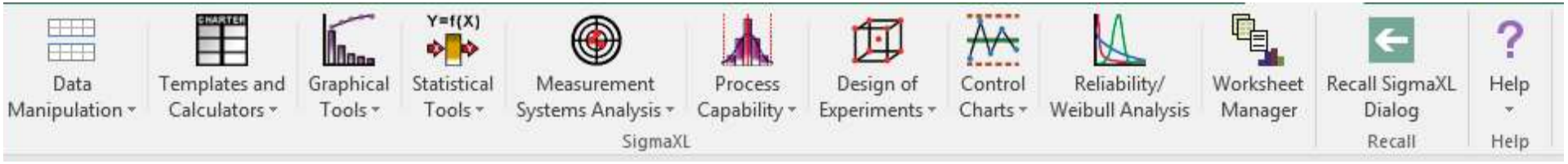
Introducing SigmaXL® Version 8

- Powerful.
- User-Friendly.
- Cost-Effective. Priced at $299, SigmaXL is a fraction of the cost of any major statistical product, yet it has all the functionality most professionals need.
- Quantity, Educational, and Training discounts are available.
- Visit www.SigmaXL.com or call 1-888-SigmaXL (1-888-744-6295) for more information.



Coming Soon in SigmaXL Version 8.1

Taguchi Templates:

- Two Level L4, L8, L12, L16 and L18
- Three Level L9
- Two and Three Level L18
- Easy to use Templates

Coming Soon in SigmaXL Version 8.1

Taguchi Templates:

- Charts are created automatically:
  - Pareto of Effects/Deltas for Means, StDevs and Signal-to-Noise Ratios
  - Pareto of ANOVA SS % Contribution for Means, StDevs and Signal-to-Noise Ratios
  - Overlay Plot of Main Effects for Means, StDevs and Signal-to-Noise Ratios
  - Interaction Plots for Means, StDevs and Signal-to-Noise Ratios (if applicable)

Coming Soon in SigmaXL Version 8.1

Taguchi Template Example – Three Factor L8 Robust Cake

Three-Factor, Taguchi L8 Orthogonal Array

Title:	Robust Cake Experiment adapted from Video "Designing Industrial Experiments", Box, Bisgaard, Fung
Date:	
Name of Experimenter:	
Response:	Taste Score (Scale 1-7 where 1 is "awful" and 7 is "delicious"); Outer Array Reps have different Cooking Time and Temp Conditions

Signal-to-Noise Ratio:	SN: Larger is Better
Target:	1

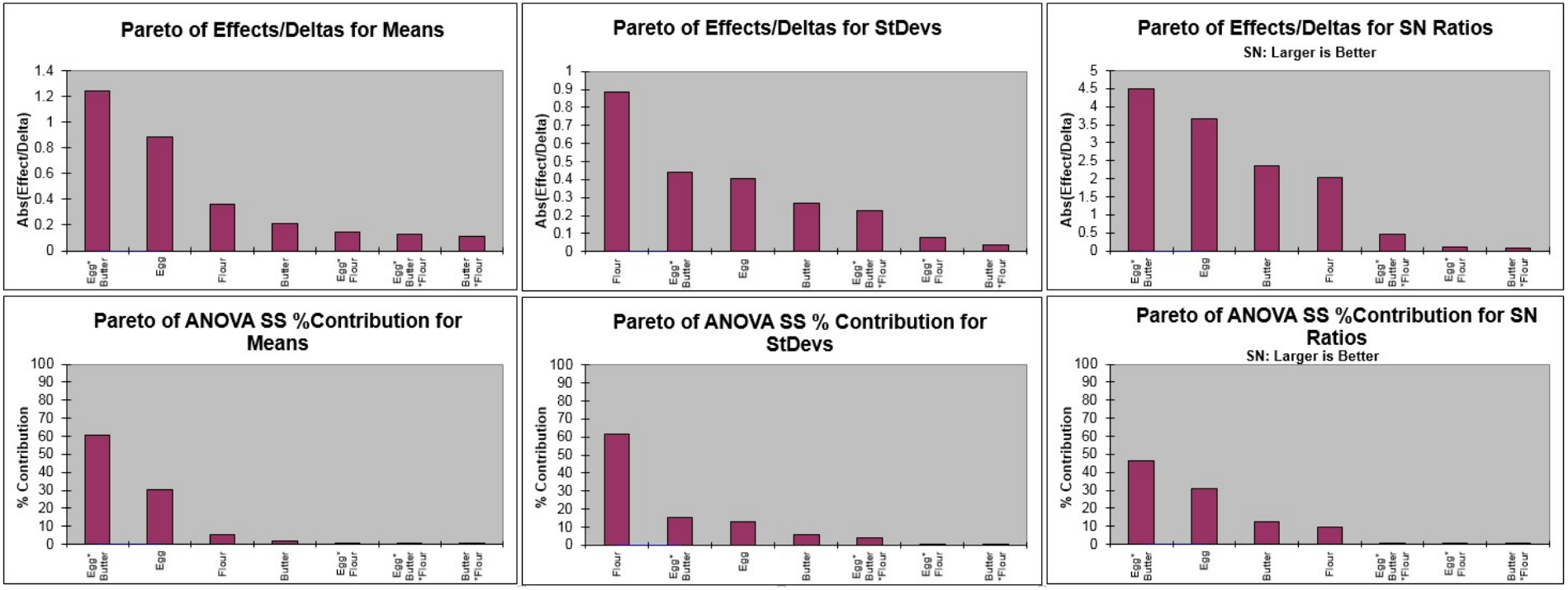
Factor	Factor Name	Low	High
A	Egg	1	2
B	Butter	1	2
C	Flour	1	2

Predicted Output for Y:

Factor Name	Enter Actual Factor Setting - uncoded	Factor setting coded	$\hat{Y}$	$\hat{S}$	SN: Larger is Better
Egg	2	2	5.9	0.681909085	15.27864445
Butter	1	1			
Flour	2	2			

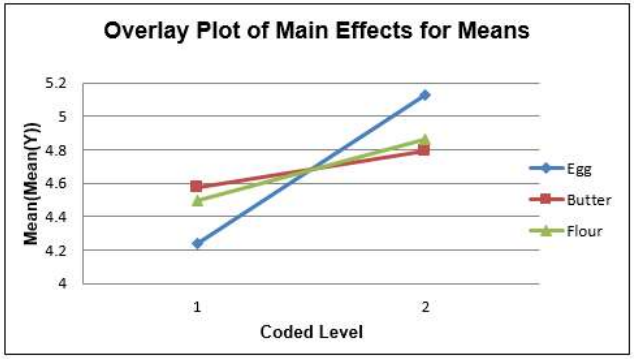
Coming Soon in SigmaXL Version 8.1

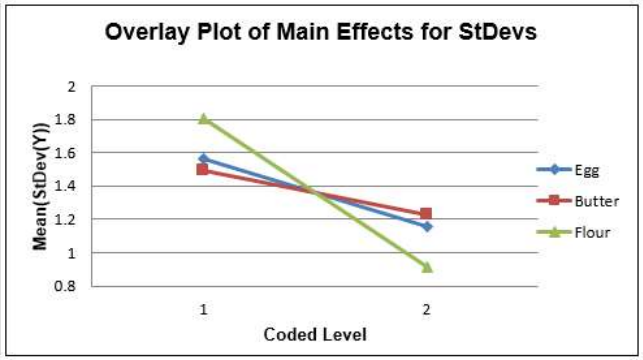
Taguchi Template Example – Three Factor L8 Robust Cake

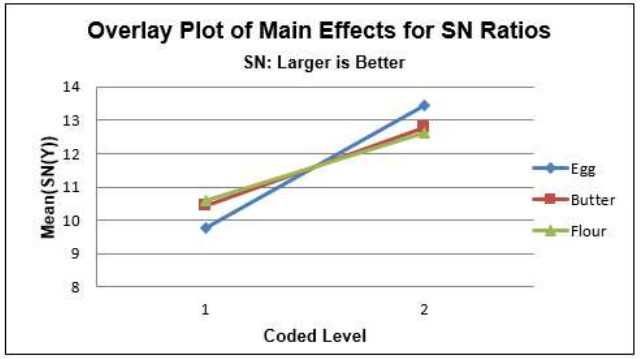


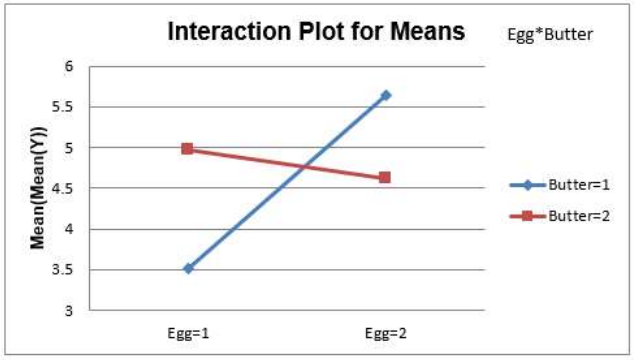
Coming Soon in SigmaXL Version 8.1

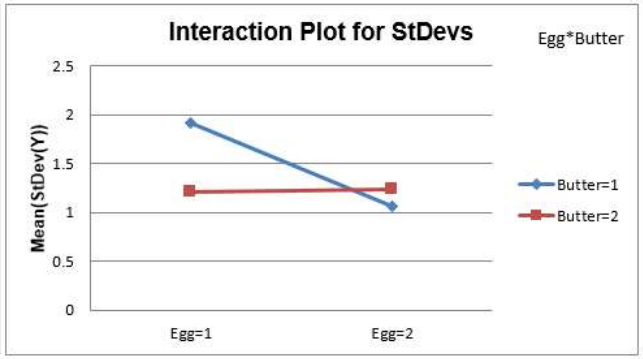
Taguchi Template Example – Three Factor L8 Robust Cake

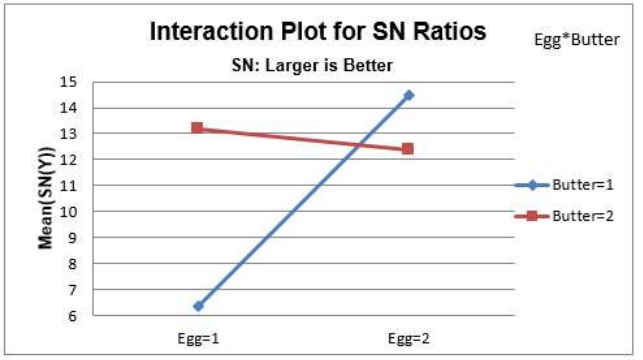










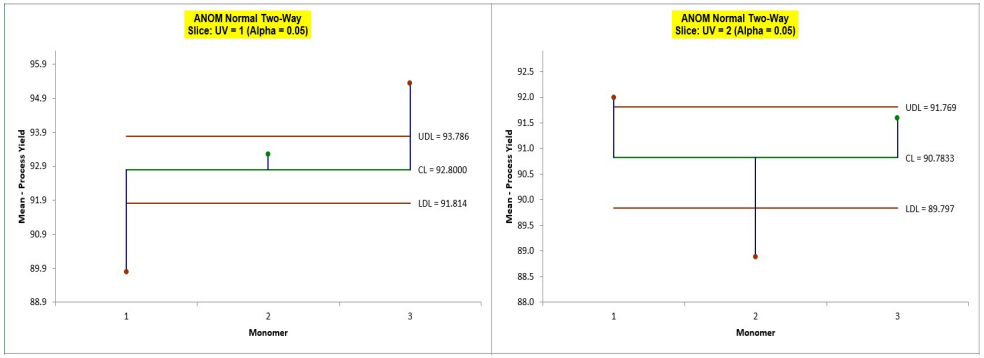


What's New in SigmaXL Version 8

SigmaXL has added some exciting, new and unique features that make multiple comparisons easy:

Analysis of Means (ANOM) Charts

- Normal, Binomial Proportions and Poisson Rates
  - One-Way
  - Two-Way
    - Main Effects
    - Slice Charts
    - Yellow highlight recommendation



- Nonparametric Transformed Ranks
- Variances & Levene Robust Variances
- Supports balanced and unbalanced data

What's New in SigmaXL Version 8

Multiple Comparisons (a.k.a. Post-Hoc)

- One-Way ANOVA
- Welch ANOVA (Assume Unequal Variance)
- Bartlett & Levene Equal Variance
- Easy to read probabilities in matrix format with significant values highlighted in red

Pairwise Mean Difference (row - column)	1	2	3
1	0	-0.8117	-0.2476
2		0	0.5641
3			0

Tukey Probabilities	1	2	3
1		0.0000	0.3777
2			0.0044
3			

- Appropriate ANOM chart available as a graphical option

What's New in SigmaXL Version 8

Chi-Square Tests & Table Associations

- Adjusted Residuals (significant values highlighted in red)
- Cell's Contribution to Chi-Square
- Additional Chi-Square Tests
- Tests and Measures of Association for Nominal & Ordinal Categories

What's New in SigmaXL Version 8

Descriptive Statistics

- Percentile Report and Percentile Ranges
- Percentile Confidence and Tolerance Intervals
- Additional Descriptive Statistics
- Additional Normality Tests
- Outlier and Randomness Tests

What's New in SigmaXL Version 8

Templates and Calculators

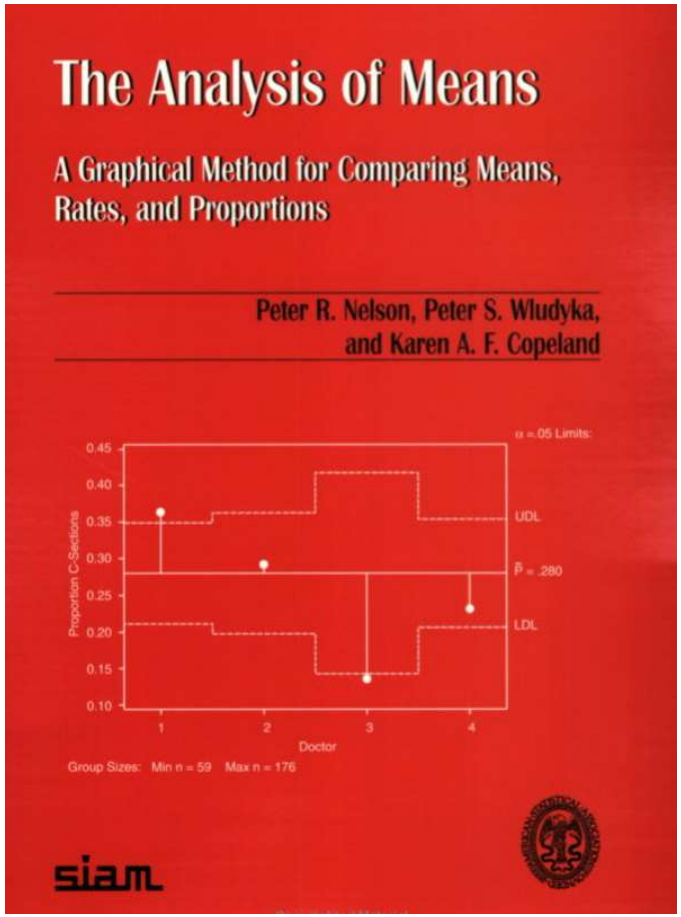
- 1 Sample Z test and Confidence Interval for Mean
- Normal Exact Tolerance Intervals
- Equivalence Tests: 1 & 2 Sample Means, 2 Proportions, 2 Poisson Rates
- Type 1 Gage Study, Gage Bias & Linearity Study

Analysis of Means (ANOM) Charts

- A statistical procedure for troubleshooting industrial processes and analyzing the results of experimental designs with factors at fixed levels.
- It provides a graphical display of data. Ellis R. Ott developed the procedure in 1967 because he observed that nonstatisticians had difficulty understanding analysis of variance.
- Analysis of means is easier for quality practitioners to use because it is (like) an extension of the control chart.

Source: http://asq.org/glossary/a.html

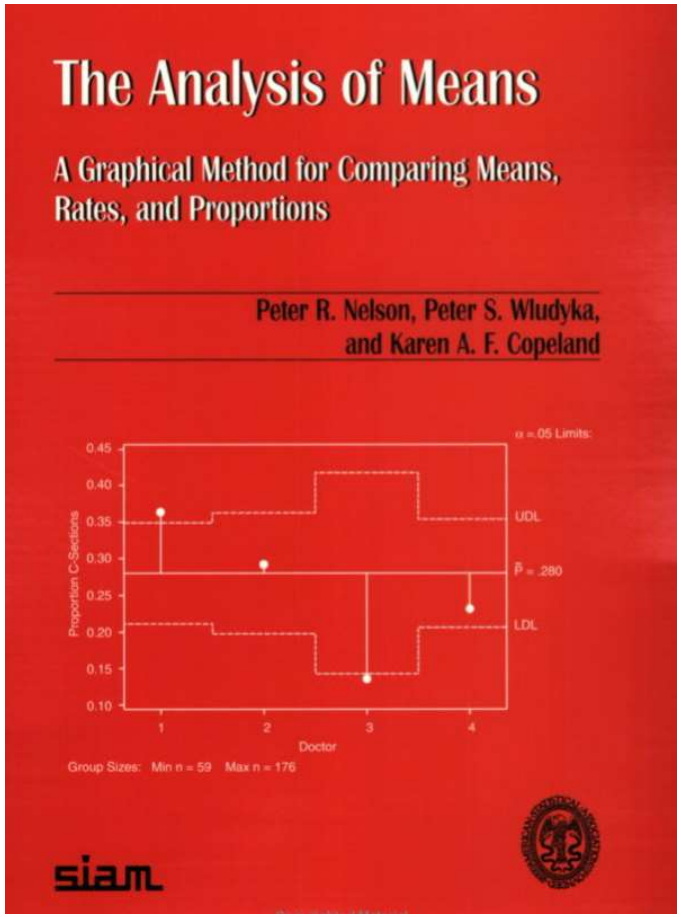
Analysis of Means (ANOM) Charts



From the Preface:

- The goal of statistical data analysis is to use data to gain and communicate knowledge about processes and phenomena. Comparing means is often part of an analysis, for data arising in both experimental and observational studies.
- The analysis of means (ANOM) is an alternative procedure (to ANOVA) for comparing means.
- ANOM has the advantages of being much more intuitive and providing an easily understood graphical result, which clearly indicates any means that are different (from the overall mean) and allows for easy assessment of practical as well as statistical significance.
- The graphical result is easy for nonstatisticians to understand and offers a clear advantage over ANOVA in that it sheds light on the nature of the differences among the populations.

Analysis of Means (ANOM) Charts



One-Way Balanced* Normal:

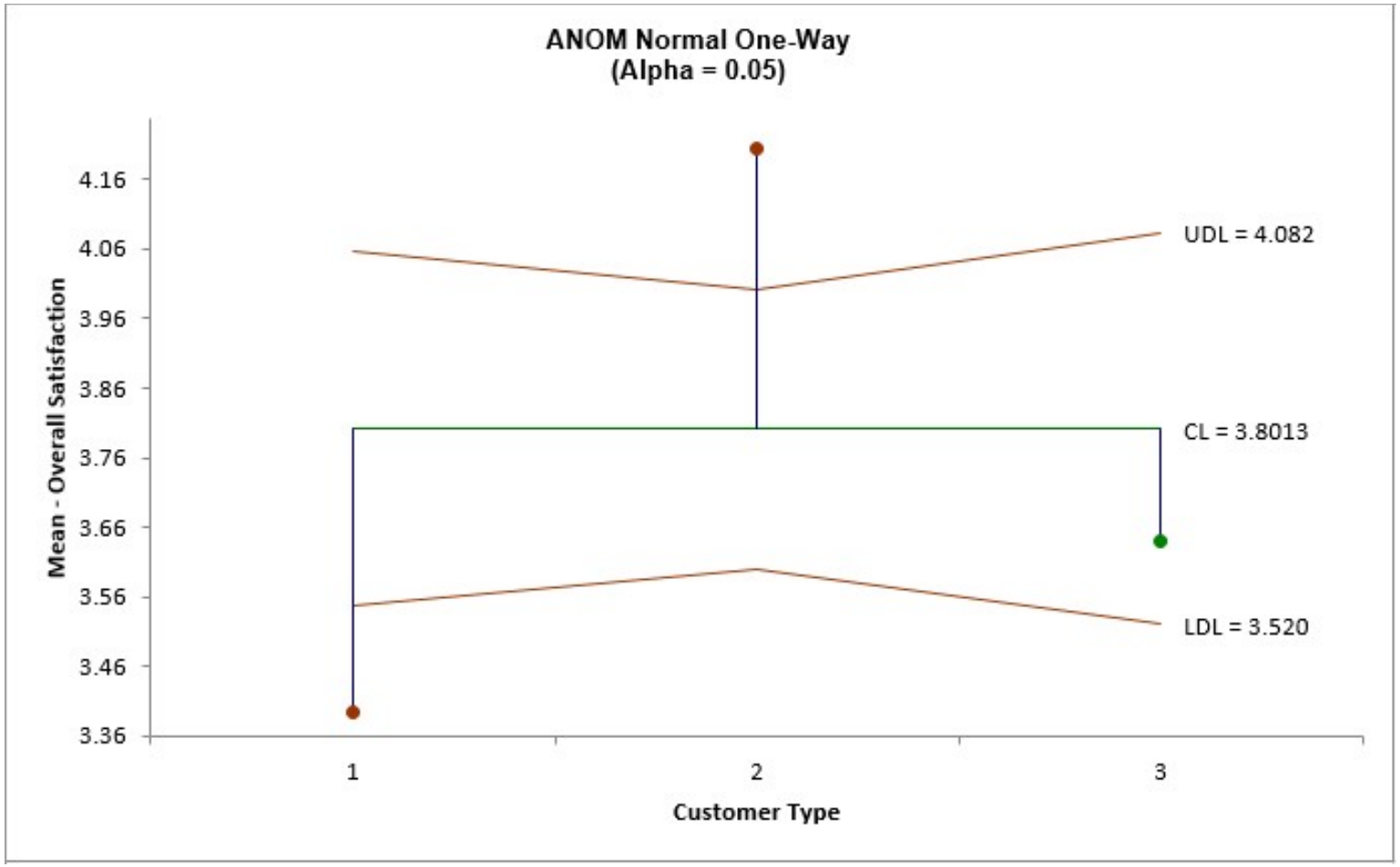
$$\text{UDL} = \bar{y}_{\bullet\bullet} + h(\alpha; I, N-I)\sqrt{\text{MS}_e}\sqrt{\frac{I-1}{N}}$$

$$\text{LDL} = \bar{y}_{\bullet\bullet} - h(\alpha; I, N-I)\sqrt{\text{MS}_e}\sqrt{\frac{I-1}{N}}$$

$\bar{y}_{\bullet\bullet}$ = Overall mean
h = Critical value from multivariate t distribution – SigmaXL uses table exact critical values (Table B.1)
N = Sample size
I = Number of levels
$\sqrt{\text{MS}_e}$ SQRT(Mean Square Error) = pooled standard deviation.

* Unbalanced uses critical values from studentized maximum modulus (SMM) distribution. SigmaXL uses table exact critical values (Table B.2). An adjustment is also made for varying sample size that results in varying decision limit values.

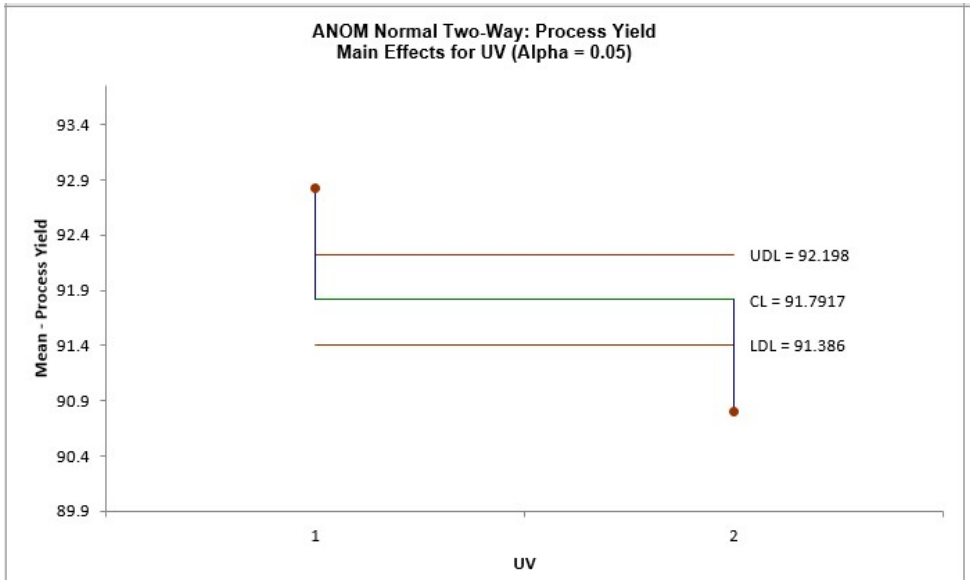
Example: ANOM Normal One-Way Overall Satisfaction by Customer Type

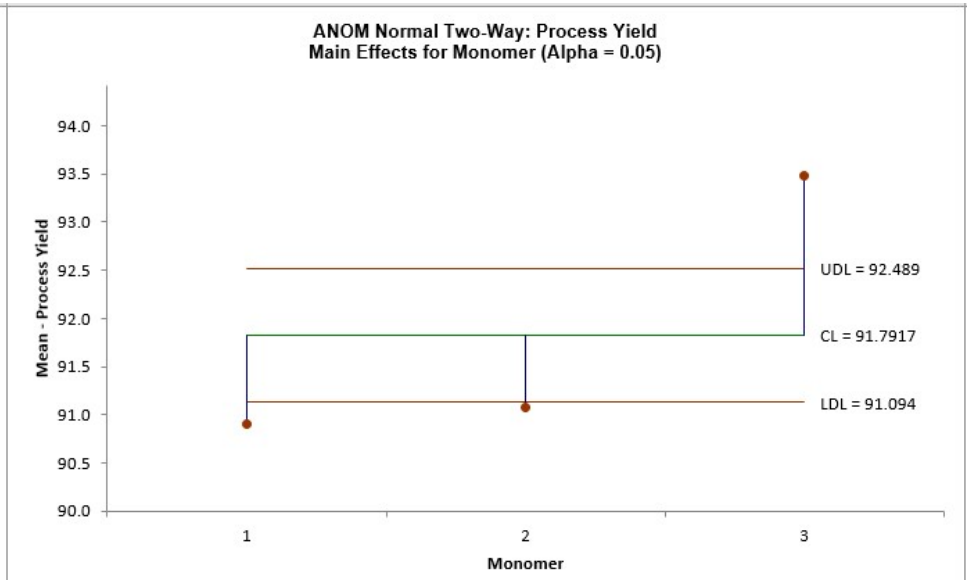


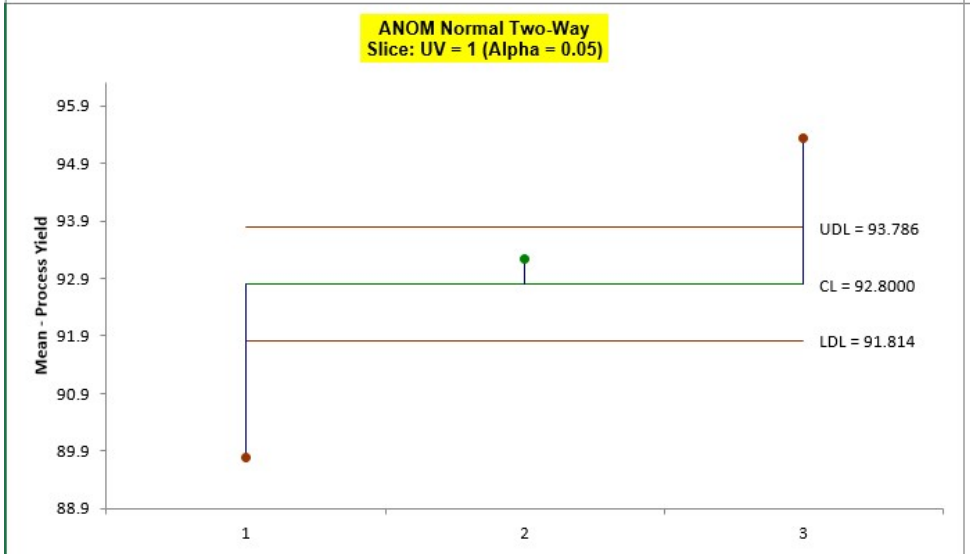
ANOM Normal Two-Way with Main Effects and Slice Charts

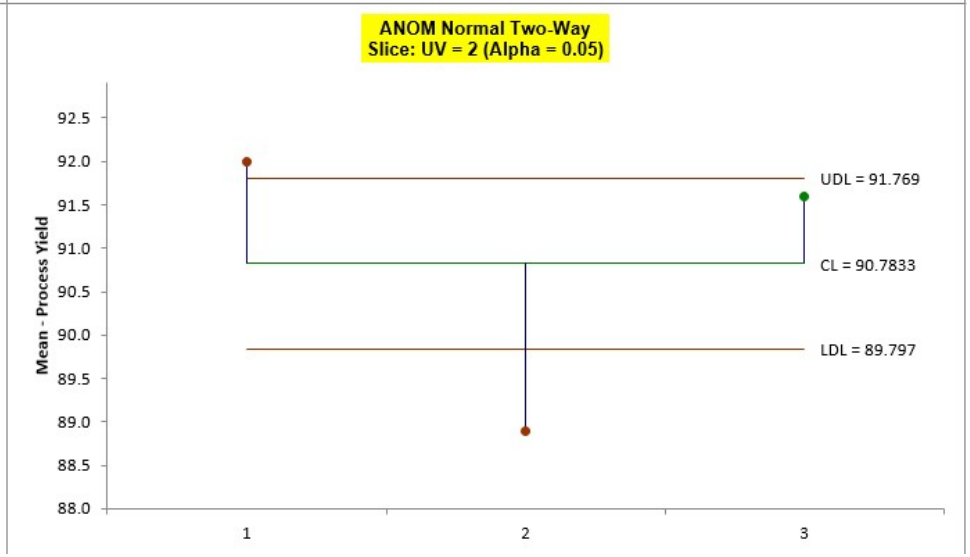
- Main Effects for Two-Way ANOM are similar to One-Way but the mean square error (MSE) is derived from the ANOVA.
- Slice Charts are a modified ANOM chart developed by Dr. Peter Wludyka that enables one to easily interpret the effects in the presence of an interaction (Wludyka 2013, 2015).
  - The basic idea is to compare the levels of one factor for each level of the other factor
  - MSE is still derived from the Two-Way ANOVA
- Yellow highlight automatically recommends Main Effects (if interaction is not significant) or Slice Chart (if interaction is significant). Interaction P-Value is determined from ANOVA
- Option to specify correction to alpha for multiple chart family-wise error rate
  - Bonferroni alpha' = alpha/m; m = number of charts

"The Analysis of Means" Example 5.3 Process Yield Experiment (used with author permission): Normal Two-Way Main Effects & Slice Charts

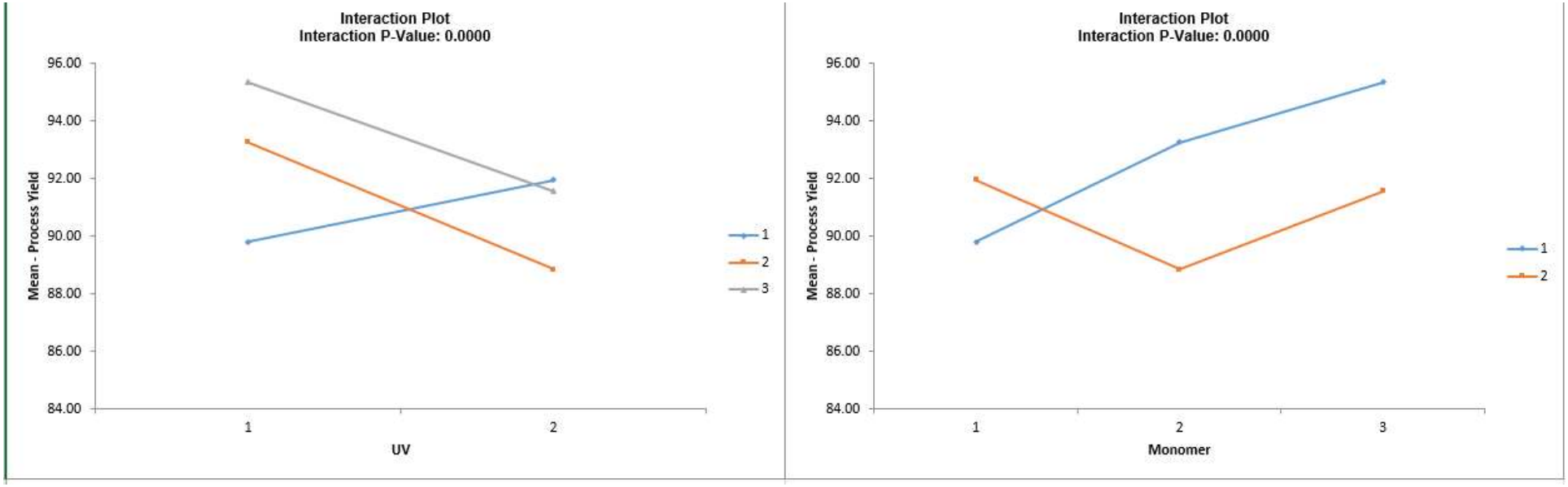








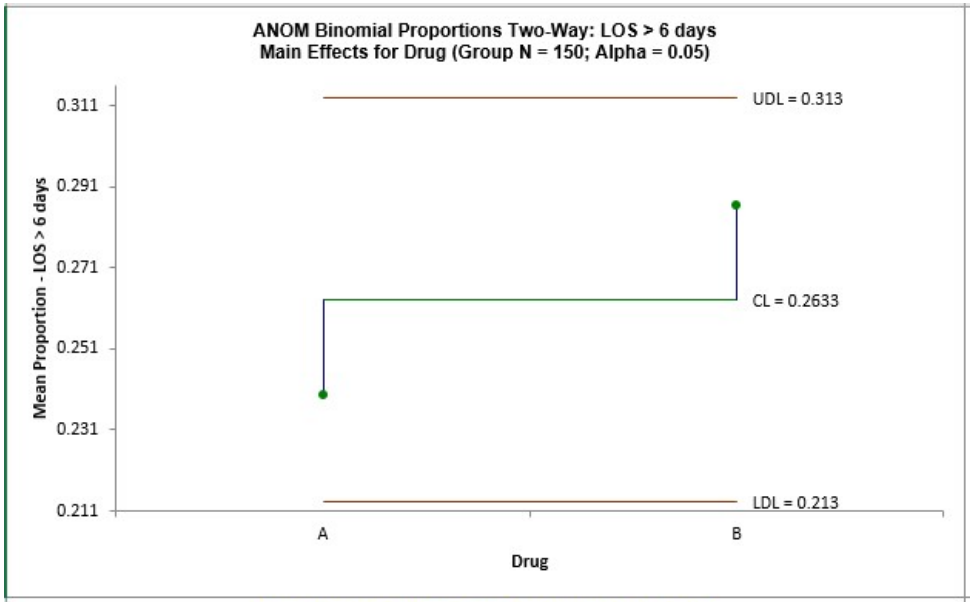
"The Analysis of Means" Example 5.3 Process Yield Experiment (used with author permission): Normal Two-Way Interaction Plots

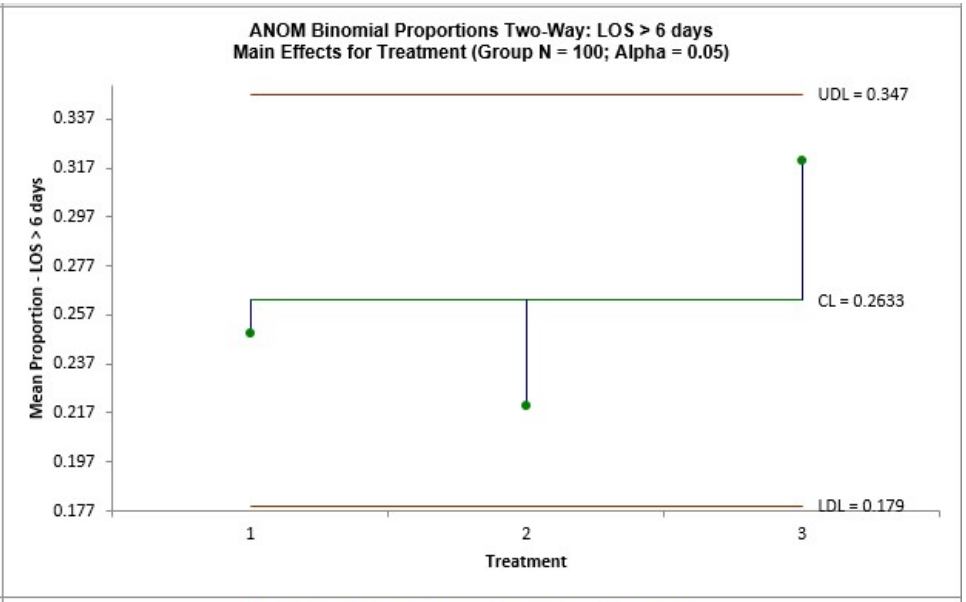


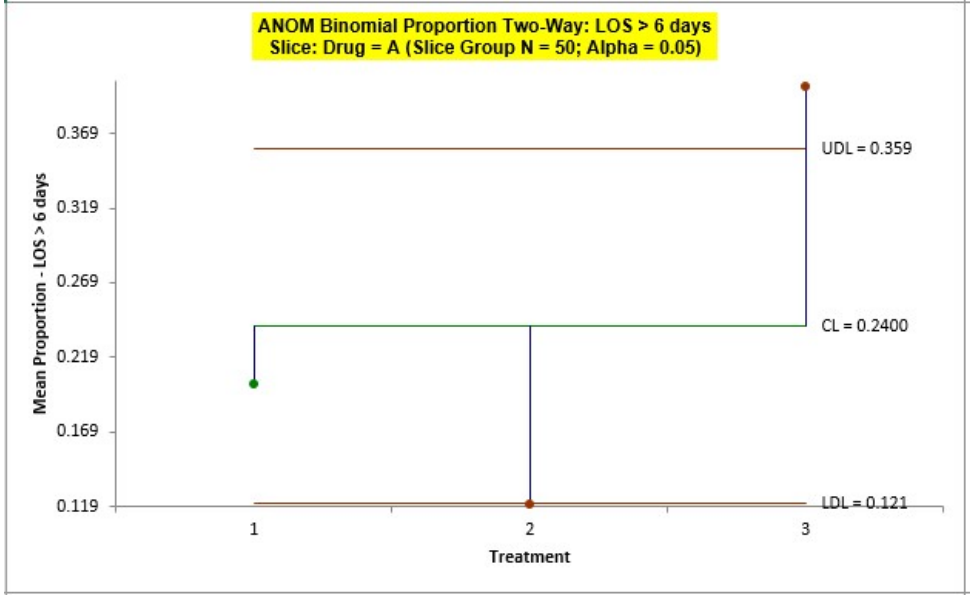
ANOM Binomial Proportions and Poisson Rates Two-Way with Main Effects and Slice Charts

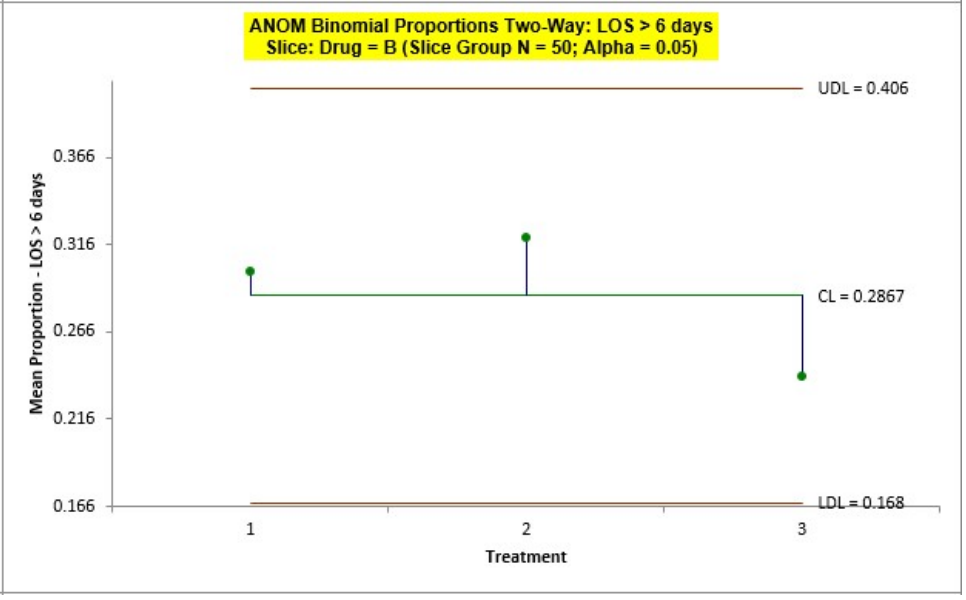
- In collaboration, Peter Wludyka and John Noguera of SigmaXL extended the Slice Charts to Binomial and Poisson (Wludyka and Noguera 2016).
  - As with Normal, the basic idea is to compare the levels of one factor for each level of the other factor
  - MSE is derived from the whole model
- Yellow highlight automatically recommends Main Effects (if interaction is not significant) or Slice Chart (if interaction is significant).
- Interaction P-Value is automatically determined from Logistic regression for Binomial Proportions and Poisson regression for Poisson Rates.
- Assumes a normal approximation to Binomial or Poisson, so a warning is given if np, nq, or nu <= 5.

"The Analysis of Means" Example 5.15 Length of Stay Data (used with author permission): Binomial Proportions Two-Way Main Effects & Slice Charts

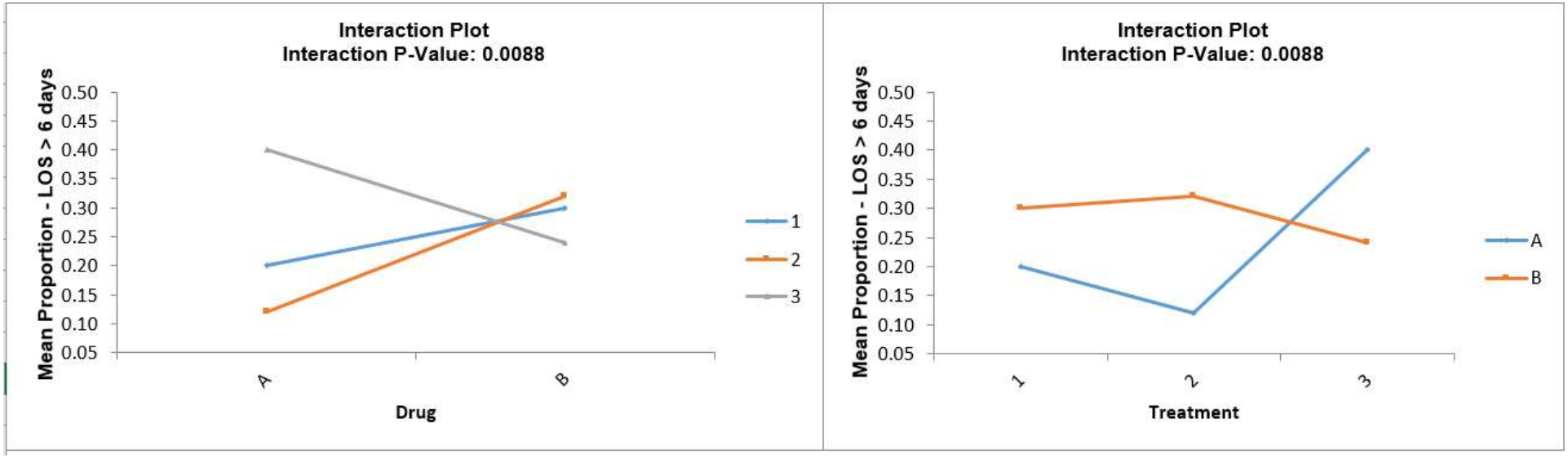




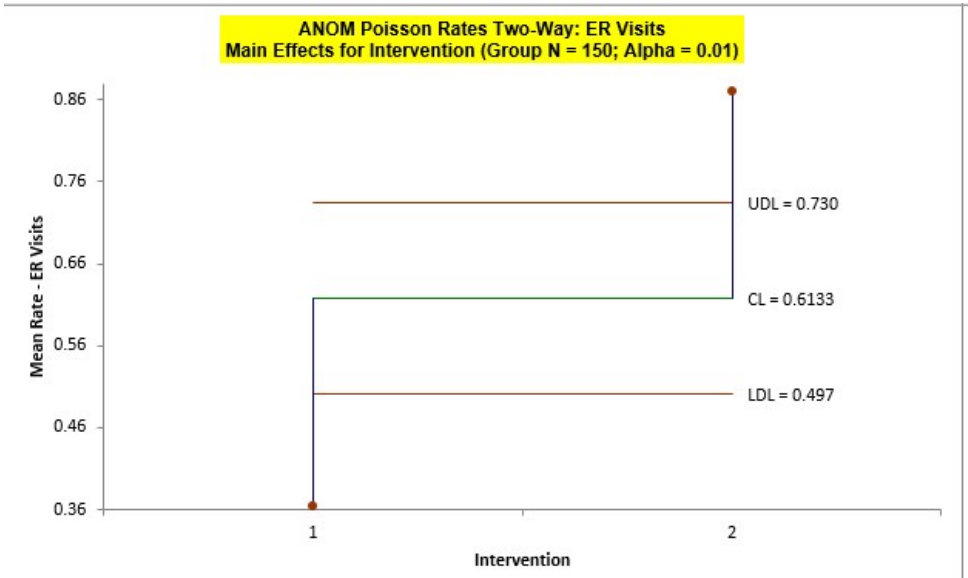


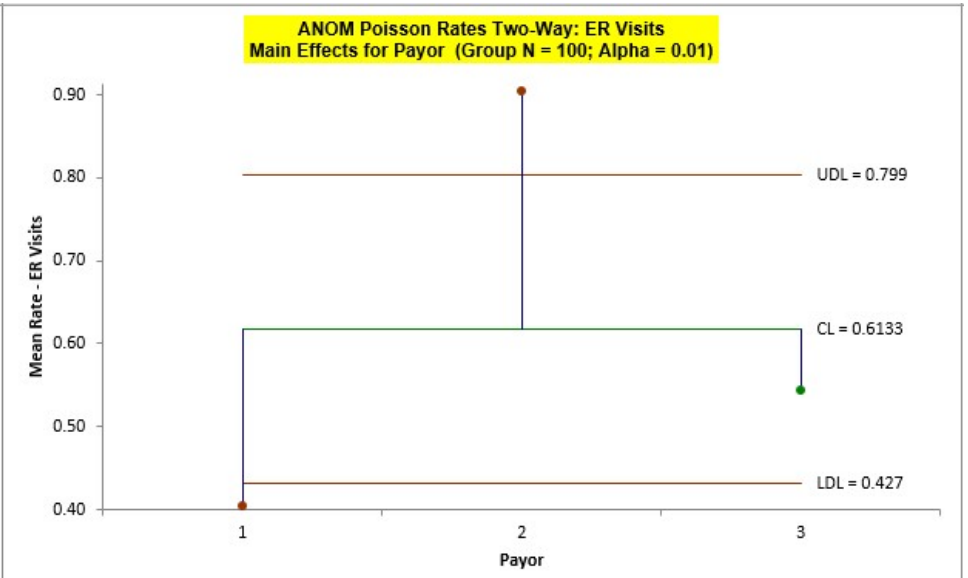


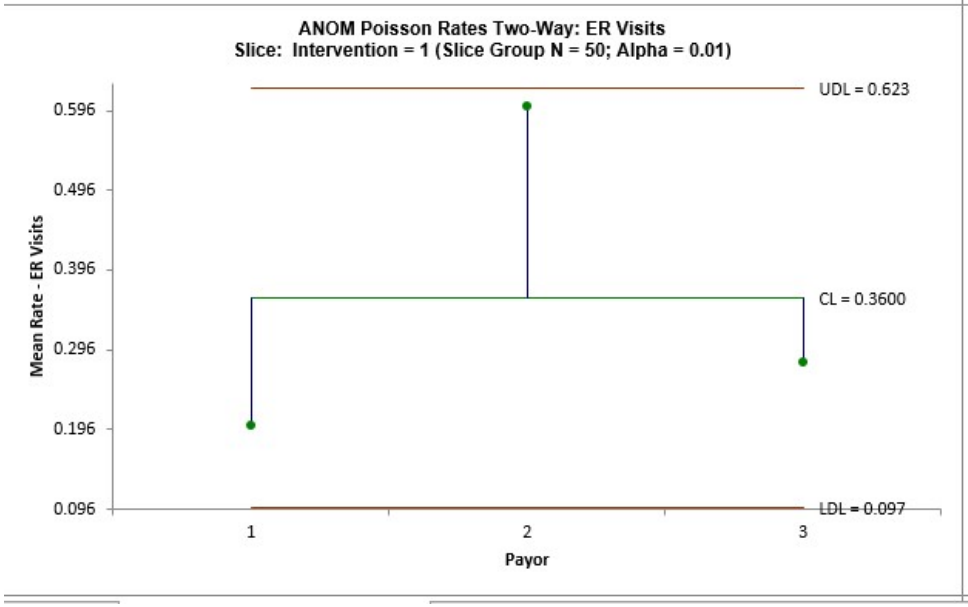
"The Analysis of Means" Example 5.15 Length of Stay Data (used with author permission): Binomial Proportions Two-Way Interaction Plots

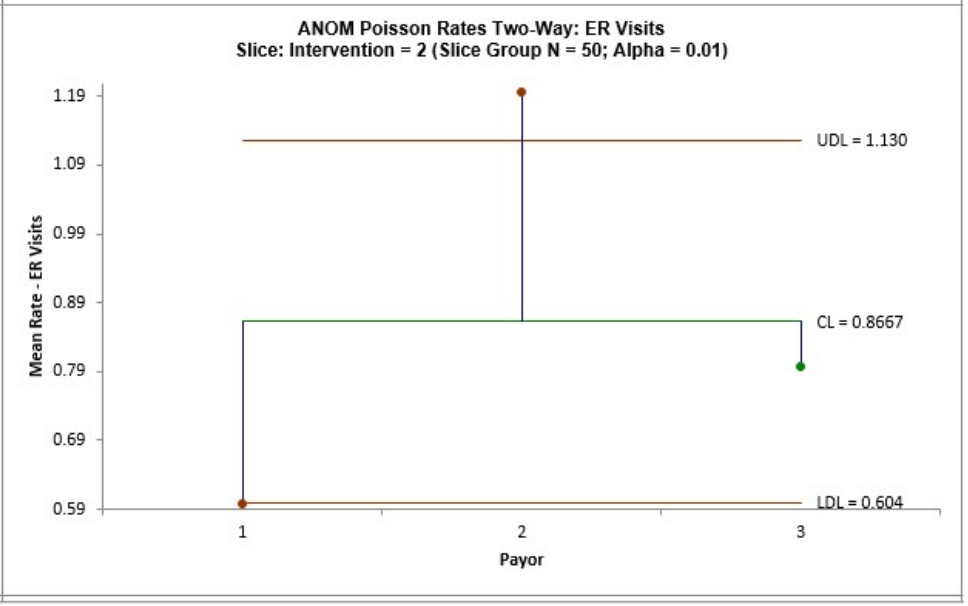


"The Analysis of Means" Example 5.16 Emergency Room Visits (used with author permission): Poisson Rates Two-Way Main Effects & Slice Charts

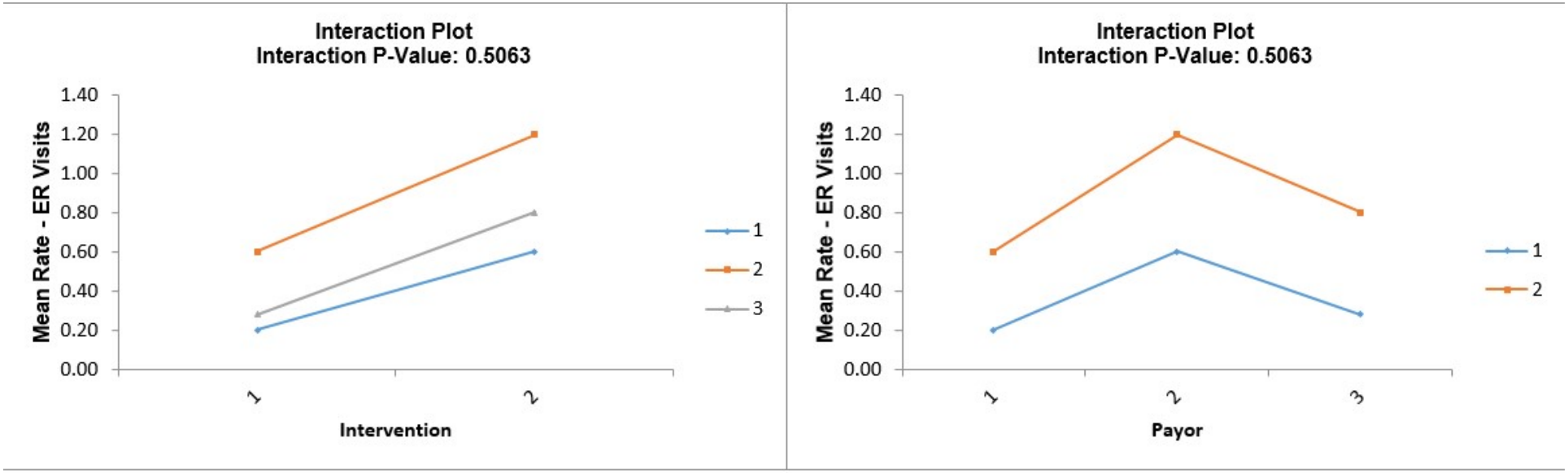








"The Analysis of Means" Example 5.16 Emergency Room Visits (used with author permission): Poisson Rates Two-Way Interaction Plots



Multiple Comparisons (a.k.a. Post-Hoc)

One-Way ANOVA

- Fisher
  - Also known as Fisher's Least Significant Difference (LSD)
  - Pairwise 2 sample t-tests with pooled standard deviation
  - Does not correct for family wise error rate, so should only be used for k = 3 means and in the restricted case where the ANOVA p-value is < alpha (this is also known as Protected Fisher LSD). For k = 3 means, Protected Fisher LSD is more powerful than Tukey.

- Tukey
  - Similar to LSD, uses pairwise tests with pooled standard deviation, but is a studentized range statistic that corrects for family-wise error rate. Recommended for k > 3.

Multiple Comparisons

Example of Fisher and Tukey Probabilities for Overall Satisfaction by Customer Type

Pairwise Mean Difference (row - column)	1	2	3
1	0	-0.8117	-0.2476
2		0	0.5641
3			0

Fisher Pairwise Probabilities	1	2	3
1		0.0000	0.1840
2			0.0016
3			

Pairwise Mean Difference (row - column)	1	2	3
1	0	-0.8117	-0.2476
2		0	0.5641
3			0

Tukey Probabilities	1	2	3
1		0.0000	0.3777
2			0.0044
3			

Multiple Comparisons

One-Way ANOVA

- Dunnett with Control
  - If one of the groups are a control reference group, Dunnett with Control is more powerful than Tukey because it is doing fewer pairwise comparisons (only considers those pairwise against the control group).
  - Uses pooled standard deviation and the multivariate t distribution that corrects for family-wise error rate.

- Option: Display ANOM Normal One-Way Chart

Multiple Comparisons

Welch ANOVA (Assume Unequal Variance)

- Welch Pairwise
  - Pairwise 2 sample t-tests with unpooled standard deviation and weighted degrees of freedom (2 sample t-test for unequal variance)
  - Does not correct for family wise error rate, so should only be used for k = 3 means and in the restricted case where the Welch ANOVA p-value is < alpha.
- Games-Howell
  - Similar to Welch Pairwise, uses unpooled standard deviation and weighted degrees of freedom, but is a studentized range statistic that corrects for family-wise error rate. Recommended for k > 3.
  - It is an extension of the Tukey test for unequal variance.
- ANOM Chart option is not available for Welch ANOVA as this requires two-stage sampling.

Multiple Comparisons

Bartlett Equal Variance

- F-Test
  - Pairwise 2 sample F-tests
  - Does not correct for family wise error rate, so should only be used for k = 3 groups and in the restricted case where the Bartlett p-value is < alpha.
- F-Test with Bonferroni Correction
  - Pairwise 2 sample F-tests with Bonferroni correction
  - Recommended for k > 3
  - Bonferroni p-value' = p-value * m
    - m = number of pairwise comparisons k(k-1)/2
- Option: Display ANOM Variances Chart

Multiple Comparisons

Levene (Robust) Equal Variance

- Levene
  - Pairwise 2 sample Levene tests
  - Does not correct for family wise error rate, so should only be used for k = 3 groups and in the restricted case where the Levene p-value is < alpha.
- Tukey ADM (Absolute Deviations from Median)
  - Application of Tukey on ADM (Absolute Deviations from Median)
  - Recommended for k > 3
  - This post-hoc test is unique to SigmaXL, inspired by the method used in ANOM Levene Variances.
- Option: Display ANOM Levene Robust Variances Chart

Chi-Square Tests & Table Associations

- Improved dialog labels for stacked data (Rows, Cols, Frequency)

- Adjusted Residuals
  - Red font highlight denotes significant cell residual value
  - Bold red highlight denotes significant cell residual value with Bonferroni adjustment
  - Note: red highlight is only active if Chi-Square P-Value is significant

- Cell's Contribution to Chi-Square

Chi-Square Tests & Table Associations (Optional)

- Additional Chi-Square Tests
  - Likelihood Ratio
  - McNemar-Bowker Symmetry (Square Table)

- Measures of Association for Nominal Categories
  - Pearson's Phi
    - In a 2x2 table, this is equivalent to Pearson's correlation coefficient
    - Cohen (1977) gives the ROT for general effect sizes: 0.1 = "Small"; 0.3 = "Medium"; 0.5 = "Large"
  - Cramer's V
    - An extension of Phi for larger tables
  - Contingency Coefficient
  - Cohen's Kappa (Agreement - Square Table)

Chi-Square Tests & Table Associations (Optional)

- Measures of Association for Nominal Categories
  - Goodman-Kruskal Lambda (Cols & Rows Dependent, Symmetric)
  - Goodman-Kruskal Tau (Cols & Rows Dependent)
  - Theil's Uncertainty (Cols & Rows Dependent, Symmetric)

Chi-Square Tests & Table Associations (Optional)

- Tests of Association for Ordinal Categories
  - Concordant - Discordant
  - Spearman Rank Correlation

- Measures of Association for Ordinal Categories
  - Spearman Rank Correlation
  - Kendall's Tau-B (Square Table)
  - Kendall-Stuart Tau-C (Rectangular Table)
  - Goodman-Kruskal Gamma
  - Somers' D (Cols & Rows Dependent, Symmetric)

Chi-Square Tests & Table Associations Nominal Example: Supplier (Cols) & Pass/Fail/Marginal (Rows)

Chi-Square 2 Way Table Statistics			
Observed Counts	**Supplier A**	**Supplier B**	**Supplier C**
Pass	160	140	150
Fail	20	30	36
Marginal	20	30	14
Expected Counts	**Supplier A**	**Supplier B**	**Supplier C**
Pass	150	150	150
Fail	28.667	28.667	28.667
Marginal	21.333	21.333	21.333
Std. Residuals	**Supplier A**	**Supplier B**	**Supplier C**
Pass	0.816497	-0.816497	0
Fail	-1.619	0.249029	1.370
Marginal	-0.288675	1.876	-1.588
Adjusted Residuals	**Supplier A**	**Supplier B**	**Supplier C**
Pass	2	-2	0
Fail	-2.14191972	0.329526111	1.812393613
Marginal	-0.374066	2.431429007	-2.05736301
Cell's Contribution to Chi-Square	**Supplier A**	**Supplier B**	**Supplier C**
Pass	0.66666667	0.666666667	0
Fail	2.62015504	0.062015504	1.875968992
Marginal	0.08333333	3.520833333	2.520833333

Chi-Square Tests & Table Associations Nominal Example: Supplier (Cols) & Pass/Fail/Marginal (Rows)

Chi-Square	12.016			
DF	4			
P-Value	0.0172			

Additional Chi-Square Tests				
Test	**Chi-Square**	**DF**	**P-Value**	
Likelihood Ratio	12.1425	4	0.0163	
McNemar-Bowker Symmetry (Square Table)	189.9572	3	0.0000	

Measures of Association for Nominal Categories				
Measure	**Value**	**Std. Error**	**95% Lower Bound**	**95% Upper Bound**
Pearson's Phi	0.1415			
Cramer's V	0.1001			
Contingency Coefficient	0.1401			
Cohen's Kappa (Agreement - Square Table)	0.0100	0.0211	-0.0314	0.0514
Goodman-Kruskal Lambda (Cols Dependent)	0.0650	0.0249	0.0162	0.1138
Goodman-Kruskal Lambda (Rows Dependent)	0.0000	0.0000	0.0000	0.0000
Goodman-Kruskal Lambda (Symmetric)	0.0473	0.0181	0.0118	0.0827
Goodman-Kruskal Tau (Cols Dependent)	0.0100	0.0057	0.0000	0.0211
Goodman-Kruskal Tau (Rows Dependent)	0.0095	0.0058	0.0000	0.0209
Theil's Uncertainty (Cols Dependent)	0.0092	0.0052	-0.0010	0.0194
Theil's Uncertainty (Rows Dependent)	0.0138	0.0078	-0.0015	0.0291
Theil's Uncertainty (Symmetric)	0.0110	0.0062	-0.0012	0.0233

Chi-Square Tests & Table Associations Ordinal Example: Satisfaction (Cols) & Salary (Rows)

Chi-Square 2 Way Table Statistics

Observed Counts	Very Dissatisfied	Somewhat Dissatisfied	Somewhat Satisfied	Very Satisfied
< 20K	5	6	19	12
20-30K	5	7	20	14
30-40K	3	12	28	24
> 40K	1	2	18	26

Expected Counts	Very Dissatisfied	Somewhat Dissatisfied	Somewhat Satisfied	Very Satisfied
< 20K	2.911	5.614	17.673	15.802
20-30K	3.188	6.149	19.356	17.307
30-40K	4.644	8.955	28.193	25.208
> 40K	3.257	6.282	19.777	17.683

Std. Residuals	Very Dissatisfied	Somewhat Dissatisfied	Somewhat Satisfied	Very Satisfied
< 20K	1.224	0.162972	0.315591	-0.956432
20-30K	1.014757961	0.343393	0.146278	-0.794905
30-40K	-0.762713	1.017372859	-0.036361522	-0.240586
> 40K	-1.251	-1.708	-0.399632	1.978

Adjusted Residuals	Very Dissatisfied	Somewhat Dissatisfied	Somewhat Satisfied	Very Satisfied
< 20K	1.426134732	0.196736411	0.465932976	-1.360693153
20-30K	1.196940639	0.419818923	0.218713418	-1.145298952
30-40K	-0.967089216	1.33704372	-0.05844315	-0.37262257
> 40K	-1.480071878	-2.095444235	-0.599449996	2.858762784

Cell's Contribution to Chi-Square	Very Dissatisfied	Somewhat Dissatisfied	Somewhat Satisfied	Very Satisfied
< 20K	1.499326463	0.026559799	0.099597859	0.914762153
20-30K	1.029733719	0.117919038	0.02139728	0.631873485
30-40K	0.581730668	1.035047535	0.00132216	0.057881515
> 40K	1.564416624	2.918900046	0.15970582	3.911611766

Note: 4 out of 16 cells have expected counts less than 5.

Chi-Square Tests & Table Associations Ordinal Example: Satisfaction (Cols) & Salary (Rows)

Chi-Square	14.572
DF	9
P-Value	0.1034

Additional Chi-Square Tests			
Test	**Chi-Square**	**DF**	**P-Value**
Likelihood Ratio	15.4156	9	0.0801
McNemar-Bowker Symmetry (Square Table)	32.8921	6	0.0000

Measures of Association for Nominal Categories				
Measure	**Value**	**Std. Error**	**95% Lower Bound**	**95% Upper Bound**
Pearson's Phi	0.2686			
Cramer's V	0.1551			
Contingency Coefficient	0.2594			
Cohen's Kappa (Agreement - Square Table)	0.0752	0.0428	-0.0087	0.1592
Goodman-Kruskal Lambda (Cols Dependent)	0.0684	0.0547	0.0000	0.1756
Goodman-Kruskal Lambda (Rows Dependent)	0.0296	0.0556	0.0000	0.1385
Goodman-Kruskal Lambda (Symmetric)	0.0476	0.0483	0.0000	0.1424
Goodman-Kruskal Tau (Cols Dependent)	0.0230	0.0136	0.0000	0.0497
Goodman-Kruskal Tau (Rows Dependent)	0.0233	0.0115	0.0008	0.0458
Theil's Uncertainty (Cols Dependent)	0.0322	0.0153	0.0022	0.0621
Theil's Uncertainty (Rows Dependent)	0.0279	0.0134	0.0017	0.0541
Theil's Uncertainty (Symmetric)	0.0299	0.0143	0.0019	0.0578

Chi-Square Tests & Table Associations Ordinal Example: Satisfaction (Cols) & Salary (Rows)

Tests of Association for Ordinal Categories		
Test	Value	P-Value
Concordant - Discordant	2707	0.0009
Spearman Rank Correlation	0.2205	0.0016

Measures of Association for Ordinal Categories				
Measure	Value	Std. Error	95% Lower Bound	95% Upper Bound
Spearman Rank Correlation	0.2205	0.0669	0.0834	0.3495
Kendall's Tau-B (Square Table)	0.1899	0.0570	0.0782	0.3017
Kendall-Stuart Tau-C (Rectangular Table)	0.1769	0.0535	0.0721	0.2817
Goodman-Kruskal Gamma	0.2700	0.0795	0.1141	0.4258
Somers' D (Cols Dependent)	0.1791	0.0540	0.0732	0.2850
Somers' D (Rows Dependent)	0.2014	0.0603	0.0833	0.3196
Somers' D (Symmetric)	0.1896	0.0569	0.0781	0.3012

Descriptive Statistics (Optional)

- Percentile Report
  - 27 values from 0.135 to 99.865
- Percentile Ranges
  - 99.865 - 0.135 (99.73%, +/- 3 Sigma Equivalent)
  - 99.5 - 0.5 (99%)
  - 99 - 1 (98%)
  - 97.5 - 2.5 (95%, +/- 1.96 Sigma Equivalent)
  - 95 - 5 (90%, Span)
  - 90 - 10 (80%, Interdecile Range IDR)
  - 75 - 25 (50%, Interquartile Range IQR)

Descriptive Statistics (Optional)

- Percentile Confidence and Tolerance Intervals
  - Interpolated or Exact
  - Minimum sample size reported if unable to compute CI or TI
  - Quartile Confidence Intervals (25, 50, 75)
  - Percentile Confidence Intervals (27 values from 0.135 to 99.865)
  - Percentile Tolerance Intervals (99.73%, 99%, 98%, 95%, 90%, 80%, 50%)

- Additional Descriptive Statistics
  - 5% Trimmed Mean
  - Standard Error of Mean
  - Variance
  - Coefficient of Variation
  - Short Term StDev (MR-bar/d2)

Descriptive Statistics (Optional)

- Additional Normality Tests
  - Shapiro-Wilk (n <= 5000) and Kolmogorov-Smirnov-Lilliefors (n > 5000)
  - Doornik-Hansen
    - Univariate omnibus test based on Skewness and Kurtosis
    - Best for data with ties (“chunky” data)
- Outlier Tests
  - Boxplot: Potential 1.5(IQR), Likely 2.2(IQR), Extreme 3.0(IQR)
  - Grubbs
- Randomness Test
  - Nonparametric Runs Test (Exact)
- Normality, Outlier and Randomness Tests use the same Green, Yellow, Red highlight used in Version 7 hypothesis tests.

Descriptive Statistics Example: Overall Satisfaction by Customer Type

Overall Satisfaction by Customer Type			
Descriptive Statistics	**Customer Type = 1**	**Customer Type = 2**	**Customer Type = 3**
Count	31	42	27
Mean	3.394	4.205	3.641
Stdev	0.824680	0.621200	0.670478
Range	3.080	2.560	2.740
Minimum	1.720	2.420	2.190
25th Percentile (Q1)	2.810	3.828	3.240
50th Percentile (Median)	3.560	4.340	3.510
75th Percentile (Q3)	4.020	4.725	4.170
Maximum	4.800	4.980	4.930
95.0% CI Mean	3.0911 to 3.696	4.0117 to 4.3988	3.3759 to 3.9063
95.0% CI Sigma	0.65901 to 1.1023	0.51113 to 0.79213	0.52801 to 0.91884
Anderson-Darling Normality Test	0.312776	0.826259	0.389291
P-Value (A-D Test)	0.5306	0.0302	0.3600
Skewness	-0.235169	-0.967994	0.139571
P-Value (Skewness)	0.5557	0.0121	0.7411
Kurtosis	-0.671690	0.679609	-0.313701
P-Value (Kurtosis)	0.3705	0.2865	0.8435
Additional Descriptive Statistics			
5% Trimmed Mean	3.413	4.251	3.648
Standard Error of Mean	0.148117	0.095853182	0.129034
Variance	0.680097	0.385889	0.449541
Coefficient of Variation	24.301	14.772	18.414
StDev (Within, Short Term)	0.678487	0.521969	0.683988
Additional Normality Tests			
Shapiro-Wilk/KSL	0.969383	0.923744	0.971664
P-Value (Shapiro-Wilk/KSL)	0.5022	0.0080	0.6463
Doornik-Hansen	0.813602	8.554	0.127399
P-Value (Doornik-Hansen)	0.6658	0.0139	0.9383

Descriptive Statistics Example: Overall Satisfaction by Customer Type

Overall Satisfaction by Customer Type			
Descriptive Statistics	**Customer Type = 1**	**Customer Type = 2**	**Customer Type = 3**
Percentile Report			
0.135	1.72	2.42	2.19
0.5	1.72	2.42	2.19
1	1.72	2.441	2.19
2.5	1.72	2.42	2.19
5	1.804	2.778	2.37
10	2.138	3.285	2.832
15	2.554	3.518	3.056
20	2.602	3.65	3.144
25	2.81	3.8275	3.24
30	2.924	3.981	3.272
35	2.97	4.091	3.298
40	3.074	4.132	3.33
45	3.248	4.3035	3.422
50	3.56	4.34	3.51
55	3.576	4.4195	3.566
60	3.804	4.464	3.644
65	3.9	4.5275	3.988
70	3.978	4.558	4.074
75	4.02	4.725	4.17
80	4.11	4.786	4.294
85	4.242	4.881	4.428
90	4.586	4.91	4.688
95	4.722	4.9655	4.878
97.5	4.8	4.97925	4.93
99	4.8	4.98	4.93
99.5	4.8	4.98	4.93
99.865	4.8	4.98	4.93
75 - 25 (50%, Interquartile Range IQR)	3.08	2.56	2.74
90 - 10 (80%, Interdecile Range IDR)	3.08	2.56	2.74
95 - 5 (90%, Span)	3.08	2.539	2.74
97.5 - 2.5 (95%, +/- 1.96 Sigma Equivalent)	3.08	2.55925	2.74
99 - 1 (98%)	2.918	2.1875	2.508
99.5 - 0.5 (99%)	2.448	1.625	1.856
99.865 - 0.135 (99.73%, +/- 3 Sigma Equivalent)	1.21	0.8975	0.93

Descriptive Statistics Example: Overall Satisfaction by Customer Type

Overall Satisfaction by Customer Type

Descriptive Statistics	Customer Type = 1	Customer Type = 2	Customer Type = 3
Percentile Confidence Intervals (Interpolated 95.0%)			
0.135	Min. sample size = 2731	Min. sample size = 2731	Min. sample size = 2731
0.5	Min. sample size = 736	Min. sample size = 736	Min. sample size = 736
1	Min. sample size = 368	Min. sample size = 368	Min. sample size = 368
2.5	Min. sample size = 146	Min. sample size = 146	Min. sample size = 146
5	Min. sample size = 72	Min. sample size = 72	Min. sample size = 72
10	Min. sample size = 36	2.5826 to 3.6589	Min. sample size = 36
15	1.8393 to 2.9095	3.1206 to 3.8676	2.4389 to 3.2707
20	2.0087 to 2.9711	3.2747 to 4.0232	2.7108 to 3.3014
25	2.4809 to 3.1075	3.4847 to 4.1163	2.9143 to 3.3899
30	2.5606 to 3.2586	3.5891 to 4.3005	3.0606 to 3.4556
35	2.6047 to 3.5658	3.7308 to 4.3359	3.1354 to 3.5275
40	2.7749 to 3.6297	3.8487 to 4.4153	3.2052 to 3.6277
45	2.906 to 3.817	3.9942 to 4.4601	3.2554 to 3.862
50	2.9535 to 3.9362	4.0946 to 4.5184	3.2891 to 4.0227
55	3.0221 to 3.987	4.1397 to 4.5458	3.3036 to 4.1239
60	3.2061 to 4.0266	4.3049 to 4.6959	3.3845 to 4.1874
65	3.387 to 4.1066	4.3441 to 4.7459	3.4401 to 4.3391
70	3.5707 to 4.2345	4.4284 to 4.8516	3.5236 to 4.4274
75	3.7743 to 4.2921	4.4737 to 4.8928	3.626 to 4.6107
80	3.8978 to 4.67	4.53 to 4.91	3.9334 to 4.7587
85	3.9853 to 4.6892	4.6717 to 4.9457	4.0779 to 4.8581
90	Min. sample size = 36	4.77 to 4.9742	Min. sample size = 36
95	Min. sample size = 72	Min. sample size = 72	Min. sample size = 72
97.5	Min. sample size = 146	Min. sample size = 146	Min. sample size = 146
99	Min. sample size = 368	Min. sample size = 368	Min. sample size = 368
99.5	Min. sample size = 736	Min. sample size = 736	Min. sample size = 736
99.865	Min. sample size = 2731	Min. sample size = 2731	Min. sample size = 2731
Percentile Tolerance Intervals (Interpolated 95.0% Minimum)			
50%	2.56 to 4.1129	3.62 to 4.8262	3.04 to 4.2764
80%	1.7453 to 4.67	3.108 to 4.97	2.4552 to 4.93
90%	Min. sample size = 46	Min. sample size = 46	Min. sample size = 46
95%	Min. sample size = 93	Min. sample size = 93	Min. sample size = 93
98%	Min. sample size = 236	Min. sample size = 236	Min. sample size = 236
99%	Min. sample size = 473	Min. sample size = 473	Min. sample size = 473
99.73%	Min. sample size = 1756	Min. sample size = 1756	Min. sample size = 1756

Descriptive Statistics Example: Overall Satisfaction by Customer Type

Overall Satisfaction by Customer Type			
Descriptive Statistics	**Customer Type = 1**	**Customer Type = 2**	**Customer Type = 3**
Outlier and Randomness Tests			
Outliers (Boxplot Rules)	No outliers found.	Potential (1.5*IQR) outlier lower count = 1.	No outliers found.
Grubbs Outlier Test	Grubbs' Test P-Value = 1.000. Fail to reject null hypothesis: "There are no outliers in the data set." Note that Grubbs' Test assumes normality and tests only if the maximum or minimum is an outlier.	Grubbs' Test P-Value = 0.105. Fail to reject null hypothesis: "There are no outliers in the data set." Note that Grubbs' Test assumes normality and tests only if the maximum or minimum is an outlier.	Grubbs' Test P-Value = 0.654. Fail to reject null hypothesis: "There are no outliers in the data set." Note that Grubbs' Test assumes normality and tests only if the maximum or minimum is an outlier.
Randomness Runs Test	Nonparametric Runs Test (Exact) P-Value = 0.066. Fail to reject null hypothesis: "data are random," so conclude that the assumption of randomness (independence) is not violated.	Nonparametric Runs Test (Exact) P-Value = 1.000. Fail to reject null hypothesis: "data are random," so conclude that the assumption of randomness (independence) is not violated.	Nonparametric Runs Test (Exact) P-Value = 1.000. Fail to reject null hypothesis: "data are random," so conclude that the assumption of randomness (independence) is not violated.

Templates and Calculators

- 1 Sample Z test and Confidence Interval for Mean
- Tolerance Interval Calculator (Normal Exact)
- Equivalence Tests - Two One-Sided Tests (TOST)
  - 1 Sample Equivalence Test for Mean
  - 2 Sample Equivalence Test (Compare 2 Means)
  - 2 Proportions Equivalence Test
  - 2 Poisson Rates Equivalence Test
- Type 1 Gage Study
- Gage Bias and Linearity Study

Tolerance Interval Calculator (Normal Exact)

Tolerance Interval Calculator (Normal Exact)		
Sample Data (user inputs):		
Sample Size	n	30
Sample Mean	x-bar	1
Sample Standard Deviation	s	1
Population Coverage (enter .99 for 99%)	100*(p)%	99.0%
Confidence Level (enter .95 for 95%)	100*(1-α)%	95.0%
Tolerance Interval Type		Two-Sided

Results:	
Upper Tolerance Limit	4.3546
Lower Tolerance Limit	-2.3546

2 Sample Equivalence Test (Compare 2 Means)

2 Sample Equivalence Test (Two One-Sided t-Tests TOST)			
Sample Data (user inputs):		**Test/Treatment Sample**	**Reference/Control Sample**
Sample Size	n	30	30
Sample Mean	x-bar	0.0000	0.5000
Sample Standard Deviation	s	1.0000	1.0000
Upper Equivalence Limit	UEL	1.0	
Lower Equivalence Limit	LEL	-1.0	
Confidence Level (enter .95 for 95%)	100*(1-α)%	95.0%	
Assume Equal Variances		Yes	
Results:			
Sample Mean Difference		-0.5000	
Standard Error Difference (using pooled variance)		0.2582	
df (equal variance)		58	
alpha		0.0500	
t1-statistic (upper)		-5.8095	
t2-statistic (lower)		1.9365	
P1-Value (upper)		0.0000	
P2-Value (lower)		0.0288	
Equivalence P-Value (maximum of P1 and P2)		0.0288	
Upper Confidence Limit Mean Difference		-0.0684	
Lower Confidence Limit Mean Difference		-0.9316	

Interpretation of p-value and Confidence Intervals
Since the Equivalence P-Value is less than alpha (0.05), conclude that equivalence is true.
Since the 95% confidence interval is within the equivalence interval, conclude that equivalence is true.

Type 1 Gage Study

Type 1 Gage Study

Gage Name:	Example Type 1 Gage Study
Date of Study:	
Performed By:	
Notes:	

Tolerance (Tol, USL - LSL):	0.2
Part Reference Value (Ref):	10
Gage Resolution:	0.0001
StDev Multiplier:	6.00
Percent of Tolerance for Cg/Cgk:	20

Trial:	Measurement Data
1	10.0063
2	10.0014
3	9.9945

Count	50
Mean	10.00071
StDev	0.004149
StDev*Multiplier (SV)	0.024893
Ref + 0.1*Tol	10.02
Ref - 0.1*Tol	9.98

Type 1 Gage Run Chart

Bias	0.00071
Bias t-Statistic	1.210106
Bias P-Value	0.2320
Gage Capability Cg	1.61
Gage Capability Cgk	1.55
Gage Repeatability % (100*SV/Tol)	12.45%
Gage Repeatability & Bias % (20/Cgk)	12.90%
Resolution % of Tolerance	0.05%

Gage Bias & Linearity Study

Gage Bias and Linearity Study

Gage Name:	Example Gage Bias and Linearity Study - AIAG MSA Reference Manual, 4th Edition, Page 99
Date of Study:	
Performed By:	
Notes:	

Process Variation (SV from Gage R&R or 6 * Historical StDev):	10

Gage Linearity Report

Part:	1	2	3	4	5
Reference Value:	2	4	6	8	10
Trial					
1	2.7	5.1	5.8	7.6	9.1
2	2.5	3.9	5.7	7.7	9.3
3	2.4	4.2	5.9	7.8	9.5
4	2.5	5	5.9	7.7	9.3
5	2.7	3.8	6	7.8	9.4
6	2.3	3.9	6.1	7.8	9.5
7	2.5	3.9	6	7.8	9.5
8	2.5	3.9	6.1	7.7	9.5
9	2.4	3.9	6.4	7.8	9.6
10	2.4	4	6.3	7.5	9.2
11	2.6	4.1	6	7.6	9.3
12	2.4	3.8	6.1	7.7	9.4
13					
14					
15					
16					
17					
18					
19					
20					

Part:	1	2	3	4	5
Reference Value:	2	4	6	8	10
Trial	Bias Calculations				
1	0.7	1.1	-0.2	-0.4	-0.9
2	0.5	-0.1	-0.3	-0.3	-0.7
3	0.4	0.2	-0.1	-0.2	-0.5
4	0.5	1	-0.1	-0.3	-0.7
5	0.7	-0.2	0	-0.2	-0.6
6	0.3	-0.1	0.1	-0.2	-0.5
7	0.5	-0.1	0	-0.2	-0.5
8	0.5	-0.1	0.1	-0.3	-0.5
9	0.4	-0.1	0.4	-0.2	-0.4
10	0.4	0	0.3	-0.5	-0.8
11	0.6	0.1	0	-0.4	-0.7
12	0.4	-0.2	0.1	-0.3	-0.6
13					
14					
15					
16					
17					
18					
19					
20					

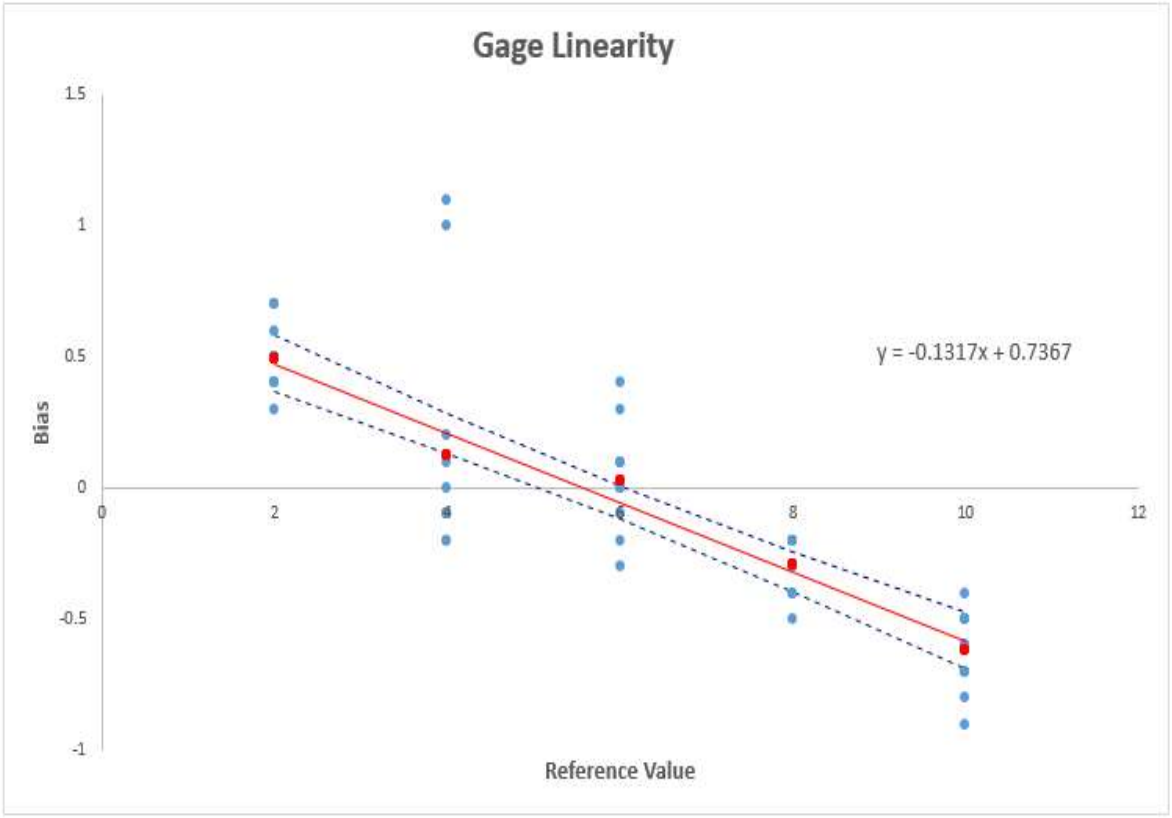
Gage Bias & Linearity Study

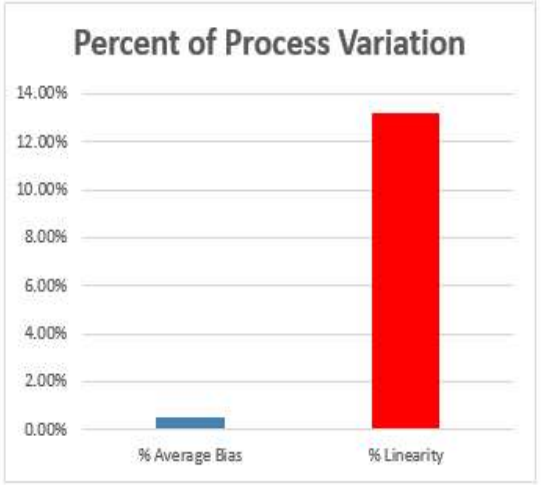
Bias	0.491666667	0.125	0.025	-0.291666667	-0.616666667
% Bias	4.92%	1.25%	0.25%	2.92%	6.17%
P-Value	0.0000	0.3540	0.6671	0.0000	0.0000

Average Bias	-0.053333333
% Average Bias	0.53%
P-Value	0.0894

	Coeff	SE Coeff	P-Value
Constant	0.736666667	0.072524273	0.0000
Slope	-0.131666667	0.010933445	0.0000

R-Square	71.43%
Adj, R-Square	70.94%
StDev	0.239539789
Linearity	1.316666667
% Linearity	13.17%





Why SigmaXL?

- Measure, Analyze, and Control your Manufacturing, Service, or Transactional Process.
- An add-in to the already familiar Microsoft Excel, making it a great tool for Lean Six Sigma training. Used by Motorola University and other leading consultants.
- SigmaXL is rapidly becoming the tool of choice for Quality and Business Professionals.

What's Unique to SigmaXL?

- User-friendly Design of Experiments with "view power analysis as you design".
- Measurement Systems Analysis with Confidence Intervals.
- Two-sample comparison test - automatically tests for normality, equal variance, means, and medians, and provides a rules-based yellow highlight to aid the user in interpretation of the output.
- Low p-values are highlighted in red indicating that results are significant.

What's Unique to SigmaXL?

- Template: Minimum Sample Size for Robust Hypothesis Testing
  - It is well known that the central limit theorem enables the t-Test and ANOVA to be fairly robust to the assumption of normality.
  - A question that invariably arises is, "How large does the sample size have to be?"
  - A popular rule of thumb answer for the one sample t-Test is "n = 30." While this rule of thumb often does work well, the sample size may be too large or too small depending on the degree of non-normality as measured by the Skewness and Kurtosis.
  - Furthermore it is not applicable to a One Sided t-Test, 2 Sample t-Test or One Way ANOVA.
  - To address this issue, we have developed a unique template that gives a minimum sample size needed for a hypothesis test to be robust.

What's Unique to SigmaXL?

- Powerful Excel Worksheet Manager
  - List all open Excel workbooks
  - Display all worksheets and chart sheets in selected workbook
  - Quickly select worksheet or chart sheet of interest

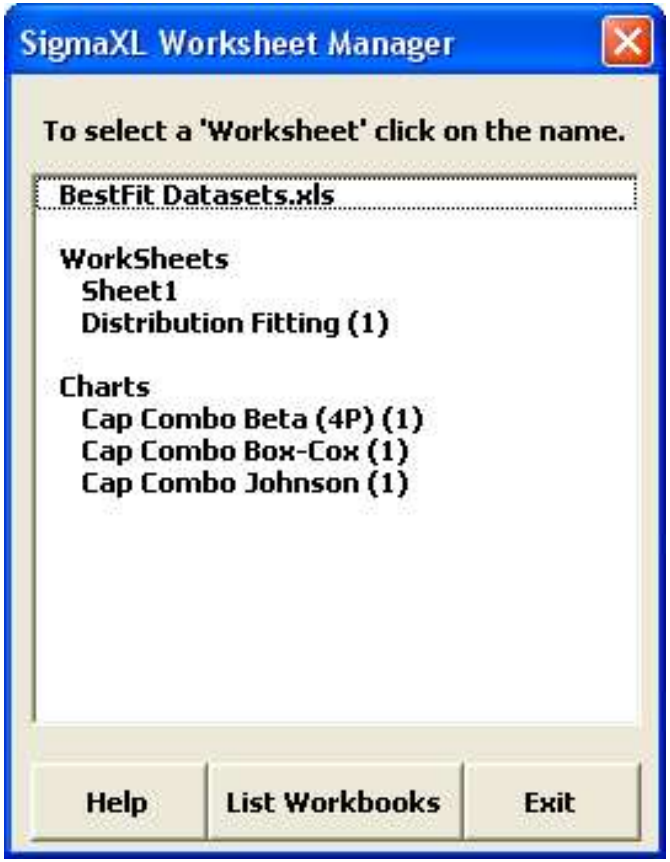
- Process Capability and Control Charts for Nonnormal data
  - Best fit automatically selects the best distribution or transformation!
  - Nonnormal Process Capability Indices include Pp, Ppk, Cp, and Cpk
  - Box-Cox Transformation with Threshold so that data with zero or negative values can be transformed!

Recall Last Dialog

- Recall SigmaXL Dialog
  - This will activate the last data worksheet and recall the last dialog, making it very easy to do repetitive analysis.
- Activate Last Worksheet
  - This will activate the last data worksheet used without recalling the dialog.

Worksheet Manager

- List all open Excel workbooks
- Display all worksheets and chart sheets in selected workbook
- Quickly select worksheet or chart sheet of interest



Data Manipulation

- Subset by Category, Number, or Date
- Random Subset
- Stack and Unstack Columns
- Stack Subgroups Across Rows
- Standardize Data
- Random Number Generators
  - Normal, Uniform (Continuous & Integer), Lognormal, Exponential, Weibull and Triangular.
- Box-Cox Transformation

Templates & Calculators

- DMAIC & DFSS Templates:
  - Team/Project Charter
  - SIPOC Diagram
  - Flowchart Toolbar
  - Data Measurement Plan
  - Cause & Effect (Fishbone) Diagram and Quick Template
  - Cause & Effect (XY) Matrix
  - Failure Mode & Effects Analysis (FMEA)
  - Quality Function Deployment (QFD)
  - Pugh Concept Selection Matrix
  - Control Plan

Templates & Calculators

- Lean Templates:
  - Takt Time Calculator
  - Value Analysis/Process Load Balance
  - Value Stream Mapping
- Basic Graphical Templates:
  - Pareto Chart
  - Histogram
  - Run Chart

Templates & Calculators

- Basic Statistical Templates:
  - Sample Size – Discrete and Continuous
  - Minimum Sample Size for Robust t-Tests and ANOVA
  - 1 Sample t-Test and Confidence Interval for Mean
  - 2 Sample t-Test and Confidence Interval (Compare 2 Means) with option for equal and unequal variance
  - 1 Sample Chi-Square Test and CI for Standard Deviation
  - 2 Sample F-Test and CI (Compare 2 Standard Deviations)
  - 1 Proportion Test and Confidence Interval
  - 2 Proportions Test and Confidence Interval

Templates & Calculators

- Basic Statistical Templates:
  - 1 Poisson Rate Test and Confidence Interval
  - 2 Poisson Rates Test and Confidence Interval
  - One-Way Chi-Square Goodness-of-Fit Test
  - One-Way Chi-Square Goodness-of-Fit Test - Exact

- Probability Distribution Calculators:
  - Normal, Lognormal, Exponential, Weibull
  - Binomial, Poisson, Hypergeometric

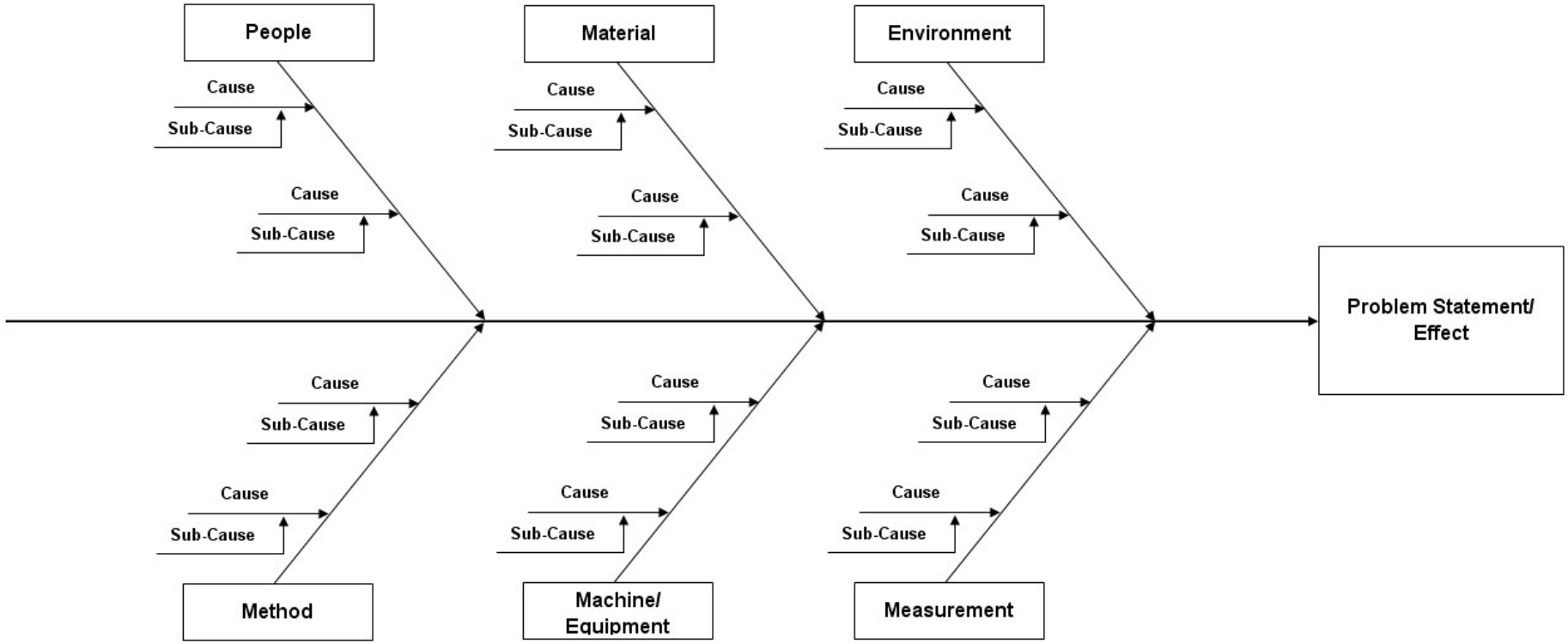
Templates & Calculators

- Basic MSA Templates:
  - Gage R&R Study – with Multi-Vari Analysis
  - Attribute Gage R&R (Attribute Agreement Analysis)
- Basic Process Capability Templates:
  - Process Sigma Level – Discrete and Continuous
  - Process Capability & Confidence Intervals
- Basic DOE Templates:
  - 2 to 5 Factors
  - 2-Level Full and Fractional-Factorial designs
  - Main Effects & Interaction Plots
- Basic Control Chart Templates:
  - Individuals
  - C-Chart

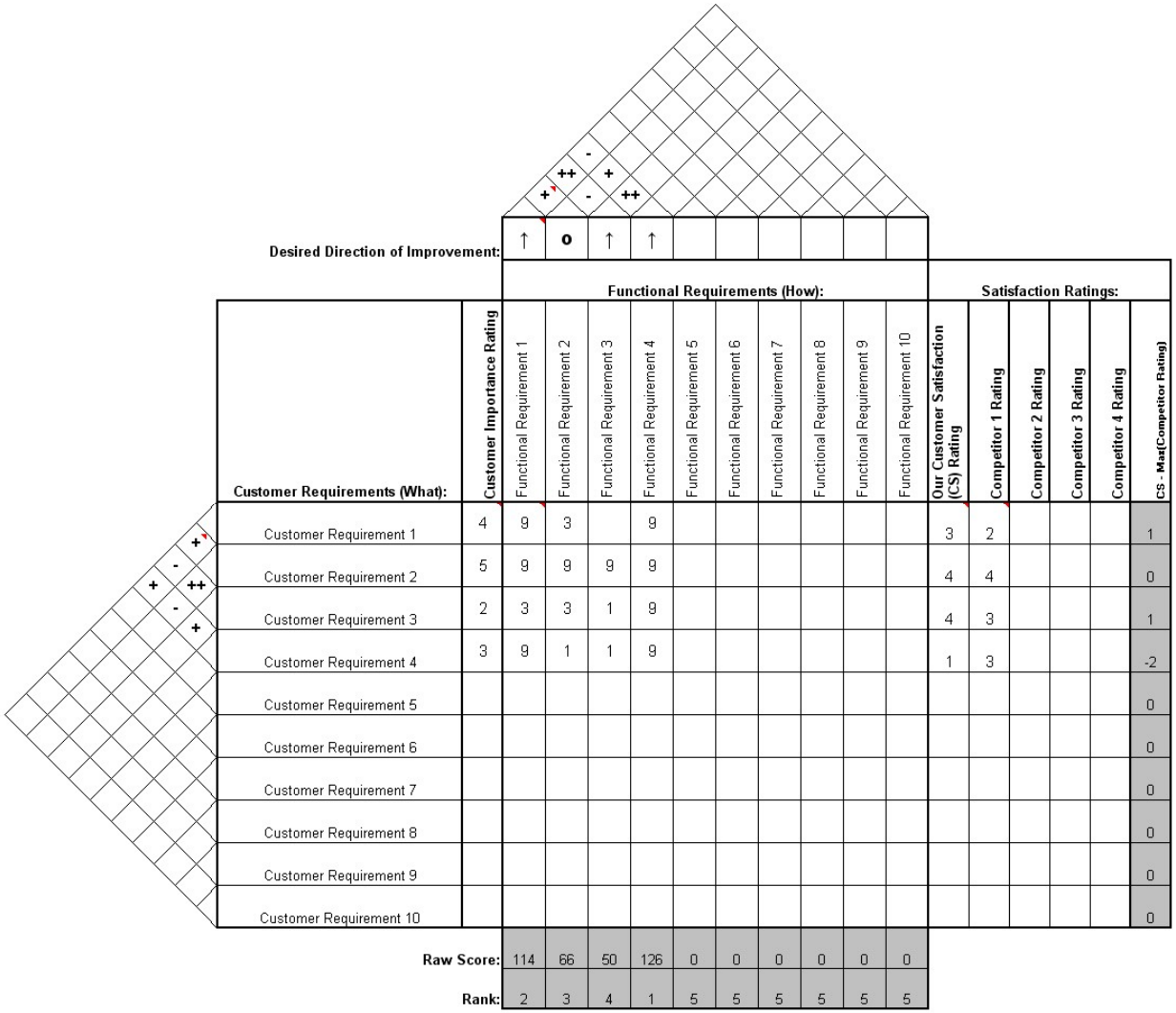
Templates & Calculators: Cause & Effect Diagram

CAUSE & EFFECT (FISHBONE) DIAGRAM

Process/Project Name:	
Date:	
Prepared By:	
Notes:	



Templates & Calculators: Quality Function Deployment (QFD)



Desired Direction of Improvement:		↑	o	↑	↑												
		Functional Requirements (How):										Satisfaction Ratings:					
Customer Requirements (What):	Customer Importance Rating	Functional Requirement 1	Functional Requirement 2	Functional Requirement 3	Functional Requirement 4	Functional Requirement 5	Functional Requirement 6	Functional Requirement 7	Functional Requirement 8	Functional Requirement 9	Functional Requirement 10	Our Customer Satisfaction (CS) Rating	Competitor 1 Rating	Competitor 2 Rating	Competitor 3 Rating	Competitor 4 Rating	CS - Max(Competitor Rating)
Customer Requirement 1	4	9	3		9							3	2				1
Customer Requirement 2	5	9	9	9	9							4	4				0
Customer Requirement 3	2	3	3	1	9							4	3				1
Customer Requirement 4	3	9	1	1	9							1	3				-2
Customer Requirement 5																	0
Customer Requirement 6																	0
Customer Requirement 7																	0
Customer Requirement 8																	0
Customer Requirement 9																	0
Customer Requirement 10																	0
Raw Score:		114	66	50	126	0	0	0	0	0	0						
Rank:		2	3	4	1	5	5	5	5	5	5						

Templates & Calculators: Pugh Concept Selection Matrix

Key Criteria	Weight	Concept A	Concept B	Concept C	Concept D	Concept E	Concept F	Concept G	Concept H	Concept I	Concept J	Current Baseline Datum
Criterion 1	4	+	S	-								S
Criterion 2	5	+	S	S								S
Criterion 3	3	S	+	-								S
Criterion 4	2	+	S	S								S
Criterion 5	5	+	+	S								S
Criterion 6												S
Criterion 7												S
Criterion 8												S
Criterion 9												S
Criterion 10												S
Criterion 11												S
Criterion 12												S
Criterion 13												S
Criterion 14												S
Criterion 15												S
Criterion 16												S
Criterion 17												S
Criterion 18												S
Criterion 19												S
Criterion 20												S

Sum of Positives (+):	4	2	0	0	0	0	0	0	0	0
Sum of Negatives(-):	0	0	2	0	0	0	0	0	0	0
Sum of Sames (S):	1	3	3	0	0	0	0	0	0	0
Positives - Negatives:	4	2	-2	0	0	0	0	0	0	0

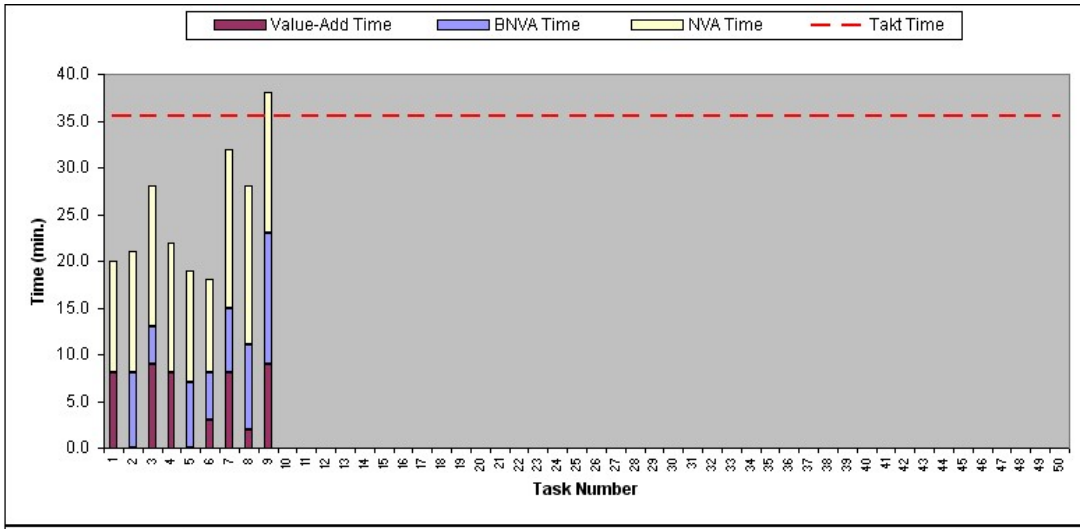
Weighted Sum of Positives (+):	16	8	0	0	0	0	0	0	0	0
Weighted Sum of Negatives (-):	0	0	7	0	0	0	0	0	0	0
Weighted Sum of Sames (S):	3	11	12	0	0	0	0	0	0	0
Weighted Positives - Weighted Negatives:	16	8	-7	0	0	0	0	0	0	0

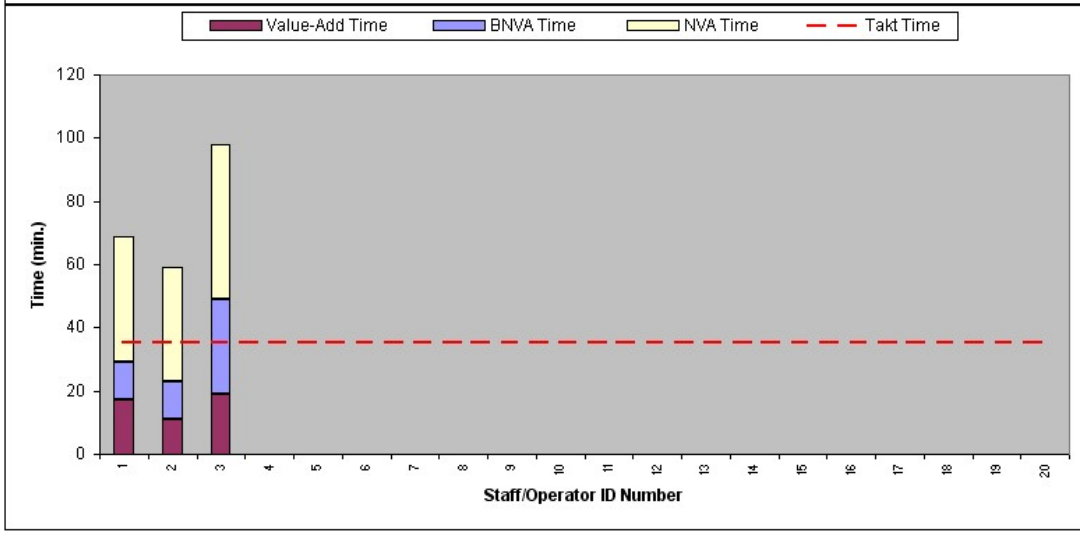
Templates & Calculators: Lean Takt Time Calculator

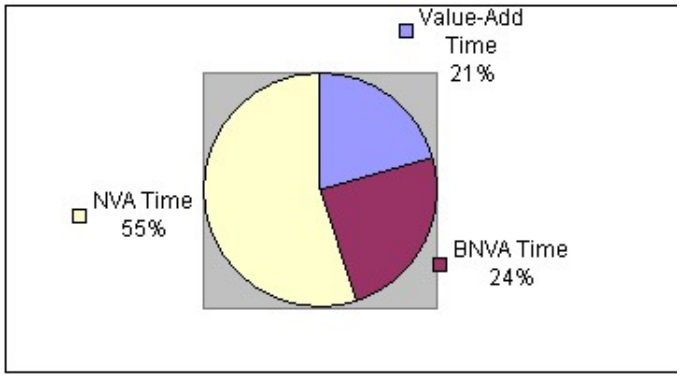
SigmaXL Lean Templates: Takt Time Calculator

Daily Customer Demand:	units per day	22
Scheduled Work:	hours per shift	8
Shifts per Day:		2
Lunch:	minutes per shift	30
Breaks:	minutes per shift	30
Planned Downtime:	minutes per shift	30
Staff/Operator Cycle Time:	minutes per unit	226
Available Time:	minutes per day	780.0
Takt Time:	minutes per unit	35.5
Required Number of Staff/Operators:		6.4

Templates & Calculators: Value Analysis/ Process Load Balance Chart

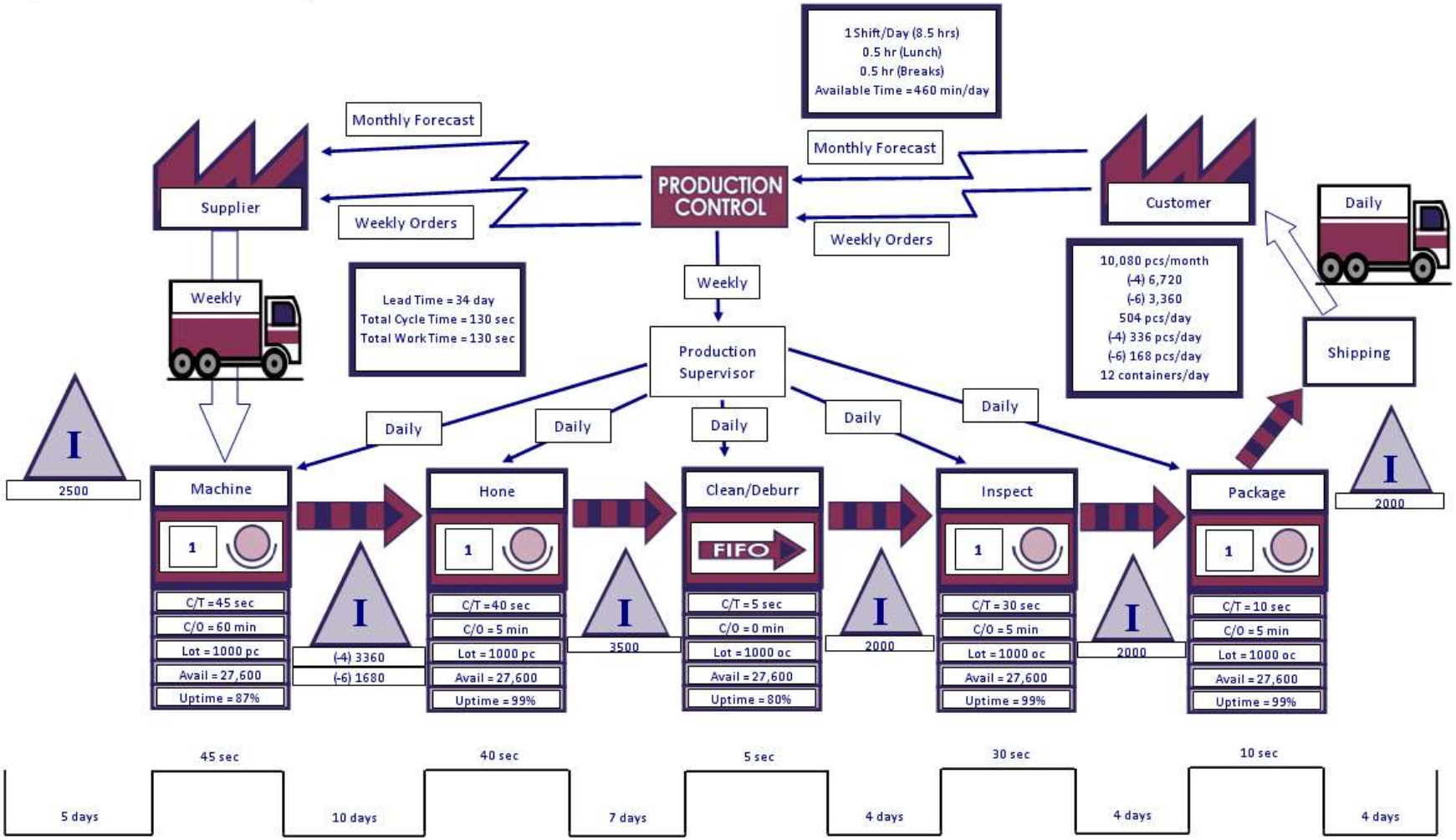






Templates & Calculators: Value Stream Mapping

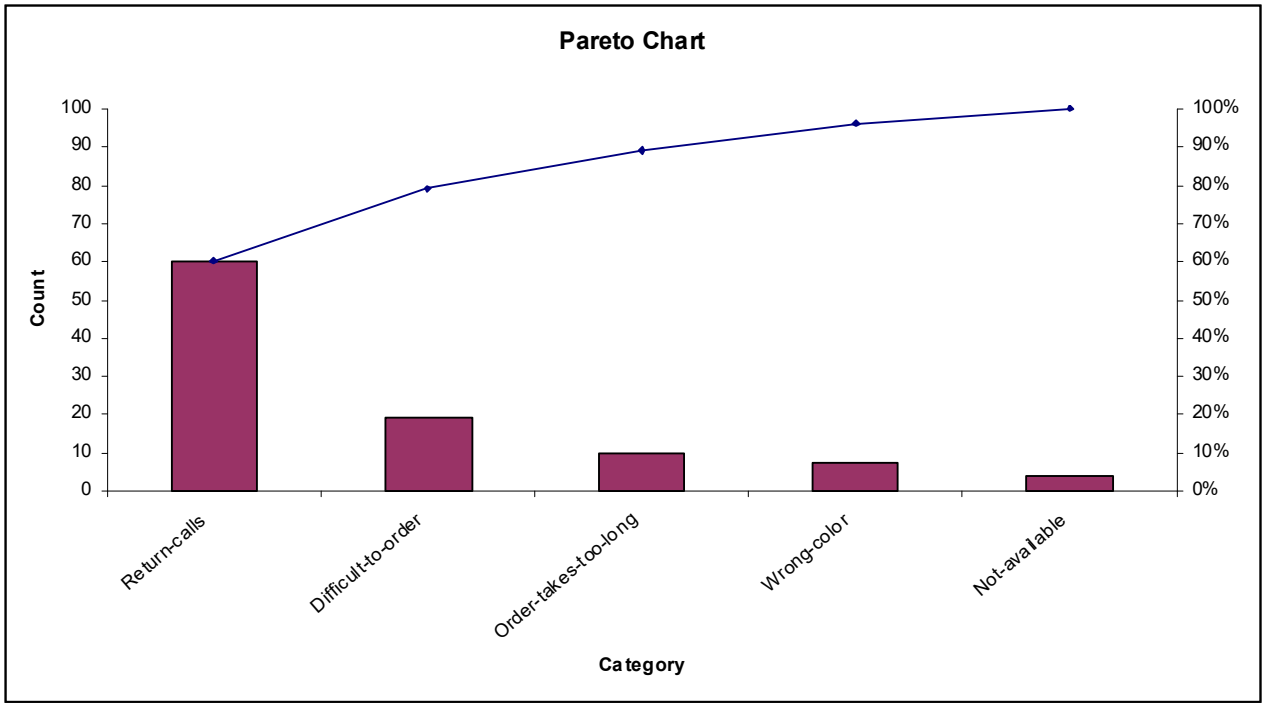
Example Present State Value Stream Map



Templates & Calculators: Pareto Chart Quick Template

Category	Count
Difficult-to-order	19
Not-available	4
Order-takes-too-long	10
Return-calls	60
Wrong-color	7

Pareto Chart



Templates & Calculators: Failure Mode & Effects Analysis (FMEA)

Potential Failure Mode & Effects Analysis

Process/Product:	Inventory Management
FMEA Team:	
Responsibility:	
Prepared By:	

Process								
Process Steps or Product Functions	Potential Failure Mode	Potential Effects of Failure	Severity (1-10)	Potential Cause(s) of Failure	Occurrence (1-10)	Current Controls	Detection (1-10)	Risk Priority Number (RPN)
Stock inventory	Stock in wrong location	Unable to locate stock	5	Correct location is full	7	Stock checked twice a year	9	315

Score	Severity Guidelines	
	AIAG	Six Sigma
10	Hazardous without warning	Injure a customer or employee
9	Hazardous with warning	Be illegal
8	Very High	Render product or service unfit for use
7	High	Cause extreme customer dissatisfaction
6	Moderate	Result in partial malfunction
5	Low	Cause a loss of performance which is likely to result in a complaint
4	Very Low	Cause minor performance loss
3	Minor	Cause a minor nuisance but can be overcome with no performance loss
2	Very Minor	Be unnoticed and have only minor effect on performance
1	None	Be unnoticed and not affect the performance

Templates & Calculators: Cause & Effect (XY) Matrix

CAUSE & EFFECT (XY) MATRIX

Process/Project Name:	Call Center Example
Date:	
Performed By:	
Notes:	

Output Variables (Y's):	Call Abandon Rate	Customer Satisfaction	Y3	Y4	Y5	Y6	Y7	Y8	Y9	Y10
Importance Score (1-10):	8	10								

Input/Process Variables (X's)	Table of Association Scores (X's to Y's)										Weighted Score
Answer Speed	9	9									162
Employee Experience	1	3									38
First Time Resolution	0	9									90
X4											0

Templates & Calculators: Sample Size Calculators

Sample Size Calculator - Discrete Data		
Sample Data (user inputs):		
Estimate of Proportion	P	0.5
Desired margin of error	delta / half-interval	0.03
Population Size (optional)	N	
Confidence level (enter .95 for 95%)	100*(1-α)%	95.0%
Results:		
Minimum Sample Size	n	1068
	n (adjusted for small N)	
	np check (should be ≥ 5)	534

Templates & Calculators: Sample Size Calculators

Sample Size Calculator - Continuous Data		
Sample Data (user inputs):		
Estimate of Standard Deviation	S	1
Desired margin of error	delta / half-interval	0.25
Population Size (optional)	N	
Confidence level (enter .95 for 95%)	100*(1-α)%	95.0%
Results:		
Minimum Sample Size	n	62
	n (adjusted for small N)	

Templates & Calculators: Minimum Sample Size for Robust Hypothesis Testing

Minimum Sample Size for Robust Hypothesis Testing		
Sample Data (user inputs):		
Hypothesis Test:		1 Sample t-Test
Alternative Hypothesis :	Ha	Not Equal To
Confidence Level:	100*(1-α)%	95%
Skewness:	Skew	1
Kurtosis:	Kurt	-0.48
Results:		
Minimum sample size for each sample/group:	n	30

Templates & Calculators: Process Sigma Level – Discrete

Process Sigma Level Calculator - Discrete Data		
Sample Data (user inputs):		
Number of units	n	500
Total number of defects observed	d	5
Number of defect opportunities per unit	o	1
Sigma Shift (typically +1.5 for long term data)		1.5
Results:		
Defects per Unit	dpu	0.01
Defects per Million Opportunities	dpmo	10,000.0
Defects per Opportunity	dpo%	1.00%
Yield	yield%	99.00%
Process Sigma Level	sigma	3.826

Templates & Calculators: Process Sigma Level – Continuous

Process Sigma Level Calculator - Continuous Data (Assumes that data are normally distributed)		
Sample Data (user inputs):		
Mean	x-bar	0
Standard Deviation	s	1
Upper Specification Limit	USL	3
Lower Specification Limit	LSL	-3
Sigma Shift (typically +1.5 for long term data)		1.5
Results:		
Expected dpm > USL		1349.9
Expected % > USL		0.13%
Expected dpm < LSL		1349.9
Expected % < LSL		0.13%
Expected dpm (overall)		2699.8
Expected yield (overall) %		99.73%
Process Sigma Level		4.282

Templates & Calculators: 2 Proportions Test and Confidence Interval

2 Proportions Test and Confidence Interval

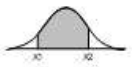
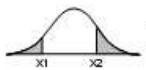
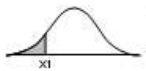
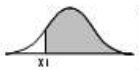
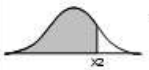
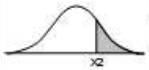
Sample Data (user inputs):		Sample 1	Sample 2
Number of Events	x	1	2
Sample Size	n	10	10
Null Hypothesis (hypothesized difference)	H_0: $P_1 - P_2$ =	0	
Alternative Hypothesis	H_a: $P_1 - P_2$	Not Equal To	
Confidence Level (enter .95 for 95%)	100*(1-α)%	95.0%	
Hypothesis Test Method		Fisher's Exact	
Confidence Interval Method		Newcombe-Wilson Score	

Results:		
Sample proportion (x/n)	0.1000	0.2000
Sample proportion difference	-0.1000	
alpha	0.0500	
Minimum expected value (should be >= 5 for normal approximation)	1.5000	
Fisher's Exact probability p-value (2-sided)	1.0000	
Upper Confidence Limit (2-sided)	0.2362	
Lower Confidence Limit (2-sided)	-0.4205	

Test Information		
Null Hypothesis H_0:	$P_1 - P_2 = 0$	Fail to Reject
Alternative Hypothesis H_a:	$P_1 - P_2 \neq 0$	

Templates & Calculators: Normal Distribution Probability Calculator

Normal Distribution Probability Calculator		
Input the following information:		
Mean	μ	0
Standard Deviation	σ	1
Lower Bound (or LSL)	X1	1
Upper Bound (or USL)	X2	2

Areas:	Select the Probability of Interest from the following probabilities:		
between X1 and X2		Prob(1 ≤ X ≤ 2)	0.135905122
outside X1 and X2		Prob(X ≤ 1 AND X ≥ 2)	0.864094878
below X1		Prob(X ≤ 1)	0.841344746
above X1		Prob(X ≥ 1)	0.158655254
below X2		Prob(X ≤ 2)	0.977249868
above X2		Prob(X ≥ 2)	0.022750132

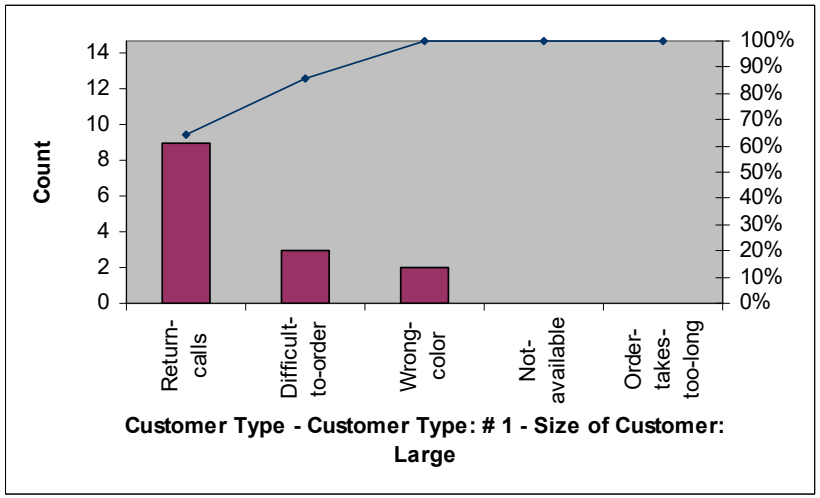
Graphical Tools

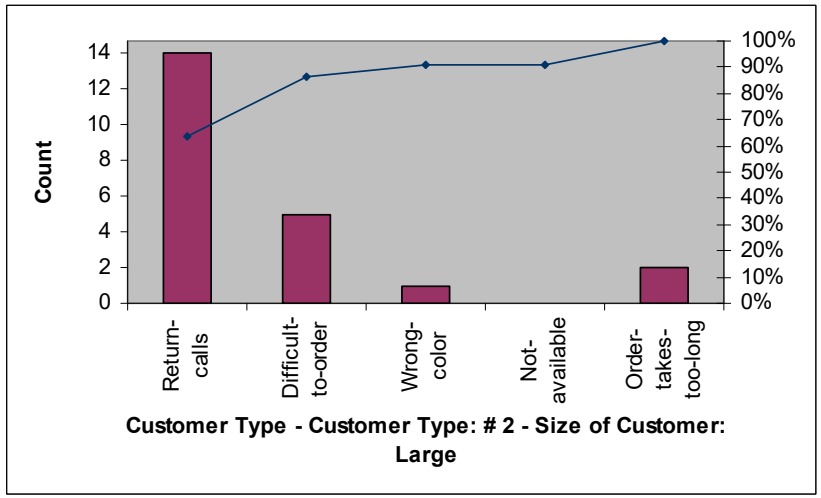
- Basic and Advanced (Multiple) Pareto Charts
- EZ-Pivot/Pivot Charts
- Run Charts (with Nonparametric Runs Test allowing you to test for Clustering, Mixtures, Lack of Randomness, Trends and Oscillation.)
- Basic Histogram
- Multiple Histograms and Descriptive Statistics (includes Confidence Interval for Mean and StDev., as well as Anderson-Darling Normality Test)
- Multiple Histograms and Process Capability (Pp, Ppk, Cpm, ppm, %)

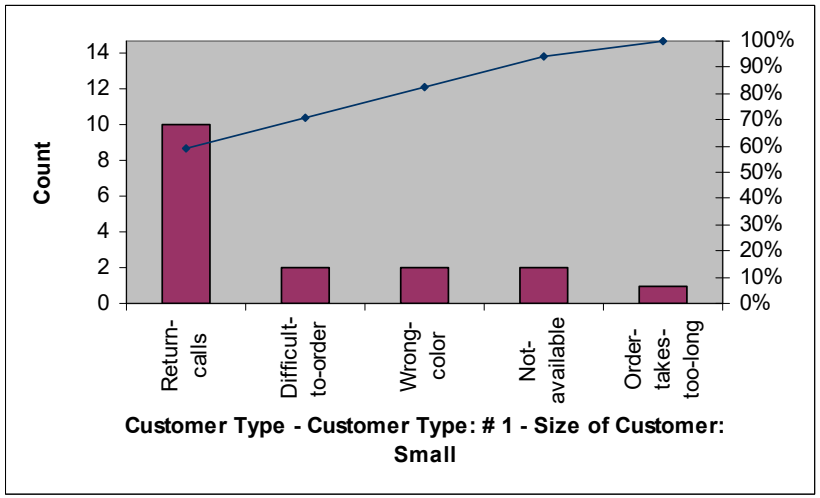
Graphical Tools

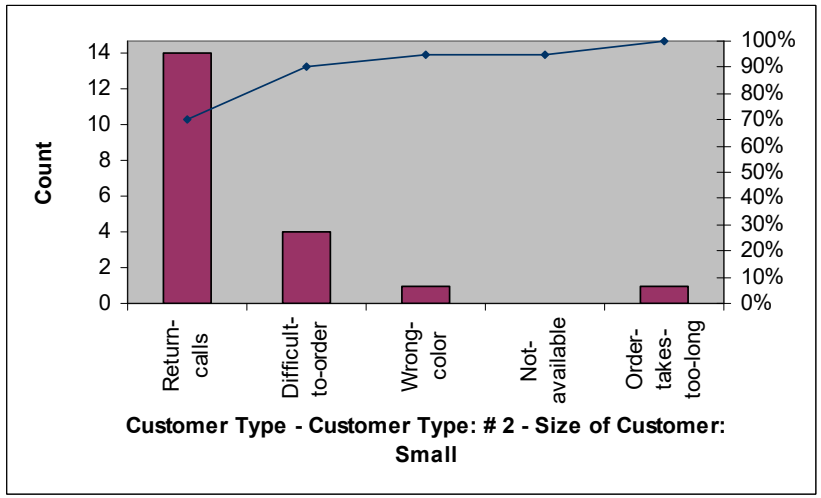
- Multiple Boxplots and Dotplots
- Multiple Normal Probability Plots (with 95% confidence intervals to ease interpretation of normality/non-normality)
- Multi-Vari Charts
- Scatter Plots (with linear regression and optional 95% confidence intervals and prediction intervals)
- Scatter Plot Matrix

Graphical Tools: Multiple Pareto Charts

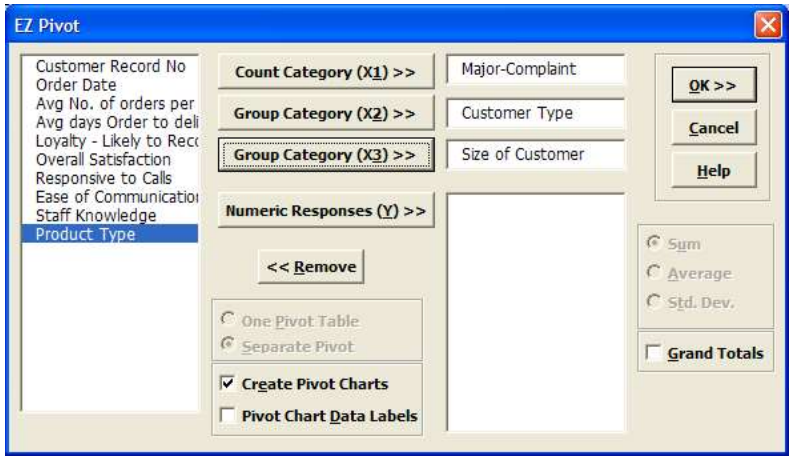




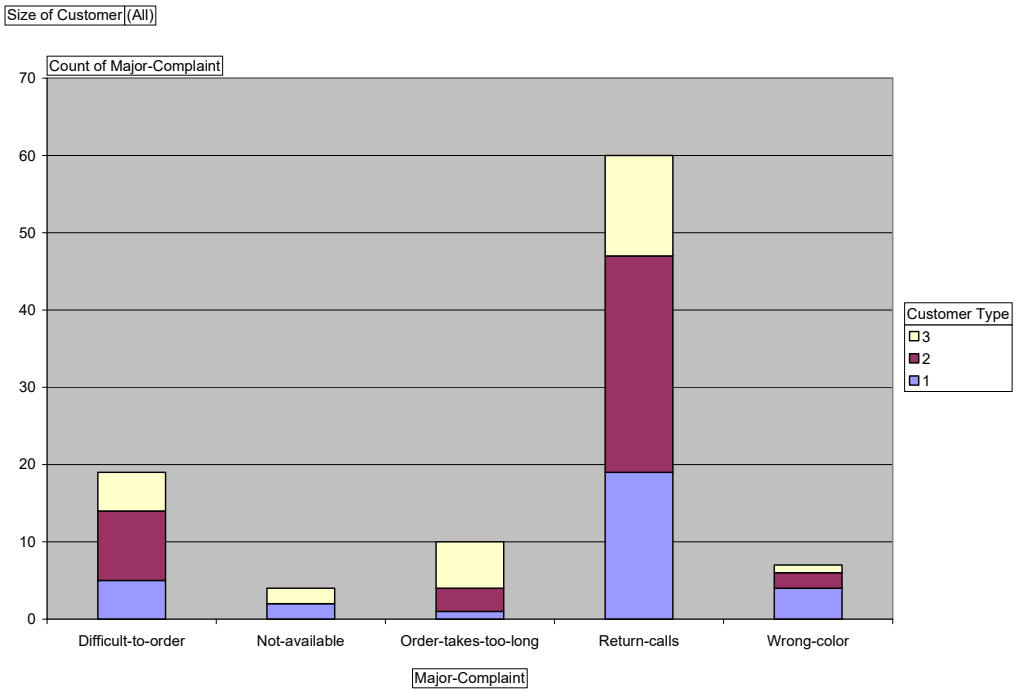




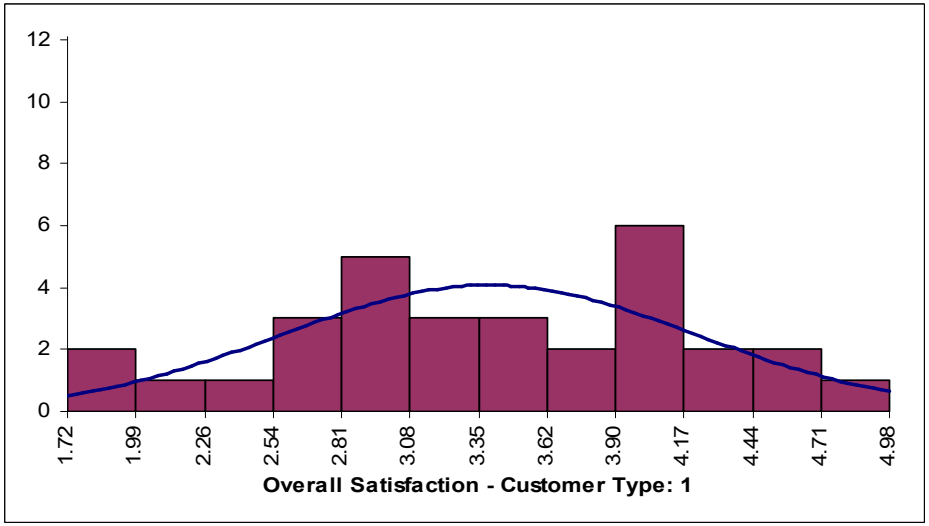
Graphical Tools: EZ-Pivot/Pivot Charts – The power of Excel's Pivot Table and Charts are now easy to use!



Size of Customer	(All)		
Count of Major-Complaint	Customer Type		
Major-Complaint	1	2	3
Difficult-to-order	5	9	5
Not-available	2		2
Order-takes-too-long	1	3	6
Return-calls	19	28	13
Wrong-color	4	2	1



Graphical Tools: Multiple Histograms & Descriptive Statistics



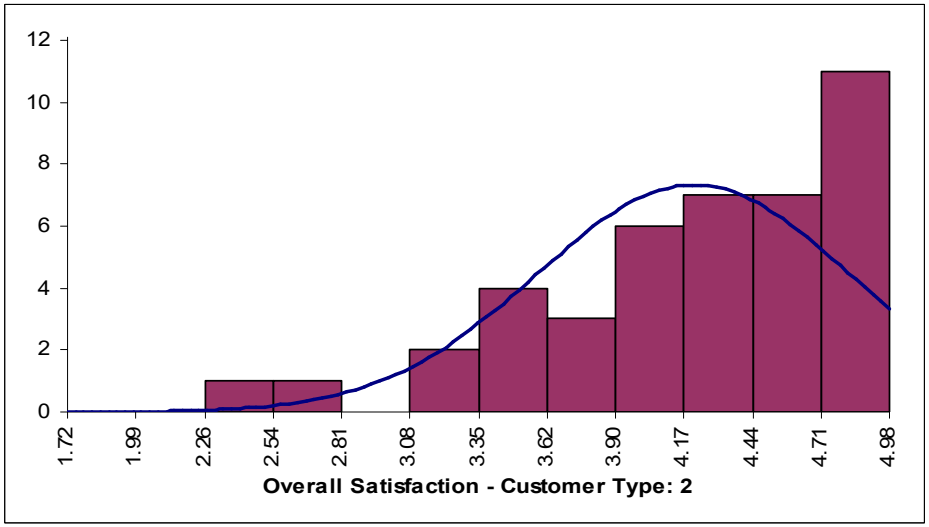
Overall Satisfaction - Customer Type: 1

Count = 31
Mean = 3.3935
Stdev = 0.824680
Range = 3.1

Minimum = 1.7200
25th Percentile (Q1) = 2.8100
50th Percentile (Median) = 3.5600
75th Percentile (Q3) = 4.0200
Maximum = 4.8

95% CI Mean = 3.09 to 3.7
95% CI Sigma = 0.659012 to 1.102328

Anderson-Darling Normality Test:
A-Squared = 0.312776; P-value = 0.5306



Overall Satisfaction - Customer Type: 2

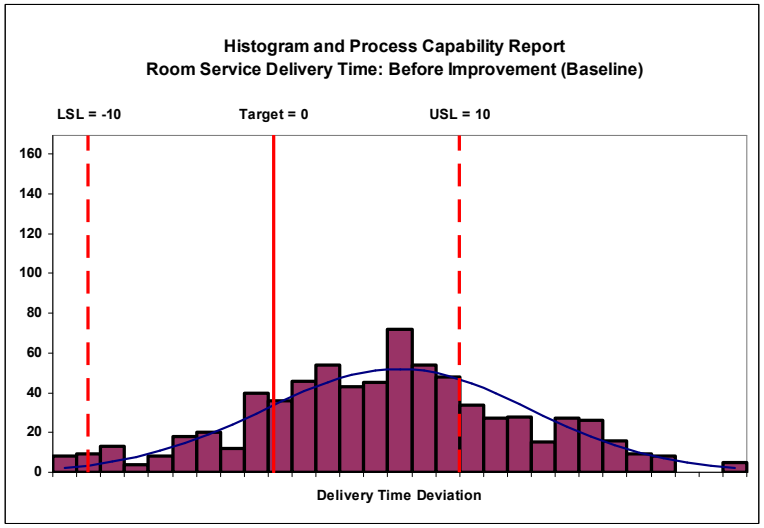
Count = 42
Mean = 4.2052
Stdev = 0.621200
Range = 2.6

Minimum = 2.4200
25th Percentile (Q1) = 3.8275
50th Percentile (Median) = 4.3400
75th Percentile (Q3) = 4.7250
Maximum = 4.98

95% CI Mean = 4.01 to 4.4
95% CI Sigma = 0.511126 to 0.792132

Anderson-Darling Normality Test:
A-Squared = 0.826259; P-value = 0.0302

Graphical Tools: Multiple Histograms & Process Capability



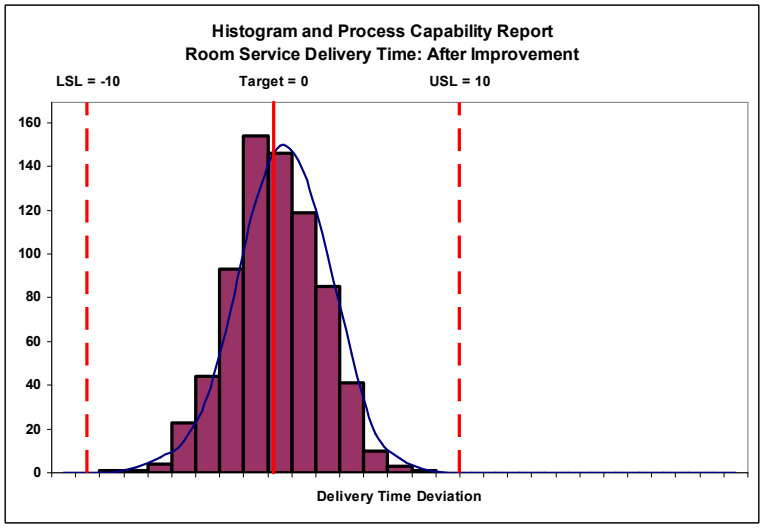
Count = 725
Mean = 6.0036
Stdev (Overall) = 7.1616
USL = 10; Target = 0; LSL = -10

Capability Indices using Overall Standard Deviation
Pp = 0.47
Ppu = 0.19; Ppl = 0.74
Ppk = 0.19
Cpm = 0.36
Sigma Level = 2.02

Expected Overall Performance
ppm > USL = 288409.3
ppm < LSL = 12720.5
ppm Total = 301129.8
% > USL = 28.84%
% < LSL = 1.27%
% Total = 30.11%

Actual (Empirical) Performance
% > USL = 26.90%
% < LSL = 1.38%
% Total = 28.28%

Anderson-Darling Normality Test
A-Squared = 0.708616; P-value = 0.0641



Count = 725
Mean = 0.09732
Stdev (Overall) = 2.3856
USL = 10; Target = 0; LSL = -10

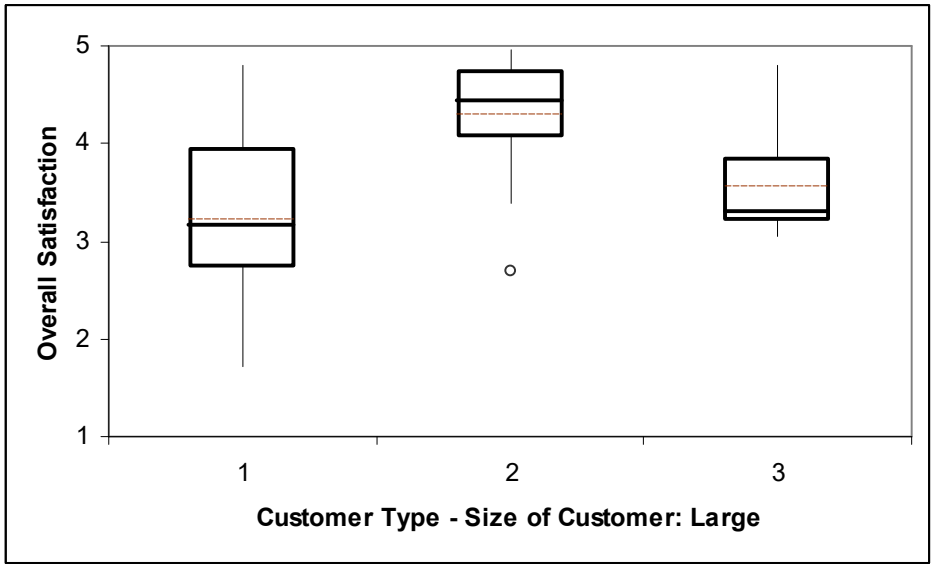
Capability Indices using Overall Standard Deviation
Pp = 1.40
Ppu = 1.38; Ppl = 1.41
Ppk = 1.38
Cpm = 1.40
Sigma Level = 5.53

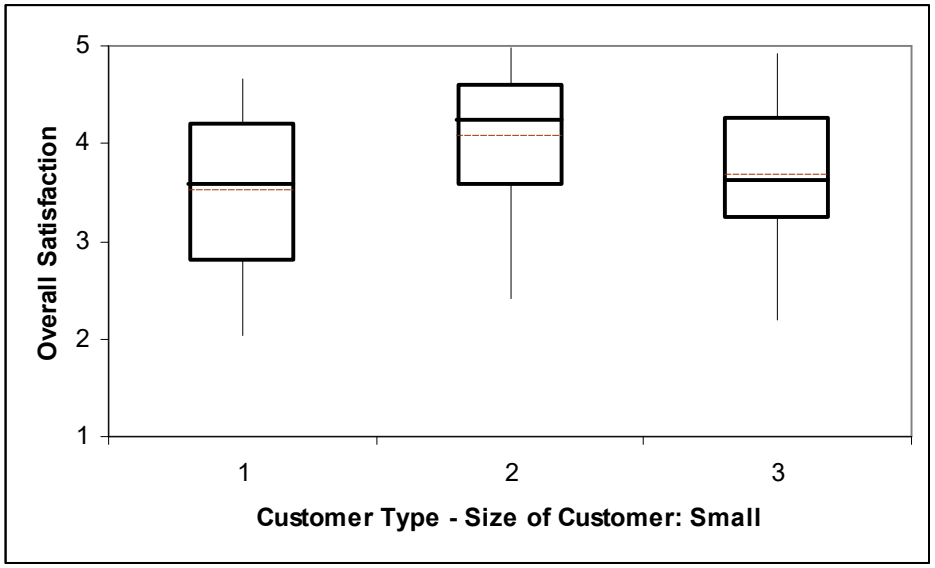
Expected Overall Performance
ppm > USL = 16.5
ppm < LSL = 11.5
ppm Total = 28.1
% > USL = 0.00%
% < LSL = 0.00%
% Total = 0.00%

Actual (Empirical) Performance
% > USL = 0.00%
% < LSL = 0.00%
% Total = 0.00%

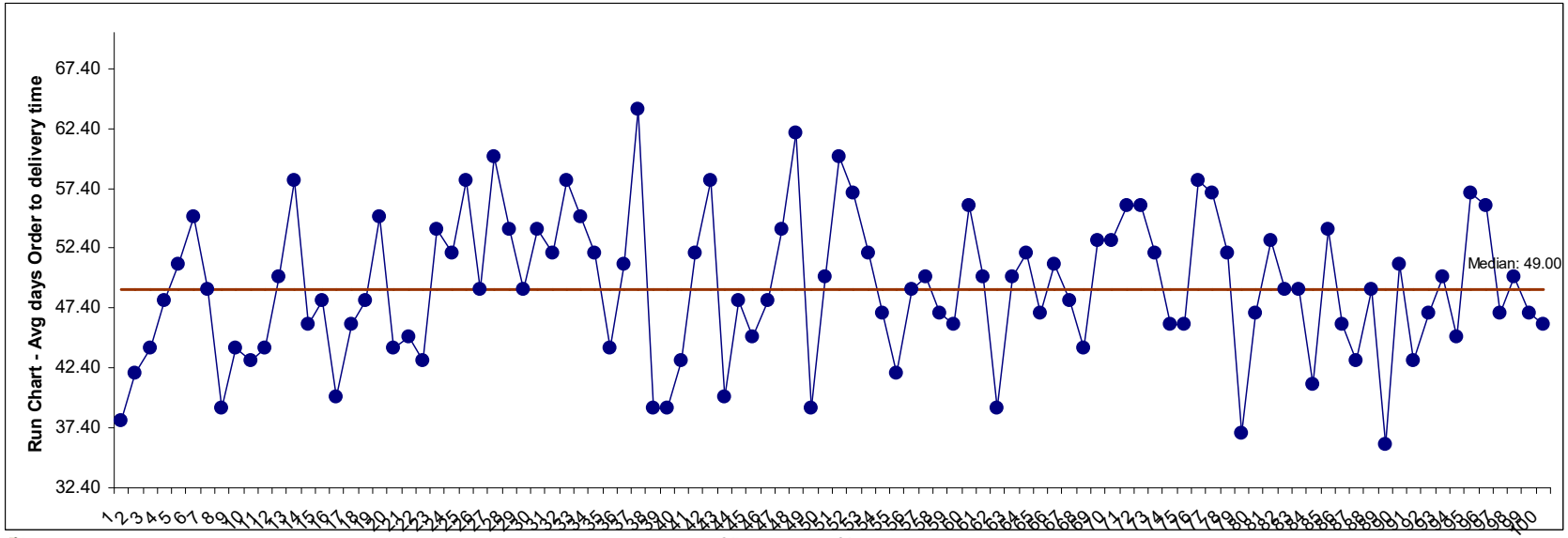
Anderson-Darling Normality Test
A-Squared = 0.189932; P-value = 0.8991

Graphical Tools: Multiple Boxplots



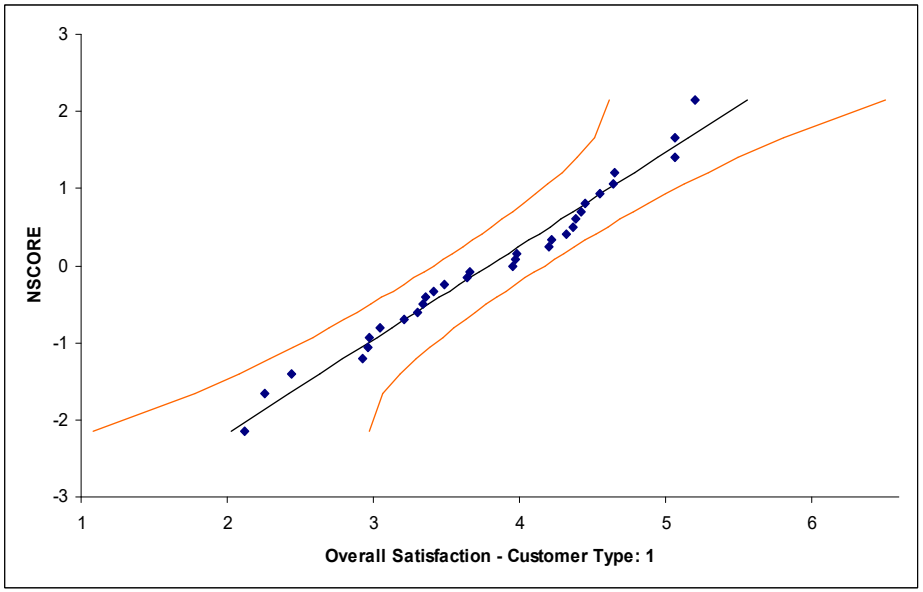


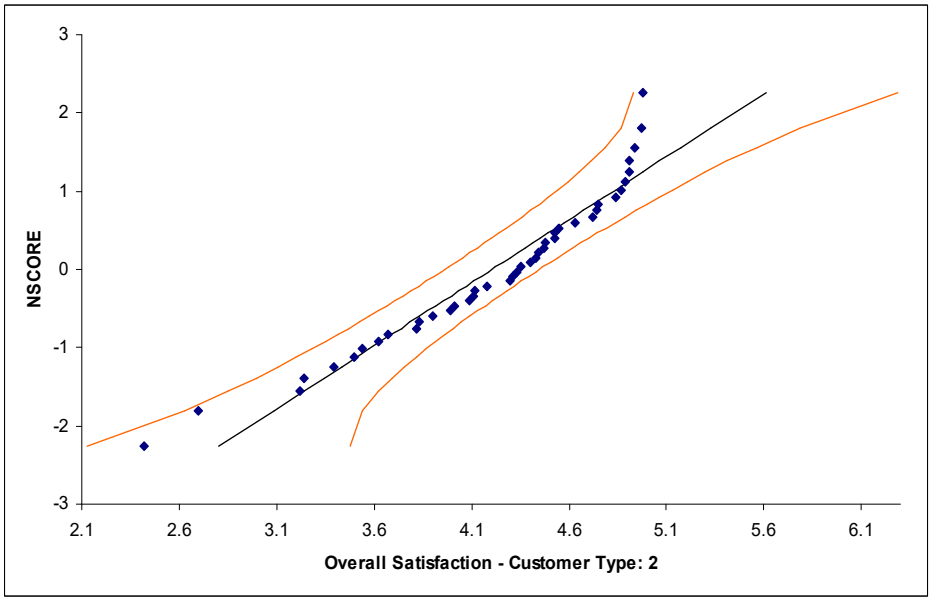
Graphical Tools: Run Charts with Nonparametric Runs Test



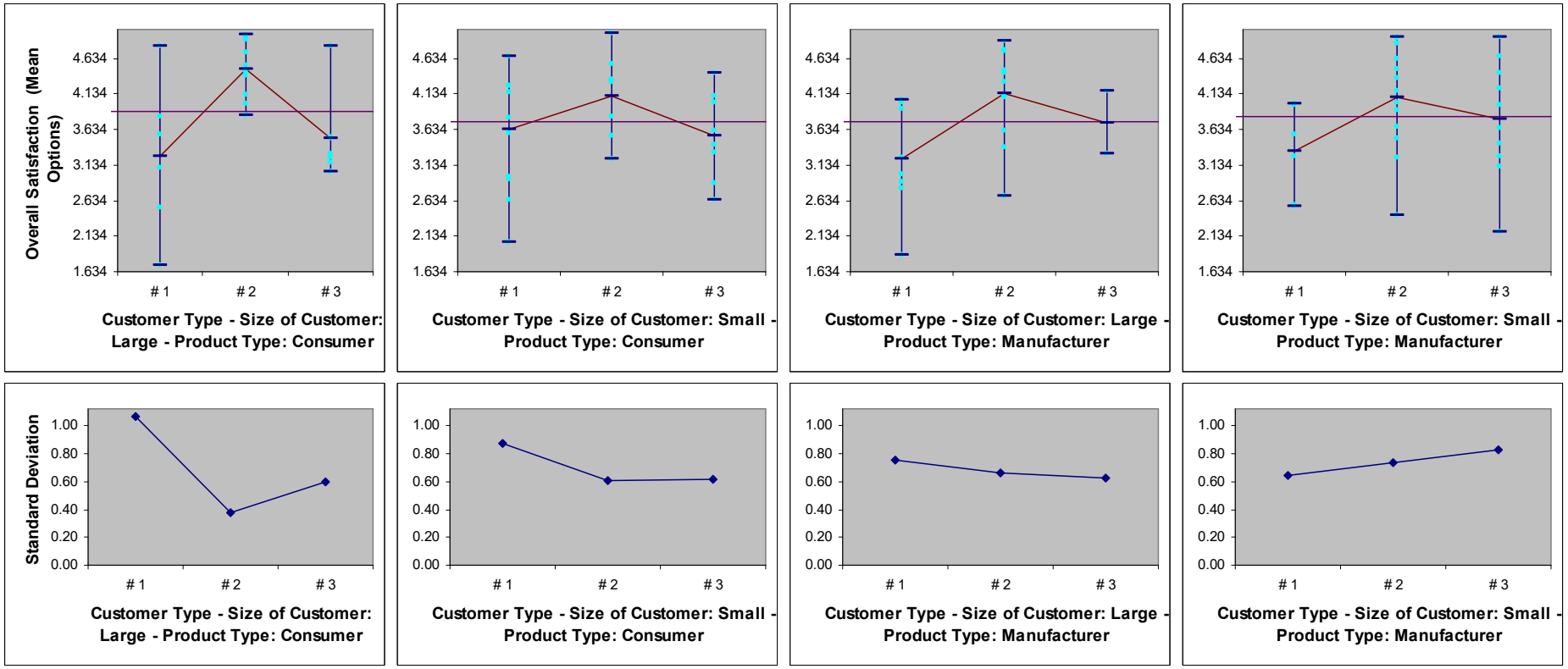
Nonparametric Runs Test: Avg days Order to delivery time	
Number of Runs about Median:	45
Expected Number of Runs about Median:	50.68
Number of Points above Median:	46
Number of Points equal to or below Median:	54
P-Value for Clustering:	0.1252
P-Value for Mixtures:	0.8748
P-Value for Lack of Randomness (2-Sided):	0.2505
Number of Runs Up or Down:	60
Expected Number of Runs Up or Down:	66.33333
P-Value for Trends:	0.0648
P-Value for Oscillation:	0.9352

Graphical Tools: Multiple Normal Probability Plots

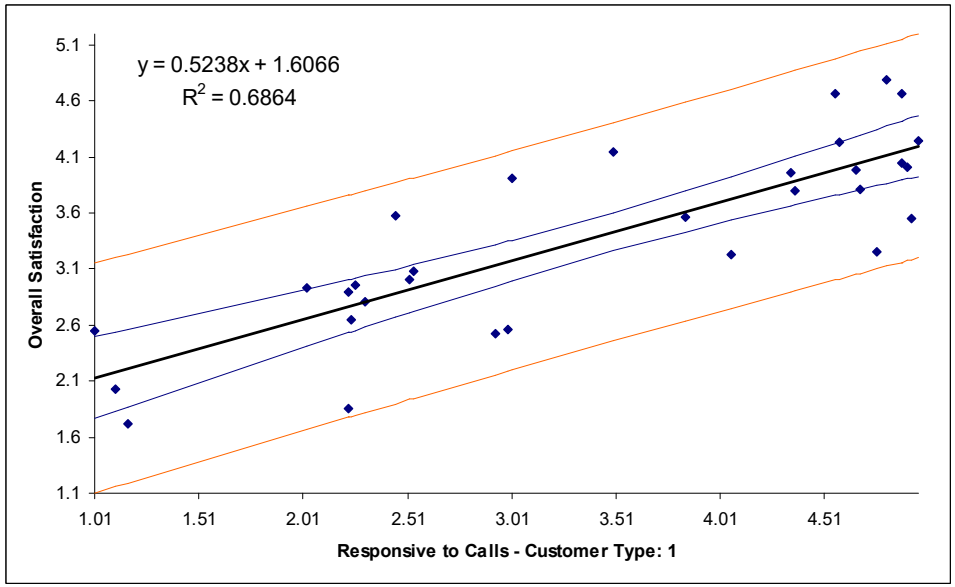


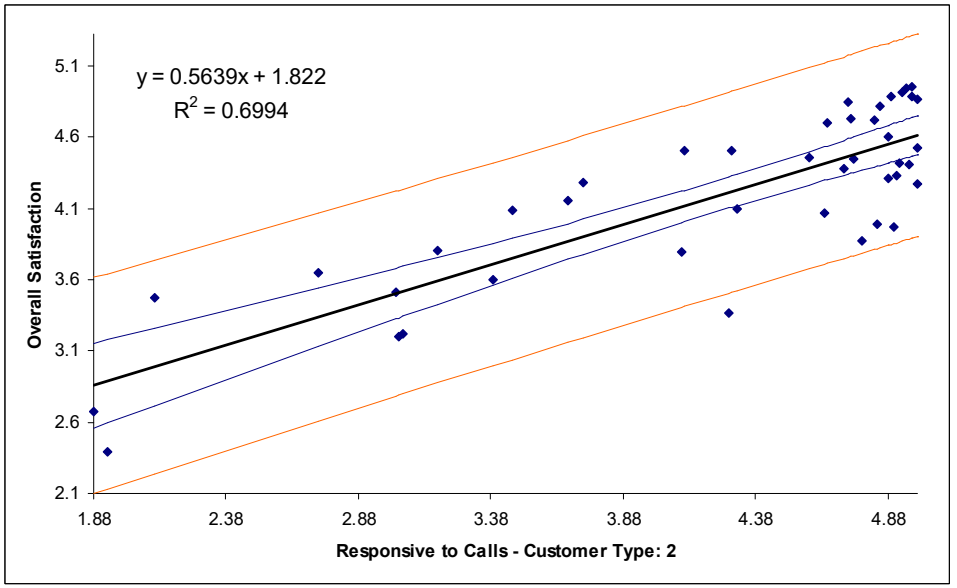


Graphical Tools: Multi-Vari Charts



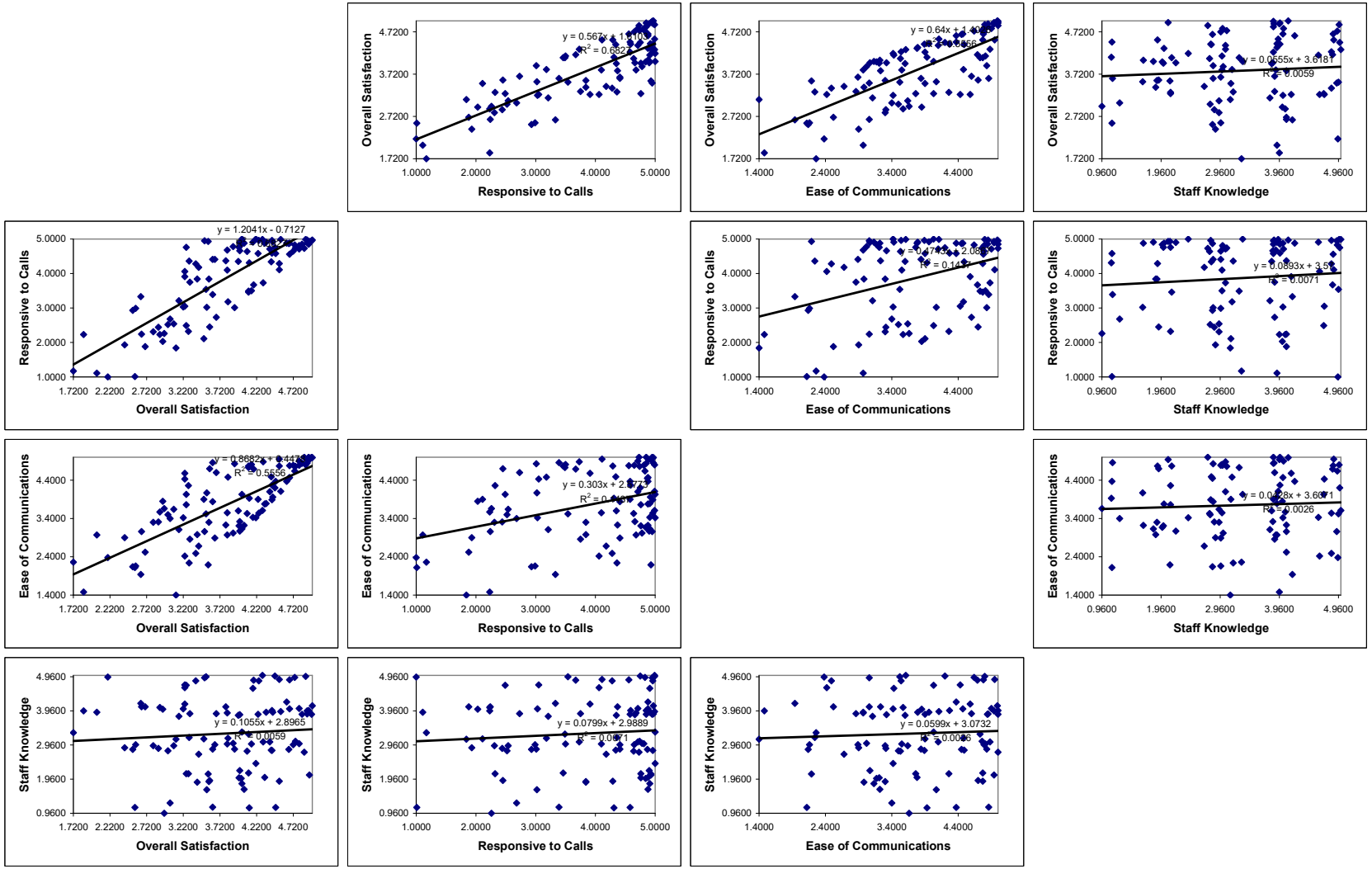
Graphical Tools: Multiple Scatterplots with Linear Regression





Linear Regression with 95% Confidence Interval and Prediction Interval

Graphical Tools: Scatterplot Matrix



Statistical Tools

- P-values turn red when results are significant (p-value < alpha)
- Descriptive Statistics including Anderson-Darling Normality test, Skewness and Kurtosis with p-values
- 1 Sample t-test and confidence intervals
  - Optional Assumptions Report
- Paired t-test, 2 Sample t-test
  - Optional Assumptions Report

Statistical Tools

- 2 Sample Comparison Tests
  - Normality, Mean, Variance, Median
  - Yellow Highlight to aid Interpretation
- One-Way ANOVA and Means Matrix
  - Optional Assumptions Report
- Two-Way ANOVA
  - Balanced and Unbalanced

Statistical Tools

- Equal Variance Tests:
  - Bartlett
  - Levene
  - Welch's ANOVA (with optional assumptions report)
- Correlation Matrix
  - Pearson's Correlation Coefficient
  - Spearman's Rank
  - Yellow highlight to recommend Pearson or Spearman based on bivariate normality test

Statistical Tools

- Multiple Linear Regression
- Binary and Ordinal Logistic Regression
- Chi-Square Test (Stacked Column data and Two-Way Table data)
- Chi-Square – Fisher's Exact and Monte Carlo Exact

Statistical Tools

- Nonparametric Tests
- Nonparametric Tests – Exact and Monte Carlo Exact
- Power and Sample Size Calculators
- Power and Sample Size Charts

Statistical Tools: Two-Sample Comparison Tests

2 Sample Comparison Test - Overall Satisfaction		
Customer Type	1	2
Count	31	42
Mean	3.3935	4.2052
Median	3.5600	4.3400
Standard Deviation	0.824680	0.621200
AD Normality Test p-value	0.5306	0.0302
Test for Equal Variances:		
F-test (use with normal data):		
F	1.7624	
p-value (2-sided)	0.0916	
Levene's test (use with non-normal data):		
p-value (2-sided)	0.0443	
2 Sample t-test for means:		
Assume Equal Variance:		
t	-4.7991	
p-value (2-sided)	0.0000	
p-value (1-sided)	0.0000	
Assume Unequal Variance:		
t	-4.6007	
p-value (2-sided)	0.0000	
p-value (1-sided)	0.0000	
2 Sample Mann-Whitney test for medians:		
p-value (2-sided)	0.0000	
p-value (1-sided)	0.0000	

P-values turn red when results are significant!

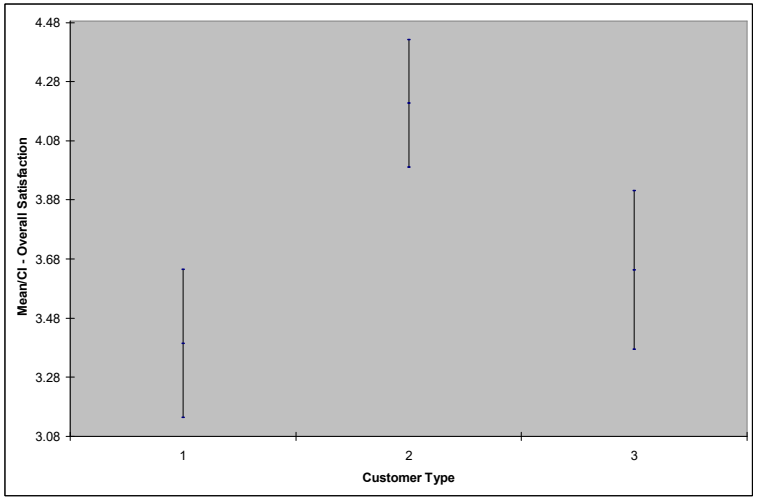
Rules based yellow highlight to aid interpretation!

Statistical Tools: One-Way ANOVA & Means Matrix

One-Way ANOVA & Means Matrix: Overall Satisfaction				
H0: Mean 1 = Mean 2 = … = Mean k				
Ha: At least one pair Mean i ≠ Mean j				
Customer Type	1	2	3	
Count	31	42	27	
Mean	3.3935	4.2052	3.6411	
Standard Deviation	0.824680	0.621200	0.670478	
UC (2-sided, 95%, pooled)	3.6441	4.4205	3.9096	
LC (2-sided, 95%, pooled)	3.1430	3.9900	3.3727	
ANOVA:				
Pooled Standard Deviation =	0.702810		R-Sq =	20.95%
DF =	97		R-Sq adj. =	19.32%
F =	12.856			
p-value =	0.0000			

Pairwise Mean Difference (row - column)	1	2	3
1	0	-0.811690	-0.247563
2		0	0.564127
3			0

Pairwise Probabilities	1	2	3
1		0.0000	0.1840
2			0.0016
3			



Statistical Tools: One-Way ANOVA & Means Matrix

One-Way ANOVA Assumptions Report			
Normality:	Anderson Darling P-Value = 0.531. Fail to reject null hypothesis: "data are sampled from a normal distribution," so conclude that the assumption of normality is not violated.	Anderson Darling P-Value = 0.030. Reject null hypothesis: "data are sampled from a normal distribution," so conclude that the assumption of normality is violated (at 95% confidence level). Skewness value = -0.9680 and Kurtosis value = 0.6796. See robustness and outliers.	Anderson Darling P-Value = 0.360. Fail to reject null hypothesis: "data are sampled from a normal distribution," so conclude that the assumption of normality is not violated.
Robustness:	Minimum sample size for a robust ANOVA test = 2. Since each sample size is greater than this, the ANOVA test is robust to nonnormality.		
Outliers (Boxplot Rules):	No outliers found.	Potential (1.5*IQR) outlier lower count = 1. It is recommended to review the data with graphical tools: Boxplot, Normal Probability Plot, Histogram and Run Chart / Control Chart. Consider using a Nonparametric Test.	No outliers found.
Randomness (Independence):	Nonparametric Runs Test (Exact) P-Value = 0.066. Fail to reject null hypothesis: "data are random," so conclude that the assumption of randomness (serial independence) is not violated.	Nonparametric Runs Test (Exact) P-Value = 1.000. Fail to reject null hypothesis: "data are random," so conclude that the assumption of randomness (serial independence) is not violated.	Nonparametric Runs Test (Exact) P Value = 1.000. Fail to reject null hypothesis: "data are random," so conclude that the assumption of randomness (serial independence) is not violated.
Equal Variance:	Levene's test for Equal Variances P-Value = 0.115. Fail to reject null hypothesis: "variances are equal," so conclude that the assumption of equal variances (or standard deviations) is not violated.		

Statistical Tools: Correlation Matrix

Pearson Correlations	Avg No. of orders per mo	Avg days Order to delivery time	Loyalty - Likely to Recommend	Overall Satisfaction	Responsive to Calls	Ease of Communications	Staff Knowledge
Avg No. of orders per mo	1	-0.0518	-0.0491	0.1155	0.1076	0.0885	0.0186
Avg days Order to delivery time		1	0.1307	0.3210	0.2725	0.2681	-0.0781
Loyalty - Likely to Recommend			1	0.6599	0.5805	0.4622	0.0176
Overall Satisfaction				1	0.8262	0.7454	0.0766
Responsive to Calls					1	0.3791	0.0845
Ease of Communications						1	0.0506
Staff Knowledge							1

Pearson Probabilities	Avg No. of orders per mo	Avg days Order to delivery time	Loyalty - Likely to Recommend	Overall Satisfaction	Responsive to Calls	Ease of Communications	Staff Knowledge
Avg No. of orders per mo		0.6090	0.6279	0.2527	0.2865	0.3812	0.8541
Avg days Order to delivery time			0.1949	**0.0011**	**0.0061**	**0.0070**	0.4398
Loyalty - Likely to Recommend				**0.0000**	**0.0000**	**0.0000**	0.8622
Overall Satisfaction					**0.0000**	**0.0000**	0.4490
Responsive to Calls						**0.0001**	0.4035
Ease of Communications							0.6171
Staff Knowledge							

Spearman Rank Correlations	Avg No. of orders per mo	Avg days Order to delivery time	Loyalty - Likely to Recommend	Overall Satisfaction	Responsive to Calls	Ease of Communications	Staff Knowledge
Avg No. of orders per mo	1	-0.0305	-0.0917	0.1006	0.0738	0.1000	0.0187
Avg days Order to delivery time		1	0.1097	0.3407	0.2489	0.2613	-0.0828
Loyalty - Likely to Recommend			1	0.6167	0.5507	0.4071	-0.0190
Overall Satisfaction				1	0.7782	0.7509	0.0890
Responsive to Calls					1	0.3204	0.0895
Ease of Communications						1	0.0716
Staff Knowledge							1

Spearman Rank Probabilities	Avg No. of orders per mo	Avg days Order to delivery time	Loyalty - Likely to Recommend	Overall Satisfaction	Responsive to Calls	Ease of Communications	Staff Knowledge
Avg No. of orders per mo		0.7629	0.3643	0.3192	0.4655	0.3222	0.8532
Avg days Order to delivery time			0.2774	**0.0005**	**0.0125**	**0.0087**	0.4127
Loyalty - Likely to Recommend				**0.0000**	**0.0000**	**0.0000**	0.8514
Overall Satisfaction					**0.0000**	**0.0000**	0.3786
Responsive to Calls						**0.0012**	0.3758
Ease of Communications							0.4792
Staff Knowledge							

Statistical Tools: Multiple Linear Regression

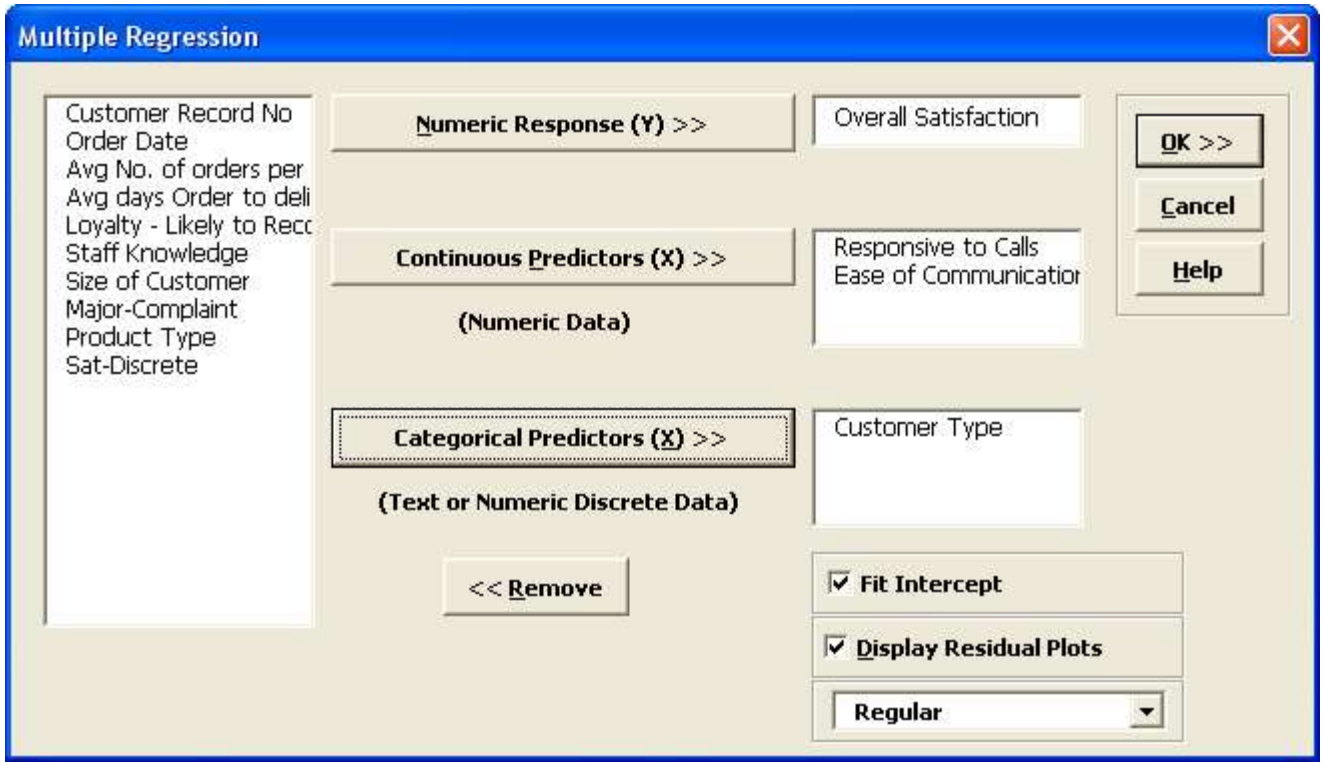
- Accepts continuous and/or categorical (discrete) predictors.
  - Categorical Predictors are coded with a 0,1 scheme making the interpretation easier than the -1,0,1 scheme used by competitive products.

- Interactive Predicted Response Calculator with 95% Confidence Interval and 95% Prediction Interval.

Statistical Tools: Multiple Linear Regression

- Residual plots: histogram, normal probability plot, residuals vs. time, residuals vs. predicted and residuals vs. X factors
- Residual types include Regular, Standardized, Studentized
- Cook's Distance (Influence), Leverage and DFITS
- Highlight of significant outliers in residuals
- Durbin-Watson Test for Autocorrelation in Residuals with p-value
- Pure Error and Lack-of-fit report
- Collinearity Variance Inflation Factor (VIF) and Tolerance report
- Fit Intercept is optional

Statistical Tools: Multiple Regression



Multiple Regression accepts Continuous and/or Categorical Predictors!

Statistical Tools: Multiple Regression

Multiple Regression Model: Overall Satisfaction = (0.552345) + (0.427400) * Responsive to Calls + (0.409625) * Ease of Communications + (0.132728) * Customer Type_2 + (0.023142) * Customer Type_3

Model Summary:

R-Square	90.58%
R-Square Adjusted	90.18%
S (Root Mean Square Error)	0.245199119

Parameter Estimates:

Predictor Term	Coefficient	SE Coefficient	T	P	VIF	Tolerance
Constant	0.552345	0.120148	4.5972	0.0000		
Responsive to Calls	0.427400	0.023788018	17.967	0.0000	1.2116	0.825379
Ease of Communications	0.409625	0.031120872	13.162	0.0000	1.3246	0.754950
Customer Type_2	0.132728	0.063914154	2.0767	0.0405	1.6551	0.604180
Customer Type_3	0.023141785	0.065217411	0.354841	0.7235	1.3944	0.717173

Analysis of Variance for Categorical (Discrete) Predictors:

Predictor Term	DF	SS	MS	F	P
Customer Type	2	0.299651	0.14982557 4	2.492000584	0.0881

Analysis of Variance for Model:

Source	DF	SS	MS	F	P
Model	4	54.901	13.725	228.29	0.0000
Error	95	5.7116	0.060122608		
Total (Model + Error)	99	60.612	0.612246		

Durbin-Watson Test for Autocorrelation in Residuals:

DW Statistic	1.7302
P-Value Positive Autocorrelation	0.0888
P-Value Negative Autocorrelation	0.9137

Durbin-Watson Test with p-values for positive and negative autocorrelation!

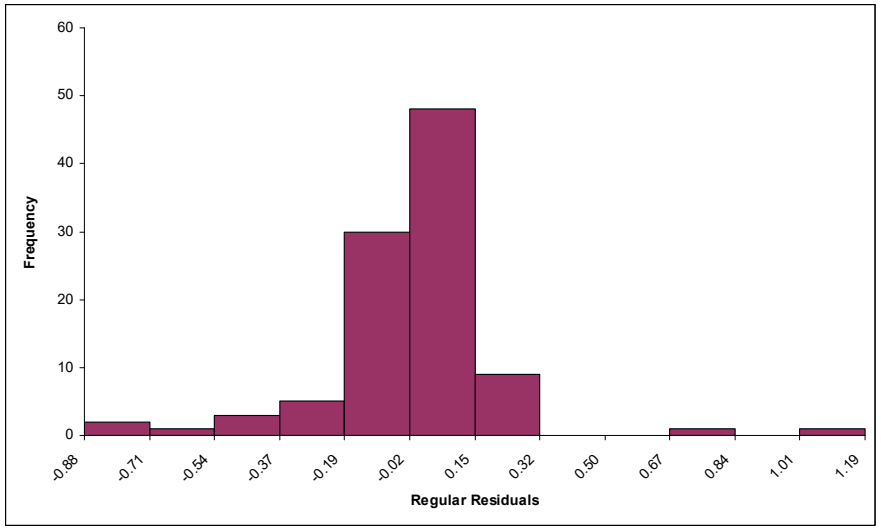
Statistical Tools: Multiple Regression – Predicted Response Calculator with Confidence Intervals

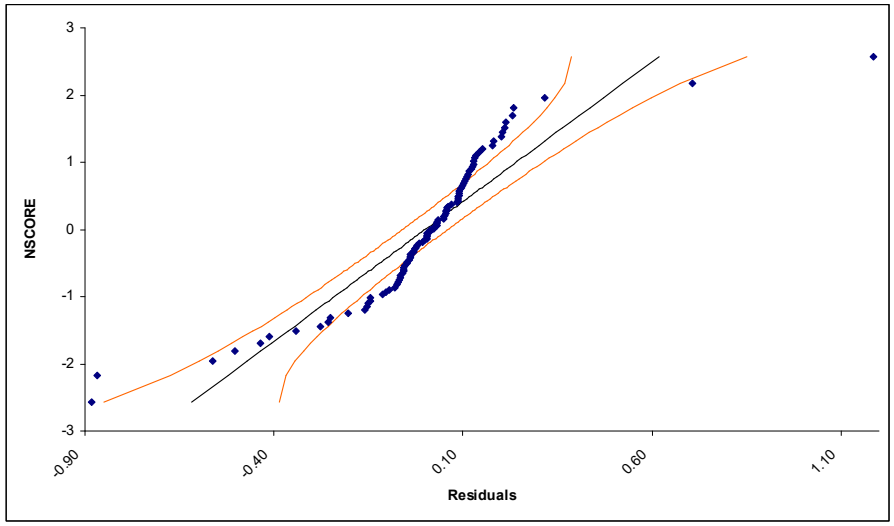
Predicted Response Calculator:

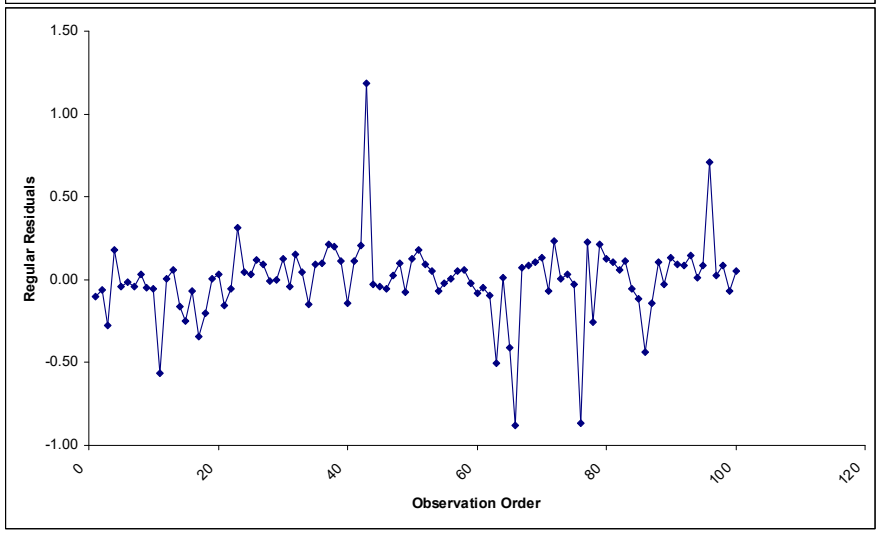
Predictors	Enter Settings:	Predicted Response	Lower 95% CI	Upper 95% CI	Lower 95% PI	Upper 95% PI
Responsive to Calls	5	0.99238657	4.778492731	4.961905131	4.374854056	5.365543806
Ease of Communications	5					
Customer Type_2	1					
Customer Type_3	0					

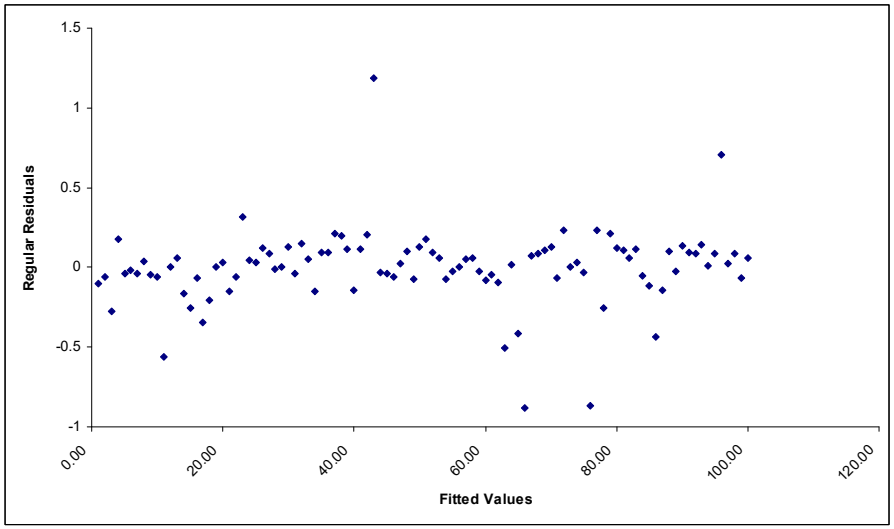
Easy-to-use Calculator with Confidence Intervals and Prediction Intervals!

Statistical Tools: Multiple Regression with Residual Plots









Statistical Tools: Binary and Ordinal Logistic Regression

- Powerful and user-friendly logistic regression.
- Report includes a calculator to predict the response event probability for a given set of input X values.
- Categorical (discrete) predictors can be included in the model in addition to continuous predictors.
- Model summary and goodness of fit tests including Likelihood Ratio Chi-Square, Pseudo R-Square, Pearson Residuals Chi-Square, Deviance Residuals Chi-Square, Observed and Predicted Outcomes – Percent Correctly Predicted.

Statistical Tools: Nonparametric Tests

- 1 Sample Sign
- 1 Sample Wilcoxon
- 2 Sample Mann-Whitney
- Kruskal-Wallis Median Test
- Mood's Median Test
- Kruskal-Wallis and Mood's include a graph of Group Medians and 95% Median Confidence Intervals
- Runs Test

Statistical Tools: Nonparametric Tests - Exact

- 1 Sample Wilcoxon – Exact
- 2 Sample Mann-Whitney – Exact & Monte Carlo Exact
- Kruskal-Wallis – Exact & Monte Carlo Exact
- Mood's Median Test – Exact & Monte Carlo Exact
- Runs Test - Exact

Statistical Tools: Chi-Square Test

Chi-Square Test			
Major-Complaint - Customer Type			
Observed Counts	1	2	3
Difficult-to-order	5	9	5
Not-available	2	0	2
Order-takes-too-long	1	3	6
Return-calls	19	28	13
Wrong-color	4	2	1
Expected Counts	1	2	3
Difficult-to-order	5.8900	7.9800	5.1300
Not-available	1.2400	1.6800	1.08
Order-takes-too-long	3.1000	4.2000	2.7000
Return-calls	18.600	25.200	16.200
Wrong-color	2.1700	2.9400	1.8900
Std. Residuals	1	2	3
Difficult-to-order	-0.366718	0.361076	-0.057396402
Not-available	0.682500	-1.2961	0.885270
Order-takes-too-long	-1.1927	-0.585540	2.0083
Return-calls	0.092747779	0.557773	-0.795046
Wrong-color	1.2423	-0.548219	-0.647380
Chi-Square	12.211		
DF	8		
p-value	0.1420		
Note: 9 out of 15 cells have expected counts less than 5.			

Statistical Tools: Chi-Square Test – Fisher's Exact

Chi-Square - Fisher's Exact			
Major-Complaint - Customer Type			
Observed Counts	**1**	**2**	**3**
Difficult-to-order	5	9	5
Not-available	2	0	2
Order-takes-too-long	1	3	6
Return-calls	19	28	13
Wrong-color	4	2	1
Expected Counts	**1**	**2**	**3**
Difficult-to-order	5.890	7.980	5.130
Not-available	1.240	1.680	1.08
Order-takes-too-long	3.100	4.200	2.700
Return-calls	18.600	25.200	16.200
Wrong-color	2.170	2.940	1.890
Std. Residuals	**1**	**2**	**3**
Difficult-to-order	-0.366718	0.361076	-0.057396402
Not-available	0.682500	-1.296	0.885270
Order-takes-too-long	-1.193	-0.585540	2.008
Return-calls	0.092747779	0.557773	-0.795046
Wrong-color	1.242	-0.548219	-0.647380
Chi-Square	12.211		
DF	8		
Chi-Square P-Value	0.1420		
Fisher's Exact P-Value	0.1469		
Note: 9 out of 15 cells have expected counts less than 5.			

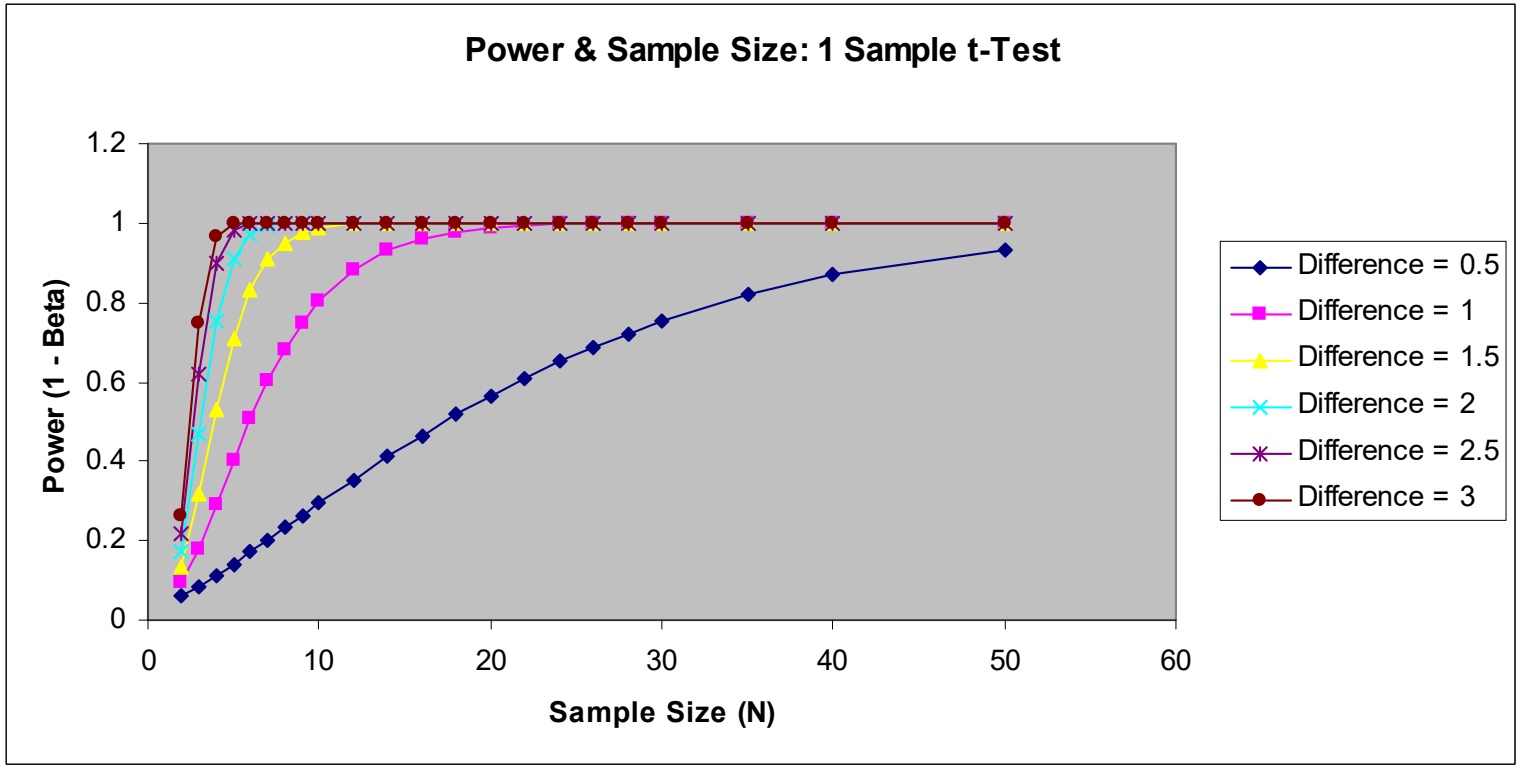
Statistical Tools: Chi-Square Test – Fisher's Monte Carlo

Chi-Square Test - Fisher's Monte-Carlo			
Major-Complaint - Customer Type			
Observed Counts	**1**	**2**	**3**
Difficult-to-order	5	9	5
Not-available	2	0	2
Order-takes-too-long	1	3	6
Return-calls	19	28	13
Wrong-color	4	2	1
Expected Counts	**1**	**2**	**3**
Difficult-to-order	5.890	7.980	5.130
Not-available	1.240	1.680	1.08
Order-takes-too-long	3.100	4.200	2.700
Return-calls	18.600	25.200	16.200
Wrong-color	2.170	2.940	1.890
Std. Residuals	**1**	**2**	**3**
Difficult-to-order	-0.366718	0.361076	-0.057396402
Not-available	0.682500	-1.296	0.885270
Order-takes-too-long	-1.193	-0.585540	2.008
Return-calls	0.092747779	0.557773	-0.795046
Wrong-color	1.242	-0.548219	-0.647380
Chi-Square	12.211		
DF	8		
Chi-Square P-Value	0.1420		
Fisher's Monte-Carlo P-Value	0.1486		
Fisher's Monte-Carlo P-Value 99% CI Upper	0.1569		
Fisher's Monte-Carlo P-Value 99% CI Lower	0.1403		
Note: 9 out of 15 cells have expected counts less than 5.			

Statistical Tools: Power & Sample Size Calculators

- 1 Sample t-Test
- 2 Sample t-Test
- One-Way ANOVA
- 1 Proportion Test
- 2 Proportions Test
- The Power and Sample Size Calculators allow you to solve for Power (1 – Beta), Sample Size, or Difference (specify two, solve for the third).

Statistical Tools: Power & Sample Size Charts



Measurement Systems Analysis

- Basic MSA Templates
- Create Gage R&R (Crossed) Worksheet
  - Generate worksheet with user specified number of parts, operators, replicates
- Analyze Gage R&R (Crossed)
- Attribute MSA (Binary)
- Attribute MSA (Ordinal)
- Attribute MSA (Nominal)

Measurement Systems Analysis: Gage R&R Template

Gage Name:	Calipers
Date of Study:	20-May-04
Performed By:	John Noguera
Notes:	

Process Tolerance	
USL:	0.05
LSL:	0.03

StDev Multiplier:	5.15

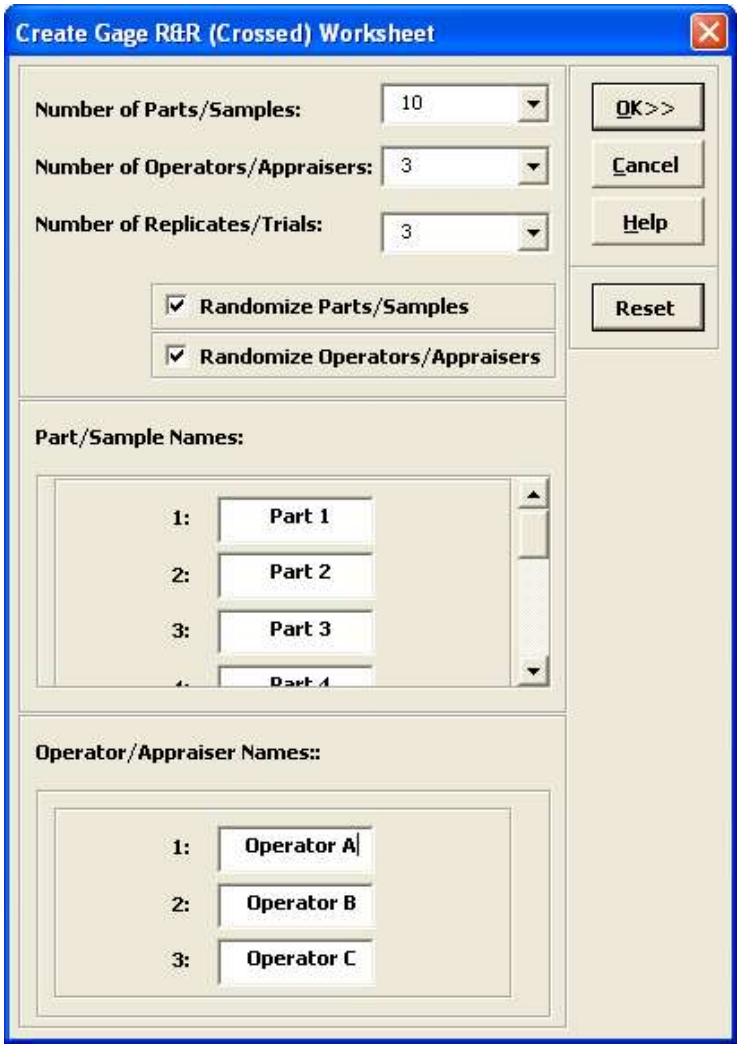
Gage R&R Metrics	StDev	StDev * Multiplier	% Total Variation (TV)	% Tolerance
Gage R&R:	0.000854184	0.004399046	11.46	22.00
Operator (AV Appraiser Variation):	0	0	0.00	0.00
Operator * Part (INT Interaction):	0.0005288	0.002723321	7.09	13.62
Reproducibility (SQRT(AV^2 + INT^2)):	0.0005288	0.002723321	7.09	13.62
Repeatability (EV Equipment Variation):	0.00067082	0.003454725	9.00	17.27
Part Variation (PV):	0.007405954	0.038140661	99.34	190.70
Total Variation (TV):	0.00745505	0.03839351	100.00	191.97

Operator A	Part 1	Part 2	Part 3
Reading 1	0.03	0.035	0.041
Reading 2	0.031	0.034	0.042
Reading 3	0.032	0.036	0.042

Operator B	Part 1	Part 2	Part 3
Reading 1	0.031	0.035	0.042
Reading 2	0.031	0.034	0.041
Reading 3	0.032	0.035	0.04

Operator C	Part 1	Part 2	Part 3
Reading 1	0.032	0.034	0.043
Reading 2	0.032	0.034	0.041
Reading 3	0.032	0.033	0.042

Measurement Systems Analysis: Create Gage R&R (Crossed) Worksheet



Gage R&R Study (Crossed) Worksheet

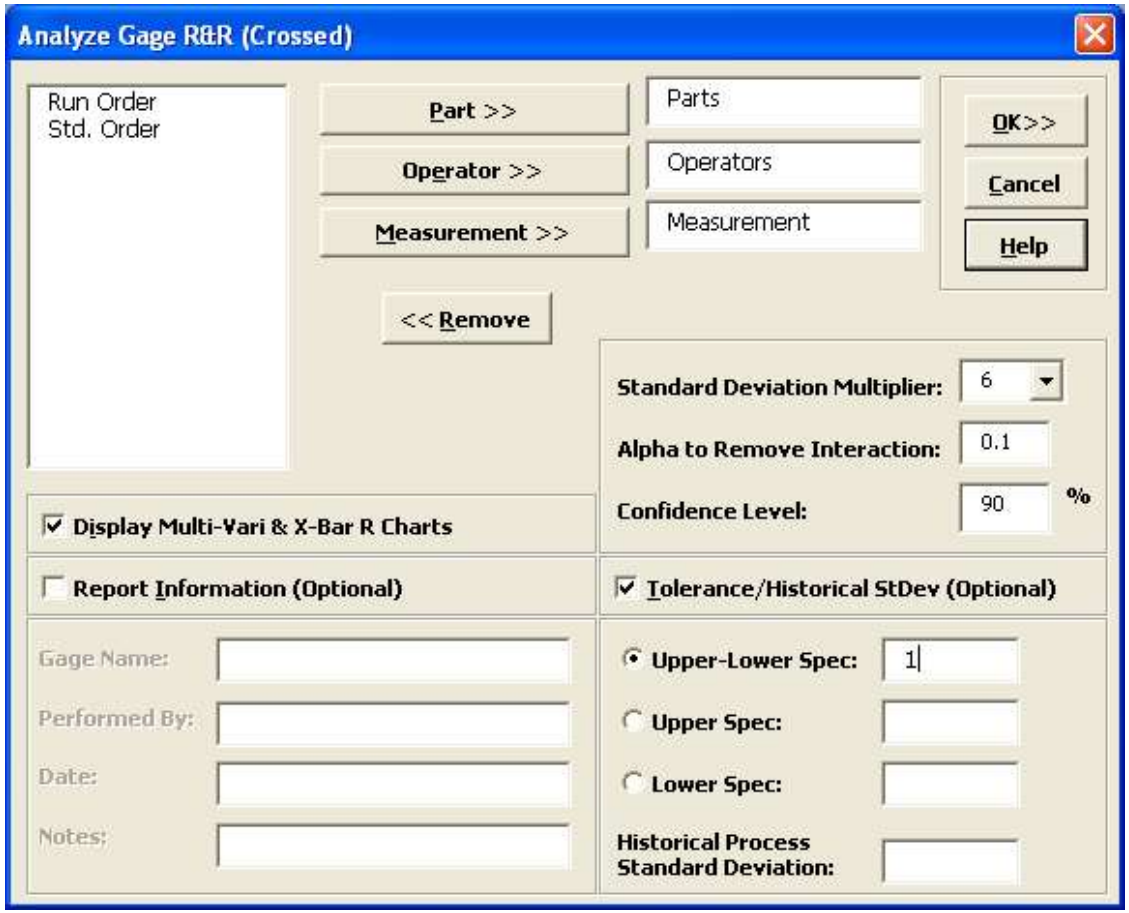
Gage Name:	Calipers
Date of Study:	26-Apr-06
Performed By:	John Noguera
Notes:	

Run Order	Std. Order	Parts	Operators	Measurement
1	12	Part 4	Operator A	0.676
2	2	Part 1	Operator A	0.898
3	20	Part 7	Operator A	0.398
4	24	Part 8	Operator A	0.948
5	17	Part 6	Operator A	0.932
6	6	Part 2	Operator A	0.934
7	27	Part 9	Operator A	0.689
8	15	Part 5	Operator A	0.538
9	29	Part 10	Operator A	0.704

Measurement Systems Analysis: Analyze Gage R&R (Crossed)

- ANOVA, %Total, %Tolerance (2-Sided or 1-Sided), %Process, Variance Components, Number of Distinct Categories
- Gage R&R Multi-Vari and X-bar R Charts
- Confidence Intervals on %Total, %Tolerance, %Process and Standard Deviations
- Handles unbalanced data (confidence intervals not reported in this case)

Measurement Systems Analysis: Analyze Gage R&R (Crossed)



Measurement Systems Analysis: Analyze Gage R&R with Confidence Intervals

Analysis of Variance with Part * Operator Interaction:

Source	DF	SS	MS	F	P
Part:	9	0.553693	0.061521481	37.103	0.0000
Operator:	2	0.013653333	0.006826667	4.1170	0.0337
Part * Operator:	18	0.029846667	0.001658148	4.1111	0.0003
Repeatability:	30	0.0121	4.033E-04		
Total:	59	0.609293	0.010327006		

Gage R&R Metrics	StDev	StDev Lower 90% CI	StDev Upper 90% CI	6 * StDev	% Total Variation (TV)	% TV Lower 90% CI	% TV Upper 90% CI
Gage R&R:	0.035904967	0.030367917	0.087410367	0.215430	33.83	20.16	68.36
Operator (AV Appraiser Variation):	0.016075631	0.004168708	0.081026508	0.096453789	15.15		
Part * Operator (INT Interaction):	0.025048102	0.017095374	0.037247076	0.150289	23.60		
Reproducibility (SQRT(AV^2 + INT^2)):	0.029762952	0.021365632	0.085000016	0.178578	28.04		
Repeatability (EV Equipment Variation):	0.02008316	0.016626072	0.025579555	0.120499	18.92		
Part Variation (PV):	0.099886046	0.071946598	0.165736	0.599316	94.10		
Total Variation (TV):	0.106143247	0.080362383	0.172845	0.636859	100.00		

Confidence Intervals are calculated for Gage R&R Metrics!

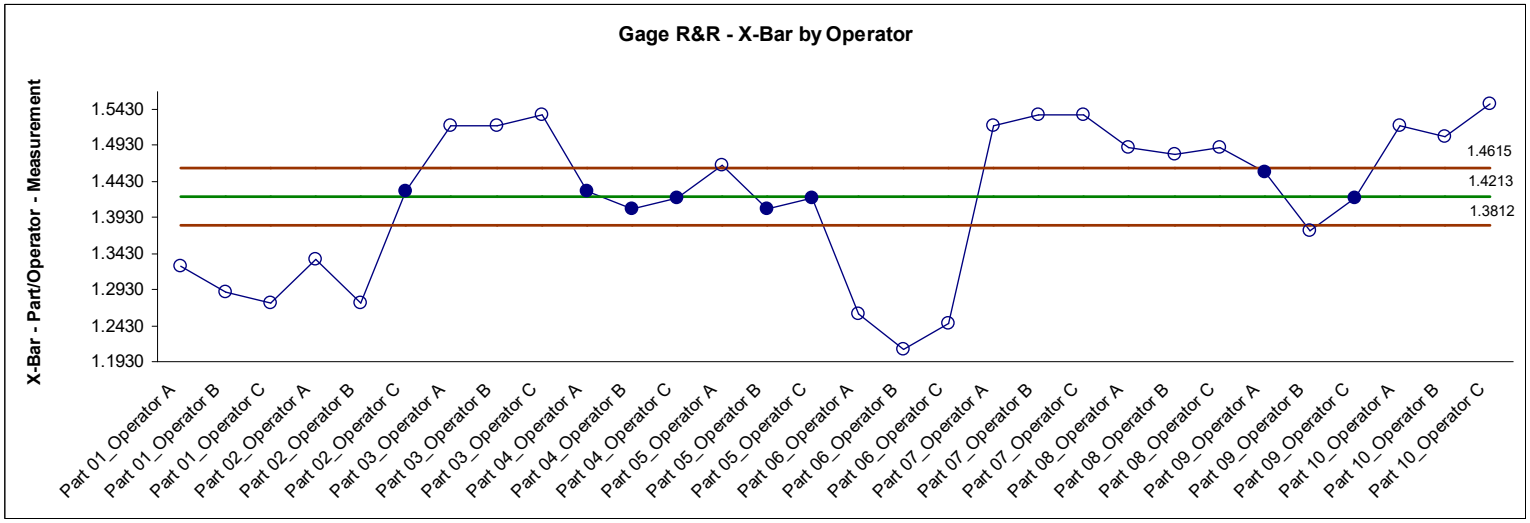
Measurement Systems Analysis: Analyze Gage R&R with Confidence Intervals

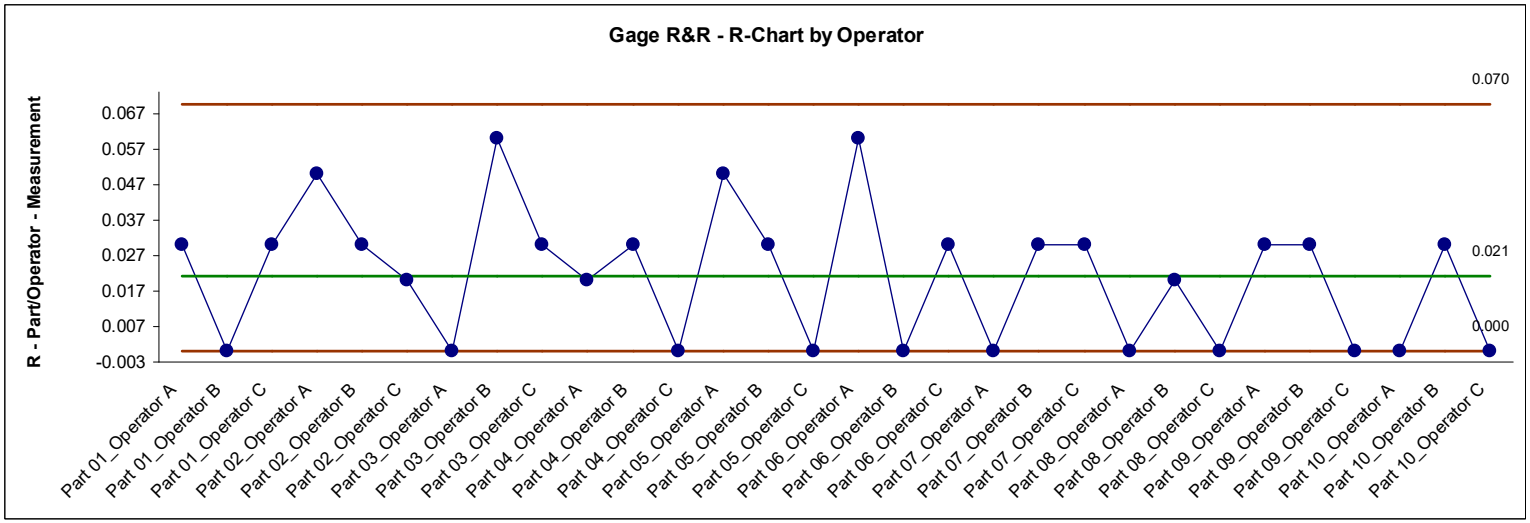
Gage R&R Metrics	% Tolerance	% Tolerance Lower 90% CI	% Tolerance Upper 90% CI
Gage R&R:	21.54	18.22	52.45
Operator (AV Appraiser Variation):	9.65	2.50	48.62
Part * Operator (INT Interaction):	15.03	10.26	22.35
Reproducibility (SQRT(AV^2 + INT^2)):	17.86	12.82	51.00
Repeatability (EV Equipment Variation):	12.05	9.98	15.35
Part Variation (PV):	59.93	43.17	99.44
Total Variation (TV):	63.69	48.22	103.71

Gage R&R Metrics	Variance Component	% Contribution of Variance Component
Gage R&R:	0.001289167	11.44
Operator:	2.584E-04	2.29
Part * Operator:	6.274E-04	5.57
Reproducibility:	8.858E-04	7.86
Repeatability:	4.033E-04	3.58
Part Variation:	0.009977222	88.56
Total Variation:	0.011266389	100.00

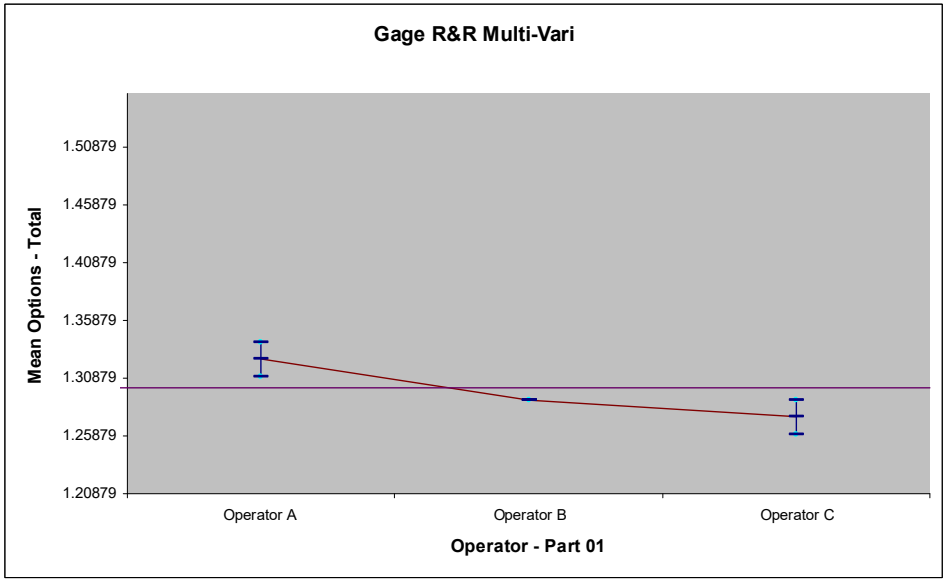
Gage R&R Metrics	NDC	NDC Lower 90% CI	NDC Upper 90% CI
Number of Distinct Categories (Signal-to-Noise Ratio: 1.41 * PV/R&R):	3.9	1.5	6.9

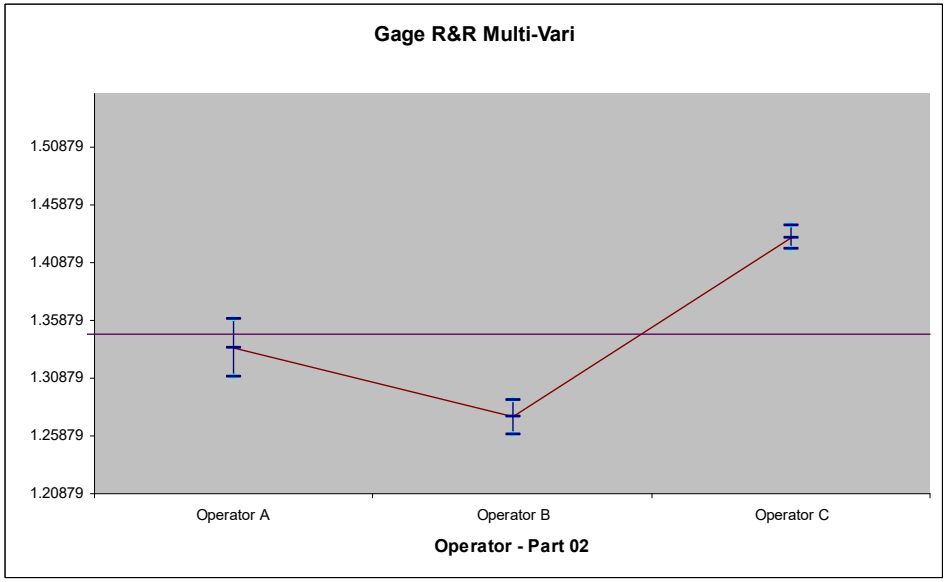
Measurement Systems Analysis: Analyze Gage R&R – X-bar & R Charts





Measurement Systems Analysis: Analyze Gage R&R – Multi-Vari Charts





Measurement Systems Analysis: Attribute MSA (Binary)

- Any number of samples, appraisers and replicates
- Within Appraiser Agreement, Each Appraiser vs Standard Agreement, Each Appraiser vs Standard Disagreement, Between Appraiser Agreement, All Appraisers vs Standard Agreement
- Fleiss' kappa

Attribute Measurement Systems Analysis

- "Traffic Light" Attribute Measurement Systems Analysis: Binary, Ordinal and Nominal
  - ✓ A Kappa color highlight is used to aid interpretation: Green (> .9), Yellow (.7-.9) and Red (< .7) for Binary and Nominal.
  - ✓ Kendall coefficients are highlighted for Ordinal.
  - ✓ A new Effectiveness Report treats each appraisal trial as an opportunity, rather than requiring agreement across all trials.

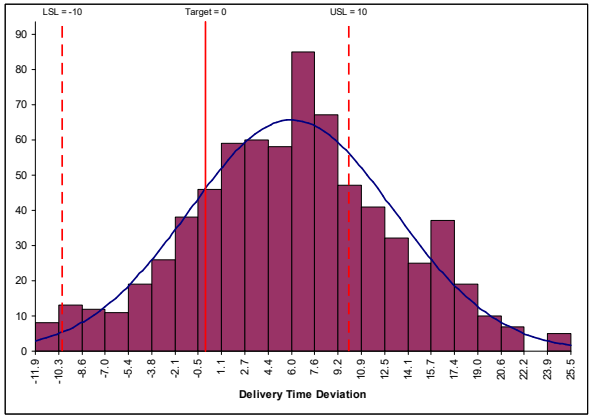
Each Appraiser vs. Standard Agreement	# Inspected	# Matched	Percent	95.0% LC (Exact)	95.0% UC (Exact)	Fleiss' Kappa	Fleiss' Kappa P-Value	Fleiss' Kappa 95.0% LC	Fleiss' Kappa 95.0% UC
A	50	42	84.00	70.89	92.83	0.8802	0.0000	0.7202	1.0000
B	50	45	90.00	78.19	96.67	0.9226	0.0000	0.7626	1.0000
C	50	40	80.00	66.28	89.97	0.7747	0.0000	0.6147	0.9347

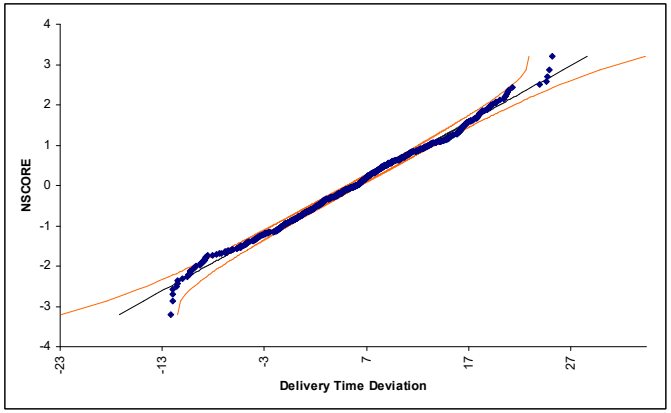
Each Appraiser vs. Standard Agreement	# Inspected	# Matched	Percent	95.0% LC (Score)	95.0% UC (Score)	Kendall's Correlation Coeff.	Kendall's Correlation P-Value	Kendall's Correlation 95.0% LC	Kendall's Correlation 95.0% UC
Joe	50	11	22.00	12.75	35.24	0.7323	0.0000	0.6218	0.8427
Moe	50	2	4.00	1.10	13.46	0.4161	0.0000	0.3057	0.5265
Sue	50	40	80.00	66.96	88.76	0.9495	0.0000	0.8391	1.0000

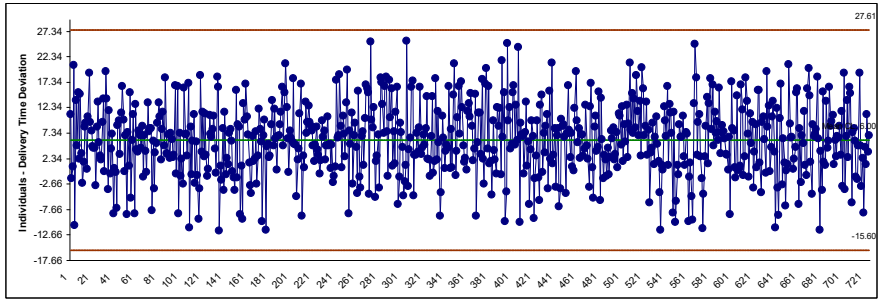
Process Capability (Normal Data)

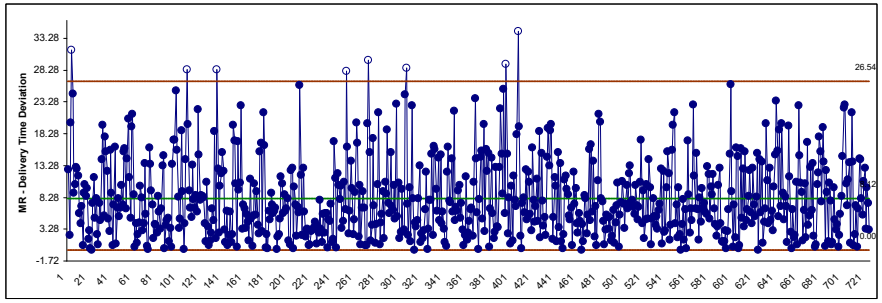
- Process Capability/Sigma Level Templates
- Multiple Histograms and Process Capability
- Capability Combination Report for Individuals/Subgroups:
  - Histogram
  - Capability Report (Cp, Cpk, Pp, Ppk, Cpm, ppm, %)
  - Normal Probability Plot
  - Anderson-Darling Normality Test
  - Control Charts

Process Capability: Capability Combination Report









Process Capability Report: Indiv & MR - Delivery Time Deviation	
Count =	725
Mean =	6.0036
StDev (Overall, Long Term) =	7.1616
StDev (Within, Short Term) =	7.2020
USL =	10
Target =	0
LSL =	-10
Capability Indices using Overall StDev	
Pp =	0.47
Ppu =	0.19
Ppl =	0.74
Ppk =	0.19
Cpm =	0.36
Potential Capability Indices using Within StDev	
Cp =	0.46
Cpu =	0.18
Cpl =	0.74
Cpk =	0.18
Expected Overall Performance	
ppm > USL =	288409
ppm < LSL =	12720
ppm Total =	301130
% > USL =	28.84%
% < LSL =	1.27%
% Total =	30.11%
Actual (Empirical) Performance	
% > USL =	26.90%
% < LSL =	1.38%
% Total =	28.28%
Anderson-Darling Normality Test	
A-Squared =	0.708616
P-value =	0.0641

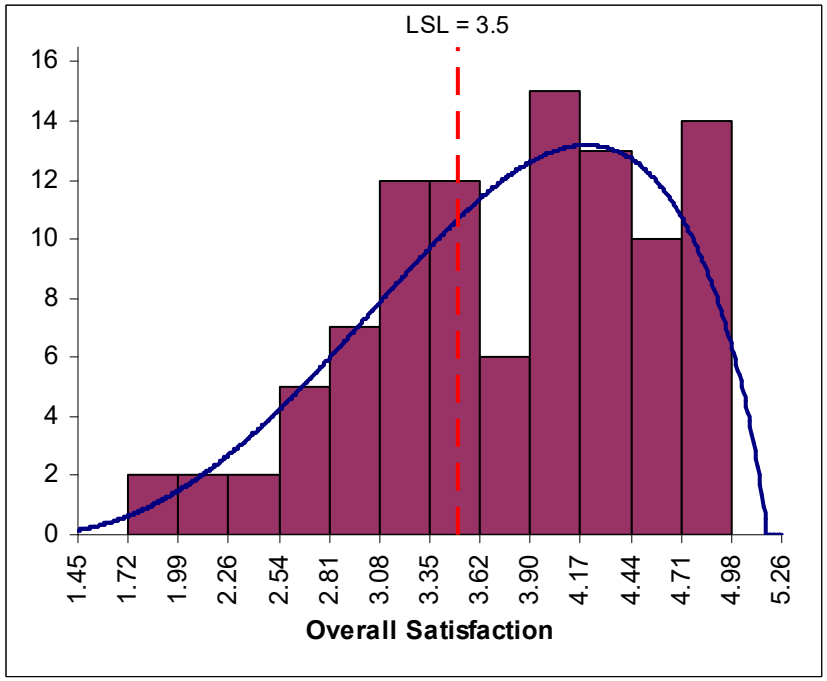
Process Capability for Nonnormal Data

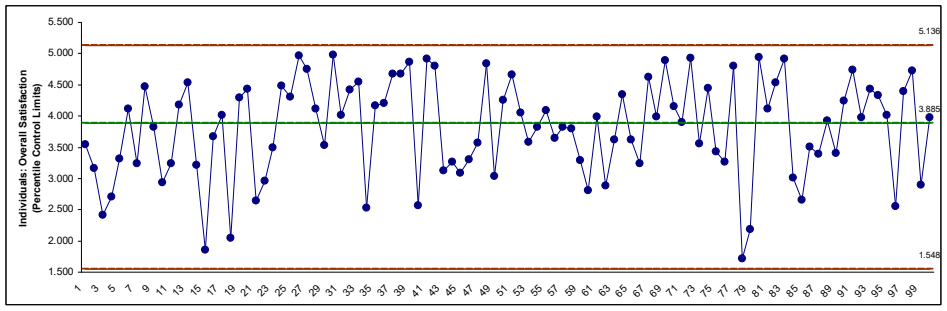
- Box-Cox Transformation (includes an automatic threshold option so that data with negative values can be transformed)
- Johnson Transformation
- Distributions supported:
  - Half-Normal
  - Lognormal (2 & 3 parameter)
  - Exponential (1 & 2 parameter)
  - Weibull (2 & 3 parameter)
  - Beta (2 & 4 parameter)
  - Gamma (2 & 3 parameter)
  - Logistic
  - Loglogistic (2 & 3 parameter)
  - Largest Extreme Value
  - Smallest Extreme Value

Process Capability for Nonnormal Data

- Automatic Best Fit based on AD p-value
- Nonnormal Process Capability Indices:
  - Z-Score (Cp, Cpk, Pp, Ppk)
  - Percentile (ISO) Method (Pp, Ppk)
- Distribution Fitting Report
  - All valid distributions and transformations reported with histograms, curve fit and probability plots
  - Sorted by AD p-value

Nonnormal Process Capability: Automatic Best Fit





Process Capability Report (Nonnormal): Overall Satisfaction	
Distribution: Beta with Lower/Upper Threshold (4 p)	
Sample Count	100
Sample Mean	3.801
Shape1	3.465
Shape2	1.775
Upper Threshold (Optimal)	5.170
Lower Threshold (Optimal)	1.117
Percentile (Overall Satisfaction)	1
StDev (Normalized Within, Short Term)	0.949670
USL	
Target	
LSL	3.5

Capability Indices (Z-Score Method)	
Pp	
Ppu	
Ppl	0.143006
Ppk	0.143006

Potential Capability Indices using Normalized Within StDev	
Cp	
Cpu	
Cpl	0.150585
Cpk	0.150585

Expected Overall Performance	
ppm > USL	
ppm < LSL	333955
ppm Total	333955
% > USL	
% < LSL	0.333955
% Total	33.40%

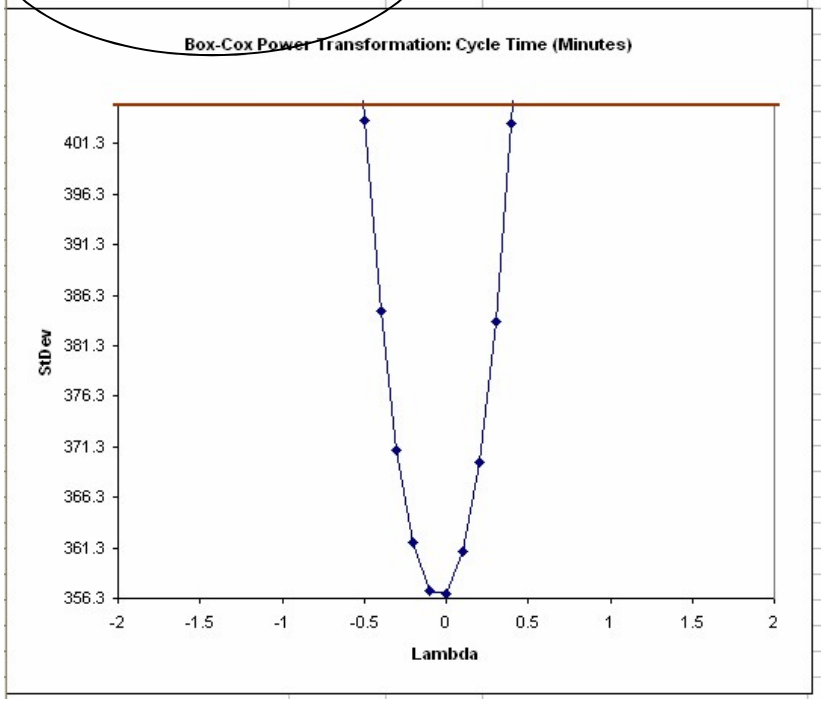
Actual (Empirical) Performance	
% > USL	
% < LSL	33.00%
% Total	33.00%

Anderson-Darling Goodness-of-Fit Tests	
AD Beta (4P)	0.199268
AD Beta (4P) p-value	0.882 (Z-Score Est.)
AD Normality Original Data	0.803438292
AD Normality P-Value Original Data	0.0363

Process Capability: Box-Cox Power Transformation

Normality Test is automatically applied to transformed data!

Box-Cox Power Transformation: Cycle Time (Minutes)	
Optimal Lambda	-0.04
Final Lambda	0
UC Lambda (95%)	0.407756
LC Lamda (95%)	-0.506879
Anderson Darling Normality Test for Transformed Data:	
A-Squared	0.326821
AD P-value	0.5063



Cycle Time (Minutes)	Transformed Data (Ln(Y))
3216	8.07589363
261	5.564520407
392	5.97126184
63	4.143134726
28	3.33220451
6101	8.716207971
151	5.017279837
46	3.828641396
1465	7.289610521
383	5.948034989
287	5.659482216
322	5.774551546
538	6.28785856
574	6.352629396
586	6.37331979
920	6.82437367
178	5.18178355
129	4.859812404
187	5.231108617
71	4.262679877
342	5.834810737
167	5.117993812
794	6.677083461
205	5.323009979
576	6.356107661
575	6.354370041
381	5.942799375
576	6.356107661
918	6.822197391
190	5.247024072

Reliability/Weibull Analysis

- Weibull Analysis
  - Complete and Right Censored data
  - Least Squares and Maximum Likelihood methods
  - Output includes percentiles with confidence intervals, survival probabilities, and Weibull probability plot.

Design of Experiments

- Basic DOE Templates
  - Automatic update to Pareto of Coefficients
  - Easy to use, ideal for training
- Generate 2-Level Factorial and Plackett-Burman Screening Designs
- Main Effects & Interaction Plots
- Analyze 2-Level Factorial and Plackett-Burman Screening Designs

Basic DOE Templates

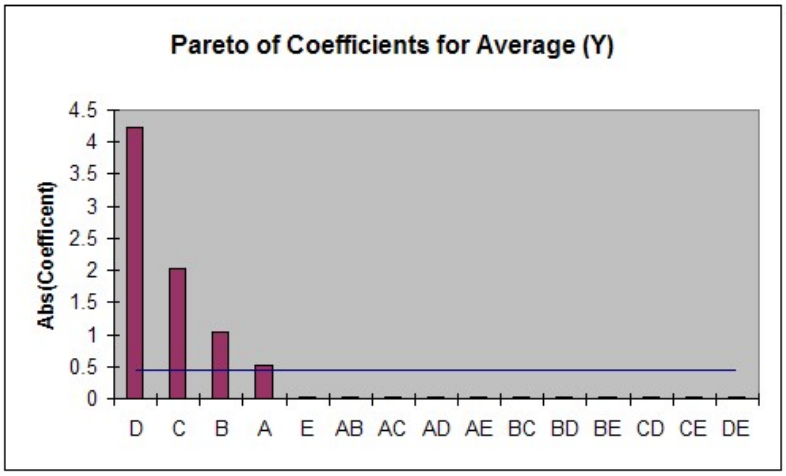
Five Factor, Two-Level, Half-Fraction Design of Experiments

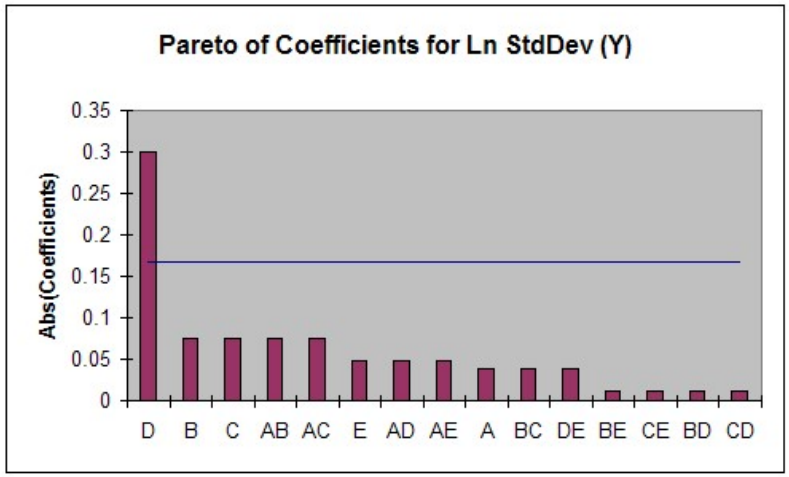
Title: Process Yield Improvement
Date: 21-May-04
Name of Experimenter: John Noguera
Response: Yield
Goal: Maximize

Factor	Factor Name	Low	High
A	Temperature	100	200
B	Power	50	100
C	Pressure	10	20
D	Speed	400	500
E	Catalyst	-1	1

Predicted Output for Y:

Factor Name	Enter Actual Factor Setting - uncoded	Factor setting coded	Y-hat:	S-hat:
Temper	150	0	9.25	1
Power	75	0		
Pressur	15	0		
Speed	450	0		
Catalys	1	1		

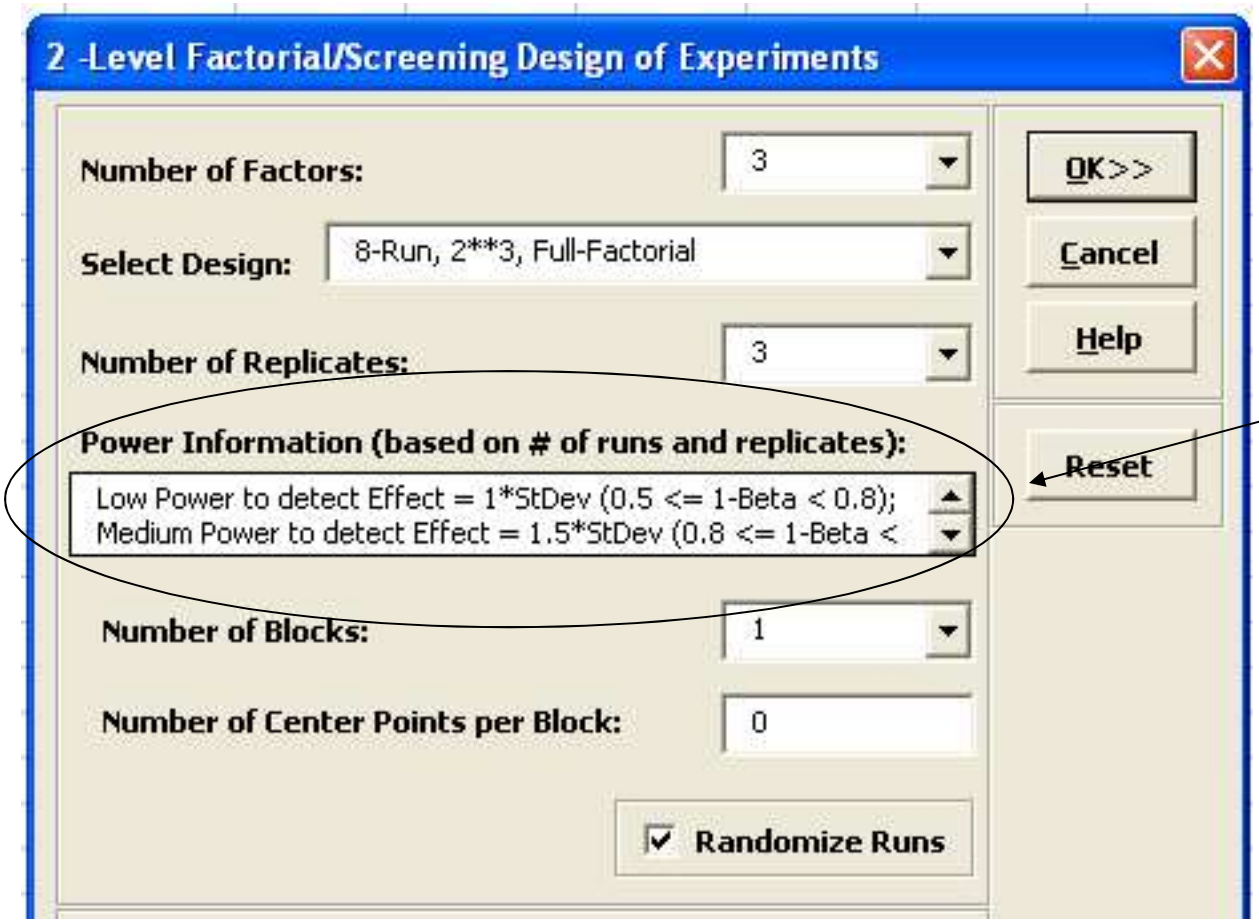




Design of Experiments: Generate 2-Level Factorial and Plackett-Burman Screening Designs

- User-friendly dialog box
- 2 to 19 Factors
- 4,8,12,16,20 Runs
- Unique “view power analysis as you design”
- Randomization, Replication, Blocking and Center Points

Design of Experiments: Generate 2-Level Factorial and Plackett-Burman Screening Designs



View Power Information as you design!

Design of Experiments Example: 3-Factor, 2-Level Full-Factorial Catapult DOE

Objective: Hit a target at exactly 100 inches!

Design of Experiments Worksheet

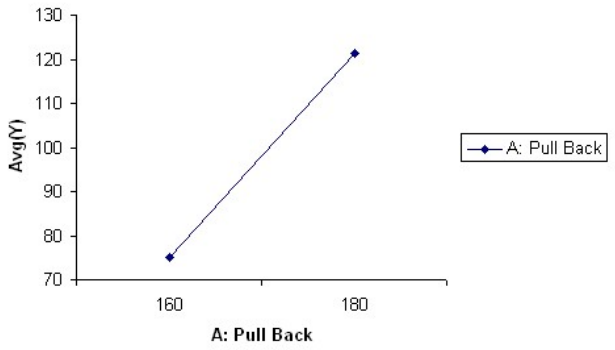
Title: Catapult
Date: April 26 2006
Name of Experimenter: John Noguera
Notes:

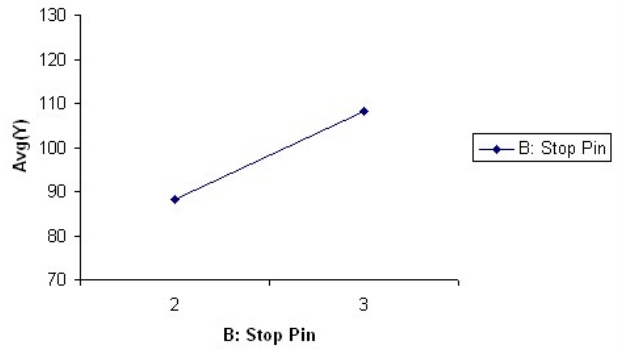
Design Type: 3 Factor, 8-Run, 2**3, Full-Factorial
Number of Replicates: 3
Number of Blocks: 1
Number of Center Points per Block: 0
Number of Responses: 1

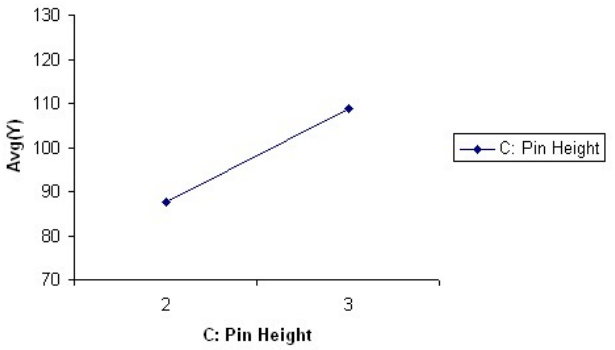
Run Order	Std. Order	Center Points	Blocks	A: Pull Back	B: Stop Pin	C: Pin Height	Distance
1	11	1	1	160	3	2	80
2	21	1	1	160	2	3	71
3	14	1	1	180	2	3	124
4	19	1	1	160	3	2	79
5	10	1	1	180	2	2	101
6	8	1	1	180	3	3	144
7	2	1	1	180	2	2	102
8	12	1	1	180	3	2	116

Design of Experiments: Main Effects and Interaction Plots

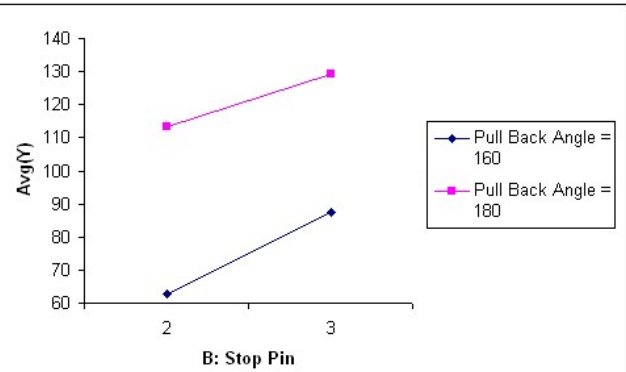
Main Effects Plots for Avg(Y)
Response: Distance

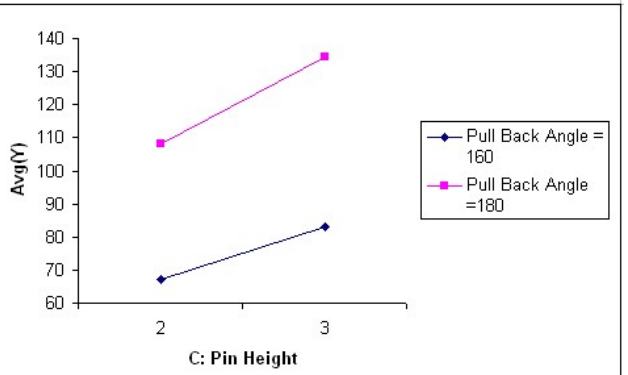






Interaction Plots for Avg(Y)
Response: Distance





Design of Experiments: Analyze 2-Level Factorial and Plackett-Burman Screening Designs

- Used in conjunction with Recall Last Dialog, it is very easy to iteratively remove terms from the model
- Interactive Predicted Response Calculator with 95% Confidence Interval and 95% Prediction Interval.
- ANOVA report for Blocks, Pure Error, Lack-of-fit and Curvature
- Collinearity Variance Inflation Factor (VIF) and Tolerance report

Design of Experiments: Analyze 2-Level Factorial and Plackett-Burman Screening Designs

- Residual plots: histogram, normal probability plot, residuals vs. time, residuals vs. predicted and residuals vs. X factors
- Residual types include Regular, Standardized, Studentized (Deleted t) and Cook's Distance (Influence), Leverage and DFITS
- Highlight of significant outliers in residuals
- Durbin-Watson Test for Autocorrelation in Residuals with p-value

Design of Experiments Example: Analyze Catapult DOE

DOE Multiple Regression Model: Distance = (98.20833333) + (23.125) * A: Pull Back + (10.125) * B: Stop Pin + (10.54166667) * C: Pin Height + (-2.125) * AB + (2.458333333) * AC + (0.625) * BC + (0.708333333) * ABC

Model Summary:

R-Square	99.95%
R-Square Adjusted	99.93%
S (Root Mean Square Error)	0.763763

Parameter Estimates:

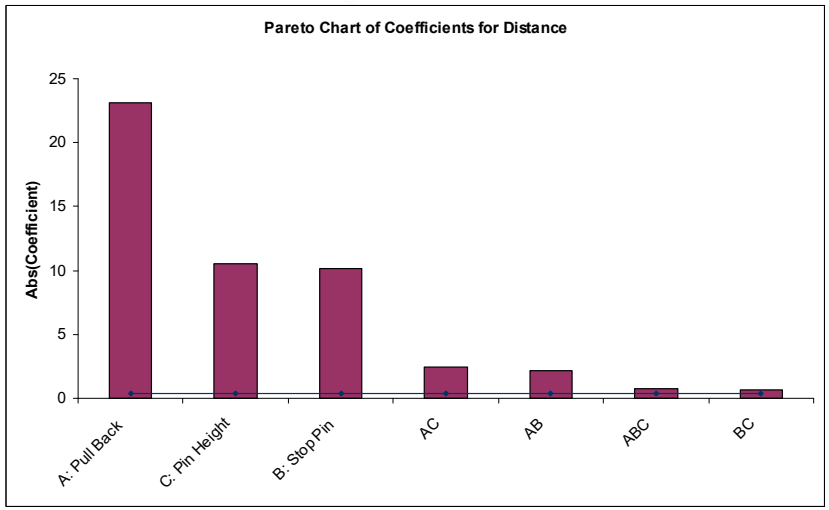
Term	Coefficient	SE Coefficient	T	P	VIF	Tolerance
Constant	98.20833333	0.155902391	629.93	0.0000		
A: Pull Back	23.125	0.155902391	148.33	0.0000	1	1
B: Stop Pin	10.125	0.155902391	64.944	0.0000	1	1
C: Pin Height	10.54166667	0.155902391	67.617	0.0000	1	1
AB	-2.125	0.155902391	-13.630	0.0000	1	1
AC	2.458333333	0.155902391	15.768	0.0000	1	1
BC	0.625	0.155902391	4.0089	0.0010	1	1
ABC	0.708333333	0.155902391	4.5434	0.0003	1	1

Analysis of Variance for Model:

Source	DF	SS	MS	F	P
Model	7	18237	2605.2	4466.1	0.0000
Error	16	9.3333	0.583333		
Pure Error	16	9.3333	0.583333		
Total (Model + Error)	23	18246	793.30		

Durbin-Watson Test for Autocorrelation in Residuals:

DW Statistic	2.0595
P-Value Positive Autocorrelation	0.5572
P-Value Negative Autocorrelation	0.4357



Design of Experiments: Predicted Response Calculator

Predicted Response Calculator:

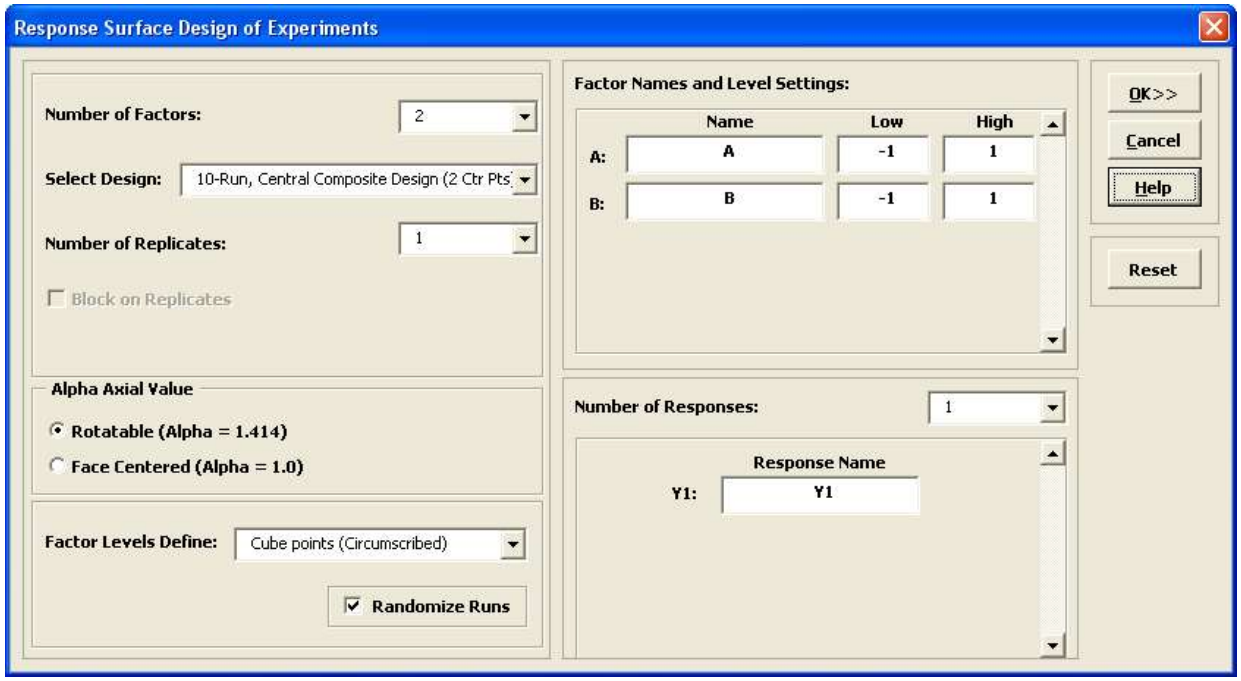
Predictors	Enter Actual Settings:	Coded Settings	Predicted Response	Lower 95% CI	Upper 95% CI	Lower 95% PI	Upper 95% PI
A:	179.3	0.93	100.0216667	99.119	100.924	98.168	101.875
B:	2	-1					
C:	2	-1					

Excel's Solver is used with the Predicted Response Calculator to determine optimal X factor settings to hit a target distance of 100 inches.

95% Confidence Interval and Prediction Interval

Design of Experiments: Response Surface Designs

- 2 to 5 Factors
- Central Composite and Box-Behnken Designs
- Easy to use design selection sorted by number of runs:

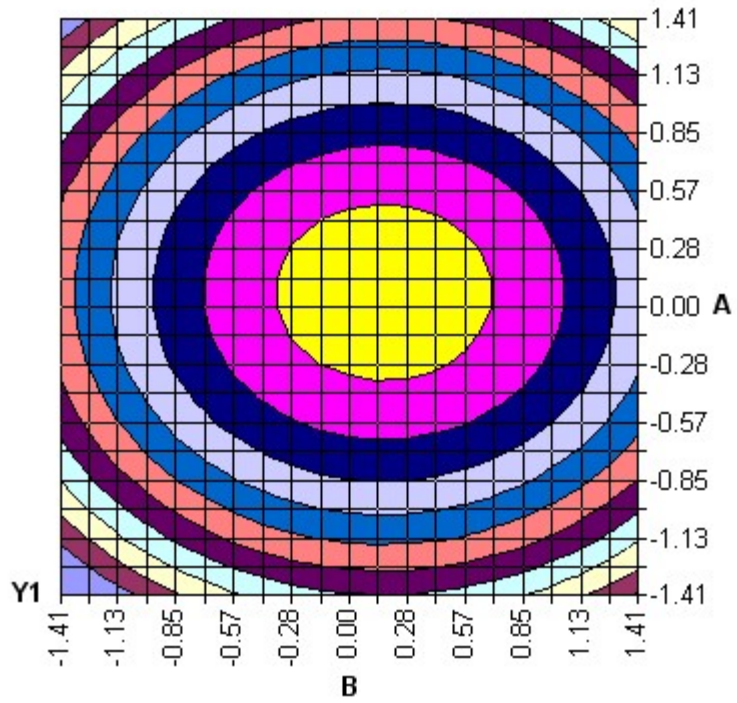


Design of Experiments: Contour & 3D Surface Plots

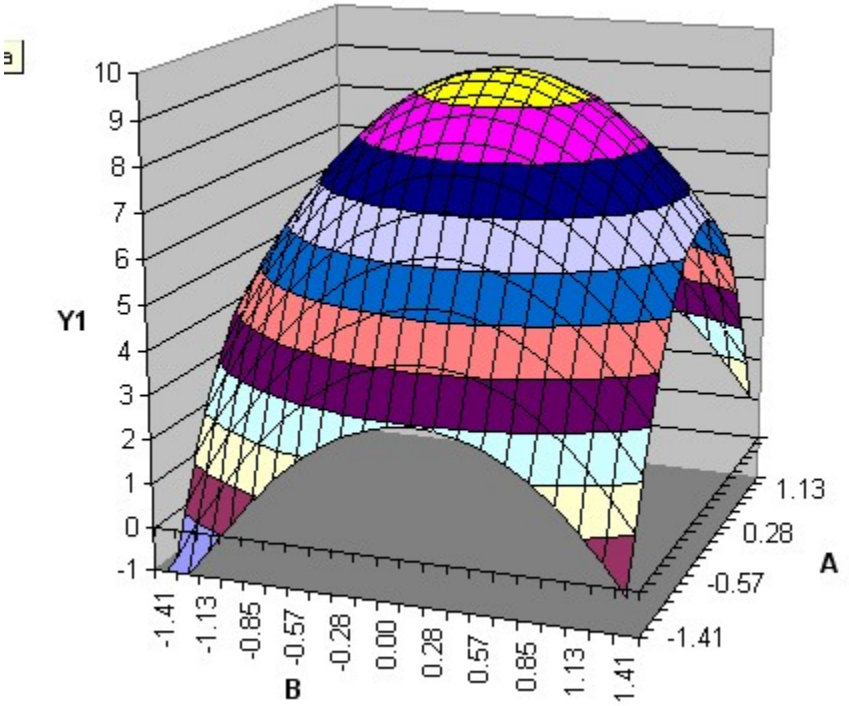
RSM Multiple Regression Model:

$$Y1 = (9.5) + (0.43) * A: A + (0.68) * B: B + (0) * AB + (-3) * AA + (-2) * BB$$

RSM Contour Plot



RSM 3D Surface Plot



Control Charts

- Individuals
- Individuals & Moving Range
- X-bar & R
- X-bar & S
- P, NP, C, U
- P’ and U’ (Laney) to handle overdispersion
- I-MR-R (Between/Within)
- I-MR-S (Between/Within)

Control Charts

- Tests for Special Causes
  - Special causes are also labeled on the control chart data point.
  - Set defaults to apply any or all of Tests 1-8
- Control Chart Selection Tool
  - Simplifies the selection of appropriate control chart based on data type
- Process Capability report
  - Pp, Ppk, Cp, Cpk
  - Available for I, I-MR, X-Bar & R, X-bar & S charts.

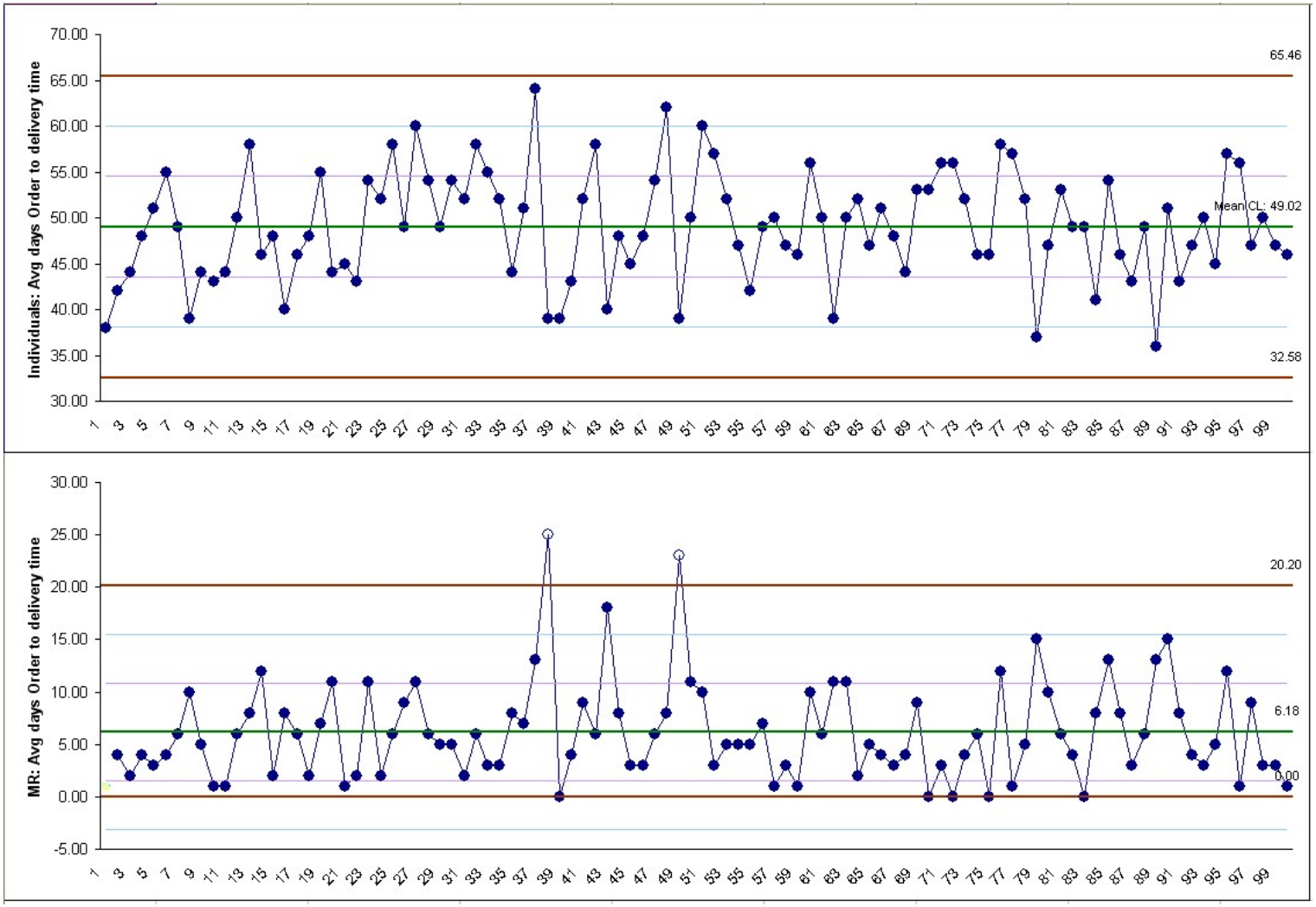
Control Charts

- Add data to existing charts – ideal for operator ease of use!
- Scroll through charts with user defined window size
- Advanced Control Limit options: Subgroup Start and End; Historical Groups (e.g. split control limits to demonstrate before and after improvement)

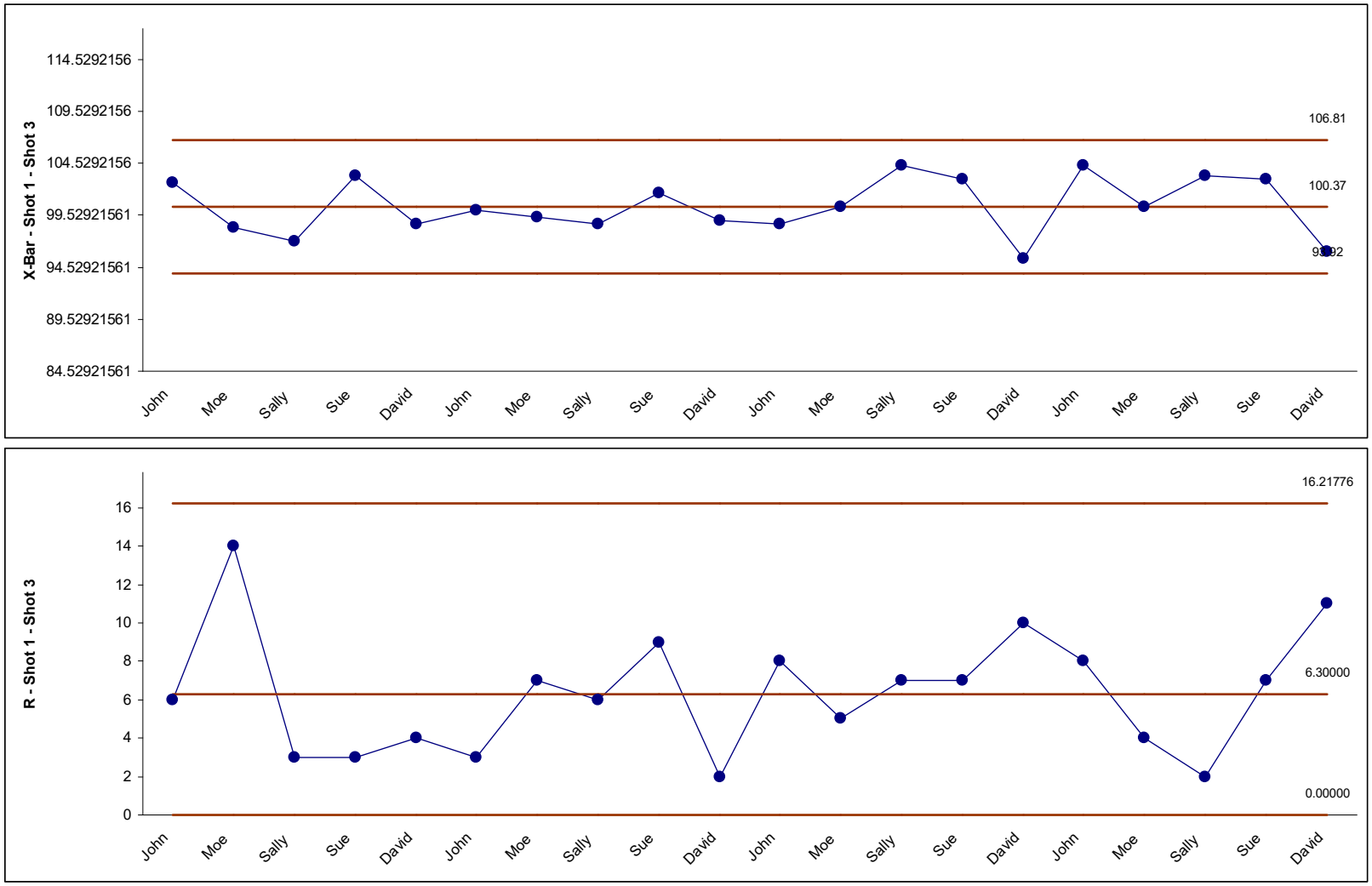
Control Charts

- Exclude data points for control limit calculation
- Add comment to data point for assignable cause
- ± 1, 2 Sigma Zone Lines
- Control Charts for Nonnormal data
  - Box-Cox and Johnson Transformations
  - 16 Nonnormal distributions supported (see Capability Combination Report for Nonnormal Data)
  - Individuals chart of original data with percentile based control limits
  - Individuals/Moving Range chart for normalized data with optional tests for special causes

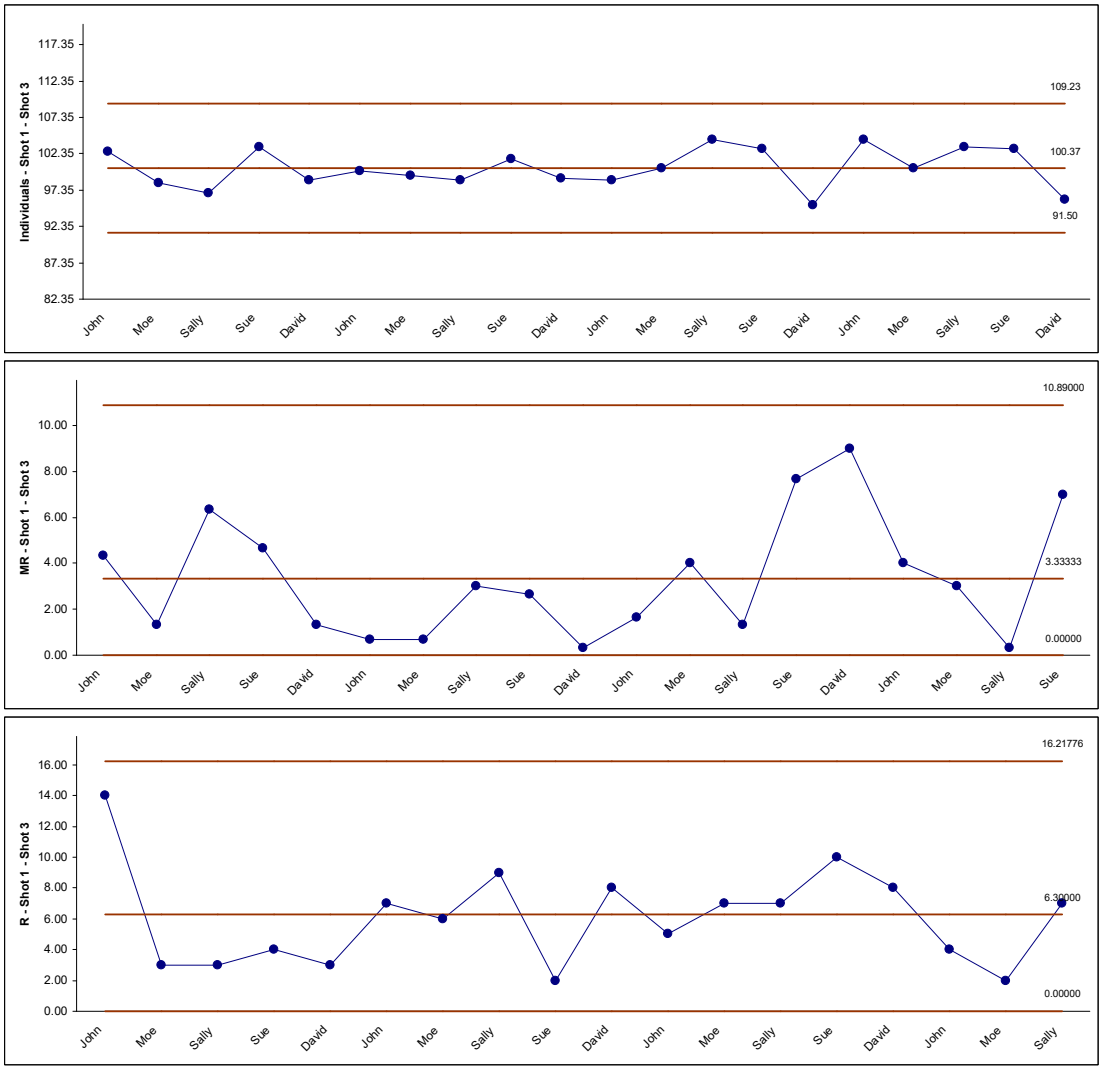
Control Charts: Individuals & Moving Range Charts



Control Charts:
X-bar & R/S Charts

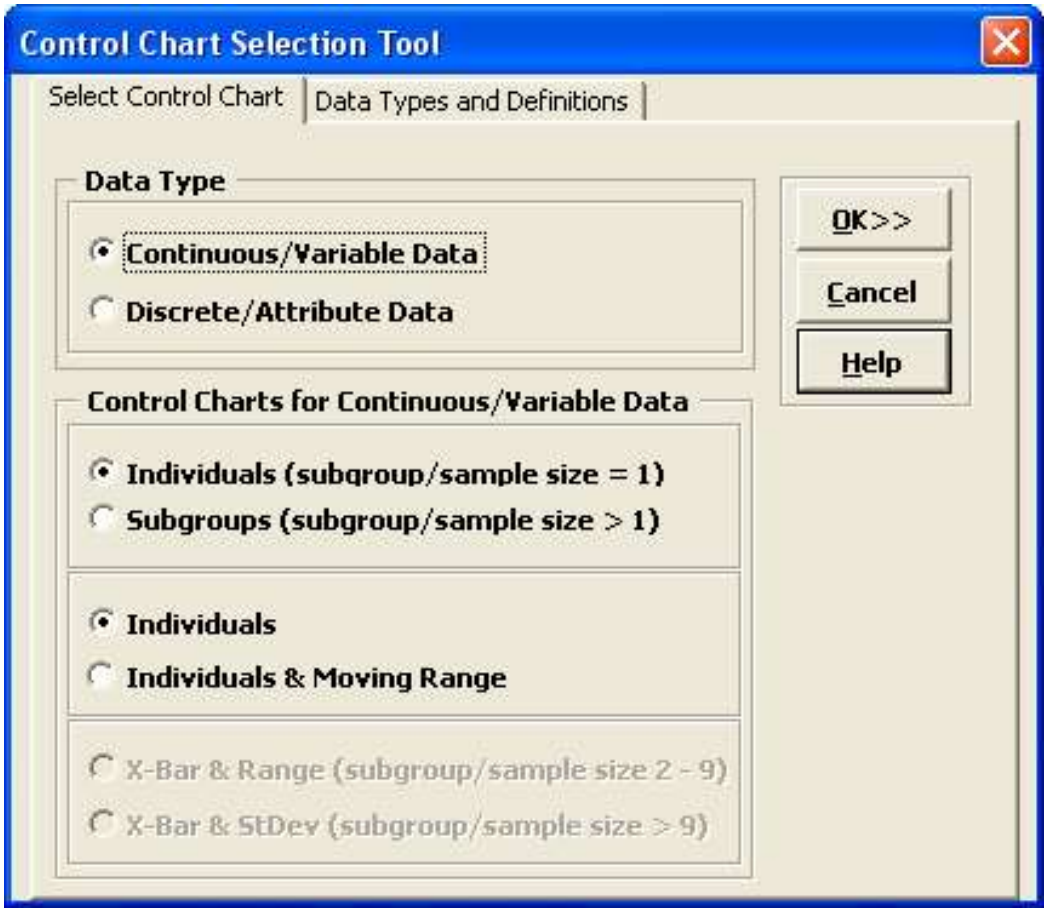


Control Charts: I-MR-R/S Charts (Between/Within)

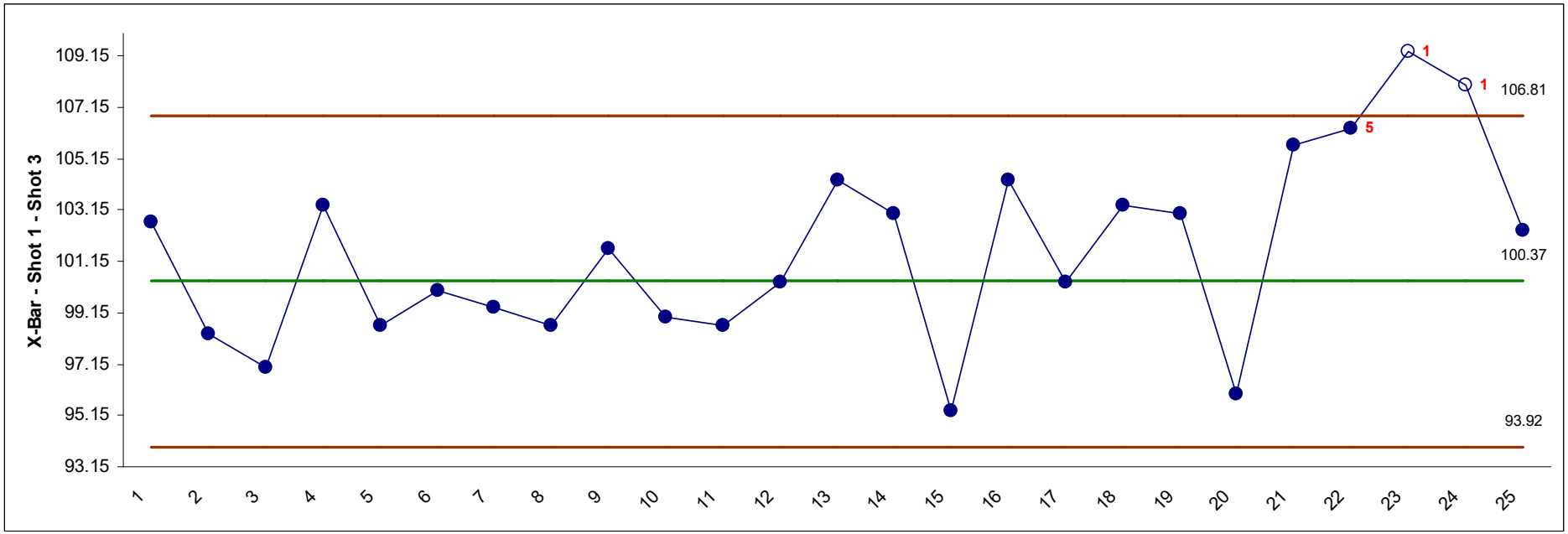


Control Chart Selection Tool

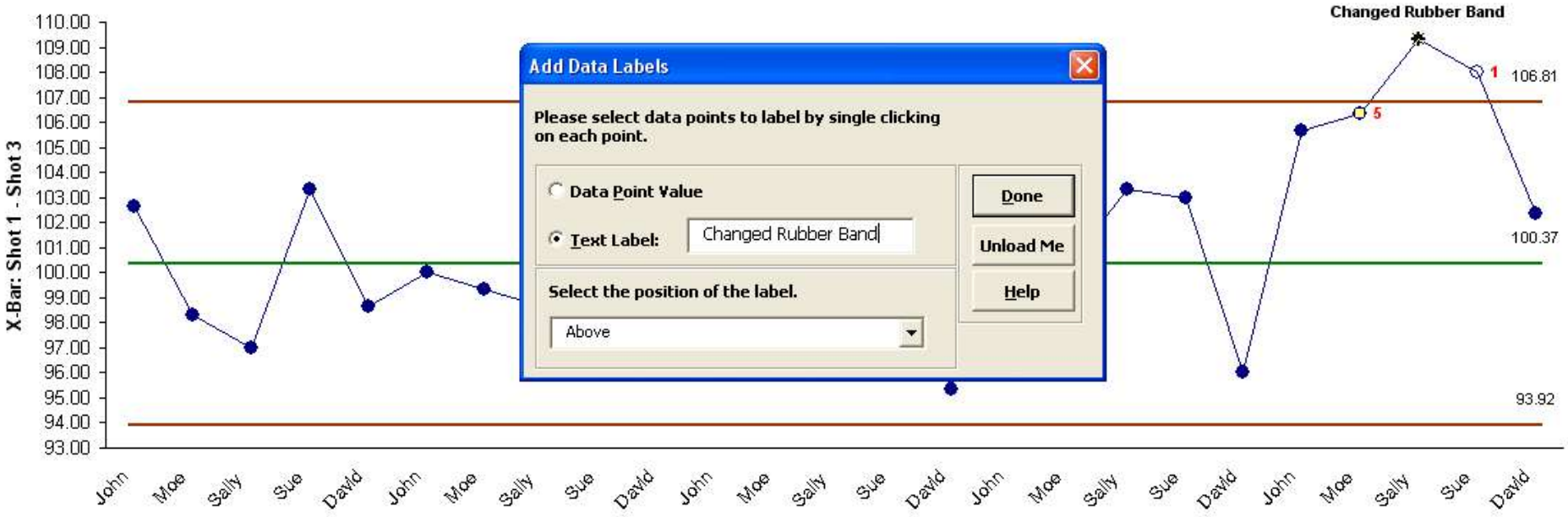
- Simplifies the selection of appropriate control chart based on data type
- Includes Data Types and Definitions help tab.



Control Charts: Use Historical Limits; Flag Special Causes



Control Charts:
Add Comments as Data Labels

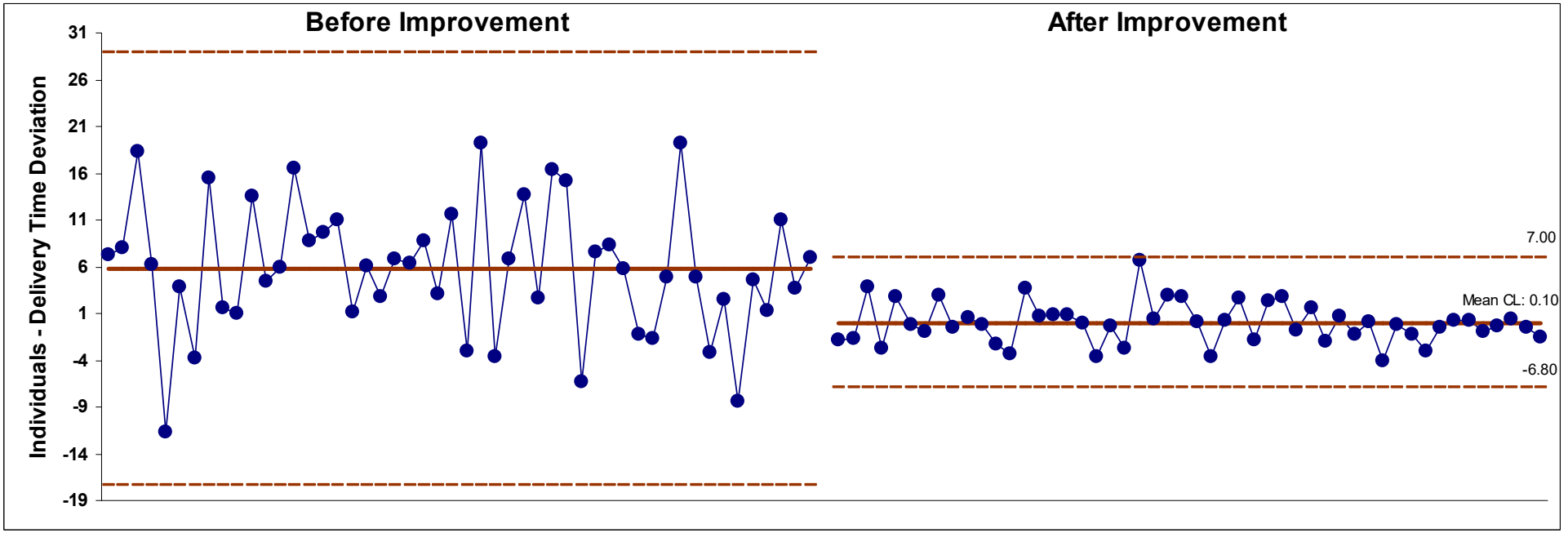


Control Charts: Summary Report on Tests for Special Causes

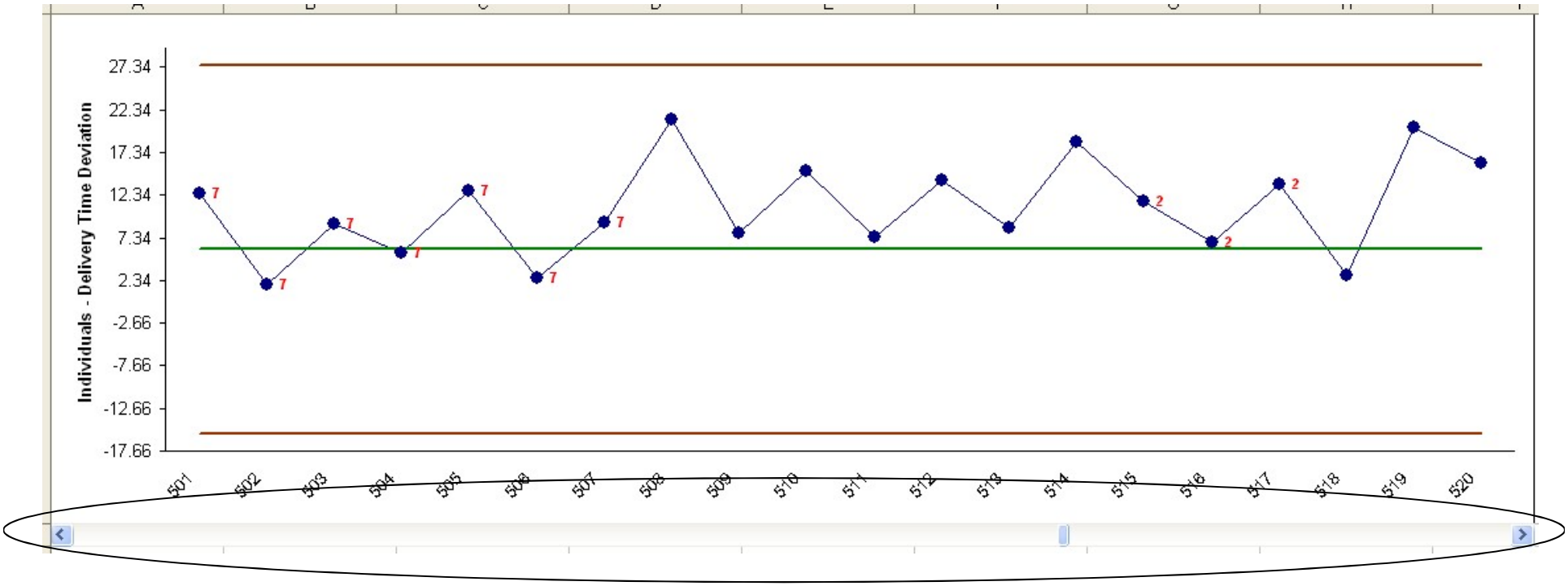
Tests for Special Causes - X-Bar - - Shot 3
Number of Data Points Failing Tests = 3

Observation No.	Test 1: 1 point more than 3 sigma from CL	Test 2: 9 points in a row on same side of CL	Test 3: 6 points in a row all increasing or all decreasing	Test 4: 14 points in a row alternating up and down	Test 5: 2 out of 3 points more than 2 sigma from CL (same side)	Test 6: 4 out of 5 points more than 1 sigma from CL (same side)	Test 7: 15 points in a row within 1 sigma from CL (either side)	Test 8: 8 points in a row more than 1 sigma from CL (either side)
22					x	x		
23	x				x	x		
24	x				x	x		

Control Charts: Use Historical Groups to Display Before Versus After Improvement



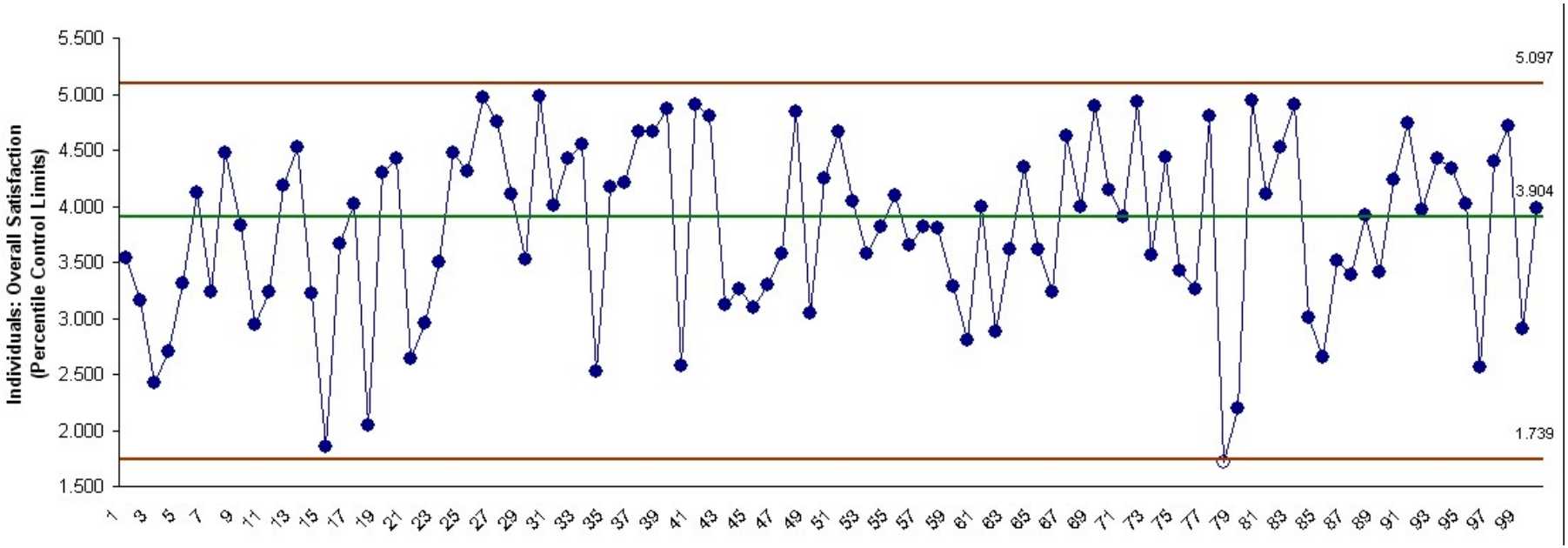
Control Charts:
Scroll Through Charts With User Defined Window Size



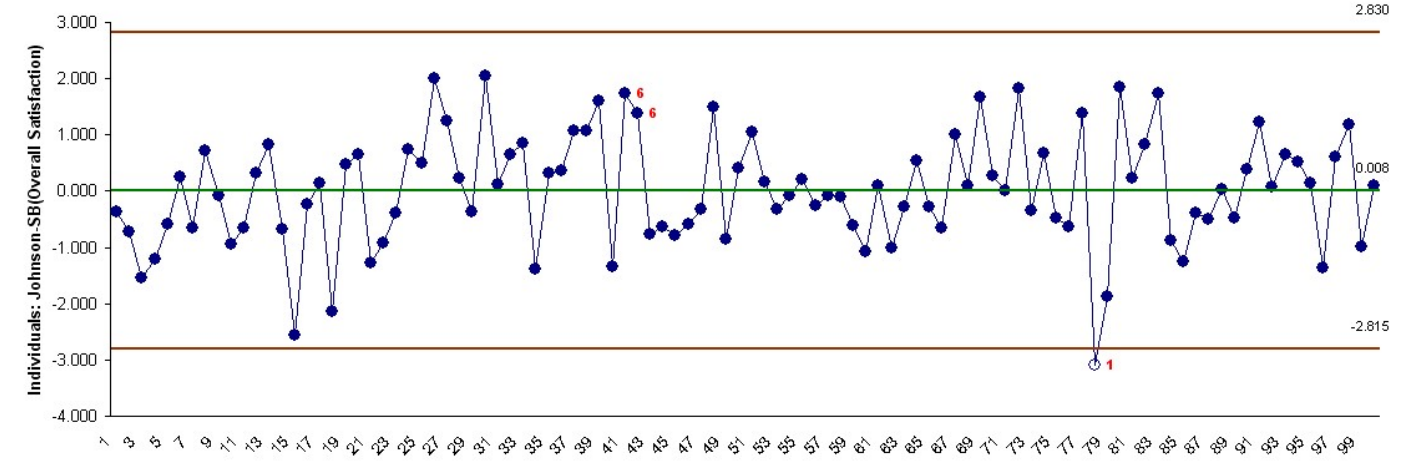
Control Charts: Process Capability Report (Long Term/Short Term)

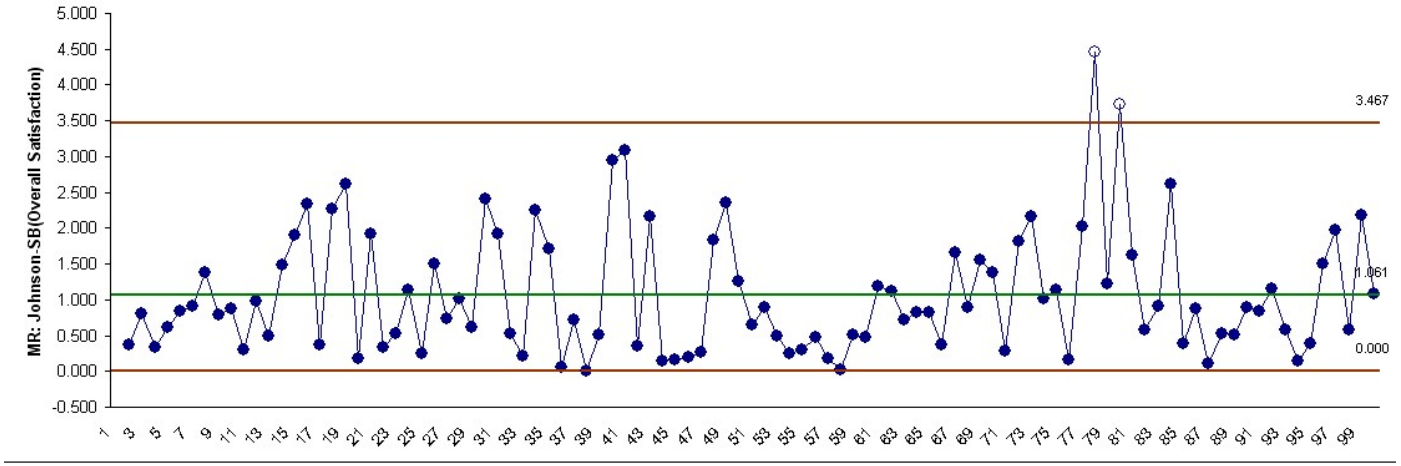
Report: X-Bar & R - Shot 1 - Shot 3	
Count =	75
Mean =	101.56
StDev (Overall, Long Term) =	4.6156
StDev (Within, Short Term) =	2.1484
USL =	108
Target =	100
LSL =	92
Capability Indices using Overall StDev	
Pp =	0.58
Ppu =	0.47
Ppl =	0.69
Ppk =	0.47
Cpm =	0.55
Potential Capability Indices using Within StDev	
Cp =	1.24
Cpu =	1.00
Cpl =	1.48
Cpk =	1.00
Expected Overall Performance	
ppm > USL =	81468
ppm < LSL =	19168
ppm Total =	100636
% > USL =	8.15%
% < LSL =	1.92%
% Total =	10.06%
Actual (Empirical) Performance	
% > USL =	5.33%
% < LSL =	4.00%
% Total =	9.33%

Individuals Chart for Nonnormal Data: Johnson Transformation



Individuals/Moving Range Chart for Nonnormal Data: Johnson Transformation



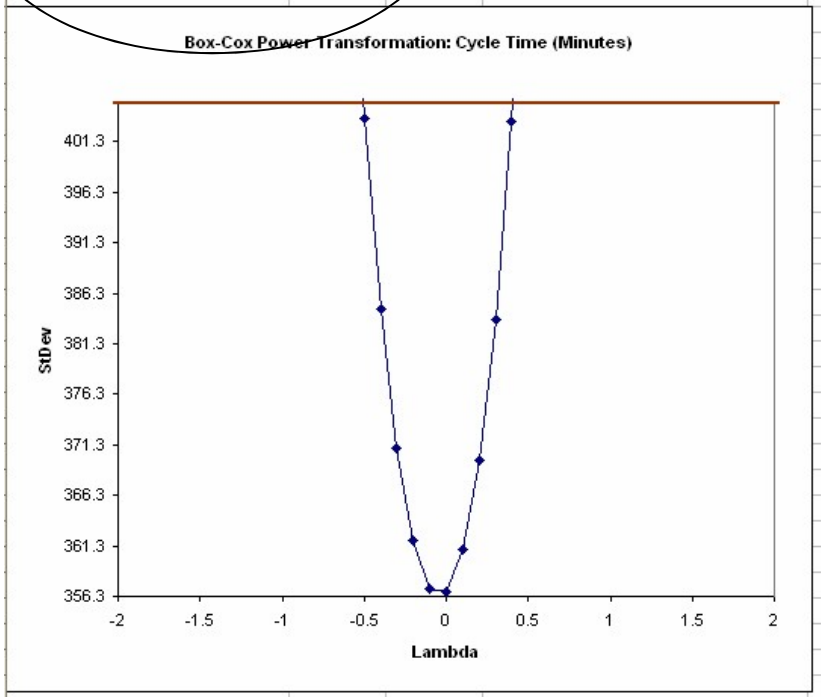


Tests for Special Causes -
Number of Data Points Failing Tests = 3

Control Charts: Box-Cox Power Transformation

Box-Cox Power Transformation: Cycle Time (Minutes)	
Optimal Lambda	-0.04
Final Lambda	0
UC Lambda (95%)	0.407756
LC Lamda (95%)	-0.506879
Anderson Darling Normality Test for Transformed Data:	
A-Squared	0.326821
AD P-value	0.5063

Normality Test is automatically applied to transformed data!



Cycle Time (Minutes)	Transformed Data (Ln(Y))
3216	8.07589363
261	5.564520407
392	5.97126184
63	4.143134726
28	3.33220451
6101	8.716207971
151	5.017279837
46	3.828641396
1465	7.289610521
383	5.948034989
287	5.659482216
322	5.774551546
538	6.28785856
574	6.352629396
586	6.37331979
920	6.82437367
178	5.18178355
129	4.859812404
187	5.231108617
71	4.262679877
342	5.834810737
167	5.117993812
794	6.677083461
205	5.323009979
576	6.356107661
575	6.354370041
381	5.942799375
576	6.356107661
918	6.822197391
190	5.247024072