

# SigmaXL® Version 9.1 Feature List Summary

## Compatible with Excel 2019 for Windows and Mac

## Menu Layout: Classical or DMAIC

## Recall Last Dialog

## Data Manipulation:

- Subset by Category, Number, Date or Random
- Stack Subgroups Across Rows
- Stack and Unstack Columns
- Random Number Generator
  - Normal
  - Uniform (Continuous & Integer)
  - Lognormal
  - Weibull
  - Triangular
- Box-Cox Transformation
- Standardize Data
- Convert to Discrete\*\*

## 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 with Pareto
  - Failure Mode & Effects Analysis (FMEA) with RPN Sort
  - Quality Function Deployment (QFD)
  - Pugh Concept Selection Matrix
  - Control Plan
- Lean Templates
  - Takt Time Calculator
  - Value Analysis/Process Load Balance
  - Value Stream Mapping
- Graphical Templates
  - Pareto Chart, Histogram, Run Chart
- Statistical Templates
  - Sample Size – Discrete and Continuous
  - Minimum Sample Size for Robust t-Tests and ANOVA
  - 1 Sample Z-test & Confidence Interval for Mean
  - 1 Sample t-Test & Confidence Interval for Mean
  - 2 Sample t-Test & Confidence Interval (Compare 2 Means)
  - 1 Sample Equivalence Test for Mean
  - 2 Sample Equivalence Test (Compare 2 Means)
  - 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 (with Fisher Exact P-Value)
  - 2 Proportions Equivalence Test
  - 1 Poisson Rate Test and Confidence Interval
  - 2 Poisson Rates Test and Confidence Interval
  - 2 Poisson Rates Equivalence Test
  - One-Way Chi-Square Goodness-of-Fit Test (with Exact and Monte Carlo P-Value)
- Probability Distribution Calculators
  - Normal, Lognormal, Exponential, Weibull
  - Binomial, Poisson, Hypergeometric
- Measurement Systems Analysis (MSA) Templates
  - Type 1 Gage Study
  - Gage Bias and Linearity Study
  - Gage R&R Study – with Multi-Vari Analysis
  - Attribute Gage R&R (Attribute Agreement Analysis)
- Process Sigma Level – Discrete and Continuous
- Process Capability & Confidence Intervals
- Tolerance Interval Calculator (Normal Exact)
- DOE Templates
  - 2 to 5 Factors
  - 2-Level Full and Fractional-Factorial designs
  - Main Effects & Interaction Plots
- Taguchi DOE Templates
  - L4, L8, L9, L12, L16, L18, L27
  - Signal-to-Noise Ratios: Nominal is Best, Nominal is Best (Variance Only), Nominal is Best (Mean Square Deviation with Target), Larger is Better, Smaller is Better
  - Pareto of Deltas (Effects) and ANOVA SS (Sum-of-Squares) % Contribution (for Main Effects and Two-Way Interactions)
  - Main Effects & Interaction Plots
- Control Chart Templates
  - Individuals, C (Count)
  - Rare Events: T, G and Probability Based G\*\*
  - Exponentially Weighted Moving Average (EWMA)\*\*
  - Tabular Cumulative Sum (CUSUM)\*\*
  - Trend/Tool Wear\*\*
  - Average Run Length (ARL) Calculators: Shewhart with Tests for Special Causes, Attribute C & P, EWMA & CUSUM\*\*

\*\* New features in SigmaXL® Version 9.0 & 9.1

# SigmaXL® Version 9.1 Feature List Summary

## Graphical Tools:

- Basic and Advanced (Multiple) Pareto Charts
- EZ-Pivot/Pivot Charts: Easily create Pivot Tables and Charts
- Basic Histogram
- Multiple Histograms and Descriptive Statistics (includes Confidence Interval for Mean and StDev., and Anderson-Darling Normality Test)
- Multiple Histograms and Process Capability (Pp, Ppk, Cpm, ppm, %)
- Multiple Dotplots, Boxplots & Multiple X Boxplots\*\*
- Run Charts (with Nonparametric Runs Test allowing you to test for Clustering, Mixtures, Lack of Randomness, Trends and Oscillation)
- Overlay Run Chart
- 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
- Analysis of Means (ANOM) Charts
  - All charts support balanced & unbalanced data
  - Normal, Binomial Proportions and Poisson Rates: One-Way & Two-Way with Main Effects and Slice Charts
  - 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. In collaboration, Peter Wludyka and John Noguera of SigmaXL extended the Slice Charts to Binomial and Poisson. Yellow highlight automatically recommends Main Effects (if interaction is not significant) or Slice Chart (if interaction is significant).
  - Nonparametric Transformed Ranks
  - Variances & Levene Robust Variances

## Measurement Systems Analysis:

- Create Gage R&R (Crossed) Worksheet:
  - Generate worksheet with user specified number of parts, operators, replicates
- Analyze Gage R&R (Crossed)
  - ANOVA, %Total, %Tolerance (with upper and/or lower specifications), %Process, Variance Components, Number of Distinct Categories
  - Gage R&R Multi-Vari and X-bar R Charts
  - Confidence Intervals for %Total, %Tolerance, %Process and Standard Deviations
  - Handles unbalanced data
- Attribute MSA (Binary, Ordinal, Nominal )
  - 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; Kendall's Coefficients (Ordinal Concordance and Correlation)
  - Confidence Interval Graphs for Percent Agreement, Fleiss' Kappa and Kendall's Coefficients
  - Kappa and Kendall color highlight to aid interpretation (Green/Yellow/Red)
  - Effectiveness Report (treats each appraisal trial as an opportunity) and Misclassification Summary

## Process Capability:

- Multiple Histograms and Process Capability
- Capability Combination Report for Individuals/Subgroups:
  - Histogram, Normal Probability Plot and Normality Test
  - Capability Report (Cp, Cpk, Pp, Ppk, Cpm, ppm, %)
  - Control Charts
- Capability Combination Report for Nonnormal Data (Individuals)
  - 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), Weibull (2 & 3), Beta (2 & 4), Gamma (2 & 3), Logistic, Loglogistic (2 & 3), Largest Extreme Value, Smallest Extreme Value
  - Automatic Best Fit based on AD p-value
  - Nonnormal Process Capability Indices: Z-Score (Cp, Cpk, Pp, Ppk) and 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

# SigmaXL® Version 9.1 Feature List Summary

## Statistical Tools:

- P-values turn red when results are significant: ( $p\text{-value} < \alpha$ )
- Descriptive Statistics including Anderson-Darling Normality test, Skewness and Kurtosis with p-values
- Descriptive Statistics options:
  - Percentile Report and Percentile Ranges
  - Percentile Confidence and Tolerance Intervals
  - Additional Descriptive Statistics and Normality Tests (Shapiro-Wilk and Doornik-Hansen Normality)
  - Outlier (Boxplot and Grubbs) and Randomness (Nonparametric Runs) Tests
- 1 Sample t-test and confidence intervals
- Paired t-test, 2 Sample t-test
- 2 Sample comparison tests:
  - Reports AD Normality, F-test and Levene's for variance, t-test assuming equal and unequal variance, Mann-Whitney test for medians.
  - Recommended tests are highlighted based on sample size, normality, and variance
- One-Way ANOVA and Means Matrix
  - Multiple Comparison of Means Probability Methods (Post-Hoc): Fisher, Tukey, Dunnett with Control
- Automatic Assumptions Check for One Sample, Two-Sample, Paired T-tests and One-Way ANOVA
  - Text report with color highlight: Green (OK), Yellow (Warning) and Red (Serious Violation)
  - Test each sample for Normality. If not, check minimum sample size for robustness of test
  - Check each sample for Outliers: Potential (Tukey's Boxplot  $1.5 \times IQR$ ); Likely ( $2.2 \times IQR$ ); Extreme ( $3 \times IQR$ )
  - Randomness (Nonparametric Runs Test)
  - Equal Variance (for 2 or more samples)
- Two-Way ANOVA (Balanced and Unbalanced)
- Equal Variance Tests (Bartlett, Levene and Welch's ANOVA)
  - Multiple Comparison of Variances Probability Methods (Post-Hoc): F-Test (with Bonferroni Correction), Levene, Tukey ADM (Absolute Deviations from Median)
  - Welch Multiple Comparison of Means Probability Methods (Post-Hoc): Welch Pairwise, Games-Howell
- Correlation Matrix (Pearson and Spearman's Rank Correlation)
  - Automatic normality check for correlation utilizing the powerful Doornik-Hansen bivariate normality test
  - Yellow highlight to recommend significant Pearson or Spearman correlation - Pearson is highlighted if the data are bivariate normal, otherwise Spearman is highlighted
- Multiple Linear Regression:
  - Accepts continuous and/or categorical (discrete) predictors
  - Interactive Predicted Response Calculator with 95% Confidence Interval and 95% Prediction Interval
  - 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
  - ANOVA report for categorical predictors
  - Pure Error and Lack-of-Fit report
  - Collinearity Variance Inflation Factor (VIF) and Tolerance report
  - Fit Intercept is optional
- 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 include Likelihood Ratio Chi-Square, Pseudo R-Square, Pearson Residuals Chi-Square, Deviance Residuals Chi-Square, Observed and Predicted Outcomes – Percent Correctly Predicted.
  - Stored data includes Event Probabilities, Predicted Outcome, Observed-Predicted, Pearson Residuals, Standardized Pearson Residuals, and Deviance Residuals.
- Chi-Square Test (Stacked Column data and Two-Way Table data)
  - With Fisher Exact (utilizing permutations and fast network algorithms) and Monte Carlo P-Values
  - Options: Advanced Tests and Measures of Association for Nominal & Ordinal Categories
- Nonparametric Tests:
  - 1 Sample Sign and 1 Sample Wilcoxon
  - 2 Sample Mann-Whitney
  - Kruskal-Wallis and Mood's Median Test (with graph of Group Medians and 95% Median Confidence Intervals)
  - Runs Test
  - With Exact and Monte Carlo P-Value
- Power and Sample Size Calculators for:
  - 1 and 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).
- Power and Sample Size Chart. Quickly create a graph showing the relationship between Power, Sample Size and Difference.

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## Statistical Tools - Advanced Multiple Regression: \*\*

- Standardization and coding of continuous predictors
- Option to display regression equation with unstandardized coefficients
- (1, 0) or (-1,0,+1) coding of categorical predictors
- Box-Cox Transformation
- Specify confidence level
- Residual Plots: Regular, Standardized and Studentized – Deleted t
- Diagnostic measures: Cook's Distance (Influence), Leverage and DFITS
- Storage of model design matrix
- Main Effects and Interaction Plots (Fitted Means)
- Contour and Surface Plots
- Optimization with optional constraints including integer continuous
- Automatic removal of extreme VIF or collinear terms (with alias and removal report)
- Specify interactions, quadratic and higher orders (all interactions or up to 3-Way)
- ANOVA Type I and/or Type III Sum-of-Squares with Pareto of Percent Contribution and Standardized Effects
- Length Pseudo Standard Error for Saturated Models (Orthogonal or Non-Orthogonal) with Monte Carlo or Student T P-Values
- Specify Test/Withhold Sample for R-square Test & StDev Test Validation
- R-Square Predicted (Leave-One-Out Cross Validation)
- R-Square K-Fold & StDev K-Fold (K-Fold Cross Validation)
- Test for Constant Variance: Breusch-Pagan. Anderson-Darling Normality test is applied to residuals in order to automatically select Normal or Koenker (Robust) version. Report includes the Overall test and Individual predictors as well.
- White robust standard errors for non-constant variance (Heteroskedasticity-Consistent)
- Durbin-Watson test for autocorrelation in residuals with P-Values
- Newey-West robust standard errors for non-constant variance with autocorrelation (Heteroskedasticity and Autocorrelation-Consistent)
- White or Newey-West automatically selected based on Durbin-Watson P-Values
- Stepwise/Best Subsets Regression:
  - Forward/Backward with alpha-to-enter, alpha-to-remove
  - Forward Selection with alpha-to-enter
  - Backward Elimination with alpha-to-remove
  - Forward, Backward Criterion: Minimize AICc, BIC; Maximize R-Square Adjusted, R-Square Predicted, R-Square K-Fold
  - Best Subsets utilizes the powerful MIDACO Solver (Mixed Integer Distributed Ant Colony Optimization) to solve best subsets with up to hundreds of continuous or categorical variables, including interactions and higher order terms. This feature gives SigmaXL a significant advantage over competitors with Best Subsets limited to 30 continuous variables.
  - Best Subsets Criterion: Minimize AICc, BIC; Maximize R-Square Adjusted
  - Hierarchical option
  - Detailed report with additional statistics such as Condition Number and Mallows' Cp.
- Multiple Response Optimization with Desirability
  - Multistart Nelder-Mead Simplex
  - MIDACO

# SigmaXL® Version 9.1 Feature List Summary

## 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
- Basic DOE Templates
  - 2 to 5 Factors, 2-Level Full and Fractional-Factorial designs
  - Automatic update to Pareto of Coefficients
  - Easy to use, ideal for training
- Main Effects & Interaction Plots
- 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
  - Residual plots: histogram, normal probability plot, residuals vs. time, residuals vs. predicted and residuals vs. X factors
  - Highlight of significant outliers in residuals
  - Durbin-Watson Test for Autocorrelation
- Contour & 3D Surface Plots
- Response Surface Designs
  - 2 to 5 Factors
  - Central Composite and Box-Behnken Designs
  - Easy to use design selection sorted by number of runs

## Control Charts:

- Control Chart Selection Tool
- Individuals, Individuals & Moving Range
- X-Bar & R, X-Bar & S
- I-MR-R, I-MR-S (Between/Within)
- P, NP, C, U
- $P^i$  and  $U^i$  (Laney) to handle overdispersion
- Control charts include a report on 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.
- Tests for Special Causes: Support for Varying Subgroup Sizes (Moving Limits), Historical Groups and MR/Range/StDev Charts (Tests 1-4)\*\*
- Process Capability report ( $P_p$ ,  $P_{pk}$ ,  $C_p$ ,  $C_{pk}$ ) is available for I, I-MR, X-Bar & R, X-bar & S charts.
- Add data to existing charts 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)
- Exclude data points for control limit calculation
- Add comment to data point for assignable cause
- $\pm 1, 2$  Sigma Zone Lines
- Control charts for Nonnormal data (Individuals)
  - Box-Cox and Johnson Transformations
  - 16 Nonnormal distributions supported (see Process Capability)
  - Individuals chart of original data with percentile based control limits
  - Individuals/Moving Range chart for normalized data with optional tests for special causes
- Control chart templates:
  - Individuals, C (Count)
  - Rare Events: T, G and Probability Based  $G^{**}$
  - Time Weighted: Exponentially Weighted Moving Average (EWMA) and Tabular Cumulative Sum (CUSUM)\*\*
  - Trend/Tool Wear\*\*
  - Average Run Length (ARL) Calculators: Shewhart with Tests for Special Causes, Attribute C & P, EWMA & CUSUM\*\*

## Reliability/Weibull Analysis:

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

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## Time Series Forecasting and Control Charts for Autocorrelated Data: \*\*

- Run Chart
- Autocorrelation Function (ACF)/Partial Autocorrelation (PACF) Plots
- Cross Correlation (CCF) Plots with Pre-Whiten Data option
- Seasonal Trend Decomposition Plots
- Spectral Density Plot with Detection of Seasonal Frequency
- Exponential Smoothing:
  - Forecast with Prediction Intervals
  - Exponential Smoothing models use Rob Hyndman's taxonomy:
  - Additive/Multiplicative Error
  - Additive/Additive Damped Trend
  - Additive/Multiplicative Seasonal
  - This includes all of the classical exponential smoothing models such as Simple/Single/EWMA, Double and Holt-Winters
  - Multiple Seasonal Decomposition (MSD) option: useful for high frequency and/or multiple frequency data, such as Monthly with frequency = 12, Daily with frequency = 7 and Hourly with frequency = 24
- Exponential Smoothing Residuals Control Chart for autocorrelated data:
  - Individuals and Moving Limits (with One-Step Ahead Forecast) Charts
  - Add Data, Show Last 30 Data Points, Enable Scroll options
  - MSD option
- Autoregressive Integrated Moving Average (ARIMA):
  - Forecast with Prediction Intervals
  - ARIMA Forecast with Predictors (Continuous and/or Categorical)
  - MSD option
- ARIMA Residuals Control Chart for autocorrelated data:
  - Individuals and Moving Limits (with One-Step Ahead Forecast) Charts
  - ARIMA Control Chart with Predictors
  - Add Data, Show Last 30 Data Points, Enable Scroll options
  - MSD option
- Utilities:
  - Difference Data
  - Lag Data
  - Interpolate Missing Values (seasonally adjusted linear interpolation)
- Time Series Forecasting Model Features:
  - ARIMA and Exponential Smoothing models are fully automatic or user specified
  - Utilizes modern State Space and Kalman Filter models for accurate parameter estimation
  - ARIMA estimates missing values with Kalman Filter; Exponential Smoothing uses seasonally adjusted linear interpolation
  - Automatic Box-Cox Transformation
  - Automatic seasonal frequency detection
- Model diagnostics:
  - ACF/PACF Plots
  - Ljung-Box p-values
  - Log-Likelihood, AIC, AICc, BIC, Residual StDev
  - Residual plots (histogram, normal probability, residual versus fits, residuals versus order)
- Forecast Accuracy:
  - In-Sample (Estimation) one-step-ahead forecast errors (RMSE, MAE, MASE, MAPE)
  - Out-of-Sample (Withhold) one-step-ahead forecast errors
  - Out-of-Sample (Withhold) multi-step-ahead forecast errors
  - Evaluated using the benchmark standard M4 forecast competition data, a total of 100,000 data sets with Yearly, Quarterly, Monthly, Weekly, Daily and Hourly data. Using a hybrid average of automatic Exponential Smoothing and ARIMA, SigmaXL (unofficially) ranked 10th out of 60 in the Overall Weighted Average forecast accuracy score, ahead of three well known commercial forecast software packages.