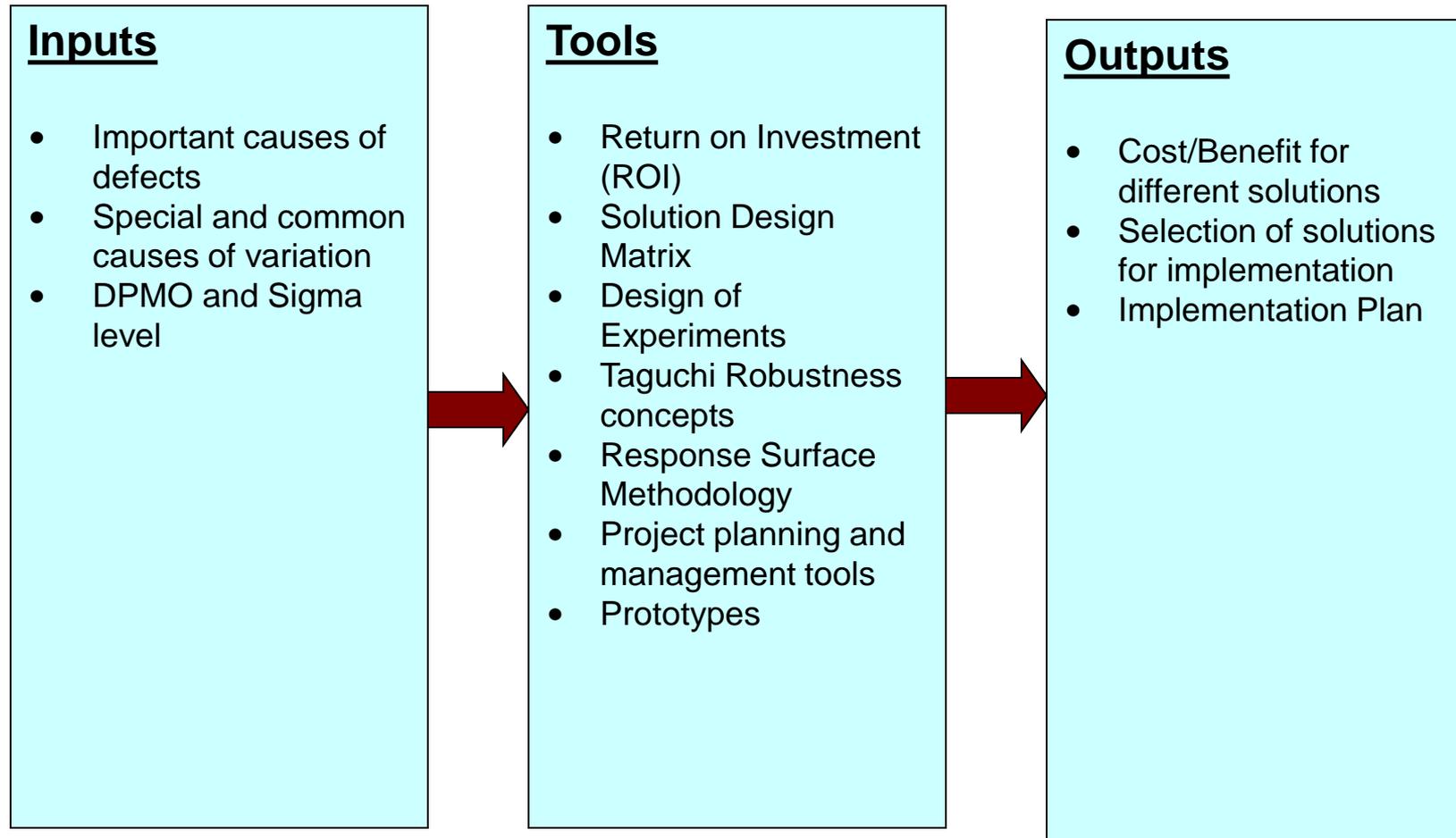


Six Sigma Green Belt - Study Guides



Index – Six Sigma Methodology (Improve)



Objective of Improve phase

- In Improve phase, our objectives are:
 - Determine which project would be selected that maximizes the Return on Investment (ROI)
 - Find out cause and effect relationships using tools like Design of Experiments (DOE) and Solutions Matrix. This helps in comparison and verification of alternate solutions.
 - Determining activities needed to meet project goals.
 - Creating work breakdown structures and detailed implementation plan for the project.
 - Determining how to re-integrate the different sub-projects.

Inputs

- Inputs for Six Sigma Improve are covered in Outputs for Six Sigma Analyze. (for details, please refer to Chapter 6: Six Sigma Methodology – Analyze)

Tools – Return on Investment (ROI)

- ROI is a measure of the income (or profit) divided by investment. ROI measures how effectively the company uses its capital to generate profits
- For a six sigma project perspective, the project cost is the investment, and income is the quantified benefits accrued from the project. So, ROI for a six sigma project is the ratio of project benefits to project costs.
- Objective of any company is to maximize ROI

ROI (continued)

- Project costs can be divided into following broad categories like human resources, infrastructure, raw material etc.
- Project benefits can be divided into categories like increased revenue, reduction in costs, cost avoidance, improved productivity, improved customer satisfaction etc.
- While comparing several alternative projects, we use tools like Design of Experiments and Solution Design Matrix. These tools help in verifying proposed solutions and ensuring that the company realizes the benefits from doing the six sigma project.

Tools – Solution design matrix

- Tool to organize alternate solutions based on information available
- Helps to compare how the proposed solutions compare with the existing system in meeting the specified criteria
- Steps in creation of Solution Design Matrix
 - Determine the key criteria on which the project will be evaluated (the criteria are got from the project charter, process map, QFD, Kano Model, Ishikawa diagrams etc.) These are written in the left hand side of the matrix.
 - Form a team who have knowledge of the existing process and understand the proposed solutions
 - Determine the benefit rating for each criteria by taking inputs from team members:
 - Existing design is provided a rating of “0” on all the criteria
 - New designs are provided a rating of “-1”, “0” or “1” where -1 indicates worse than existing design, 0 indicates same as existing design and 1 indicates better than existing design.
 - Determine the importance rating for each criteria: This is done in a scale from 1 through 5 where 1 denotes “Not Important” and 5 denotes “Very Important.”
 - Determine the sum of positives, sum of negatives, sum of zeroes, weighted sum of positives and weighted sum of negatives.
 - The project which has the highest value of weighted sum of positives minus weighted sum of negatives is selected.

Case study – Solution Design matrix

- A popcorn manufacturer would like to improve its processes to produce better quality popcorn at lower cost. A six sigma project was initiated, and a six sigma expert was assigned to the project. Analysis phase for the project is complete and we would like to decide between two available alternatives (project A and project B) which are under consideration. The six sigma expert suggests doing a solution design matrix to compare the available alternatives.
- Steps followed:
 - A project team is selected which has good understanding of the existing popcorn manufacturing process and the pros/cons of the suggested processes
 - The key criteria for the solution matrix are determined. They are:
 - Time to cook
 - Percentage of cooked popcorns
 - Taste
 - Cost of materials
 - Complexity of manufacturing process
 - Criteria rating and Importance rating are provided by the project team as shown in the diagram

Case study – Solution Design matrix (continued)

	Importance rating	Criteria Rating		
		Existing Process	Project A	Project B
Key criteria				
Time to cook	4	0	-1	0
Percentage of cooked corns	3	0	0	1
Taste	5	0	1	1
Cost of materials	3	0	1	-1
Complexity of manufacturing process	2	0	-1	0
Sum of positives				
Sum of negatives				
Sum of zeroes				
Weighted sum of positives				
Weighed sum of negatives				
Overall weightage				

- Please calculate the sum of positives, sum of negatives, sum of zeroes, weighted sum of positives, weighted sum of negatives and overall weightage.
- Which project would you recommend?

Case study – Solution Design matrix (continued)

Key criteria	Criteria Rating					
	Importance rating	Existing Process	Project A	Calculation Project A	Project B	Calculation Project B
Time to cook	4	0	-1		0	
Percentage of cooked corns	3	0	0		1	
Taste	5	0	1		1	
Cost of materials	3	0	1		-1	
Complexity of manufacturing process	2	0	-1		0	
Sum of positives		0	2		2	
Sum of negatives		0	-2		-1	
Sum of zeroes		5	1		3	
Weighted sum of positives		0	8	$1*5+1*3$	8	$1*3+1*5$
Weighted sum of negatives		0	-6	$-1*4-1*2$	-3	$-1*3$
Overall weightage		0	2	8-6	5	8-3

- Project B is recommended because it has the highest overall weightage

Design of Experiments

- Design of experiments is a very powerful statistical tool to determine cause and effect relationships to determine the most optimal solution.
- Every process can be considered to be a black-box with some inputs and some outputs. Using Design of Experiments, processes or settings are changed in a systematic way so that the optimal solution can be found.
- Consider an example where the project team would like to decrease cycle time (Y). This is possible by a combination of following 4 input factors (X):
 - Getting better equipment
 - Improving worker training
 - JIT processes
 - Better vendor management.

However, there is a cost associated with making changes to the factors mentioned above. Using Design of Experiments, the team would be able to determine the most appropriate combination of input factors (X) which would maximize the cycle time (Y)

Benefits of Design of Experiments

- Some benefits of Design of Experiments include:
 - Better Quality
 - Lower Cycle time
 - Reduction of defects
 - Reduction of process variability
 - COPQ decreases
 - ROI increases
 - Increase in customer satisfaction
 - Improvement in customer satisfaction
 - Learning more about the process

Design of Experiments: Important terms and concepts

- Factor: Any variable that may influence a process
- Levels: Setting or category that a variable may take. Two or more levels could be chosen for each category
- Trial: One run during the experiment. Factors are set at different levels for each trial
- Response Variable: Specific parameter used to decide if the process is improving; helps in determining the type of data to be collected

Design of Experiments: Important terms and concepts

- Interaction between factors: When an experiment is being run, two or more factors may interact and influence the response variable. It is important to understand the interaction between factors while doing Design of Experiments study
- One-factor-at-a-time: Level of the first factor is changed while others stay the same. One or more trials are run until the best level of first factor is determined which maximizes the response variable. These are the simplest experiments used in DOE.
- Factorial Design: Allows experimentation on many factors simultaneously. Some examples:
 - **Two-factorial design:** Two factors are changed simultaneously and the impact on the response variable is studied.
 - **Fractional factorial experiment:** Only some of the possible factors and levels are studied simultaneously
 - **Full factorial experiment:** All the combinations of factors and levels are studied simultaneously

Design of Experiments

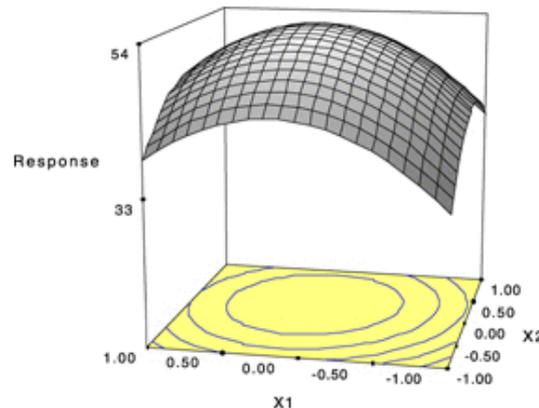
- As mentioned earlier, detailed study of Design of Experiments will be done in a six sigma black belt level course.
- The six sigma green belt course discusses some basic concepts for DOE and provides an understanding of where DOE should be used.

Taguchi Robustness concepts

- Genichi Taguchi (Jan 1924 – Aug 2001) was born in Takamachi, Japan and studied technical engineering at Kiryu College. After the Second World War, Japanese companies had limited resources and were perceived as providing goods with low quality. In the era where good quality was considered expensive, Taguchi revolutionized the concept of improving quality of goods produced while simultaneously reducing costs.
- Taguchi theorized that manufacturing processes are impacted by the external disturbance i.e. noise which impacts quality of goods produced. The noise should be minimized wherever possible but some noise (e.g. bad weather) cannot be avoided. Systems should have “robustness” i.e. ability to function satisfactorily in spite of the noise and external disturbance
- Taguchi divided variables that have impact on the processes into two types:
 - Controllable variables: These can be controlled and incorporated into Design of Experiment studies. Their impact on the process under study is predictable. Taguchi’s concepts helped in determining the settings for the controllable variables which minimize the variability of the y variable or ensure that y variable is always near desired levels.
 - Uncontrollable variables: These variables cannot be controlled e.g. weather, natural calamities etc. Taguchi tried to determine if some of these uncontrollable variables could be made controllable? Alternately, what would be the best settings for the controllable variables to minimize effects of the uncontrollable variables?

Response Surface Methodology

- Response Surface Methodology (RSM) can be defined as a statistical tool that uses quantitative data from appropriate experiments to study, improve or optimize a process.
- After DOE experiments are conducted (e.g. Fractional or full factorial experiments), the responses need to be studied to determine the best solutions. RSM provides a means to study the responses either in the form of contours or as a 3-D rendering.



Example of a Response surface from Dekker.com

Response Surface Methodology (continued)

- In many applications of RSM, a sequential process is performed. Some steps are as follows:
 - At the start, the project may have several factors and levels that are being studied. All these factors need not have an impact on the response variable. In order to determine initially which of these has an impact on the response variable, a *screening design* is often performed.
 - Screening Design will potentially reduce the number of factors that need to be investigated in detailed experiments : this eliminates unimportant factors before investing time and money in a more elaborate experiment (i.e., second-order design).
 - After screening design, RSM experts use a concept referred to as “Method of steepest ascent” to determine which combination of factors maximizes the response variable
- Detailed study of RSM will be taken up in a six sigma black belt course

Project Planning and Management tools

- In the Improve phase of a six sigma project, we have good idea about the project and project management tools are used to ensure that appropriate project planning is done. Project planning includes a detailed implementation plan.
- Some important project management and planning tools are discussed in chapter 3: Setting up and managing a six sigma project
- Detailed study of Project Management is beyond the scope of this course. Recommended course for studying about Project Management is the Project Management Professional (PMP) preparatory course offered by www.pmstudy.com. Important Concepts about project management can be got from www.pmi.org.
- Overview of project management knowledge areas and project management processes is provided in the next page.

Project Planning and Management tools (continued)

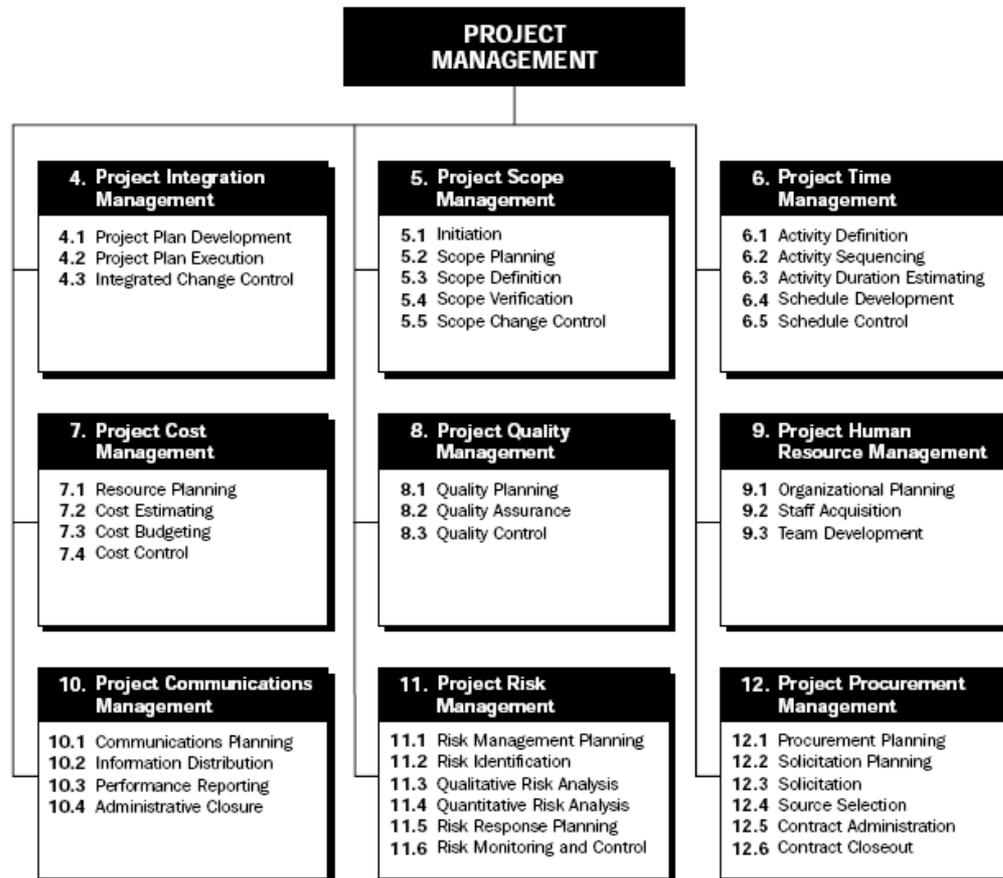


Figure 1-1. Overview of Project Management Knowledge Areas and Project Management Processes

Prototypes

- As defined in Webster, “ prototype is an original or model after which anything is copied.” From a six sigma project perspective, prototype is a small scale working model which provides idea of the final product, process or service
- In several occasions, projects are used to develop new products or services or make radical changes to existing processes. There may be a lot of uncertainty and complexity because of the nature of the changes or innovation required. Prototypes help in providing a small scale working model and identifying issues which may have been overlooked in earlier design phases. They are also a powerful tool to ensure buy-in from all stakeholders and to provide justification about the validity of the project. They help in reducing risks and facilitate project planning and implementation.
- For example, prototyping is a commonly used tool in the construction industry where small-scale prototypes of buildings, highways etc. are created and approved by relevant stakeholders before the final project implementation is done.

Outputs : Cost/Benefits of different solutions

- ROI, Solution Design Matrix and Design of experiments help in evaluating different project alternatives, and providing costs and benefits associated with all the alternatives.
- At the end of Improve phase, we have a clear idea of the costs and benefits associated with all suggested options.

Selection of solutions for implementation

- Costs and Benefits of all available alternatives are known at the end of Improve phase.
- At the same time, Design of Experiments and RSM provide quantitative knowledge about how different factors must be tuned to maximize the response variable.
- With the above information, management is able to make an informed decision about which solution should be implemented to maximize ROI for the company.

Implementation Plan

- After the appropriate option has been selected by management, six sigma experts work with project managers to create an implementation plan for the project.
- Project planning and management tools are used, and if required prototypes may be created.
- The implementation plan would include a detailed project plan with planned deliverables and schedules. Detailed work breakdown structures should be created to ensure that all the project team-members know their tasks, roles and responsibilities.