Phases, Steps and Tools for Six Sigma

Phase	Objective of the Phase	Step	Objective of the Step	Subject or tool	Objective of the subject / tool
Define	Define who is the customer and what their needs are Translate the customer needs to quality characteristics (CTQ's). Select the project CTQ. Describe the project (IntCTQ) in measurable definitions (operationalising). Identify which process or product is targeted for improvement. Develop a high-level process map for the key process steps (Scope). Calculate the Business Case and write a project charter.	1) What does the customer want?	Define the customers and their needs	Customer identification	Start with an overview of all the customers
				Customer needs identification (customer surveys)	Use different sources to identify the customers needs
				Affinity Diagram	Affinity helps you to cluster the customer needs in logical groups
				Customer Needs Mapping	Customer needs mapping creates a hierarchical structure in the customer needs
				Kano	Kano model classifies needs in different categories
				Quality Function Deployment	QFD links needs and process steps or departments
		2) Establish measurement definitions	Translate the project from the customers perspective to an internal improvement project and describe the Internal CTQ in measurable definitions	Pareto	Pareto helps you to prioritize different CTQ's and tells which CTQ you should work on
				CTQ-tree or CTQ flow down	A CTQ-tree shows how different CTQ's are related
				Correlation diagram	Use a correlation diagram to find out how strong External CTQ and Internal CTQ are correlated
				Operationalisation	Make an Operational definition of the Internal CTQ
		3) What is the project?	Identify which process is targeted for improvement and the scope of the project. Describe problem statement, target and benefits in a project charter.	SIPOC	SIPOC creates an overview of the process and the customers. Use SIPOC for scope definition (start and end of the process).
				Process Map	Create a process map of the process in the way it really is. Identification of Quick Wins
				Business Case	Calculate the benefits and costs of the project. Is the project profitable enough to work on.
				Project Charter	Write a project charter to give an overview of the project; problem, goals, benefits scope etc.
Measure	Define and validate a measurement system for the CTQ. Collect CTQ data (accurate and precise). Calculate the current process capability and define statistical success.	4) Define Measurement System	Define a measurement system for the CTQ and create a sufficient sample	Measurement system definition	Define exactly how the CTQ will be measured
				Sampling (representativeness)	Create a sample that is representative for the population (strata, randomness,
				Sample Size (continuous data)	Calculate how many data points you need for an accurate Process Performance Analysis
				Sample Size (discrete data)	Calculate how many data points you need for an accurate Process Performance Analysis
				Acceptance sampling by attributes	Create a sampling plan to make a decision whether to accept or reject an entire lot (batch) of product, based on the number of defects found in that sample
				Acceptance sampling by variables	Create a sampling plan to make a decision whether to accept or reject an entire lot (batch) of product, based on the number of defects found in that sample
		5) Validate measurement system	Validate measurement system	Gauge R&R (crossed)	Validate measurement system for continuous data
				Gauge R&R (nested)	Validate measurement system for continuous data, destructive measurements
				Attribute Gauge R&R	Judge Bias & repeatability given a continuous measurement with a binary outcome label
				Type 1 Gauge Study	To estimate bias and repeatability (a sneak preview)
				Linearity & Bias Study	To find out whether the measurement system measures with a small or large deviation (bias & linearity)
				Time & motion studies	To estimate the variance caused by the operate when replication is impossible
				Kappa test (with and without known standard)	Validate measurement system for discrete data
		6) Actual Process Performance	Calculate actual process performance related to the customers specification limits	Control chart individuals (normal, box-cox); tests	Make a control chart to show 'the heartbeat' of the process. Distinguish between common cause and special cause variation. Is the process stable and statistically in control?
				Run Chart	Make a run chart to determine if the process show any pattern. If any, PCA is limited to short term.
				Probability Plot (Normal, Weibull)	Use probability plots to determine whether a particular distribution fits your data. Many statistical tools use a probability distribution. These tools can only be used if the distribution is applicable
				Individual Distribution Identification	Use Individual Distribution Identification to find out which probability Distribution best fits
				Goodness of fit test for Poisson	Use a Goodness of fit test for Poisson to determine if the data follow a Poisson distribution
				Chi square Goodness of fits test	Use a Goodness of fit test for Poisson to determine if the data follow a multinomial distribution with certain proportions
				Capability Analysis (Normal)	Calculate the current process capability. Use the type that is appropriate for your data. This is the starting point for improvement
				Capability Analysis (Weibull)	
				Capability Analysis (other distributions)	
				Capability Analysis Between / Within	
				Binominal Cap An	
				Poisson Cap An	
		7) Define Statistical Success	Should-be performance: how much should the process improve?	Calculation of the mean and standard deviation of the improved process	Calculate the mean and standard deviation which are needed to a defect rate that meets the target.

Copyright ProjectsOne 2010.
All rights reserved. No part of this training material may be reproduced in any form.

Analyse		8) Identify causes of defects	Identify all possible causes using explorative data analyses and expert knowledge	Exploratory Data Analysis (Control- and Run Charts, Probability Plots, Scatter plots, Histogram, Box plots, Dot plots, Individual Value plot, Interval plots, Pareto charts, Etc.)	Use graphs to find as many potential influence factors (X's) on Y (the output of our process) as possible
				Main Effects Plot	Use the main effects plot for comparing magnitudes of main effects.
				Interactions Plots	Interactions plots are useful for judging the presence of interaction between different factors.
				Symmetry Plot	Symmetry plots help you to determine if the data comes from a symmetric distribution.
				Multivari chart	Multi Vari Charts are charts that show patterns of variation from several possible causes on a single chart, or set of charts
				Time Series Analysis	Time series procedures can be used to analyze data collected over time, including simple forecasting and smoothing methods, correlation analysis methods, and ARIMA modelling.
				Multivariate Analysis	Multivariate Analysis can help you to 1) Analyze the data covariance structure to understand it or to reduce the data dimension, 2) Assign observations to groups and 3) Explore relationships among categorical variables.
				Exploratory Data Analysis	EDA methods are particularly useful for identifying extraordinary observations and noting violations of traditional assumptions, such as nonlinearity or nonconstant variance .
				Cause & Effect Diagram (Ishikawa)	Cause and Diagram can be used in a brainstorm with experts to collect possible influence factors (causes)
				Failure Mode and Effects Analysis (FMEA)	Use FMEA to make an overview of potential X's that can negatively impact process performance (Y).
				Expert Knowledge (Brainstorm)	Always use the process knowledge of experts. Discuss the results from the explorative data analysis with an expert. Brainstorm with experts to find possible causes (X's).
				1 sample t-test	Use this test to assess the difference between the mean from a sample versus an historical mean from another population when s is unknown
				2 sample t-test	The means of two normally distributed samples are tested for differences against each other
				Paired t-test	Use a paired t-test when pairs of data points are dependent or related. It tests if the differences of the pairs are significantly differ from 0.
				2 variances	Use to perform hypothesis tests for equality, or homogeneity, of variance among two populations using an F-test and Levene's test. Many statistical procedures, including the two sample t-test procedures, assume that the two samples are from populations with equal variance. The 2 variances test procedure will test the validity of this assumption.
				Correlation	You can use correlation to measure the degree of linear relationship (correlation coefficient) between two variables.
				Covariance	You can calculate the covariance for all pairs of columns. Like the Pearson correlation coefficient, the covariance is a measure of the relationship between two variables. However, the covariance has not been standardized, as is done with the correlation coefficient.
				Test for equal variances	Use variance test to perform hypothesis tests for equality or homogeneity of variance using Bartlett's and Levene's tests. An F Test replaces Bartlett's test when you have just two levels.
				Single regression (1e 2e and 3e order)	Use regression to find out if a X variable (continuous) influences the outcome in Y. A p-value tells you if the relationship is significant.
				Binary Logistic regression	Use binary logistic regression to perform logistic regression on a binary response variable.
				One Way Anova (stacked & unstacked)	Anova is used to determine whether the means of samples are identical (Null-hypothesis) or differ due to a factor
				Two way Anova	A two-way analysis of variance tests the equality of population means when classification of treatments is by two variables or factors .
				Analysis of Means	A graphical analogue to ANOVA that tests the equality of population means. The graph displays each factor level mean, the overall mean, and the decision limits. If a point falls outside the decision limits, then evidence exists that the factor level mean represented by that point is significantly different from the overall mean.
				Chi Square test	A chi square (c2) statistic is used to investigate whether distributions of discrete variables differ from one another.
				One sample Wilcoxon	An assumption for the one-sample Wilcoxon test and confidence interval is that the data are a random sample from a continuous , symmetric population.
				Mann-Whitney	You can perform a 2-sample rank test (also called the Mann-Whitney test , or the two-sample Wilcoxon rank sum test) of the equality of two population medians, and calculate the corresponding point estimate and confidence interval .
				Kruskal Wallis	You can perform a Kruskal-Wallis test of the equality of medians for two or more populations.
				Moods Median	Mood's median test can be used to test the equality of medians from two or more populations and, like the Kruskal-Wallis Test, provides an nonparametric alternative to the one-way analysis of variance. Mood's median test is more robust for outliers.
				Runs Test	Use Runs Test to see if a data order is random. Runs Test is a nonparametric test because no assumption is made about population distribution parameters. Use this test when you want to determine if the order of responses above or below a specified value is random. A run is a set of consecutive observations that are all either less than or greater than a specified value.

Copyright ProjectsOne 2010.
All rights reserved. No part of this training material may be reproduced in any form.

Improve	In the Improve phase you and your project team will: Determine the optimal settings in order to reach your performance goal Specify tolerances on the critical X's to meet our CTQ performance goal Update the initial Business Case towards a final Business Case Define implementation plan and approach Write the implementation plan	10) Determine vital causes	Determine Transfer Function between Y & X's and identify optimal settings for these X's	Multiple regression	Use Multiple regression to determine a transfer function for a continuous Y and one or more continuous X's (linear)
				General Regression (Minitab 16)	Use Multiple regression to determine a transfer function for a continuous Y and one or more continuous X's (non-linear) and one ore more categorical X's
				General Linear Model	General linear model is a technique that enables you to create a model out of multiple X's for their impact on Y (our internal CTQ). These X's are continuous or categorical by nature. The Y must be continuous.
				Doe Full Factorial / Plackett Burmann (Design; Analysis; Optimise)	These advanced Design of Experiments (DOE) capabilities help you improve your processes. You can screen the factors to determine which are important for explaining process variation. After you screen the factors, Minitab helps you understand how factors interact and drive your process. You can then find the factor settings that produce optimal process performance
				Doe Response Surface (Design; Analysis; Optimise)	Response surface methods are used to examine the relationship between one or more response variables and a set of quantitative experimental variables or factors. These methods are often employed after you have identified a "vital few" controllable factors and you want to find the factor settings that optimize the response. Designs of this type are usually chosen when you suspect curvature in the response surface.
				Doe Taguchi (Design; Analysis; Results)	Taguchi is a robust parameter design, which is an engineering method for product or process design that focuses on minimizing variation and/or sensitivity to noise.
				Queuing theory	Queuing theory is the mathematical study of waiting lines, or queues. The theory enables mathematical analysis of several related processes, including arriving at the (back of the) queue, waiting in the queue (essentially a storage process), and being served at the front of the queue. The theory permits the derivation and calculation of several performance measures including the average waiting time in the queue or the system, the expected number waiting or receiving service, and the probability of encountering the system in certain states, such as empty, full, having an available server or having to wait a certain time to be served
		11) Define tolerance limits	Specify tolerances on the critical X's to meet our CTQ performance goal	Eliminating disturbances: Expert Knowledge (analogy, anti-solution, brain writing, etc.)	If you need creativity to find a solution for the problem, brainstorming can help.
				Eliminating disturbances: Selection of the best solution (pugh matrix)	Evaluating multiple options against each other, relative to a baseline option.
				Robust design: tolerance design	Use buffering for model errors (residuals) to create a robust design
Control	In the Control phase you and your project team will: Ensure your measurement system is adequate to measure the Vital X's Implement all process changes and confirm that your improvement goal is achieved Implementations must be sustainable and the process will stay in control Ensure that you can detect when your process runs 'out of control' of our X's, so that you can undertake actions to prevent defects from occurring Calculate the final benefits after performing the PCA on the improved process	12) Validate measurement system	Validate measurement systems for X's	Methods see step 5	Methods see step 5
				Tolerance design: Buffering for variance of due to the measurement system	Buffer for errors of the measurement systems of X's. Calculate control limits (LCL, UCL) for all X's
		13) Determine new process capability	After the implementation of all appropriate improvement actions we have to determine that we were successful. Statistically confirm that our improvement goal has been achieved!	Capability analysis: see step 6	See step 6
				Cap An Multiple Variables (normal & non-normal)	Capability Analysis Multiple Variables compares the capability of two datasets, for example before improvement and after improvement.
		14) Implement Process Controls	To control and anchor long term results. Finally we hand over the project with its results to the organisation, who owns this process	Control chart individuals (normal, box-cox); tests	See step 6
				Control chart EWMA	Use the control chart that is most appropriate for your situation
				Control chart Cusum	
				Control chart X Bar & R	
				Control chart X Bar & S	
				Control chart (all other charts)	
				Multivariate Control Charts	
				Out of Control Action plan	Make an action plan that comes into operation when there are signals shown on the Control Chart
				Poka Yoke	Determine which mistakes are most likely and define suitable mistake-proofing methods
				Hand-over document	Describe everything that is needed for the process owner and the employees to run the process on the higher performance level (procedures, instructions)
Basic Statistics		Basic Statistics	Basic Statistical knowledge for data-analyses	Types of Data	Continuous, discrete (binary, category, count)
				Mean	Average
				Median	Middlemost value
				Long term Standard Deviation	Overall standard deviation
				Short term Standard Deviation	Average moving range
				Pooled Standard Deviation	Meant to pool standard deviation across groups
				Other types of Standard Deviation	Other types of Standard Deviation
				Standard Error of the Mean	Standard deviation divided by the square root of the sample size
				Confidence intervals (mean, median)	Interval within which the parameter of the population is (with a certain confidence level)
				Modus	Most frequent value in a set of data
				Quartiles	Q1 (First Quartile): 25% smaller, 75% larger, Q2 (Second Quartile): 50% smaller, 50% larger, Q3 (Third Quartile): 75% smaller, 25% larger
				Skewness & Kurtosis	Skewness is a measure for symmetry, Kurtosis is a measure of similarity to the normal distribution
				Probability Density Function	Probability density function (pdf), or density of a continuous random variable is a function that describes the relative likelihood for this random variable to occur at a given point --> the probability of a certain outcome
				Cumulative Density Function	The probability for the random variable to fall within a particular region is given by the integral of this variable's density over the region.
				Normal Probability Distribution	Probability distribution for continuous data which can be used to describe the data and calculate probabilities. For example: the probability of a defect
				Weibull Probability Distribution (2 and 3 parameter)	
				Exponential distribution	
				Binominal Probability Distribution	Probability distribution for discrete data which can be used to describe the data and calculate probabilities. For example: the probability of a defect
				Poisson Probability Distribution	
				Box Cox Transformation & inverse functions	Translate the data with a certain function to make it more normal distribution-like
				Johnson Transformation & inverse functions	

Copyright ProjectsOne 2010.
All rights reserved. No part of this training material may be reproduced in any form.