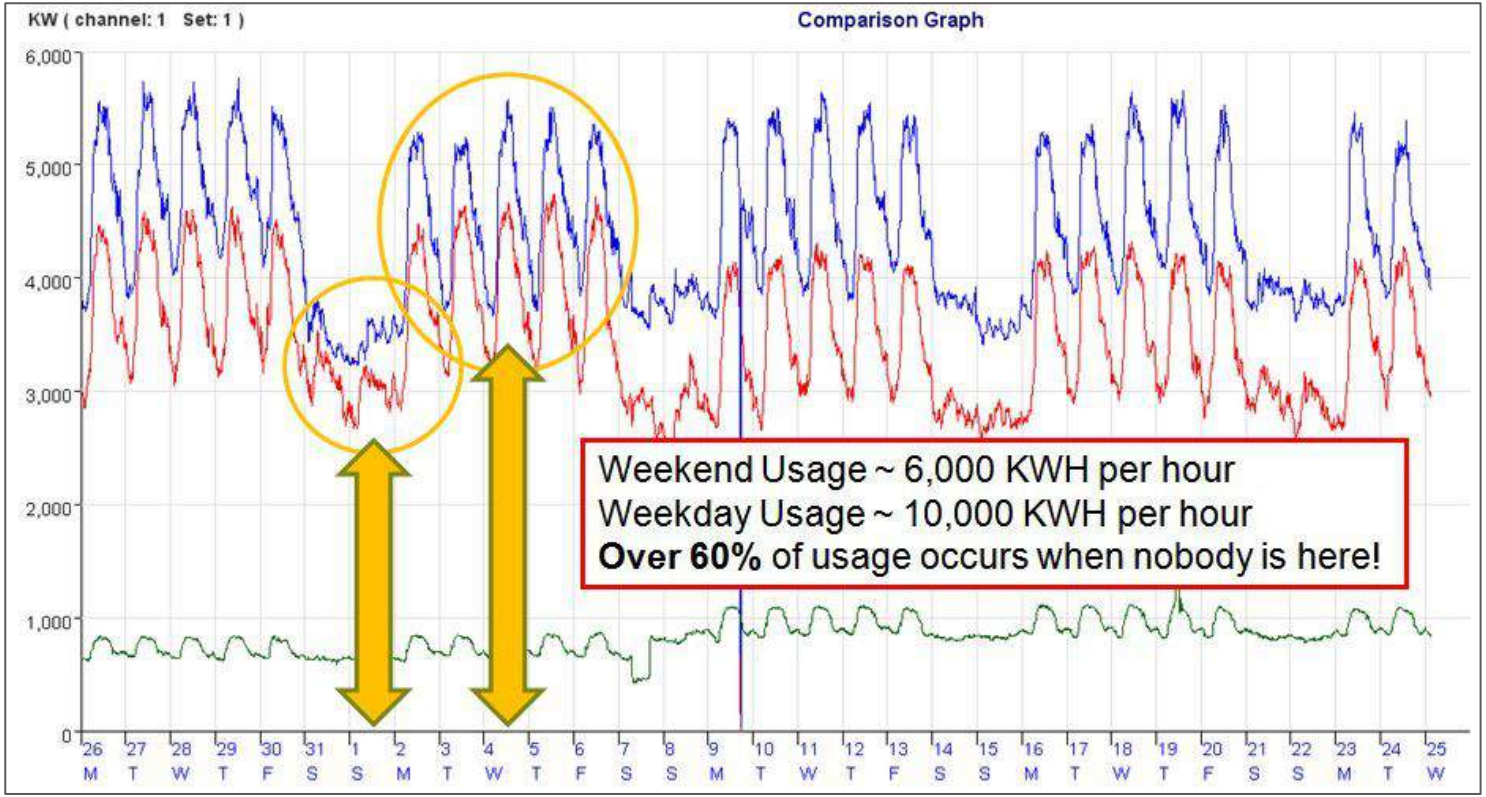
# Electricity Reduction Project

- Define: Company is spending $4M a year in electricity
- Measure
- Analyze
- Improve
- Control

# Electricity Reduction Project

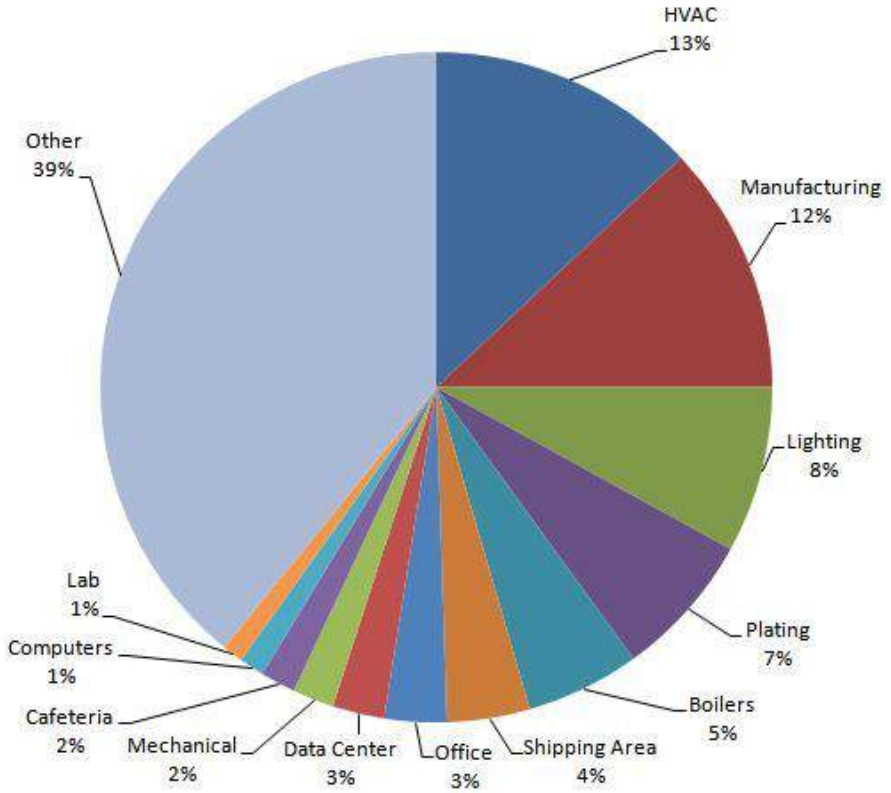
- Define: Company is spending $4M a year in electricity
- Measure: Utility bill data, but no detailed data by area
  - Gathered data by hand over holidays, input from maintenance staff
- Analyze:
- Improve
- Control

# High base load usage, where is that coming from?



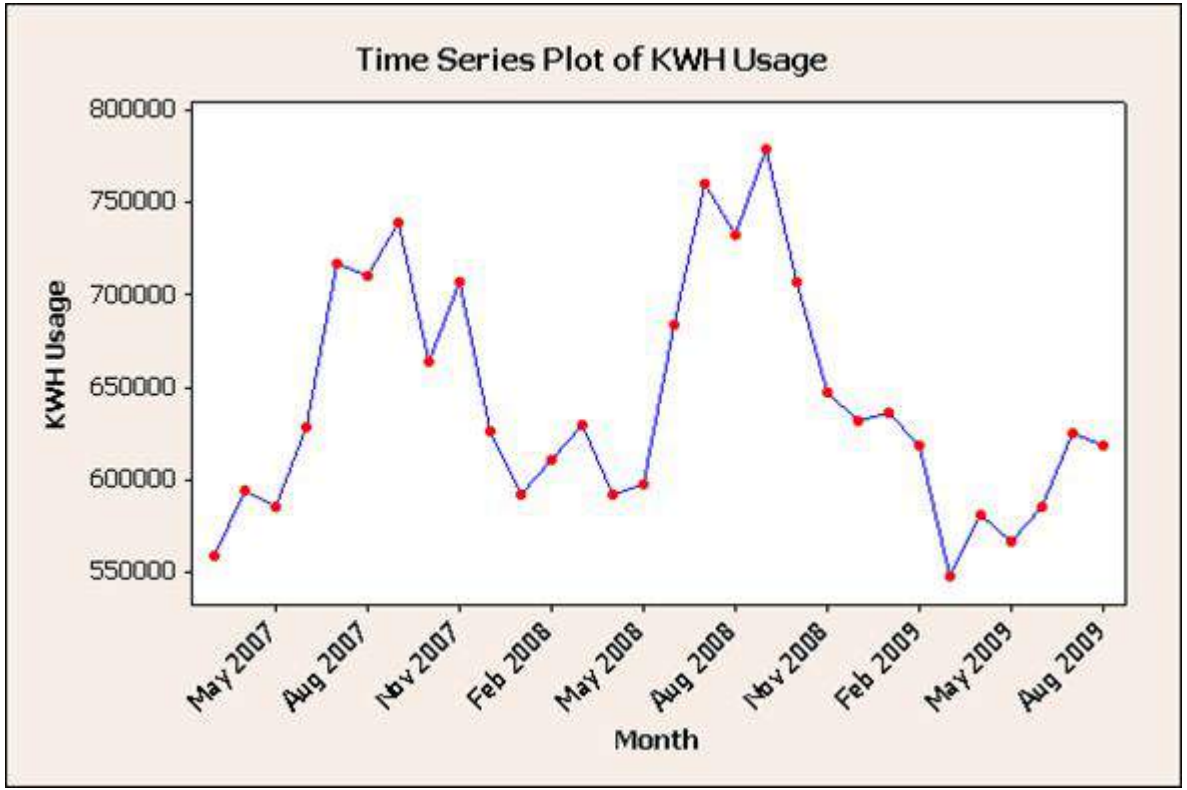
# Data Collection results

- HVAC is one of the highest drivers of electricity
- Matches feedback from maintenance workers
- Would be part of base load usage (runs 24/7)



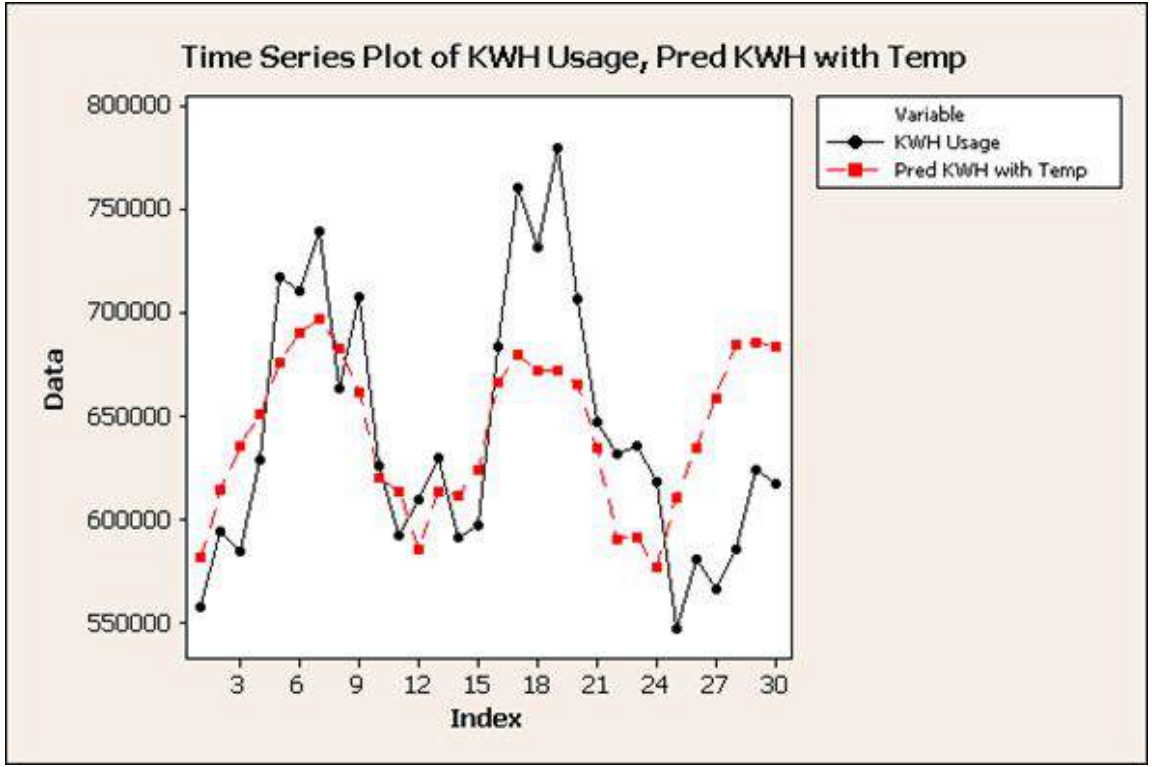
# Regression Analysis

- Summary of kWh by month



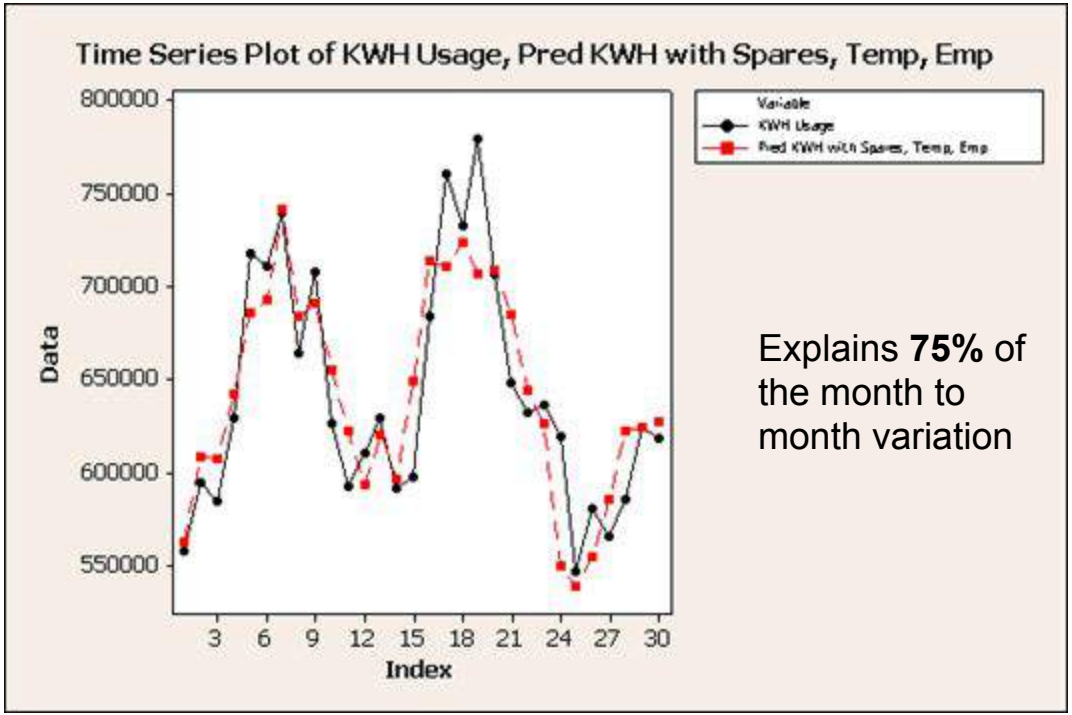
# Regression Analysis

- Avg High Temp explains 50% of variation
- Can we do better?



# Other Factors

- **Avg High Temp**
- **Spares Output**
- Employee Count
- Final Product Output
- Working Days
- **Employees**




Explains **75%** of the month to month variation

**KWH Usage = - 740670 + 6500 Avg High Temp - 33.6 Spares Output Qty + 647 Employees**

# Electricity Reduction Project

- Define: Company is spending $4M a year in electricity
- Measure: Utility bill data, but no detailed data by area
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- Analyze: Perform statistical analysis to identify opportunities
  - Focused on HVAC, determined building being heated and cooled 24/7
- Improve
- Control

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  - Showed significant savings, developed plan to roll out to entire building
- Control

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- Improve: Pilot project in one building with shut off
  - Showed significant savings, developed plan to roll out to entire building
- Control: Override buttons added and tracked
  - Savings resulted in $300K per year, 3 million kWh

# Design of Experiments (DOE)

A/B Split Testing

- Works for testing two scenarios
- Ex: Facebook Ad Color: Red vs Blue

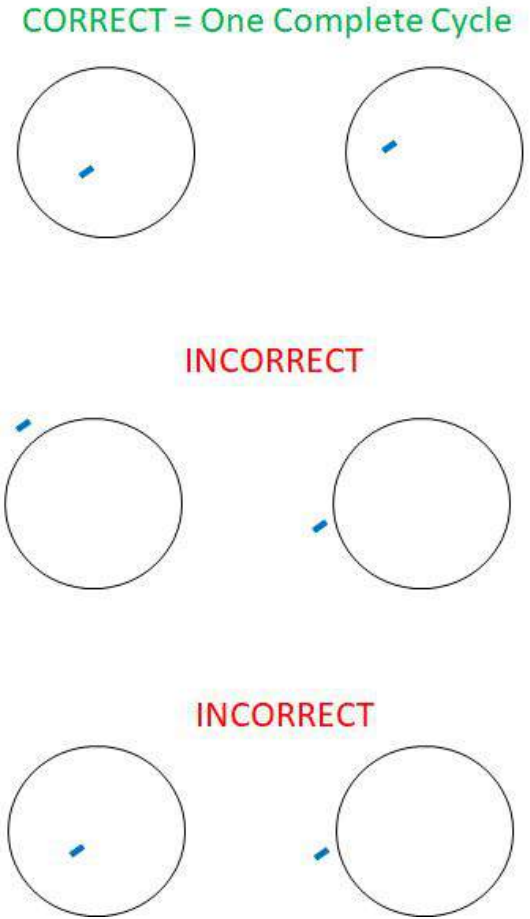
?


What if more complicated?

- Color: Red vs Blue
- Image: Nature vs Business
- Message: Shocking vs Inspirational
- Title: Price included or Not Included

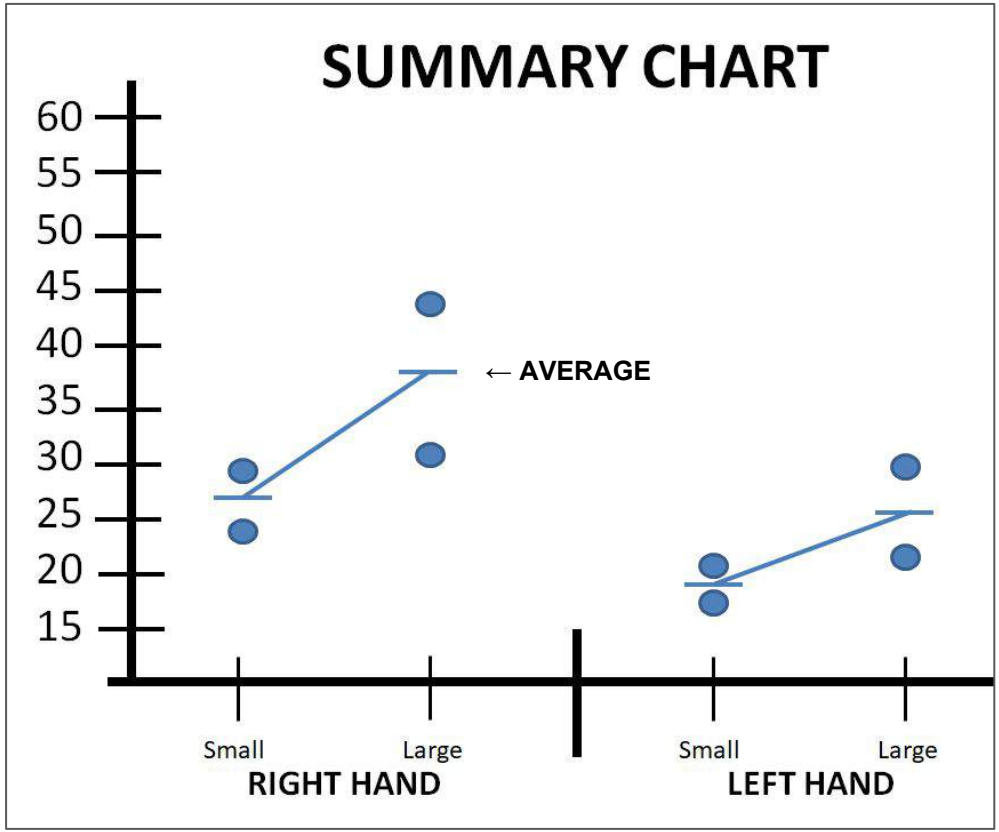
# Circle and Hand DOE Exercise

- For each trial, use right or left hand to go back and forth as fast as you can between the two circles, and place a mark inside each circle with marker
- One complete cycle requires both marks to be within the circle
- You will have 15 seconds per trial
- Count the number of complete cycles and record on the data sheet



# Fill in Summary Chart

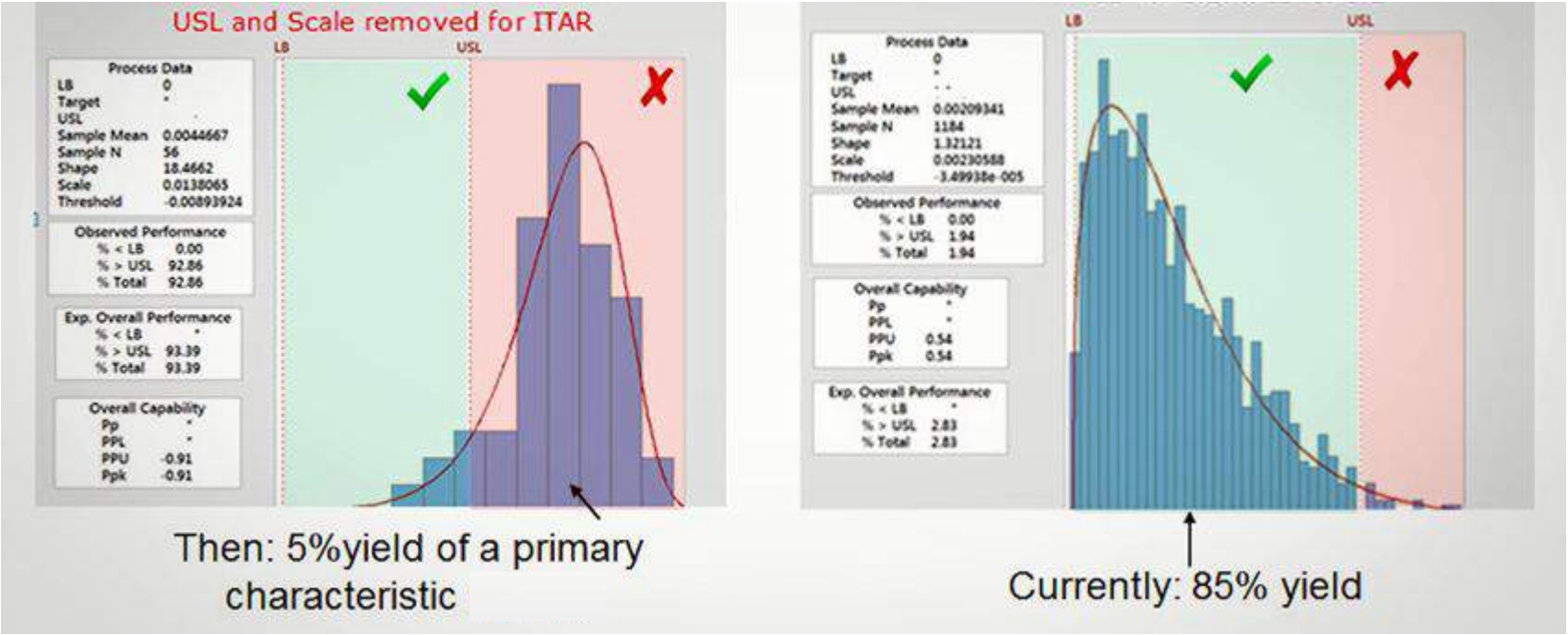
- Were you consistent?
- Which is more impactful, hand or circle size?



# Belt System

- Based on martial arts belt system
  - **White Belt** - This class
  - **Yellow Belt** - Basic tools + White Belt
  - **Green Belt** - Advanced tools (1-2 weeks)
  - **Black Belt** - More advanced tools (4-5 weeks)
  - **Master Black Belt** - Even more advanced tools + deployment planning (6-10 weeks)
- Level increase also requires project experience
- Pros and cons of certification

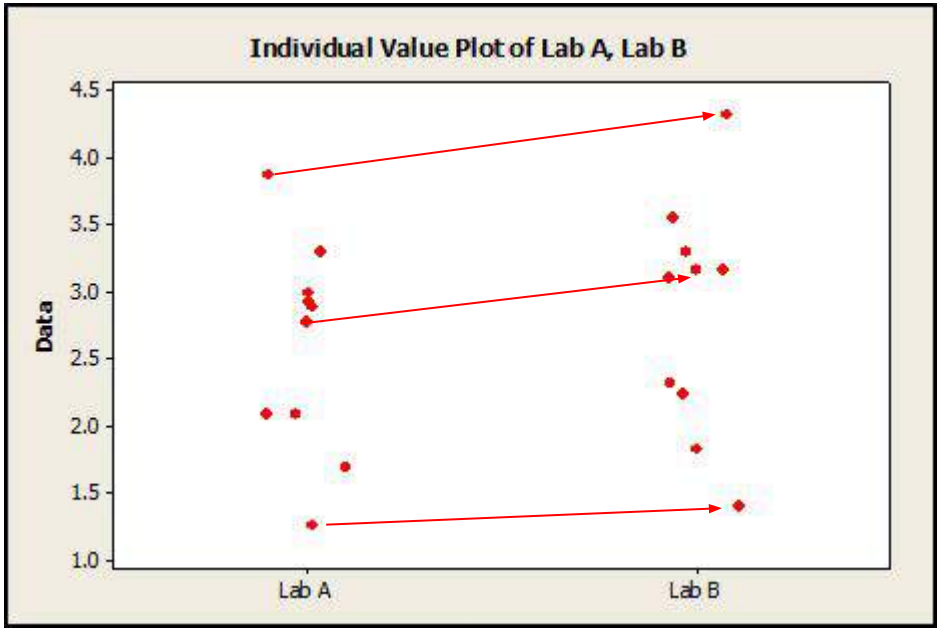
# Supplier Customer Analysis Project



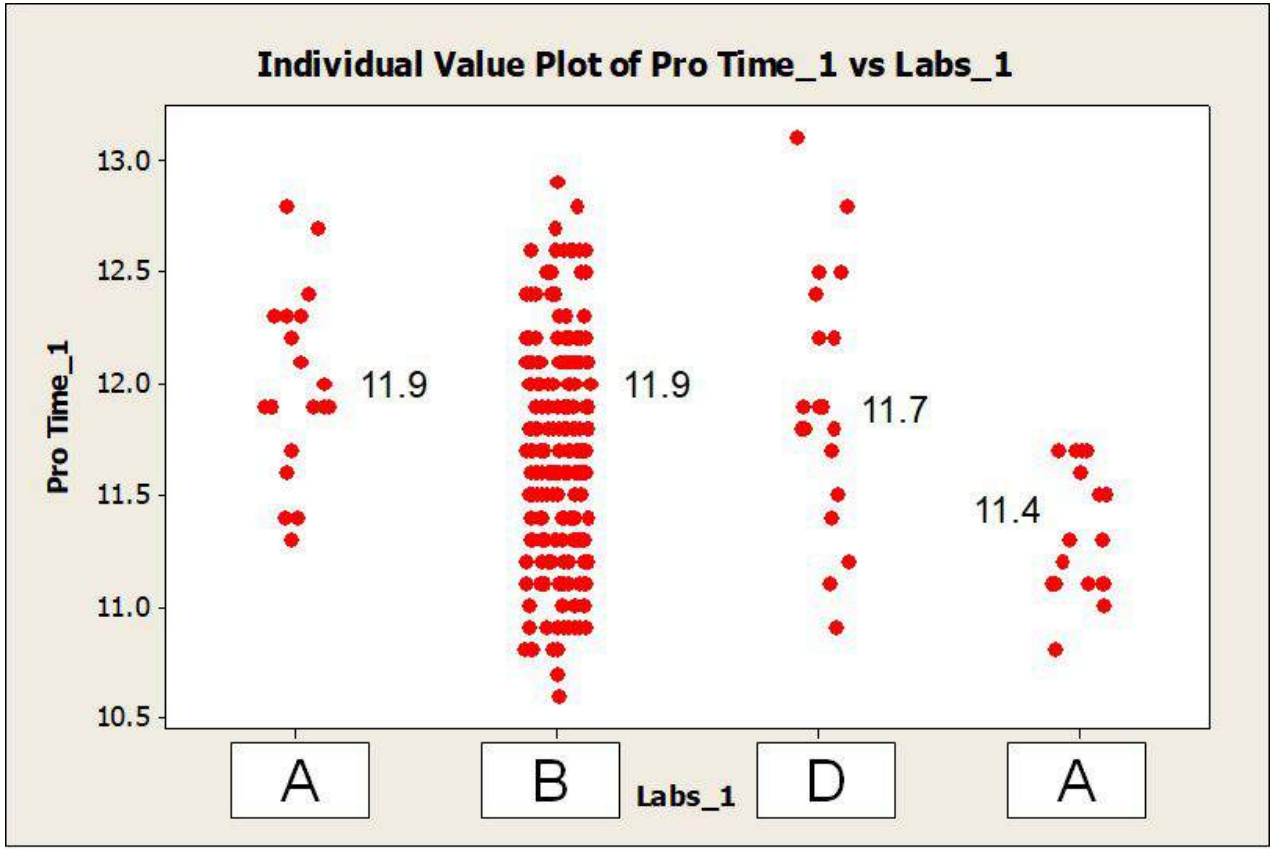

**Saved $500K per year!**

# Healthcare Example

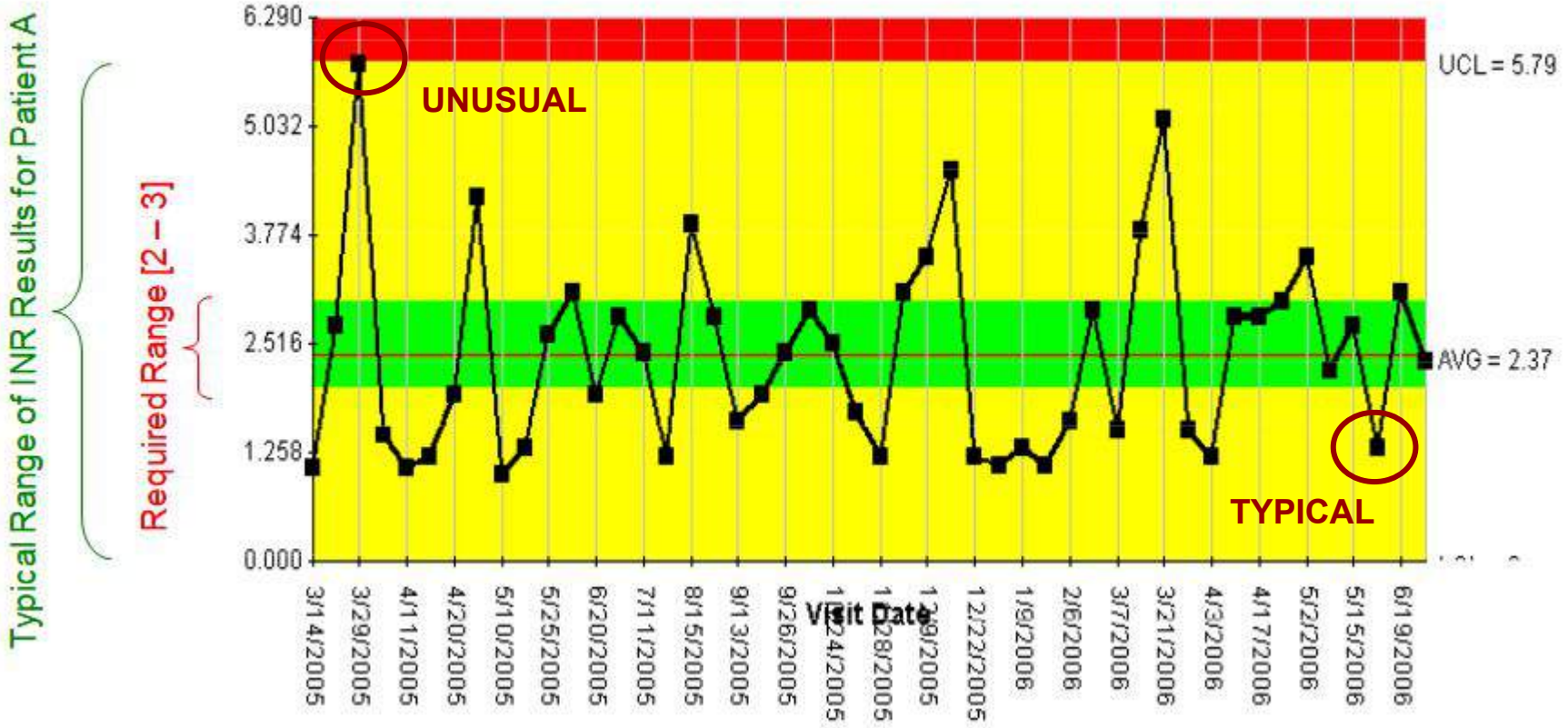
| Patient | Pro Times | | INR | |
|---|---|---|---|---|
| | Lab A | Lab B | Lab A | Lab B |
| 1 | 20.27 | 20.47 | 2.78 | 3.17 |
| 2 | 17.50 | 17.47 | 2.10 | 2.32 |
| 3 | 20.67 | 20.27 | 2.89 | 3.11 |
| 4 | 15.67 | 15.50 | 1.69 | 1.83 |
| 5 | 20.80 | 20.43 | 2.92 | 3.16 |
| 6 | 13.47 | 13.57 | 1.27 | 1.41 |
| 7 | 24.10 | 23.97 | 3.88 | 4.32 |
| 8 | 17.47 | 17.17 | 2.09 | 2.24 |
| 9 | 21.07 | 20.90 | 2.99 | 3.30 |
| 10 | 22.17 | 21.70 | 3.30 | 3.55 |
| Avg | 19.32 | 19.14 | 2.59 | 2.84 |



# Healthcare Example



# INR Results for Patient A



# Lean vs Six Sigma

- Start with Lean, easier to get everyone involved in improvements
  - Some people are scared off by numbers/analysis
  - Everyone can identify and eliminate waste (non-value added) or increase value added work
- DMAIC structure works well for larger projects (Lean and Six Sigma)
- Six Sigma tools ideal for:
  - Complex or difficult problems
  - Processes with a lot of data and variation
  - After you've tried easier improvements and still not good enough
  - Risk mitigation and prevention
  - Need very high quality performance (3 sigma or greater)

# Other Ideas?

- **Gage R&R**
  - Does your data match your customers? Is data being collected consistently? Do workers make the same decisions and categorize issues the same?
- **SPC**
  - Trend expenses, sales, website traffic, email/call volume, defect rates, on-time delivery performance, supplier data, website speed, employee turnover or absenteeism rate
- **Capability**
  - Forecast accuracy goals, customer response time, how likely will we meet our goal? Do we have enough staff to meet demand?
- **ANOVA/Regression**
  - Quote prediction, hiring success factors, employee time differences, electricity usage, compare two processes or machines to each other, seasonal modeling, staffing to customer demand, event attendance/food estimation
- **DOE**
  - Online ad and email click-thrus, worker performance, process optimization, complex processes

# How can you apply Six Sigma?

# Resources

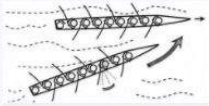
- Six Sigma Training and Certification: 6sigma.US (Nationwide locations)
  - All belt levels available, plus Lean, and Design for Six Sigma

- Six Sigma Certification: ASQ.org
  - Study guides for exam: Quality Council of Indiana

LEANPORTLAND

LinkedIn Meetup

# Eventbrite

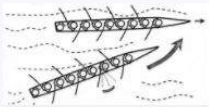


THU, DEC 14 3:30 PM
**FREE Culture of Collaboration Workshop**
Hatch Innovation, Portland
FREE #Business #Seminar

THU, DEC 21 2:30 PM
**FREE Six Sigma Primer Workshop**
Hatch Innovation, Portland
FREE #Business #Seminar

TUE, JAN 2 5:30 PM
**Jan 1st Tuesday Lean Portland Happy Hour**
Lucky Labrador Beer Hall, Portland
FREE #Business #Networking

THU, JAN 11 3:30 PM
**FREE Behavior Change for Lean Workshop**
Hatch Innovation, Portland
FREE #Business #Seminar



WED, JAN 24 3:30 PM
**FREE Culture of Collaboration Workshop**
Hatch Innovation, Portland
FREE #Business #Seminar

THU, JAN 25 3:30 PM
**FREE Lean Primer Workshop**
Hatch Innovation, Portland
FREE #Business #Seminar



BPI LEANPORTLAND

# Q&A

# Plus / Delta

**Brion Hurley**
Lean Six Sigma Master Black Belt
**Business Performance Improvement LLC**

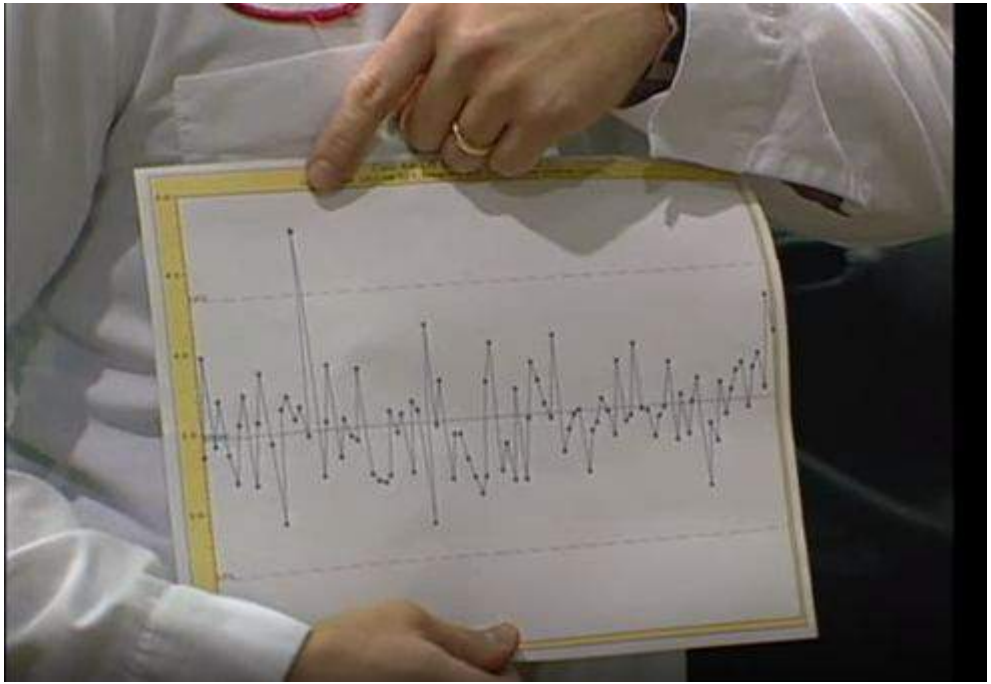
Community Consulting Lead
**Lean Portland**

brion@biz-pi.com
www.biz-pi.com
321.271.5361

# Thank you!

# Backup

# SPC at Honda



https://www.youtube.com/watch?v=Sdj-8ZBYYmo