MSc Program

Engineering Management

MANAGING TEAM EXCELLENCE BY SIX SIGMA THROUGH DMAIC MODEL

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AFFIDAVIT

I, **Augusto Manuel Gomes dos Santos Tomas**, hereby declare

1. that I am the sole author of the present Master Thesis, "Managing Team Excellence by Six Sigma through DMAIC model",
   seventy three pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master Thesis as an examination paper in any form in Austria or abroad.

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ABSTRACT

There is an assumption that Managing Human Resources (HR) is the same as Managing Working Teams, but the scope, the entities and the final results different and in a certain extent they are complementary. The HR department is responsible to build effective systems like HR planning, Reward system, Appraisal system, Career system, but the Project/Functional manager that has the Team Leader function has the key to create a high-performance team or to destroy a team, independently of the systems established by the HR department.

Nevertheless, in the business world, many people are not hired via the official HR department, and even in the case that is does, the HR department usually doesn’t do a full analysis of the integration of the social and personality of the candidate into the current team environment and team members profiles.

Since usually the core business of a Project/Functional manager is not its own people, there is no priority in equipping the Project/Functional manager with a toolset to take out the best of its people to achieve successfully the targets set to its own core business.

The purpose of this Thesis is to describe a method for the Project/Functional manager to use, both in industry or services, to start with a group of people and develop them towards a high-performance team to achieve excellent business results.

The Define-Measure-Analyze-Improve-Control (DMAIC) model is part of the Six Sigma system, and its one of the methods that will allow the Project/Functional manager managing Team Excellence for the purpose of achieving business excellence.

Team development by nature is a social and psychological subject, hence, we hardly can predict the outcome of the DMAIC model, but the replicability of the process of using the DMAIC model in the business is successfully demonstrated by some of the best companies of the World as General Electric, Motorola, Bayer, etc.

1 INTRODUCTION

Based on the IEEE paper “Leadership: so easy even an engineer can do it!” (Polito and Martinich, 2008), we will understand the importance of knowing how to handle a team to be successful has an Engineer Manager.

Engineers are well trained as engineers. However, they need additional training to make a successful transition to engineering management.

Usually when Engineers are promoted into leadership positions, they often try to acquire the skills they need through informal means. They ask for coaching and mentoring from their own managers. They read articles in trade journals and the commercial press. They attend informational meetings, trade shows, conferences and engineering projects. They are well-trained as engineers, but they are not receiving the training they need to succeed as managers. Polito C. and Martinich L. (2008) have seen this to be true on a global scale. They have seen the problems that result in China, India, Australia, Canada, Europe and the United States. Projects fail, not because of engineering challenges, but because engineering managers lack of communication, collaboration, negotiation and business alignment skills.

Polito C. and Martinich L. (2008), defined the content of a program with the input of the focus group participants. They used Rapid Requirements Gathering techniques to obtain and rank the desired content.

Follow On “Hot Topics”, to be handle by the new Engineer Manager:

- Managing Up
- Let Go off Engineering Tasks: Maintaining Competency while Shifting Focus
- Hiring and Retaining the Right People
- Diversity
- Managing your Time
- Building Trust within Your Team

The last of the above topics "Building Trust within Your Team", will be the aim that this Thesis will cover.

The first part of Thesis will be to describe the fundamentals of Team Development stages and types of teams. The high-performance team type that is the Self-Directed Working Teams, will be defined.

A state-of-the-art application of the Self-Directed Working Teams can be seen on the Define-Measure-Analyze-Improve-Control (DMAIC) model of the Six Sigma system. Each stage of the DMAIC model will be explained.

To be able to properly evaluate the DMAIC model in a real-case of company, it was used a company example Bayer MaterialScience, that competed on the International Team Award Process (ITEA) of American Society of Quality (ASQ). Bayer MaterialScience presented how they applied the DMAIC model for a real-business problem.

The criteria methodology of ITEA/ASQ that was used to evaluate the Bayer’s case is described. The criteria are also of great value to be used as a base for audit systems for team development in companies, independently of using the DMAIC model or not.

The Bayer case will be described organized around the criteria of ITEA/ASQ.

Hence, by give the fundamentals, a model, audit criteria, and a real company case, it is expected that this Thesis will give directions for a successfully replicability of managing Team Excellence in the business World.

2 FUNDAMENTALS

Based on the IEEE paper "The Use of Work Teams in Organizations" (LaFollette et al., 2008), we will describe different types of teams and its implementation.

One of the approaches that many companies are adopting to become more flexible and responsive is that of work teams, especially self-directed work teams (SDWTs). Much has been written over the last five years about successful implementations of SDWTs in companies like Volvo, General Electric, Boeing, Bayer, just to name a few. This concept is not new. Procter & Gamble and General Foods began experimenting with work teams in 70s, as did Digital Equipment Corp., TRW and Cummins Engines (Lee 1990). Those who are employing SDWTs often cited increased sales and earnings, improved productivity and quality, lower scrap, reduced rework and absenteeism, and improved employee morale and ownership as just of few of the advantages of the technique. While the use of SDWTs has led to impressive results for many, it has also met with disappointing failure for others.

2.1 Self-Direct Working Teams (SDWTs) Defined

From a conceptual perspective, it is likely that work teams are part of a continuum of employee involvement, where SDWTs represent the highest level of employee empowerment. The basic tenet of SDWTs is that jobs and organizations should be designed around processes instead of functions and that the basic production unit should be the team not the individual (Dyer, 1995). These teams set their own work goals and perform all the tasks associated with the work process as scheduling, hiring, firing, training, troubleshooting, maintenance, material ordering, and budgeting (Lee 1990). Teams may even conduct peer performance reviews and provide for corrective action. Tasks are typically rotated within the team, requiring team members to learn all the tasks that they should perform.

A mature SDWT functions autonomously, with little or no supervision, and performs all the functions associated with a process, including those once reserved solely for management. Growth to team maturity is a slow process, involving several steps or transitions along the way. Each team's development transition poses new challenges to team development and survival. The following section examines some of the characteristics of transitions made during group formations and development.

2.2 Tuckman's Model of Group Formation

In general, groups go through five stages of development from start-up to maturity. These stages included (Schermerhorn, Hunt and Osborn 1994):

- Forming
- Storming
- Norming
- Performing
- Adjourning

2.2.1 Forming Stage

In this stage the primary concern is the entry of individuals into the group. Questions of concern include: "What can the group do for me?" and "What can I offer to the group."

2.2.2 Storming Stage

In this stage activities are centered on challenging management expectations. Tension and conflict may develop over leadership and authority. Hopefully, at the end of this stage, members begin to understand each other's interpersonal styles

2.2.3 Norming Stage

This stage, also referred to as the Initial Integration Stage, is when the group starts maturing as a unit. During this stage there is a balancing of forces. Often, in order to maintain this balance, opposing points of view are discouraged.

2.2.4 Performing Stage

The group in this stage, also called the Total Integration Stage, s characterized as mature, organized, and well functioning. The group can now handle complex tasks and is challenged by issues of “continual improvement and self-renewal”. Groups during this stage are able to adapt quickly and handle opposing points of view from its members.

2.2.5 Adjourning Stage

At some time in time, a well-integrated group might find it necessary to disband. This is especially true when the groups are temporary and have served their purpose.

2.3 Five stages of SDWTs

Similar to the five stages of group development cited above, self-directed work teams develop through five stages. These steps include (LaFollette et al, 2008):

- Formation
- Initiation
- Initial Integration
- Total Integration
- Self-Direction

However, in addition to describing the individual activities that occur during each stage (Moran and Musserwhite, 1993), also describe the team, management and organizations activities that occur during each stage of team development. These activities can be integrated into the stages of team development to form a model of group development. As seen in the Table 1), the successful implementation of work teams requires a total integration of the concept into all levels of the organizational hierarchy. Each stage presents challenges to all parties that must be dealt with, for the group to be successful. Also, this model suggests that work team implementation is not a quick fix but a methodical, deliberate organizational change effort.

Table 2 A model of self-direct work team development

Stage of Development	Individual	Group	Management	Organization
Forming	Information gathering	No formalized activities; no cohesion	Formalized direction and control	System audits; controls individual performance
Storming	Discomfort; emotionality; aggression; withdrawal; dogmatism;	Disagreements over role transitions; interpersonal tension	Reconciliation; mediation; support;	System maintenance
Initial Integration	Definition of personal roles and goals; seeks direction	Coordination; Norming; regulation; emphasis on cohesion	Redefinition of managerial roles; support and direction; job training;	Sub-system redesign; reward systems stress group performance
Total Integration	Acceptance of personal roles; loyalty to group; continuous self-renewal	Mature group norms and high cohesion; continuous improvement	Job retraining; coaches; recognition of group performance	System evaluation performance evaluation and disciplinary systems redesigned
Self-Direction	Acceptance of changing roles; willingness to learn new tasks	Cross-functional coordination with other teams; team identification with corporate mission	Coaches; coordinates activities among teams	Integration of team-based systems

2.4 Levels of Team Implementations within Organizations

As seen in Table 3), there are several levels of work team implementation. Each level represents increased commitment on the part of senior management to the team concept. Essentially a continuum can be established for work team implementation. Strategies for implementation are based on the amount of autonomy given to the team members. In organizations, the team continuum ranges from project teams found in many traditional organizations to self-directed work teams where members have the autonomy to select team members, schedule work, and perform other traditional managerial tasks.

Specifically, the following types of teams may be utilized in an organization (LaFollette et al, 2008):

- Project Teams
- Matrix Teams
- Semi-Autonomous Work-Teams
- Self-Directed (Autonomous) Work-Teams

The four types of teams described above do not represent the only types but represent points along the team continuum. Each organization is different and should make their choice of team based on their strategic direction and goals. Also, the type of team development chosen must also be based on organizational support, employee skill levels, union development, and employee trust. The type of team approach chose should be contingent on these factors, if team implementation is to be successful.

2.4.1 Project Teams

Usually found in traditional functional organizations where departments assign individuals to work on specific projects. Group assign meats are made by the department head and disband when the project is completed. Rewards are not usually based on group performance. There is no cross-departmental involvement in the team.

2.4.2 Matrix Teams

Based on the use of a matrix organization where team members are appointed from different functional units of organization. The team is usually temporary in nature and is formed for the completion of specific tasks. When the task is completed the group disbands. While this form of team development utilizes cross-functional teams, team-member selection, rewards, and other managerial duties are administered by the functional department heads. Team members often cite role-conflict problems due to conflict between their functional role and team membership.

2.4.3 Semi-Autonomous Work-Teams

In the continuum of work teams described here, semi-autonomous teams represent the first permanent form where members are assigned to a team for a long term of period of time. These teams also are given some autonomy or freedom to make decisions on work processes. Typical decisions include cross-training and team member assignments. Management still controls the assignment of members to a specific team and the rewards of individuals on the team.

2.4.4 Self-Directed Work-Teams (SDWTs)

Self-directed work teams represent the highest level of implementation. There teams control almost every aspect of the work process. Teams conduct their own selection, training and rewarding of members. They also negotiate work scheduling and are responsible for issues of quality and safety. Rewards are usually issued on a team basis.

2.5 The Future of Work Teams

In a perfect world, a strong case could be made for the use of SDWTs in numerous contexts. To date, many organizations have been successful in creating environments that enable people to contribute, grow and profit from their efforts. SDWTs not only mobilize the human element of the organization but, by virtue of functioning as a group, they may also dramatically improve the quality of decisions being made within the organization on a daily basis. However, though SDWTs may give the illusion of being a panacea to many business problems, participative management does not process any more of solutions to organizational problems than did Taylorism at the turn of the century. Many of those writing on the subject of SDWTs today would lead you to believe that come the twenty-first century either your business will be operating through SDWTs or it will not be operating at all. There are too many realities in the current business environment that make it difficult to accept such a vision.

One factor that challenges the future SDWTs is the short-term focus of Globalization business. Executives and managers want to know how quickly they can expect to see bottom-line results from SDWTs. Organizations are asked to commit time and resources to a process that work in three to five years. Such gloomy projections force many managers to discharge SDWTs as another philanthropic concept contrived by those who do not know how to run a business in the first place. The extent to which quarterly dividends and monthly performance remain important primary criteria in business will predict sluggish growth of the work team concept in our Global world.

Adoption of SDWTs will probably follow steady but limited growth in the future. Self-directed work teams are not appropriate for all organizations, work situations and employees. Still, most companies can, and should, reap considerable benefits from the work team concept. The twentieth century has experienced more social transformations than many on record (Drucker, 1994), and many companies are responding to increased environmental complexity through the use of groups and work teams. The ultimate challenge is not to find a way to make working SDWTs, rather it is to find a management process that can respond well to a rapidly changing environment. Therefore, the critical assessment is not whether SDWTs are appropriate for a particular organization, but what level of team involvement is appropriate. Organizations should determine what level of individual, group, management, and organizational control best represents the need of the company, and develop a work group concept that falls somewhere along the work team continuum.

2.6 An example of SDWTs: Six Sigma DMAIC model

The next part of this Thesis will be to show a state-of-the-art example of Self-Direct Working Teams, the Six Sigma DMAIC model.

3 STATE OF THE ART

Based on the books “The Six Sigma Way” (Pande et al., 2000), and “The Six Sigma Way Team Fieldbook” (Pande et al., 2002), we will describe the DMAIC model of establishing Teams to ensure a successful implementation of Six Sigma.

3.1 Six Sigma Defined

The term “Six Sigma” is a reference to a particular goal of reducing defects to near zero. Sigma is the Greek letter that statisticians use to represent the “standard deviation of a population”. The sigma, or standard deviation, tells you how much variability there is within a group of items (the “population”). Six Sigma is a comprehensive and flexible system for achieving, sustaining and maximizing business success. Six Sigma is uniquely driven by close understanding of customer needs, disciplined use of facts, data, and statistical analysis, and diligent attention to managing, improving, and reinventing business process.

The Six Sigma system introduced six critical ingredients needed to achieve Six Sigma capability within an organization:

- Genuine focus on the customer.
- Data- and Fact-driven management
- Process focus, management, and improvement.
- Proactive management.
- Boundaryless collaboration.
- Drive for perfection, tolerate failure.

The essential Six Sigma methods and tools are summarized on the Fig. 1.

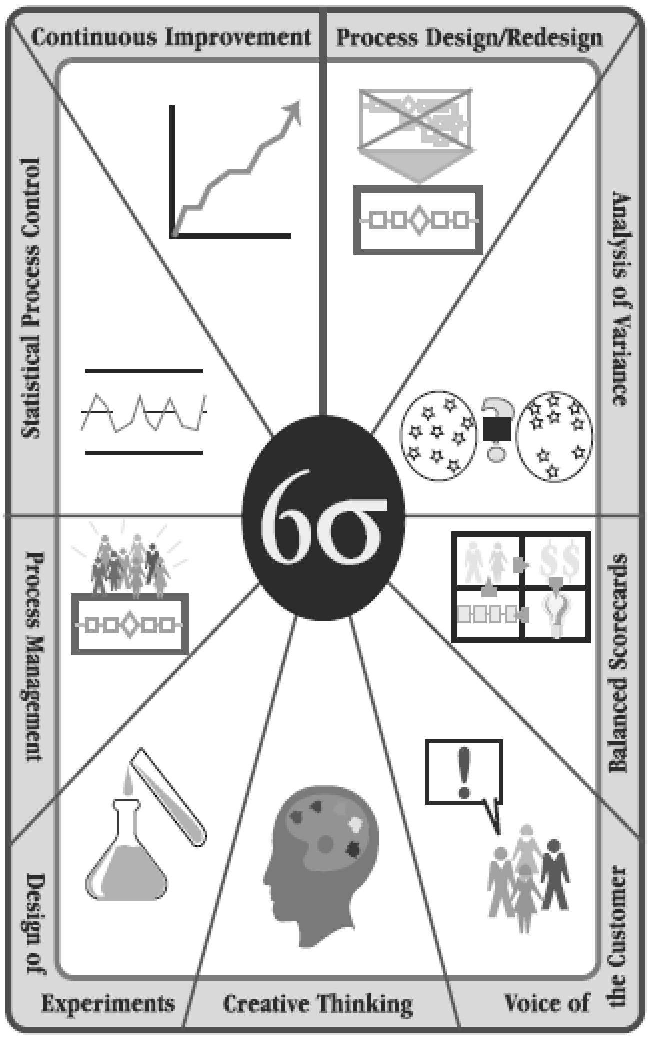

Fig. 1. Six Sigma toolbox and methods (Pande et al., 2000)

Six Sigma teams are formed to address specific business issues and improve processes, products, and services.

3.2 Process Improvement – DMAIC model

One of the missions of Six Sigma is Process continuous improvement. Process Improvement refers to a strategy of findings solutions to eliminate the root causes of performance problems in processes that already exit in your company. Process Improvement efforts seek to fix problems by eliminating the causes of variation in the process while leaving the basic process intact. In Six Sigma terms, Process Improvement teams find the critical Xs (causes) that create the unwanted Ys (defects) produced by the process.

Process Improvement teams use a five-step process to approach problems:

- Define
- Measure
- Analyze
- Improve
- Control

This five-step process is often called DMAIC, see Fig. 2.

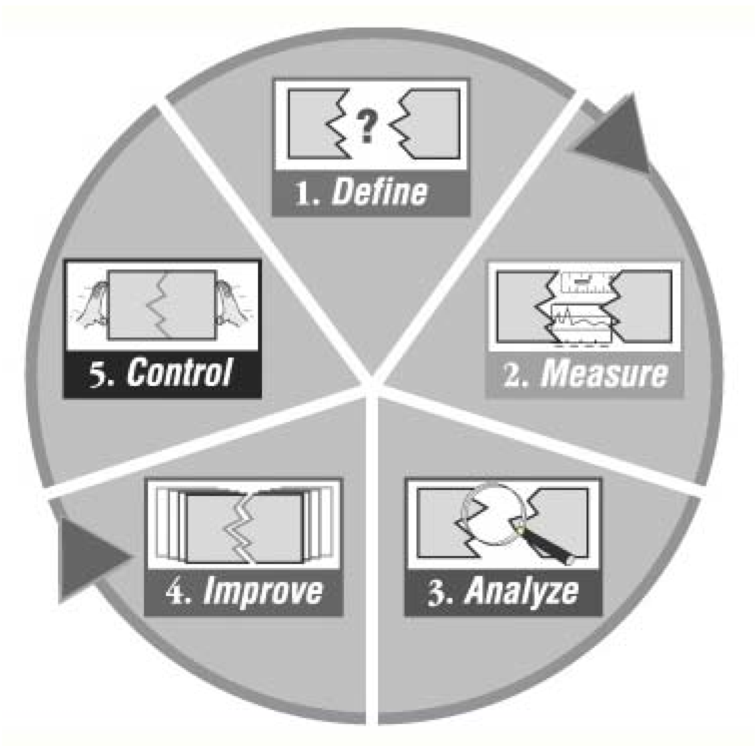

Fig. 2. DMAIC five-steps of process improvement (Pande et al., 2002)

3.3 Organizing for Six Sigma

There are seven functions and roles that must be developed to implement a Six Sigma organization:

- Leadership Group or Council.
- Project Sponsors and Champions.
- Implementation Leader.
- Six Sigma Coach (Master Black Belt).
- Team Leader/Project Leader (Black Belt or Green Belt).
- Team Members.
- Process Owner.

Different companies use these “Belts” in different combinations with Sponsors and Champions to guide teams. Several options are shown in Fig. 3.

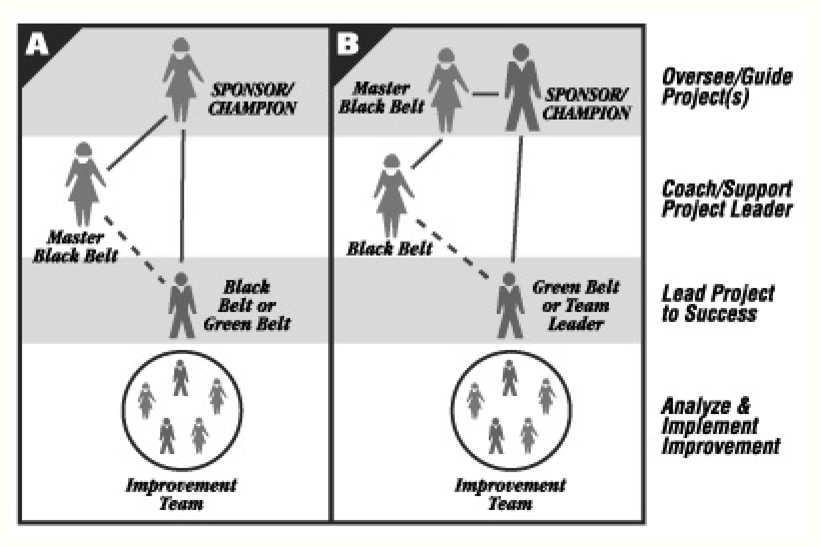

Fig. 3. Organizing the roles needed to support Six Sigma efforts(Pande et al., 2002)

3.4 DMAIC vs. Team Dynamics

Along the way, the people on the team will experience highs and lows, good times and bad. Knowing about these experiences in advance, and understanding that they are part of normal development, will help the members to move from a group of individuals looking out themselves to a team sharing a mutual responsibility to accomplish the project goals.

As state on the section before, Team development is described in five stages Forming, Storming, Norming, Performing and Adjourning. Those stages matches the DMAIC model five stages, as seen in Table 2).

Table 2 DMAIC vs. Tuckman stages

DMAIC's model stages	Tuckman's model stages
Define	Forming
Measure	Storming
Analyze	Norming
Improve	Performing
Control	Adjourning

Given a serious business problem, most teams would normally Define the problem, Measure the extent of the problem, Analyze the data to discover the causes, Improve the existing process by getting rid of the causes, and then Control the improved process to make sure the old problem didn't reappear in the future.

The DMAIC stages will be described following three perspectives:

- Purpose
- Toolbox
- Team Development

3.5 Define (DMAIC first stage)

3.5.1 <u>Define (purpose)</u>

In the Define step, a team refines its Problem Statement and goal, identifies the customers served by the process being studied, defines customer requirements, and writes the plan of how to complete the project. Throughout this work, the team should also keep in contact with its Champion, to ensure that it stays aligned with business goals, priorities, and expectations.

3.5.2 <u>Define (toolbox)</u>

Following, an example of a toolbox to be used on the Define stage:

- DMAIC Project Charter Worksheet
- Problem/Opportunity Statement Worksheet
- DMAIC Project Plan Worksheet
- Gantt Chart
- Project Stakeholder Analysis Worksheet
- Service or Output Requirements Instructions
- Requirement Statement Worksheet
- Kano Analysis Instructions
- Suppliers-Input-Process-Output-Customers(SIPOC) Analysis and Map
- Define Completion Checklist
- Define Tollgate Preparation Worksheet
- The QFD Cycle

An example of the SIPOC tool is shown on the Fig. 4.

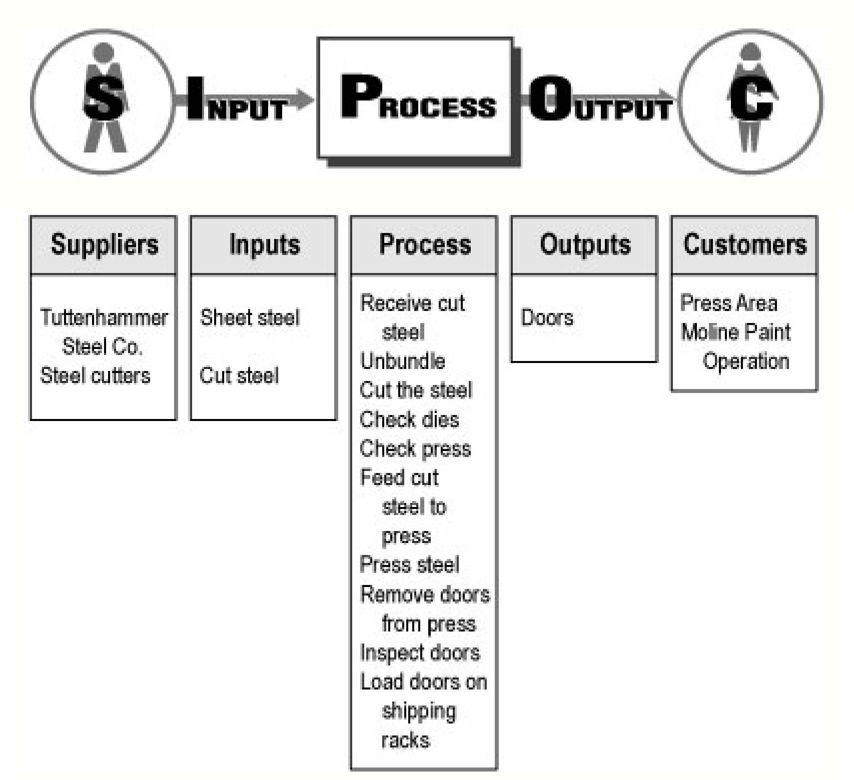

Fig. 4. SIPOC model and a diagram example (Pande et al., 2002)

3.5.3 Define (team development)

The Define stage is correlated to the Forming phase of Team Development. Six Sigma team members gradually clarify the team's goals, their own jobs on the team, and their relationships with other team members as the Team Member and/or Champions. Without good direction from the Team Leader and the use of DMAIC, the team might make little real progress or would jump to short-term solutions that turn out to ineffective.

During this stage there are a number of advises to be followed:

- Allow time for team members to socialize.
- Foster the collaboration to create ground rules as soon as possible.
- Get focused on the Project Charter.
- Make sure that the team members take turns leading parts of the meeting and passing around the job of facilitator, scribe and recorder/minutes keeper.

The most common failures on this stage that are important to be known are:

- The Problem Statement is actually a solution for an implied problem.
- The Project is too broad and imprecise
- Lack of Measurable Customer Requirements

3.6 Measure (DMAIC second stage)

3.6.1 Measure (purpose)

In the Measure step, a team measures the defects and process operation. There are four basic concepts when measuring:

- Observe first, then measure.
- Know the difference between discrete and continuous measures.
- Measure for a reason.
- Have a measurement process.

There are two main guidelines that have to be followed on the Measure stage:

- Plan and measure performance against customer requirements.
- Develop baseline defect measures and identify improvement opportunities.

3.6.2 Measure (toolbox)

Following, an example of a toolbox to be used on the Measure stage:

- Measure Planning Worksheet
- CTQ Tree
- Stratification Factors
- Measurement Assessment Tree

- Operational Definition Worksheet
- Process and Population Sampling
- Daily and Weekly Sampling Charts
- Sigma Calculation Worksheet
- Proportion Defective and Yield Calculation Instructions
- Cost of Poor Quality (COPQ) Calculations
- Tollgate Preparation Worksheet
- Tracking Long-Term Variation and Process Shifts

An example of the Proportion Defective and Yield Calculation Instructions tool is shown on the Fig. 5.

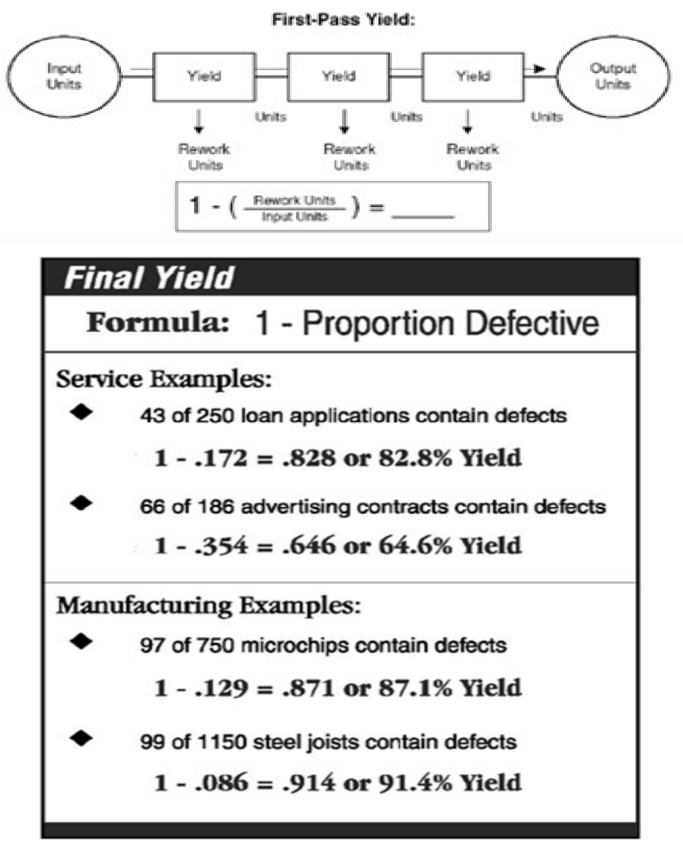

Fig. 5. First-pass and Final Yield calculations (Pande et al., 2002)

3.6.3 *Measure (team development)*

The Measure stage is correlated to the Storming phase of Team Development. Team leaders themselves nay contribute to storming problems during the Measure phase if they try to play too many roles: facilitator, scribe, and timekeeper. The team members are reduced to passive critics focused on the team leader instead on the project at hand.

For a team to survive and even gain strengths from the Storming phase, there are some basics that must be followed:

- Clear goals, an action plan, and well-defined roles in your Project Charter.
- Good guidelines on communication in your ground rules.
- Tools for reaching decisions in the Improve stage.
- Structured processes to attack problems, as DMAIC.
- Awareness of the natural evolution of teams from forming to performing.

The most common failures on this stage that are important to be known are:

- The Team measures the wrong things.
- Measurement systems “Drift”.
- Expect the data you collect to confirm your assumptions.

3.7 Analyze (DMAIC third stage)

3.7.1 *Analyze (purpose)*

In the Analyze step, the goal is to analyze the data by using data analysis tools and process analysis techniques to identify and verify root causes of the problem.

There are three phase of the root cause analysis:

- Exploring
- Generating hypotheses about causes
- Verifying or eliminating causes

Both the above three phase should be analyzed in two ways:

- Data Analysis
- Process Analysis

3.7.2 Analyze (toolbox)

Following, an example of a toolbox to be used on the Analyze stage:

- Pareto Analysis and Chart.
- Run Chart, Trend Chart, Time Plot.
- Histogram or Frequency Plot.
- Cause-and-Effect Analysis (Fishbone or Ishikawa Diagram).
- Relations Diagram.
- Scatter Plot or Correlation Diagram.
- Stratified Charts.
- Process Manipulation/Experimentation Worksheet.
- Detailed Process Maps or Flowcharts.
- Cross-Functional or Deployment Process Map.
- Process Value and Time Analysis.
- Analyze Checklist.

- Analyze Tollgate Preparation Worksheet.
- Hypothesis Testing: Determining Statistical Significance.
- Regression and Correlation Analysis.
- Exploring Complex Relationships: Using Design of Experiments.

An example of the Flowchart tool is shown on the Fig. 6.

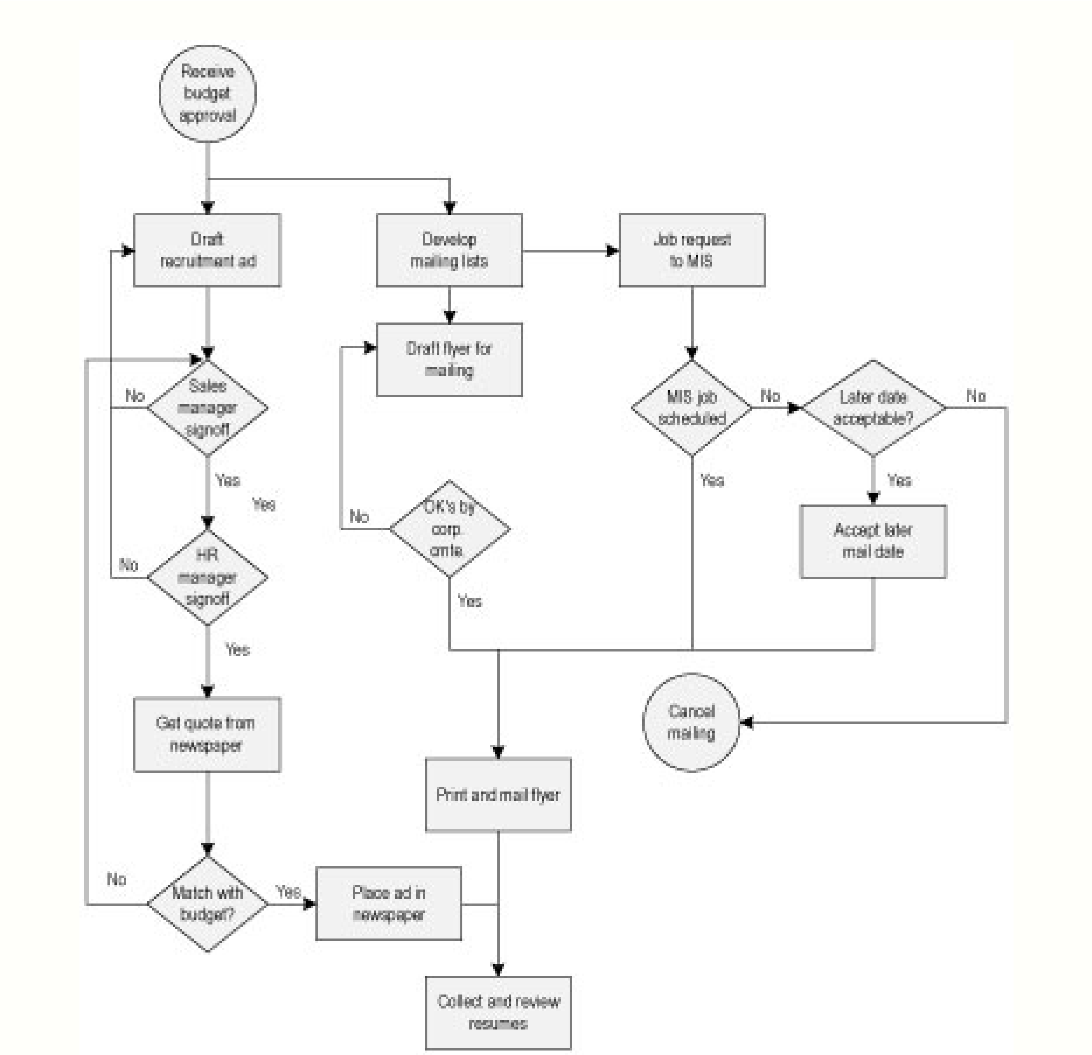

Fig. 6. Flowchart example for sales staff recruitment (Pande et al., 2002)

3.7.3 *Analyze (team development)*

The Analyze stage is correlated to the Norming phase of Team Development. The project is becoming clearer as data comes in, and team members are willing to learn new tools to analyze the data. Nevertheless, there are ways to prevent the recurrence of Storming at same time the team moves its work along. These include:

- Draw attention to progress the team's already made.
- Create milestones to motivate the team on short-term.
- Revisit and update team ground rules.
- Pay more attention to how the team works together.

The most common failures on this stage that are important to be known are:

- The Team gets too involved on the analysis and can't identify root causes of problems and unwelcome variation.
- Jumping to conclusions about causes before all the Data is in.

3.8 Improve (DMAIC fourth stage)

3.8.1 *Improve (purpose)*

In the Improve step, a team develops ideas to remove root causes of defects.

There are some guidelines that have to be followed on the Improve stage:

- Whatever the team selects as a solution should address the root causes of the problem and the goal the team set for itself in the Project Charter.
- Although the team will brainstorm many possible solutions, one or two will be better than others; the team must decide which are the best options and determine what it will take to make them work.
- The solutions must not cost so much or be so disruptive that the expenses outweigh the benefits in the long run.

3.8.2 Improve (toolbox)

Following, an example of a toolbox to be used on the Improve stage:

- Advanced Creativity Techniques
- Assumption Busting
- The Practicality Scale
- Tree Diagram for Solution Development
- Impact/Effort Matrix
- Criteria or Decision Matrix
- Force Field Analysis
- Pilot Planning Checklist
- Pilot Testing Checklist
- Improve Checklist
- Improve Tollgate Preparation Worksheet
- Failure Modes and Effects Analysis (FMEA)
- Design of Experiments (DOE)

An example of the Impact/Effort Matrix tool is shown on the Fig. 7.

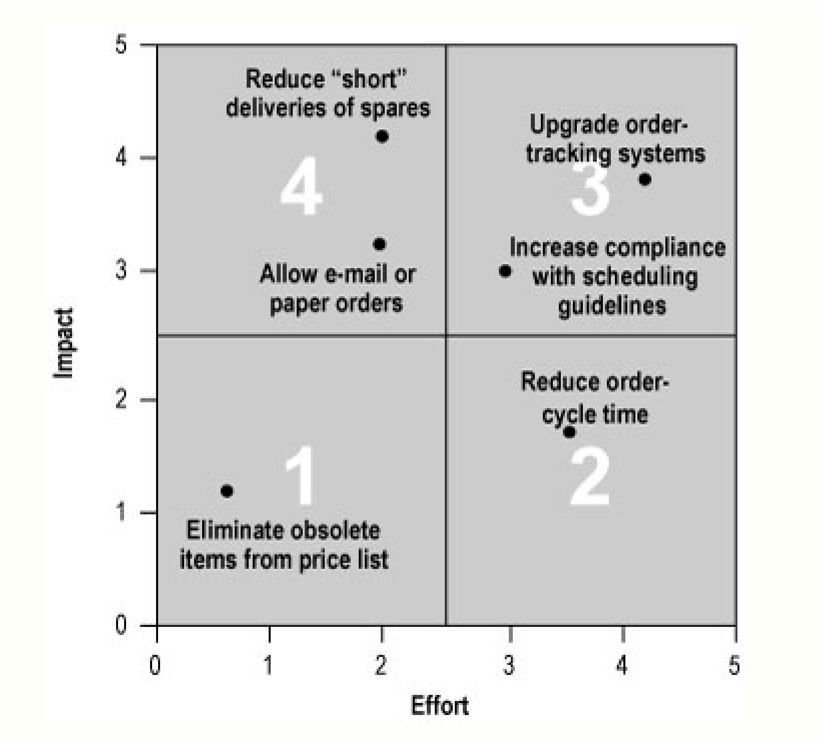

Fig. 7. Impact/Effort Matrix (Pande et al., 2002)

3.8.3 Improve (team development)

The Improve stage is correlated to the Performing phase of Team Development. At this stage, after twisting and turning its way through Define-Measure-Analyze, the team is ready to pilot the first solutions. The team members are fluent in the language of DMAIC, and work together comfortably and supporting each other. Team members have come to respect one another's approach to their mutual work. Solidarity and group loyalty may emerge as the team collectively faces healthy opposition to its work and its solution.

During this stage there are a number of advises to be followed:

- Review ground rules and tem membership
- Pay attention to detail and stick to your schedule
- Keep the Champion involved and committed.

The most common failures on this stage that are important to be known are:

- Not getting very creative with solutions.
- Failure to Pilot the chosen solution in a small-scale before doing a full implementation.
- Failure to win support and defuse opposition to the solution.
- Settle for routine improvements.

3.9 Control (DMAIC fifth stage)

3.9.1 Control (purpose)

In the Control step, a team controls the process to make sure that defects don't recur. The goal is to maintain a process whose operation is stable, predictable, and meets customer requirements.

The Control stage has the following five parts:

- Discipline.
- Documenting the improvement.
- Keeping score: establishing ongoing process measures.
- Going to the next step: building a process management plan.
- Ending the Project.

3.9.2 Control (toolbox)

Following, an example of a toolbox to be used on the Control stage:

- Process Documentation Checklist
- Control Charts
- Process Management Chart
- Response Plan Worksheet
- Process Dashboards
- Control Checklist
- Control Tollgate Preparation Worksheet

An example of the Process Dashboard tool is shown on the Fig. 8.

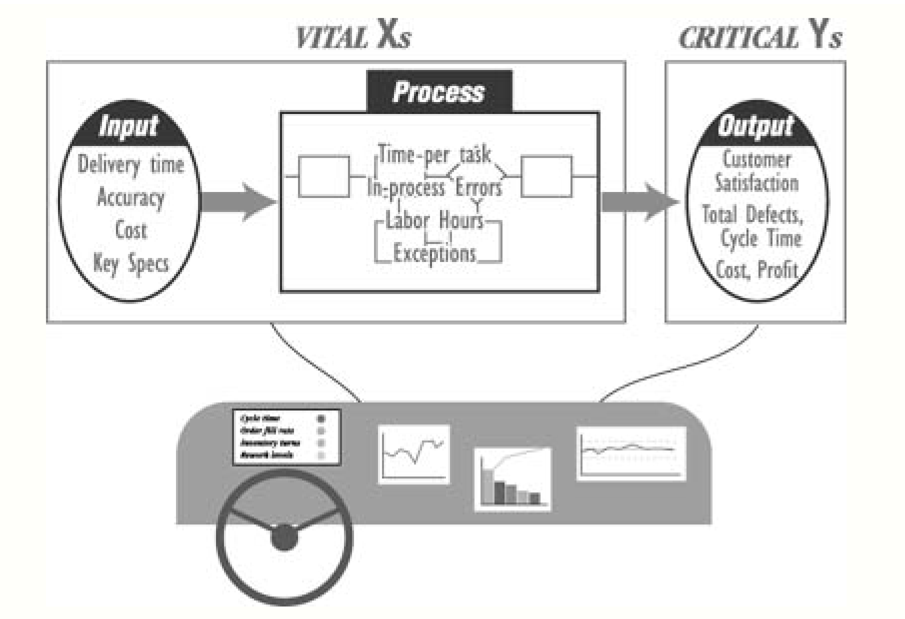

Fig. 8. Process Dashboard (Pande et al., 2002)

3.9.3 Control (team development)

The Control stage is correlated to the Adjourning phase of Team Development. At this stage, the team shows the characteristics of a “performing” team, where people are working together efficiently, and personalities take a backseat to getting the work done right.

Nevertheless, the project needs to come to an end, and there are number of advises to help the team end gracefully:

- Asking everyone to reflect on what they will take away from the project, especially methods or tools that will help them in their everyday jobs.
- Identifying ways that members will be involved in maintaining the gains made.
- Identifying who will be the official keeper of the team documentation.
- Discussing ways to share results of your project within the organization.

The most common failures on this stage that are important to be known are:

- Poor documentation of process improvement.
- Weak hand-over from Team to Process Owner.
- Forget the process maps.
- File the updated process documents away.

4 CRITERIA METHODOLOGY

The Case used on this thesis was evaluated by the criteria of the International Team Excellence Award Process organized by American Society of Quality (ITEA/ASQ, 2008).

The Team Excellence Award process is an excellent way to capture national and international recognition for an organization’s team-based improvement efforts. Past winners have received extensive press coverage and high honors both internally and externally. Several past finalists have won previous awards or used the knowledge gained from the Team Excellence Award Process to enter other prestigious competitions like the Malcolm Baldrige National Quality Award (xxx2).

All entrants to the International Team Excellence Award Process receive a Feedback Report and a Score Sheet detailing how they rated in each Team Criterion area. The Criteria provide a generic guideline for successful management of projects or work tasks, and the Feedback Report contains expert feedback on strengths as well as opportunities for improvement (xxx2).

The International Team Excellence Award Process is organized in five major criteria:

- 1 Project Selection and Purpose
- 2 Current Situation Analysis
- 3 Solution Development
- 4 Project Implementation and Results
- 5 Team Management and Project Presentation

4.1 1 Project Selection and Purpose

4.1.1 *<u>1A Explain the methods used to choose the project</u>*

The project may be selected by the team or assigned by management, but the process used to select the project must be clear and well stated.

- 1A.a Describe the types of data and quality tools used to select the project.
- 1A.b Explain the reasons why the project was selected.
- 1A.c Describe the involvement of potential stakeholders in project selection.

4.1.2 *1B Explain how the project support/aligns with the organization's goals, performance measures, and/or strategies*

Organizational goals can vary in type and style, from organization to organization; some companies have vision/mission statements that guide the direction of the business. Some have goals that may be more specific than the vision/mission statements, and still others may have very specific objectives related to their goals and/or strategies. Regardless of how the organization presents its high-level guidance to its associates, this item is looking for the link between the team's project and those goals and/or strategies.

- 1B.a Identify the affected organizational goals, performance and/or strategies.
- 1B.b Identify the types of impact on each goal, performance and/or strategies.
- 1B.c Identify the kind of impact on each goal, performance and/or strategies.

4.1.3 *1C Identify the potential stakeholders and explain how they may be impacted by the project*

"Stakeholders" defines anyone who may be affected by the project. Stakeholders might include internal/external customers/clients, suppliers, employees, *etc*.

- 1C.a Identify and explain the potential internal and external stakeholders.
- 1C.b Identify and explain the types of potential impact on stakeholders.
- 1C.c Identify and explain the degree of potential impact on stakeholders.

4.2 2 Current Situation Analysis

4.2.1 *2A Explain the approach/process the team used to identify the potential root causes/improvement opportunity(ies).*

This item focuses on how the team analyzed the current situation including the processes, data, and information; how stakeholders were involved; and how the team validated its final root cause(s)/improvement opportunity(ies). Note: Most teams are "problem-solving teams" of one kind or another and they first attempt to identify the root cause(s)/improvement opportunity(ies) of the problem they are working on.

- 2A.a Describe the methods and tools used to identify possible root causes/improvement opportunities.

- 2A.b Describe the team’s analysis of data to identify possible root causes/improvement opportunities.
- 2A.c Describe how or if any of the stakeholders were involved in identifying the possible root causes/improvement opportunities.

4.2.2 *2B Describe how the team analyzed information to identify the final root cause(s)/improvement opportunity(ies).*

Having identified a variety of possible root causes/improvement opportunities, in 2A, how did the team go about narrowing down the possibilities to identify the true root cause(s)/improvement opportunity(ies) for this project?

- 2B.a Describe the methods and tools used to identify the final root cause(s)/improvement opportunity(ies).
- 2B.b Describe the team’s analysis of data to select the final root cause(s)/improvement opportunity(ies).
- 2B.c Identify the root cause(s)/improvement opportunity(ies) and explain how the team validated the final root cause(s)/improvement opportunity(ies).

4.3 3 Solution Development

4.3.1 *3A Explain the methods used to identify the solution or improvement actions.*

Once the final root cause(s)/improvement opportunity(ies) is/are identified, the team should demonstrate how it developed its solution(s) to/improvement action(s) for the problem.

- 3A.a Describe the methods and tools used to develop possible solutions or improvement actions.
- 3A.b Describe the team’s analysis of data to develop possible solutions or improvement actions.
- 3A.c Indicate the criteria the team decided to use in selecting the final solutions or improvement actions.

4.3.2 *3B Explain how the final solution or improvement actions were determined.*

Explain how the team selected/determined the final solution or improvement actions from the list it generated in 3A above.

- 3B.a Describe the methods and tools used by the team to select the final solution or improvement actions.
- 3B.b Describe the team's analysis of data to select the final solution or improvement actions.
- 3B.c Describe the involvement of stakeholders in the selection of the final solution or improvement actions.

4.3.3 *3C Explain the final solution or improvement action, validation, and the benefits expected to be realized by implementing the team's solution or improvement action.*

Explain how the team validated the final solution or improvement actions and what benefits the team expects the organization to realize once the team's solution or improvement actions are implemented.

- 3C.a Describe the final solution or improvement actions and explain how the team validated the final solution or improvement actions.
- 3C.b Indicate the types of tangible and intangible benefits that are expected to be realized by implementing the team's solution or improvement actions.
- 3C.c Explain how the team used data to justify the implementation of the team's solution or improvement actions.

4.4 4 Project Implementation and Results

4.4.1 *4A Explain how buy-in/agreement was achieved for implementation.*

This section addresses how the team sought and secured buy-in, what approaches it used to plan for and implement its solution or improvement actions, and what results were achieved.

- 4A.a Indicate the types of internal and external (if applicable) stakeholder involvement in implementation.

- 4A.b Describe how various types of resistance were identified and addressed.
- 4A.c Explain how stakeholder buy-in was ensured.

4.4.2 <u>4B Explain the approach used by the team to implement its solution or improvement actions and to ensure the results.</u>

In this section, the team is asked to provide information regarding how it went about implementing its solution or improvement actions and ensuring that the desired results would be achieved and sustained.

- 4B.a Describe the plan developed by the team to implement its solution or improvement actions.
- 4B.b Describe the procedure, system, or other changes that were made to implement the solution or improvement actions and to sustain the results.
- 4B.c Describe the creation and installation of a system for measuring and sustaining results.

4.4.3 <u>4C Describe the results achieved.</u>

This section describes the results that were achieved by implementing the solution or improvement actions the team selected.

- 4C.a Indicate the types of tangible and intangible results that were realized.
- 4C.b Explain how the project's results link with the organization's goals, performance measures, and/or strategies.
- 4C.c Explain how results were shared with stakeholders.

4.5 5 Team Management and Project Presentation

4.5.1 <u>5A Team Member Selection and Involvement</u>

Describe how and why the team members were selected. The team's response should include an explanation of how/why the various members of the team were selected including: any specific skills, capabilities, knowledge, qualifications, and/or any selection criteria used in selecting the team members. The team should also describe how the various team members were involved throughout the project including any specific tasks, roles, responsibilities, *etc*., they may have had during the project.

4.5.2 <u>5B Team Member Preparation/Development</u>

Describe how the team members were prepared to work together effectively as a team. The team's response should include an explanation of any training or other preparation the team received prior to or during the project to help it operate more effectively as a team, as well as any training it received related to the process improvement methodology/approach used by the team–including the various tools and techniques used throughout the project to collect, analyze, and/or present data and information.

4.5.3 <u>5C Team Management</u>

Explain how the team members worked together effectively throughout the project. The team's response should include an explanation of how the team capitalized on the skills of its individual members as they carried out their roles and responsibilities, how team members shared data and information throughout the project, how they ensured effective communication within the team, and how the team managed its performance with respect to project deadlines/deliverables/milestones. Responses might include a description of how meetings were conducted, any electronic means the team may have used, or any other methods it used to share data and information. Regardless of the approach(es) the team used, an explanation of how it ensured effective communication within the team is appropriate.

4.5.4 <u>5D Project Presentation</u>

The team will be scored on the organization, clarity, and overall effectiveness of its presentation. Effective use of any audio/visual aids and any other presentation aids and/or techniques will also be considered in this item. It is important to note that the judges will assess how clearly and effectively the team communicated the story of its project.

5 MAIN PART – CASE ANALYSIS

In this section it will be described an industrial case BAYER MaterialScience (Bayer/ASQ, 2008).

The team BAYER Material presented its based on them daily processes, in the International Team Excellence Award (ITEA) of American Society of Quality (ASQ) of 2008. The team achieved the Bronze medal with their case showing the replicability of the DMAIC model in the real-world business. The team was evaluated under the five main criteria discussed before for the ITEA/ASQ.

Bayer MaterialScience is a global manufacturer of polymers used as raw materials for products ranging from compact disks to automotive finishes to furniture. Bayer MaterialScience ships billions of pounds of material each year to thousands of customers. Shipping costs are a significant component to the Cost of Goods Sold. In July, 2005 one of the transportation representatives identified a potential problem with the way carriers were chosen. While examining a sample of shipment data for truck shipments in the 16,000 to 25,000 lb range he observed that 83% were shipped "sub-optimally", hence more costly. Extrapolating this rate of sub-optimal shipping implied over $1 Million could be saved by shipping correctly. The team main doubt was if this extrapolation was valid? And if so, what were the root causes of failure in the shipping process?

The Bayer's Team was composed by:

- Sean Ritchie - Team Leader
- Kristen Hermick - Customer Master Data
- Laurie Colao - Business Intelligence
- Sam Phipps - Finance
- Marko Dodig - Technology Services
- Ron Gadzinski – Logistics

During this section, it will be describe how this team of Bayer put in practice the DMAIC model to achieve the need answers!

An example of the Bayer Material Science product portfolio is shown on the Fig. 9.

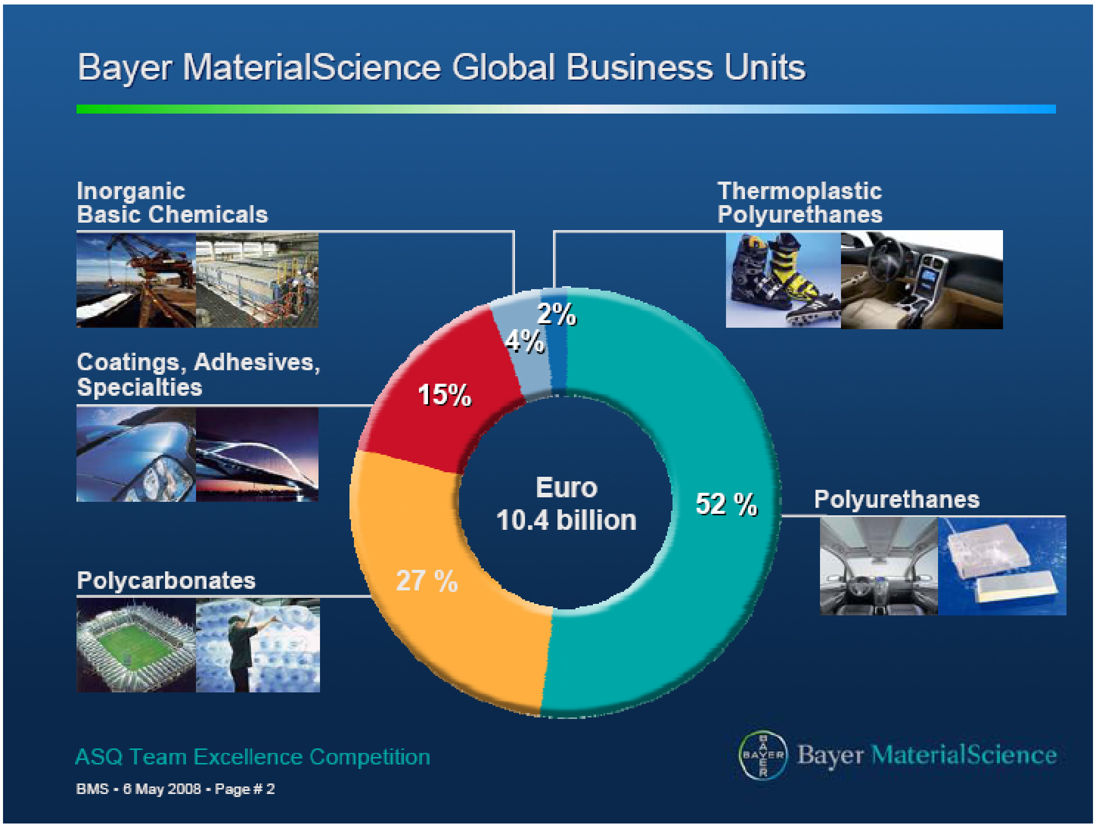

Fig. 9. Bayer Material Science Global Business Units (Bayer/ASQ, 2008)

5.1 Bayer - 1 Project Selection and Purpose – Define/DMAIC

Bayer's Define Phase is a rigorous study of the project's potential impact, cost and feasibility.

A project moves forward only if the stakeholders are enrolled and formally endorse the project stakeholders from the outset providing them with the information they need to make an informed decision.

A project is formally sanctioned and resources provided only if the stakeholders are convinced of its alignment with organizational priorities, return on investment and feasibility.

A preliminary assessment of the problem led the team to believe correcting it:

- Improving profitability.
- Improving Customer Relations.
- Encouraging “Grass Roots” initiatives.
- Developing Lean Six Sigma as an Organizational Core Competency.
- The Return of Investment appeared high because the team were confident the project would cost much less than the opportunity of $1 million.
- Was feasible because Key stakeholders agreed that this was a significant problem that they would provide resources to correct it.

The first step was to identify potential stakeholders and bring them together in a Discovery Kaizen event. During highly focused brainstorming sessions it was developed a SIPOC diagram, (Suppliers, Inputs, Process, Outputs, Customers) and a value stream map to clearly view the “as is” process flow and identify decision points, organizational transitions and potential non-value added steps.

Based on the results of these tools, it was checked for identification of all key stakeholder groups. It was then interviewed key stakeholders both within inside the business and as customers of the process.

Using baseline data available from the transportation system, it was examined trends and measured baseline performance. It was evaluated questions of feasibility and resource requirements and developed a preliminary timeline for the project in Gantt chart format.

It was then consolidated all of this into a document which it was called a Project Charter. The Project Charter is an integral part of a formal signoff process in which senior management representing key stakeholder groups must endorse a project before it can move forward.

The collective resources and process knowledge of the working team of stakeholder representatives gave us the horsepower to extract a much larger sample of data from the transportation system. Moreover, now it had the capability to extract fields which allowed to segment data chronologically and in terms of issues such as mode of shipment. This greatly increased the confidence in the original extrapolation and verified the problem was potentially a $1 million savings opportunity.

The “swim lane” organizational process map that it was developed allowed to see the hand-offs between different parts of the organization, decision points and potential root causes for sub-optimal shipments. It was discovered that root causes for sub-optimal shipment were too complex to be solved by a simple policy change of the truckload (TL) and less than truckload (LTL) weight breakpoint.

Several segments of the organization were identified as potential stakeholders. Representatives from these groups participated in the development, evaluation and eventual endorsement of the Project Charter. They also went on to take the project through the measurement, analysis, improvement and control phases.

Another fundamental element of the project charter is an assessment of the degree of alignment of the project with overarching organizational goals.

The project was founded to align strongly with the goals of cost reduction and simplification. Existing performance metrics of cost per pound, on time in full and carrier turndown rates were all projected to be positively affected. Finally, it was aligned well with the strategic organizational thread, “Order to Cash”, was synergistic with a multi-million dollar project involving premium freight costs and advanced the strategy to increase Lean Six Sigma competency. Each of the goals, performance measures and strategies identified in the project charter were affected in a positive way. Cost per pound went down by eight tenths of a cent. It may not sound like much but given the size of the transportation expenses, that translates into over a million dollars per year. Elimination of non-value added steps reduced the complexity of the process and supported the goal of simplification. On-Time-in-Full is a key performance indicator of importance to the customers. In the project charter one of the objectives that were established was to reduce cost without adversely affecting On-Time-in-Full. It was achieved this and even edged up a bit.

Before beginning any Lean Six Sigma project it is a must to identify and engage stakeholders. The preliminary analysis discussed on previous slides was developed by a stakeholder team. Meeting and working together, representatives from potential stakeholder groups evaluated if the right groups and the right representatives were present.

Potential stakeholders are evaluated considering their:

- Involvement (Are they working within or accountable for the performance of the current process?)

- Impact (How integral are they to current processes? Are they suppliers to, customers of, or workers within the current process? How might they be affected by potential change?)

- Influence (What would happen if they don't support the project and it's potential changes)

Based on this evaluation, it was formed a core team, established management champions, sponsors and identified people required as technical support resources.

Identifying and engaging stakeholders as participants in a cross-functional team are fundamental to the methodology. The high level process description or SIPOC, (supplier, inputs, process, outputs and customers) and a cross-functional process map helped to identify stakeholder groups. Initial identification of champions and working team was an ad hoc assignment by the logistics sub-process owner, and discussions with process experts. This ad hoc working team used SIPOC and organizational "swim lane" value stream process mapping to validate and add to the core team. Support resources were identified when the working team developed a preliminary Gantt chart. The final core team was emerged as a result of this process.

Shipment carriers were recognized as an external stakeholder group. After much consideration it was decided against including carrier representatives on the core team, however, because proprietary and confidential information concerning the negotiated transportation rates of all carriers would have to be part of the data that would be analyzed.

Brainstorming together, the core team of stakeholder representatives took information from both subjective tools like the cause and effect analysis and value stream mapping as well as from objective tools like customer data segmentation and on time and full performance KPI. From this it was possible to see which stakeholders had higher potential positive and negative impacts to plan accordingly. Potential positive and negative impacts were assessed in a variety of ways.

An example of the ITEA criteria 1C.a is shown on the Fig. 10.

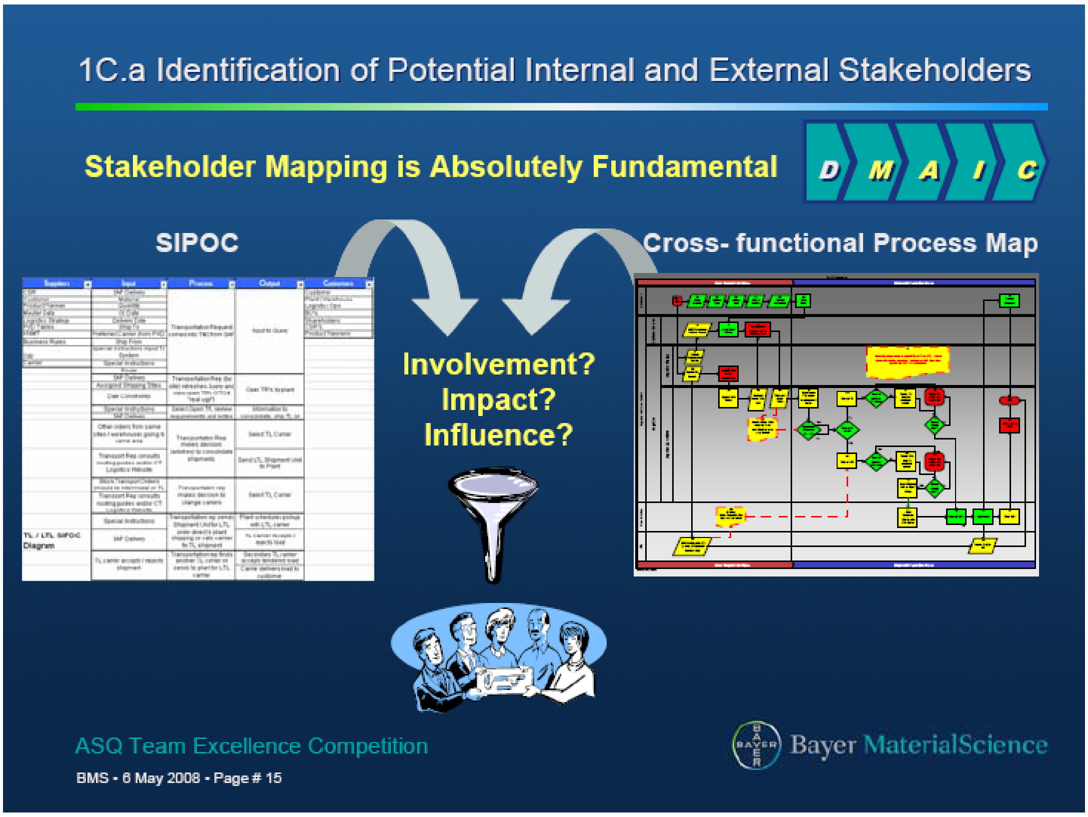

Fig. 10. Identification of Potential Internal and External Stakeholders (Bayer/ASQ, 2008)

5.2 Bayer - 2 Current Situation Analysis – Measure/DMAIC

A fundamental principle of the Lean Six Sigma methodology is the recognition that the output of the process, “Y” is a function, potentially, of several contributing input variables or “Xs”. Before beginning problem analysis there is a critical need to assess the accuracy of the data used in the analysis. Otherwise there is a risk in drawing incorrect conclusions regarding root cause, along with implementation of corrective actions which at best may fail and at worst may degrade performance.

It was begun with Process Variables Mapping. Building upon the SIPOC developed in the Define Phase it was identified input variables and assessed the degree to which each are under the control. Building on the SIPOC and the Process Variables Map, it was developed a Cause and Effect Matrix in which it was estimated the degree of impact of various input variables on output performance. This information helped us to think ahead about data segmentation desirable for analysis and clarified appropriate requests of the technical support staff who would be extracting data from various systems. Even though there weren't dealing with data that lent itself to traditional Gage R&R or Attributes Agreement, it was understood a need to test the integrity of the data. Each step along the way the team challenged the origin, operational definitions and potential sources of inaccuracy or bias in the data.

A Process Variables Map provided insight into which input variables were within the control and which not.

The Cause and Effects Matrix improved the understanding of the degree of correlation and impact of process inputs on the output value to the customer. It gave a numerical basis for ranking issues from the customer's set of priorities. For example, it was drilled further into consolidation decision making and the actions related to transportation requests in order to assist the Logistics reps' in their decision-making.

An example of the ITEA criteria 2A.a is shown on the Fig. 11.

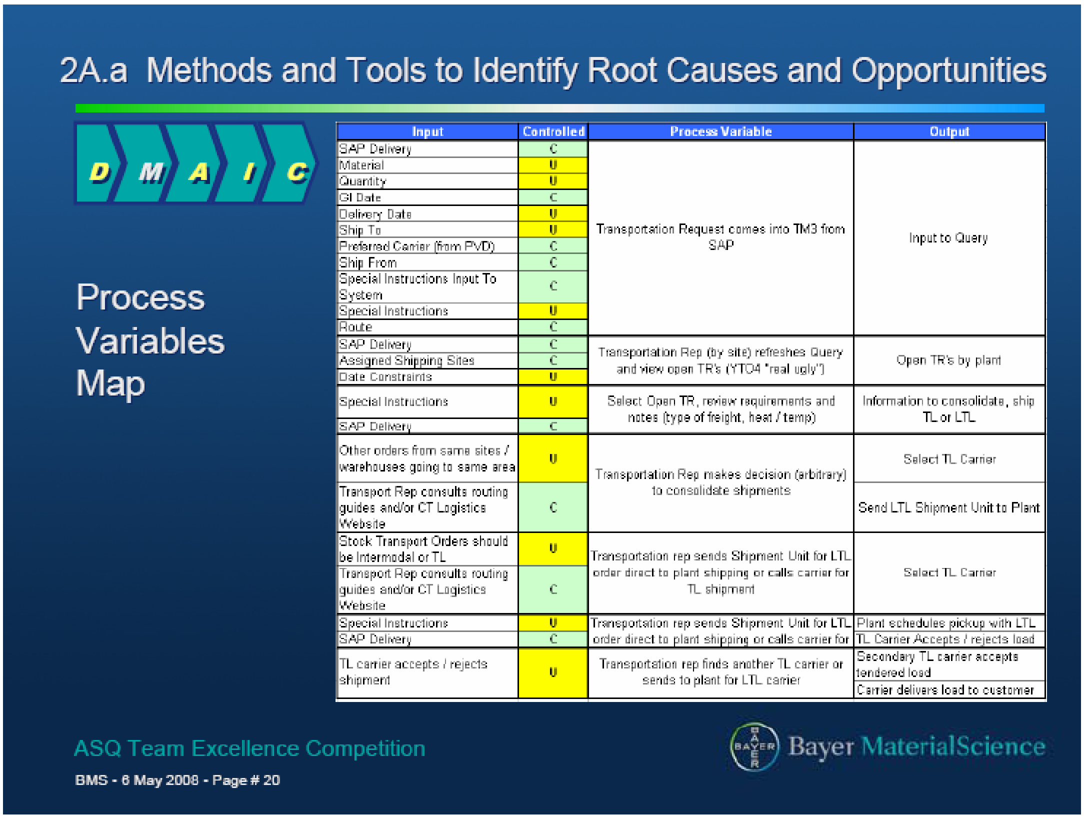

Fig. 11. Methods and Tools to Identify Root Cause and Opportunities (Bayer/ASQ, 2008)

5.3 Bayer - 3 Solution Development – Analyze/DMAIC

Having become confident in the reliability of the data, it was begun the Analysis phase to identify potential root causes and opportunities.

Failure Modes and Effects Analysis (FMEA) and data segmentation were the principal analysis tools.

During the development of the Cause and Effect Matrix in the Measure Phase it was begun to identify and prioritize potential root causes based on the Voice of the Business and the Voice of the Customer. The Process Variables Map identified which inputs were within the control and which were not. Now, in the Analysis Phase it is needed to conduct a Failure Modes and Effects Analysis. Facilitated as another Kaizen event, the team spent six hours over two days identifying potential failure modes and ranking each in terms of: their probability of occurrence, the severity of the impact should they occur and the ability to detect the failure.

For each potential failure mode it was ranked the Severity, Frequency and Detectability of the risk with 1 low risk and 10 high risk. Multiplying these three yielded a Risk Probability Number (RPN).

With a sample size of over three hundred shipments per month and extraction of granular data for each shipment such as date, carrier, mode, origin, destination, product, customer and, of course, cost per pound the team was in a position to stratify and segment the data in an attempt to gain insights into the relationship between cost per pound and a variety of potential input variables.

At the outset of this project it was suspected the reason shipping costs were high was because it was incorrectly shipping too much with full truck load carriers as opposed to LTL. In this data stratification example, it was grouped shipments into arbitrary weight brackets and examined the percentage of shipments shipped LTL versus full truckload. It was clear there was an opportunity to direct more shipments to the lower cost LTL mode. It was defined a defect as a shipment within a certain weight range shipped as full truckload instead of LTL. The proportion shipped incorrectly according to this definition gave a different perspective when viewing baseline performance.

Several segments of the organization were identified as potential stakeholders. Representatives from these groups participated in the development, evaluation and eventual endorsement of the Project Charter. They also went on to take the project through the measurement, analysis, improvement and control phases.

Previously it was discussed the FMEA as a method to identify potential root causes. During the selection of final root causes it was ranked each potential failure mode on the basis of its Risk Probability Numbers. Those with the highest RPNs were judged to be root causes with the highest impact. For example, the failure mode with the highest RPN was found in shipment consolidations. The failure mode identified that consolidation opportunities were not visible to the transportation rep in the system. The severity of this error was ranked a 10, the highest possible value. Because the reps could not consolidate these shipments, the probability of occurrence was also ranked a 10. And the ability to detect the error was ranked as 10, meaning virtually undetectable, because there was no way to know when this type of error occurred.

The RPN, therefore, was 1000. The fact that the transportation system did not provide transportation reps with visibility of consolidation opportunities was, therefore, selected as one of the final root causes.

It was described the use of data in identifying and selecting root causes. It was equally important to use data to challenge assumptions of root cause, and both identify and quantify potential confounding issues. It was discussed the use of data to identify the potential root cause of a transportation rep making an incorrect mode selection (TL/LTL). In the analysis of all such issues, the data was careful considered which would contradict the conclusions. It was found, for example, if the shipment was a rush with agreed upon carrier lead times, available LTL shippers may refuse the shipment forcing the shipment to be placed via full truckload. In this situation the root cause was not incorrect carrier selection but rather the handling of rush orders. The origin of rush orders was outside the scope of the Project Charter but it was helpful to understand this issue and its possible affect on the data.

A process map was laid out, so it was possible to visualize the hand-offs between various internal and external stakeholder groups. Steps are color coded: those important to the customer are green, important to business or required by the business are in yellow, those identified at important to neither, and hence non-value added, are in red. Analysis of the value stream map revealed non-value added steps. As it was compared this process map to the FMEA, it was realized some important steps were missing and correlated to failure modes, root causes and improvement opportunities. As part of the FMEA, it was assigned each failure mode a potential cause. Looking down the list of failure modes ranked in terms of their RPN, these four root causes, or variants of them, appeared repeatedly. Grouping these similar potential causes for each failure mode resulted in the list. Thus, “affinity” mapping provided us with the first level of validation. Another validating observation was the reaffirmation of the links between failure modes in the FMEA and the key input and output relationships in the cause and effects matrix. The identification of non-value added steps and the correlation between missing steps in the current process with failure modes, potential cause and improvement opportunities provided further validation that these four major categories represented the significant root causes for shipping errors in this weight class.

The key tools employed in developing solutions were the Design FMEA and Organizational Process Mapping.

Design FMEA entailed developing a potential improvement or corrective action for each of the fifty failure modes identified within the FMEA.

Each corrective action or improvement was designed to mitigate or significantly reduce the probability of occurrence and/or increase the detectability of a given failure mode. For example, the failure mode in which shipping consolidation opportunities were not visible to transportation reps had a baseline RPN of 1000. A potential corrective action was identified which could reduce the RPN to 225. Just as it was experienced in the grouping of root causes, now it is seen groupings of corrective actions with similar themes emerging. A force field analysis of the feasibility for implementing an improvement versus the risk probability number (RPN) of the failure mode it addressed was used to select and prioritize final improvements.

The team wanted to reduce shipping costs as rapidly as possible. Having already grouped and ranked improvement opportunities based on RPN, it was token another cut and overlaid feasibility criteria.

The improvements highlighted in green were selected for implementation. Those in orange are examples of potential improvements which were deemed to have an unfavorable feasibility to RPN ratio and not selected for implementation. It was also set the criteria of SMART design: specific, measurable, achievable, responsible, time-bound.

There were members of the management stakeholder group and the core team who believed that a simple policy change increasing the breakpoint at which shipments should be sent TL versus LTL would suffice to reduce the cost per pound. The team was proud to have shrugged off that developing paradigm and continued on applying the Lean Six Sigma methodology with open-mindedness; following the data wherever it led. Not only were there root causes unaffected by a change in the TL/LTL breakpoint, there were other root causes acting to prevent a breakpoint policy change from being effective.

The key analysis used to select final improvements was therefore a synthesis of results obtained from:

- Improvement opportunities associated with FMEA failure modes with the highest risk probability numbers
- Analysis of value added and non-value added steps within the organizational process map
- Assessment of feasibility of implementation versus impact of implementation

Internal stakeholders covered various roles and responsibilities in the selection of final improvements to be implemented:

- Responsible – "The Buck Stops Here" with overall responsibility to make certain this step happens.
- Accountable – The people who perform the identification based upon the data and information available through work with the team.
- Consulted – People with specific knowledge to the project focus area that brings their specific abilities (such as datamining) to the project to enable decision making.
- Informed – People who are told the project is in progress and updated where their specific area is impacted or change on their part may be required.

The team identified four major improvements.

- It was established a new TL/LTL weight breakpoint but based on data, not conjecture. Moreover, it was hard coded carrier recommendations into the system.
- It was given the transportation reps visibility of consolidation opportunities and the ability to sort on origin, destination and weight. This addressed the failure mode with the highest Risk Probability Number.

- Enhancement of the carrier tables offered a software and process execution upgrade which provided transportation reps with accurate carrier recommendations based on weight and origin-destination pair and a vendor managed lane rating system created a closed loop with the external transportation billing service.

- Enabling the routing guides provided another level of visibility to the transportation reps. For any proposed shipment the routing guide now provides four carrier options consistent with established BMS Logistic and Procurement contracts.

Concurrently, it was worked to inform product planning about missed opportunities to utilize lower cost intermodal equipment due to lack of planning time, and it was embedded text messages in the master data for a Poke-Yoke or mistake proofing solution.

Cost reduction was the key objective and the most tangible measure of the affect of the improvements. Implementation of improvements began in February of 2006 and was validated a savings of $505,000 for that year. In 2007 it was reduced the cost by over $800,000, and the project continues to generate results.

New measurements were established to chart the cost per pound of shipments within the affected range. These charts are published and pushed electronically to 15 people each month. In addition, backup files show that the cost per pound of shipments within the range studied is within controls established by the team.

Carrier shipment refusals are down by 50% in the one to two day notice timeframe and down about 30% for same day notice. This effect had a collateral positive impact on transportation reps because they now spent less time chasing backup carriers to make transportation arrangements.

As an outcome of the project, it was held a number of Lunch and Learn events open to all employees engaged in transportation planning entitled “Transportation: Balancing Costs and Service”. Feedback from these meetings showed there were a number of cost drivers that were not clearly communicated to people influencing carrier selection. One such cost driver was the use of the word “guaranteed” when discussing freight arrangements with a carrier. “Guarantees” can drive costs for transportation upwards by as much as 40%. Control charts and hypothesis testing were used to validate that the improvements had the desired effect. Care was taken to consider any confounding issues like carrier price negotiations or fuel surcharges.

The improvements were based on feasibility. Those which could were implemented immediately, followed within a month or two by a next wave as it was developed and implemented changes to SAP software. Here it was seen the impact of improvements over these various implementation phases. Note: Not only did the mean cost per pound decrease in a statistically significant way, the variance in cost decreased as well.

Another way to view improvement was by using a p-chart: the defect is defined as a shipment which should have gone LTL but was incorrectly shipped via a full truckload carrier. A two sample t test had a P value of zero indicating that a shift in mean cost per pound from baseline to post improvement was statistically significant. It was checked the confidence interval and used it to provide the management sponsors and champions with a statistical projection of the upside and downside potential for savings.

An example of the ITEA criteria 3B.b is shown on the Fig. 12.

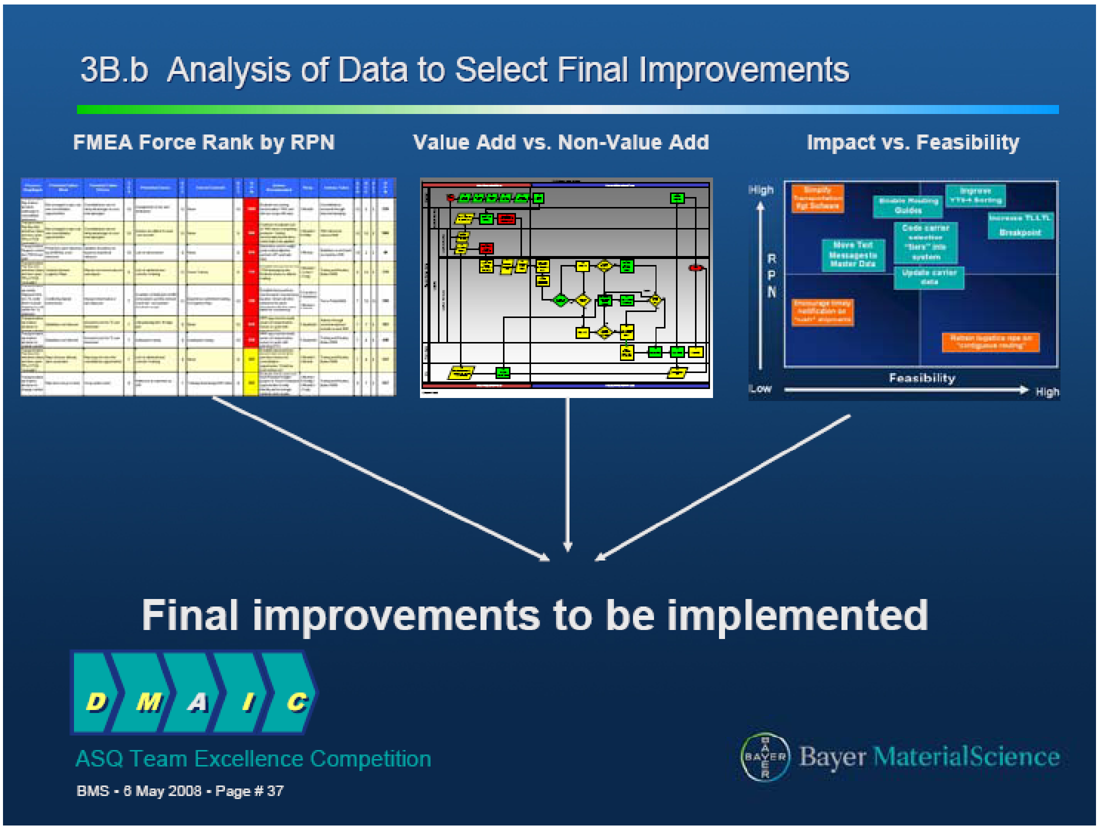

Fig. 12. Analysis of Data to Select Final Improvements (Bayer/ASQ, 2008)

5.4 Bayer - 4 Project Implementation and Results – Improve/DMAIC

Internal stakeholders were integral to the selection and implementation of each improvement.

Due to internal proprietary issues and legal implications of confidentiality agreements with the carriers, it was not possible to involve them in the decision making process. Normal communications channels through the Logistics and Procurement Group were employed to obtain feedback from these external stakeholders.

The principal strategy to identify and address potential resistance to change was to ensure:

- The right stakeholder groups represented on the core team.
- The stakeholder group was represented by respected people from that group.
- Identification of root cause and planning for corrective action was a collaborative process.
- Core team stakeholder representatives provided good two way communication with members of their respective groups to discuss potential changes and resistance in advance of implementation

Stakeholder buy-in was assured first through consensus of the core team who represented all major stakeholder groups. In addition, core team representatives communicated with their colleagues throughout all phases of the project. Logistics and Procurement communicated with carriers as appropriate.

A detailed action plan was developed for implementation in which each task was identified, assigned and a deadline established. The core team met regularly to assess progress and make adjustments as necessary. By meeting and communicating regularly it was possible to stick pretty close to the original plan.

The team implemented four major changes through Kaizen events:

- Established a new TL/LTL weight breakpoint and entered carrier recommendations into the system.
- Improved the ability to sort based on origin, destination and weight.
- Enhanced the carrier tables through a software and process execution upgrade to provide transportation reps with accurate carrier recommendations based on weight and origin-destination pair.
- Provided routing guides and trained reps on their use.

It was kept in touch with the stakeholders' needs and educated production planners to take advantage of lower cost intermodal freight. It was verified text messages as they were converted into Master data and eliminated "whisper down the lane" errors.

A Microsoft Excel based lane-rating measurement tool was published and distributed, and personnel trained for the Logistics Reps to use when choosing carriers. This tool provided a simple, sort-able method to show which carrier would be preferred for a particular shipment. In addition, the freight payment vendor has an online query available to rate lanes that include the actual cost for the shipment. This is particularly useful when shipping to a new customer location. Coding the information from the routing guides into the transportation management software provided a virtually mistake proof or Poke Yoke way for transportation reps to choose an appropriate carrier.

Bayer MaterialScience goals, performance measures and strategies were linked to the project through the charter and ended up in positive territory as a result of the teams efforts.

Shipping cost per pound went down by eight tenths of a cent. Given the size of the transportation expenses, this small amount translated to $800,000 dollars per year of cost reduction. Elimination of 5 non-value added steps reduced process complexity hence supporting Bayer's goal of simplification. "On Time in Full" is a key performance indicator of importance to the customers. It was managed to reduce cost without adversely affecting "On time in Full", in fact the metric edged up a bit.

Business stakeholders (Customer Service, Transportation, Product Planning and Master Data) were provided with the opportunity to attend "lunch and learns". These meetings were well attended by management stakeholders and persons involved in the transportation decision making process. Following completion of the project it was also communicated results to the project sponsor and key stakeholders.

An example of the ITEA criteria 4A.a is shown on the Fig. 13.

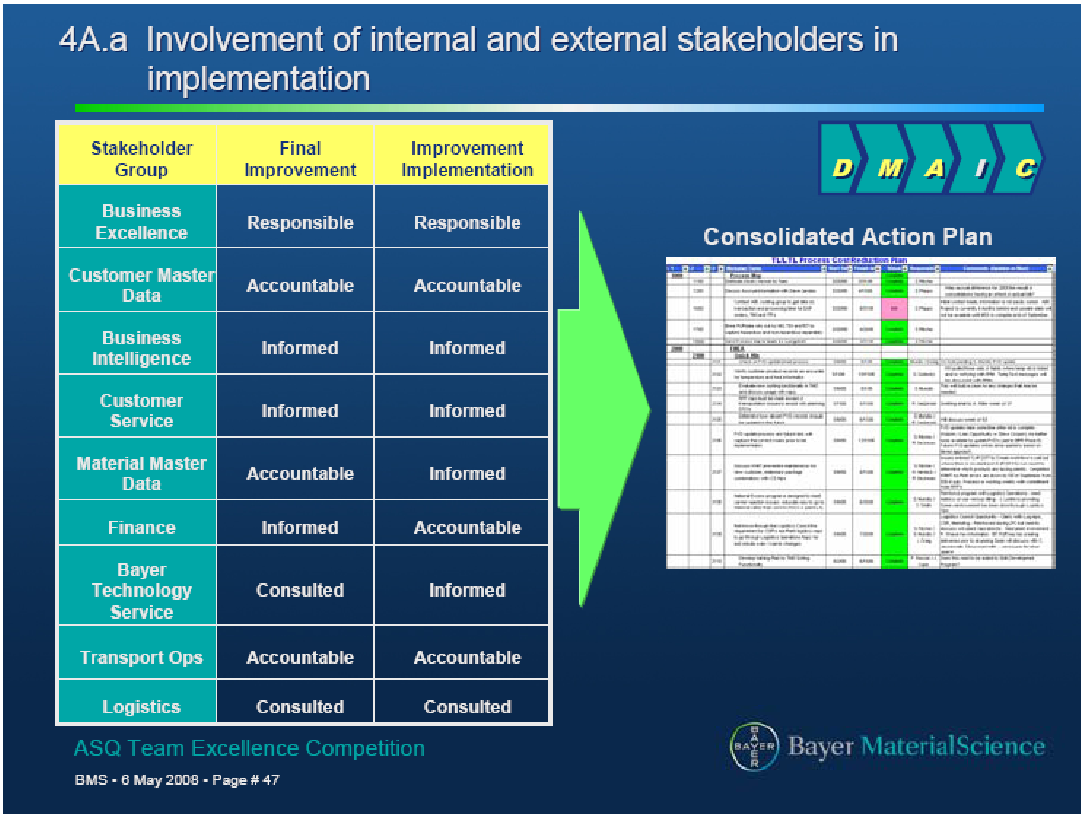

Fig. 13. Involvement of internal and external stakeholders in implementation (Bayer/ASQ, 2008)

5.5 Bayer - 5 Team Management and Project Presentation – Control/DMAIC

The first step in identifying team members occurred during the Define Phase in which it was used a high level SIPOC, process map and preliminary Gantt chart to identify functional groups involved in the process, potentially impacted by any change to the process, and technical support functions required to obtain data, analyze data and help implement any required changes to software or SOPs.

Once there was a list of functional groups required for the project, it was possible to start the process of selecting core team members. The criteria for selection varied depending on the functional group. It was felt strongly that functional groups directly involved in the current process needed to have a representative on the core team with expertise in the details of their functional group's role in the process. They would not, however, necessarily require expertise in the SAP system and its software, as an example. Likewise, those providing systems expertise in data mining or software development would not need to have prior intimate knowledge of the shipping process. It was needed to find people with both the time, and the backing of their functional management to attend meetings and do the work required of the project. The sponsor group helped with this task. Before to begin to work on the project itself, it was needed to talk about how it was going to work as a team. The following questions had to be answered before the team start-up:

- What were the relative roles and responsibilities?
- Was it needed any additional team members?
- What were the mutual agreements regarding how the team could conduct themselves?
- What did we expect of each other?
- What did we think management expected?
- How much of our time will this require and over what period?
- How will we make decisions?
- What is Lean Six Sigma and how is it different from what we've been doing?

It was spent some extra time reviewing the DMAIC process and some of the tools that would be using along the way. It was important to working out these basics before laying down the foundation to be an effective team.

It was not just talking about roles and responsibilities or mutual expectations in that first meeting and then forgetting about it. Having identified and prioritized improvement opportunities, it was made commitments to one another relative to who would do what and when it should be completed. It was published the list so that all could see if the team were on track and make adjustments as necessary. As a part of the Lean Six Sigma methodology, the core team was required to provide regular, face to face, presentations to the sponsors and champions outlining the team's progress, findings, and performance against plan. This not only helped motivate and keep the team on track, but more importantly managed the expectations of the sponsors and provided regular and formal opportunities for the team to identify potential roadblocks and solicit the help of the sponsor group. As a team, it was agreed to meet weekly or bi-weekly depending upon project objectives and resource loading. Project action item updates were published following meetings. It was also ran special meetings whenever the team felt they were necessary to take remedial action to put things back on track.

An example of the ITEA criteria 5C is shown on the Fig. 14.

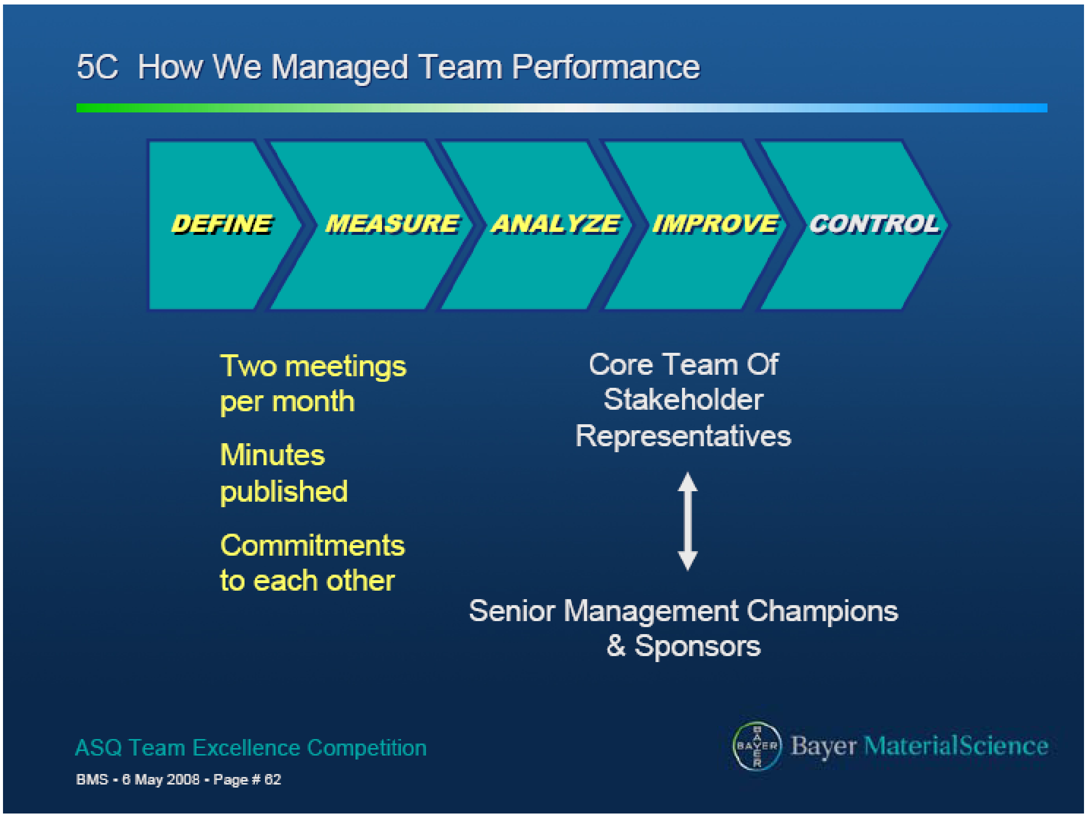

Fig. 14. How it was managed Team Performance (Bayer/ASQ, 2008)

6 RESULTS OF THESIS

Based on the IEEE paper "An Empirical Study of the Relationship Between Team Performance and Team Maturity" (Elrod and Tippett, 2008), I will established the flow of this thesis from the concept to practice.

6.1 The Team performance construct

Katzenbach and Smith conceptually defined the relationship between team performance and team maturity in "The Wisdom of Teams: Creating the High Performance Organization" (Katzenbach and Smith, 1993).

Change is one of the few constants in organizations today. In order to understand and analyze how change affects the workplace, it is helpful to specify which proportions of the organization are affected by a given action. The team performance construct shown in the Fig. 15, identifies the four major elements of a team-based entity: the individual, the team, the organization and the external environment (Tippett, 1998). This construct also identifies the boundary layers (or interfaces) between organizational elements as critical components of the model. The region of interest is noted in the construct as the area internal to the parent organization including the individual-team and team-organization boundaries.

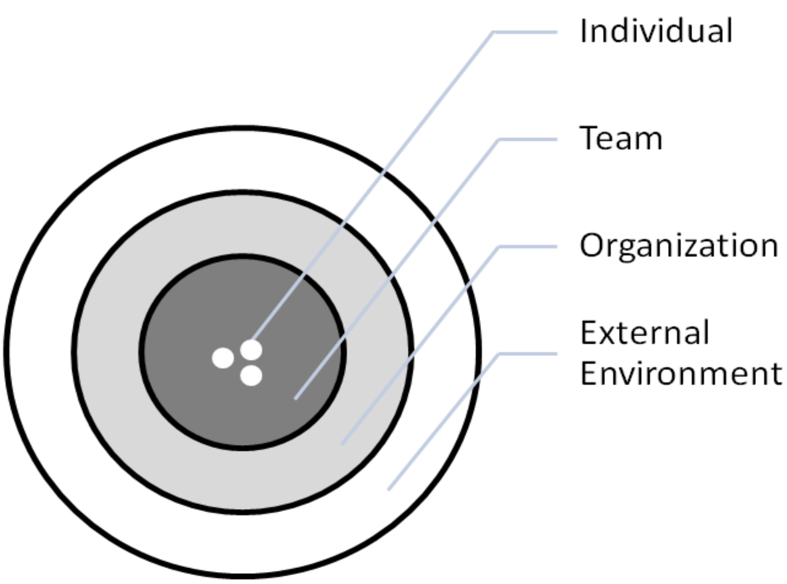

Fig. 15. Team performance construct (Elrod and Tippett, 2008)

6.2 The Change curve

The emotional voyage of the change process involves ten phases: Equilibrium, Denial, Anger, Bargaining, Chaos, Depression, Resignation, Openness, Readiness, and Reemergence (Perlman and Takacs, 1990). This expanded change process is illustrated on the Fig. 16. The horizontal axis of this figure generally represents the time. The vertical axis can take on many identities. Contentment, performance or ability to function, and acceptance of reality are representative examples of these identities. Each of these "change models" is transitions from normality to a re-defined normality. In the initial state of normality, a reasonable level of performance can be maintained. However as an individual, or an organization goes through the region of disruption, performance can be expected to be diminished. In the final state, a Te-defined normality, the understandings and expectations of the changed entity (individual or organization) are more closely aligned with reality. Given this closer alignment of perception and fact, one can expect performance to be improved over that of the initial stage.

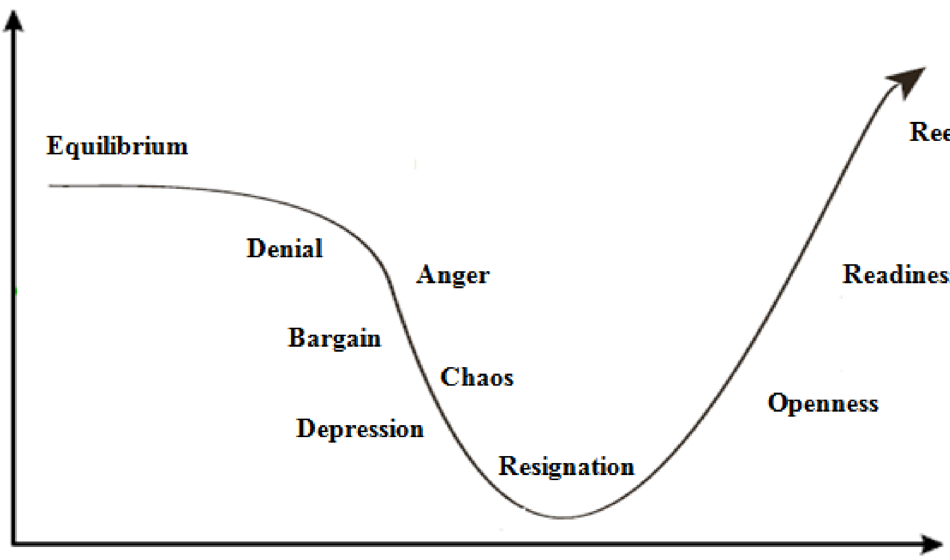

Fig. 16. The Change Curve (Elrod and Tippett, 2008)

6.3 The Team Performance Curve

The Wisdom of Teams (Katzenbach and Smith, 1993) discusses the team maturation process and introduces them “team performance curve”, illustrated on the Fig. 17. This curve illustrates the relationship of a team’s performance (vertical axis) to the effectiveness of the team’s implementation of teamwork (horizontal axis). The axis can also be thought as a measure of the team’s development or maturation as a team from its initial to its final state.

The five stages of team development on the team performance curve correspond well with the stages of the organizational change process described earlier. Katzenbach and Smith tracked the performance of teams as they move from an initial equilibrium state of reasonable effectiveness (working group), to an intermediate state of diminished effectiveness (pseudo-team). This intermediate state is analogous to the intermediate states in the grief work models of change in that is involves disorder and uncertainty. In this state, old ties and relationships are broken, and the new ties and relationships are yet to be established. Teams that emerge from this trough can be expected to move toward becoming a “potential team”. This is a group that is really trying to improve its effectiveness and performance. It has built new relationships and work processes to take the place of the original ones, but there are not yet honed and fully developed. The real performance gains are achieved in the next portion of the development process, which is graphically portrayed as the steepest portion of the curve. Here, small incremental gains can result in significant performance improvements. Mutual accountability and shared goals emerge as dominant motivational factors for the team. The final state is the “high performance team”. Members of this team are not only deeply committed to group effectiveness, but are also committed to individual growth and success. This state is attainable, but in practice-very few teams reach it.

Self-Working Directed Teams are touted as a path to improving organizational productivity (Versteeg, 1990) and profits. Intuitively, most managers realize that there gains do not come without cost or risk. The trough portion of the team performance curve represents the cost. During this period productivity and effectiveness actually decrease. The risk is that the team may not ever successfully navigate out of the trough into the region of improved performance (Hitchcock, 1995). Thus the team maturation process described by Team Performance Curve has great significance to those who are held accountable for profitability and competitiveness of the organization.

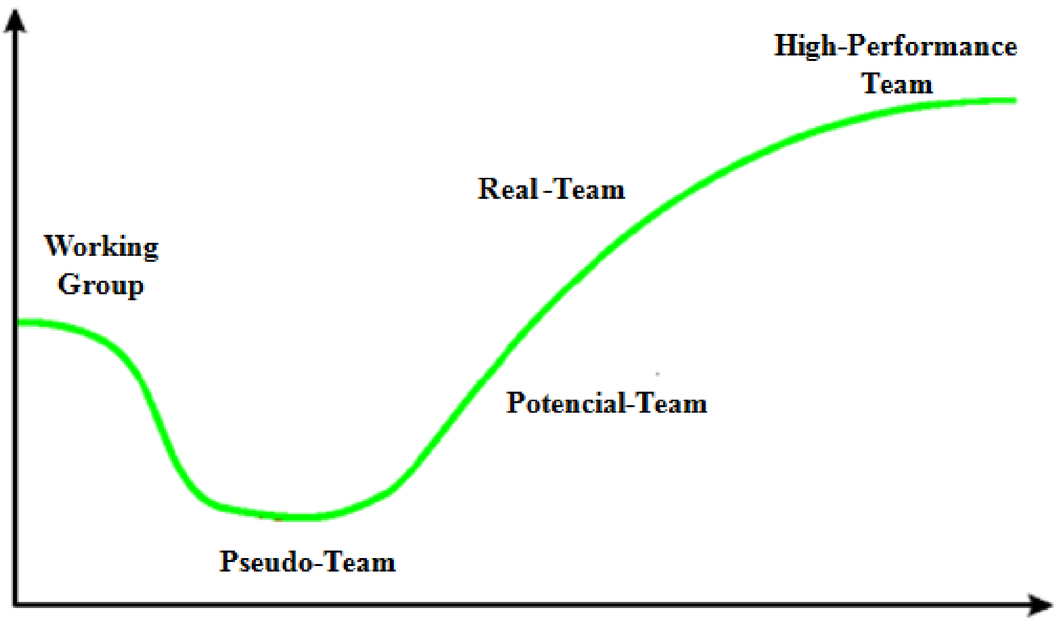

Fig. 17. The Team Performance Curve (Elrod and Tippett, 2008)

Managers involved in the transition of organizations from traditional command and control structures to self-managed teams should act upon knowledge of this team performance-team maturity relationship to prepare all of the organizational stakeholders (customers, owners, employees) for the true positive and negative effects of the transition. Armed with an understanding of the process, managers should be better equipped to guide transformation process. The productivity decline associated with the initial stages of the transition to team should not come as surprise to organizations. It should be understood and anticipated by all involved. Similarly the potential gains available from transitioning to a team based organization should not be treated as a hypothetical possibility, but as an achievable goal.

6.4 Conclusions

The Thesis goals was to provide an integrated approach to manage people in technical environments, both industry and services.

The DMAIC model, as a set of methods and tools of the Six Sigma system, will only be applied successfully if the correlations to the team development stages are fully understood and put in practice.

It was my intention that the contents of this Thesis could be of highly interest for this three entities:

- New Manager
- Change Manager
- Team Excellence

The New Manager, if currently in transition from Engineer to Manager, will have a set of methods and tools for immediately application on his/her new management function. The main change of the new Manager will be how to motivate his team to do his/her previous job that he/she did it so well.

The Change Manager will have a technical concept like the DMAIC stages, that is highly visible and quantifiable as an opportunity to introduce change on the organization by following the Team Development stages as background.

The Team Excellence has a target for high-performance. The DMAIC model stages follow the Team Development stages, which we can consider as milestones. Those short-term milestones are important to give persistence and endurance to arrive to final stage of high-performance, in spite of problems and setbacks that will appear on the way.

7 SUMMARY

This Thesis can be resumed in two parts, managing team excellence and executing it successfully by using the DMAIC model of Six Sigma system.

To managing team excellence there are five key success factors as described on the book of “X-teams: how to build teams that lead, innovate and succeed” (Ancona and Bresman, 2007). Those five key factors represent a summary of the importance of knowledge about Team development described on this Thesis.

To execute successfully the DMAIC model, the American Society of Quality (ASQ) is one the main references to provide guidelines and official certifications. The International Team Excellence Award (ITEA) of ASQ can be used as benchmark of real-world company examples for collecting experiences of the DMAIC model implementation.

7.1 Team’s Five Key Success Factors

The X-team’s five key Success Factors described by Deborah Anconna (Ancona and Bresman, 2007) are the same to be applied to all kind of teams programs:

- You must have commitment from the top
- A solid launch
- A stringent structure
- Support and feedback mechanisms
- A clear endgame

7.1.1 Success Factor 1: Commitment from the Top

An X-team program won’t succeed without strong commitment from the top management team. Management active involvement not only provides legitimacy to the program and ensures the support of others in organization; it also helps motivate participants and ensures that there is a follow-up on the projects of the X-teams.

Building an X-team culture involves openness to spanning boundaries, sharing information, and challenging dogma at all levels of the organization. Top management can help build this culture by breaking down barriers, by fighting the "Not-Invented-Here" mentality, and by fostering a culture of sharing information, crossing boundaries, and nurturing innovation at lower levels of firm.

7.1.2 Success Factor 2: A Solid Launch

Beginnings can hold the key to the way almost any endeavor unfolds, and this is never more true then when launching an X-team. At the launch, X-team members begin to identify and choose their projects, learn about what an X-team is and how to become one, and spend time together learning about other team members and preparing a plan for how they will work together. After X-teams members have had all their preliminary training, it is time to go to work. The more time that team members can spend getting to know each other and preparing for their early work of exploration, the higher the chance of hitting the ground running and succeeding.

7.1.3 Success Factor 3: A Stringent Structure

A stringent structure begins with deadlines and deliverables for each step along the road. It is very helpful to have all the teams meet for the launch and again following exploration and for the final presentations. Common meetings allow for what is known as "temporal crossing points", when everyone pauses at same time. Hence, projects can be evaluated simultaneously, members can shift teams if necessary, everyone is open to feedback and change since they are in pause mode, and shifts in the entire project structure can reflect the progress of all team projects.

7.1.4 Success Factor 4: Support and Feedback Mechanisms

Teams need sponsorship whereby someone from the company is evaluating their project deliverables and letting them know whether they are on the right track. This allows the team to redirect, or to make its case again, to ensure a high-quality outcome. Support can also come in the form of an effective information system. This is particularly important for X-teams operating in a context widely dispersed and changing knowledge. Such a system may include databases that give access to critical know-how, as "know-how" databases and expert-finding systems.

7.1.5 Success Factor 5: A Clear Endgame

The last critical success factor is managing the ending of the team. Here top managers need to listen to the project results and recommendations, praise the X-teams members for the work they have done. Decide which projects will move forward and which will not, and begin to ensure that whatever follow-up activities, need to take place, are assigned to the appropriate manager. The final presentations are an opportunity for X-teams members to have the visibility and voice that they were promised.

7.1.6 DMAIC vs. Team Development

As resume the X-team five key factors are fully aligned to the team development stages described along this Thesis, and are as well in synchronization with the DMAIC mode, as we can see in the Table 3).

Table 3 DMAIC vs. Team stages

Tuckman Model stages	**Self-Directed Working Team stages**	**Team Performance Curve**	**ITEA/ASQ assessment stages**	**X-team's 5 key Success Factors**	**DMAIC Model stages**
Forming	Forming	Working Group	Project Selection and Purpose	Commitment from the Top	Define
Storming	Storming	Pseudo-Team	Current Situation Analysis	A Solid Launch	Measure
Norming	Initial Integration	Potential-Team	Solution Development	A Stringent Structure	Analyze
Performing	Total integration	Real-Team	Project Implementation and Results	Support and Feedback Mechanisms	Improve
Adjourning	Self-Direction	High-Performance Team	Team Management and Project Presentation	A Clear Endgame	Control

7.2 DMAIC impact on Quality Systems

One of the aims of this thesis was to prove that the DMAIC model can be replicable.

It was given a real-world company example, Bayer, assessed by the International Team Excellence Award of American Society of Quality. The criteria methodology of ITEA/ASQ can be used as a self-survey to review the performance of a self-direct working team.

Beside of the books mentioned throughout this Thesis, there are other sources that can help guide a successfully DMAIC model implementation. The American Society of Quality provides Black and Green Belt certifications that will create a serious base for the implementation of the DMAIC model.

The DMAIC model is also based on the Deming's model Plan-Do-Check-ACT cycle, which means that is a model based on Quality principles that are the foundations of the Six Sigma system.

Independently of implementing or not a Six Sigma system, the DMAIC model can be applied as a general model for any company that wants to be able to manage excellence within its teams for the successful implementation of a Quality system.

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9 LIST OF FIGURES

10 LIST OF TABLES

11 LIST OF ABREVIATIONS

HR – Human Resources

SDWT – Self-Direct Working Team

DMAIC – Design, Measure, Analyze, Improve, Control

ITEA – International Team Excellence Award

ASQ – American Society of Quality

RPN - Risk Probability Number

TL/LTL – TruckLoad/Less than TruckLoad

FMEA – Failure Modes and Effects Analysis

QFD – Quality Function Deployment

SIPOC – Suppliers, Inputs, Process, Outputs, Customer

CTQ Tree – Critical-To-Quality Tree

COPQ – Cost Of Poor Quality

DOE – Design of Experiments