First Pass Yield Improvement on Audit Results

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Abstract — *This research project was focused in the First Pass Yield improvement for Quality Audit results in Aerospace Company. The first pass yield is defined as the number of units coming out of a process divided by the number of units going into that process over a specified period of time. Only good results of the audits that are in compliance with the company requirements are counted as coming out of an individual process. In order to improve the first pass yield, the DMAIC methodology was used. DMAIC is an acronym for a series of steps used to measure defects in business processes and improve profitability. The term DMAIC stands for the five main steps in the process; Define, Measure, Analyze, Improve and Control. This research seeks to improve the yield for the audits results and improve the yield of the serviced deliverables. This is important for the process because it will reduce rework, reduce negative impact in the compliance with the AS9100 certification and will increase the customer satisfaction. DMAIC methodology brings a structure and the tool to improve a process by optimizing and stabilizing business process. In this case increase the yield for the audit results in an Aerospace company and the company will be in compliance with the AS9100 certification.*

Key Terms *— AS9100 Certification. Audit Process, DMAIC, Product Realization.*

INTRODUCTION

Aerospace companies have a lot of challenges due to the changing global expectations and the competition with other Aerospace companies. They focused in cost reduction and increment profits sales, through increasing the customer satisfaction and obtaining certifications like the AS9100 that help them to gain more business and increase their customer satisfaction. Other challenge for the Puerto Rico site is the internal competency. For example, the same company has many plants around the world that can do the same work and can be their competition.

This research project will be focused in an improvement of the yield for the audit process that will help the company to maintain the AS9100 certification.

PROBLEM STATEMENT

The first pass yield for the audit results for compliance with the AS9100 and procedure has had an increase on defects during the last few months. The increase on defects cause a negative impact on the customer satisfaction, deliverables can be delivered with defects and the company it's on risk to lose the AS9100 certification. With the reduction of these defects, a better yield at the company can be achieved. The goal is to increase and maintain Audit results First Pass Yield (FPY). In order of achieve this goal, use a DMAIC project methodology is going to be used.

RESEARCH DESCRIPTION

This research is about increasing the yield of the audit results and increases the customer satisfaction. This is important for the process to reduce rework, increase customer satisfaction and delivered products in compliance.

RESEARCH OBJECTIVES

This project aims to achieve an increase and maintain the audit results first pass yield at 93%.

This will reduce the reworks and maintain the AS9100 certification.

RESEARCH CONTRIBUTIONS

This project seeks to maintain the AS9100 certification and increase customer satisfaction. This improves the company to maintain the certification and also get new customers to increase their portfolio. If the companies maintain the AS9100 certification and reduce the rework created by the findings, the cost associated to the rework and the loss of the certification can be reduced. This represents approximately $150,000 per year.

LITERATURE REVIEW

AS9100 is the quality management systems standard applicable to companies that supply to aerospace and defense industries. The AS9100 standard provides the requirements for establishing and maintaining a quality management system for the aerospace industry. To assure high levels of customer satisfaction, aerospace industry organizations need to produce, and continually improve, safe and reliable products that meet or exceed the requirements of customers and regulatory authorities. A quality management system is set up by an organization to achieve high levels of customer satisfaction and continual improvement, focusing on common requirements and the reduction of variation and waste in the supply chain [1]. This can be performed by establishing a quality policy and quality objectives, and establishing the means to achieve those objectives [1]. This standard incorporates all of ISO 9001 with additional industry specific requirements for aerospace. AS9100 is a widely adopted and standardized quality management system for the aerospace industry. It was released in October, 1999, by the Society of Automotive Engineers and the European Association of Aerospace Industries.

The company performed internal audits to review the requirements of the AS9100. The purpose of this is to verify the compliance of the organization quality management system to the AS9100 standard.

The AS9100 standard is divided into five main sections that state requirements for the primary process "categories" in the company:

- Quality management system processes, including developing the QMS documentation, control and records control. These "QMS" requirements are found in Clause 4.
- Management processes, including planning and management review. These Management Responsibility are found in Clause 5.
- Resource management processes, including human resources, infrastructure, and the work environment. These "Resource Management" requirements are found in Clause 6.
- Product realization (production) processes, including sales order review, product design, purchasing, calibration, and the actual "production" of your product or service. These "Product Realization" requirements are found in Clause 7.
- Measurement, analysis and improvement processes, including internal auditing, inspection, testing, and corrective/preventive action. These "Measurement, Analysis & Improvement" requirements are found in Clause 8.

General Concepts of DMAIC Methodology

DMAIC is an abbreviation of five improvements steps: Define, Measure, Analyze, Improve and Control. DMAIC refers to a data-driven improvement cycle used for improving, optimizing and stabilizing business processes and designs. The DMAIC cycle is the core tool that is used to manage the Six Sigma projects. All of the DMAIC process steps are required and always proceed in the given order [2]. DMAIC can be used to any improvement project or application. (See figure 1)

- Define: Define who the customer is, what the requirements for the product or the service are and what their expectations are. In this phase,

the project boundaries is defined and mapping the process to understand the flow.

- Measure: Create and develop a data collection plan for the process, you shall collect data from many sources to determine types of defects and metrics.
- Analyze: The data is collected to be analyzed and determine root causes of defects and opportunities for improvement. In this Phase, gaps are identified between current performance and goal performance, also help identify the sources of variation and prioritize opportunities to improve.
- Improve: The target process by designing creative solutions to fix the problem and prevent future occurrences. In the Improve phase, innovate solutions are created to develop and deploy the implementation plan.
- Control: The phase of Control help to maintain and improve the new process implemented. This help to prevent reverting back to the "old way". This phase require the development, documentation and implementation of an ongoing monitoring plan [2].

PROJECT METHODOLOGY

A systematic approach needs to be used as a methodology to achieve the goals of the project. Since the purpose of the project is to improve the yield of the audit process for the Product Realization process, the DMAIC tools will be used. In order to achieve the goal of increase the audit results yield and reduce the quantity of the defects founded during the audits.

Figure 1
DMAIC

At the Define steps the following tools will be used:

- Project Charter, is a statement of the scope, objectives and participants in a project. It provides a preliminary delineation of roles and responsibilities, outlines the project objectives, identifies the main stakeholders, and defines the authority of the project manager. It serves as a reference of authority for the future of the project.

At the Measure steps the following tools will be used:

- SIPOC is a tool that summarizes the inputs and outputs of one or more processes. The acronym SIPOC stands for Suppliers, Inputs, Process, Outputs, and Customers [3]. The diagram is utilized as a high level view of the process. The SIPOC diagram helps to understand which are the supplier and customers of the process, the input and output variables of the process, and finally the process steps.
- Voice of the Customer is a market research technique that produces a detailed set of customer wants and needs, organized into a hierarchical structure, and then prioritized in terms of relative importance and satisfaction with current alternatives.

For the following steps (Analyze, Improvements and Control) tools to be used will be determined during the project process according the previous steps results.

RESULTS AND DISCUSSION

The results obtained through the five phases of the DMAIC methodology follows.

Define – As part of the define phase the Project Charter tool was performed in order to determine the problem statement, the goal of the project and the metrics that will be defined. See Table 1.

Another tool that was used for the Define stage is the Thought Process Map. A TMAP is a visual representation of a Black Belt's, team leader's or an entire team's thoughts, ideas and questions relative

to accomplishing the project goal. It should be one of the first tools employed when starting any Six Sigma or process improvement project. A TMAP presents a structure of information and helps a team progress through the DMAIC process. It is a living document that will change throughout the project and has no set format. A TMAP can be used to drive specific actions and select the Six Sigma tools that should be employed. The most important benefits of using a TMAP in a Project it ensures that nothing is left out or missed. It is an effective tool for ensuring all potential questions and issues of a Project have been both identified and addressed from the beginning of a Project to completion. See Table 2.

Table 1
Project Charter

Project Charter
Problem Statement: An increase in audits defects were detected during the last Product Realization audit causing a negative impact in the customer satisfaction and risking the AS9100 certification.
Goal: Increase the audit yield from 86% to 95% of compliance and reduce the qty of defects that were found during the audit.
Metric Definition: First Pass Yield

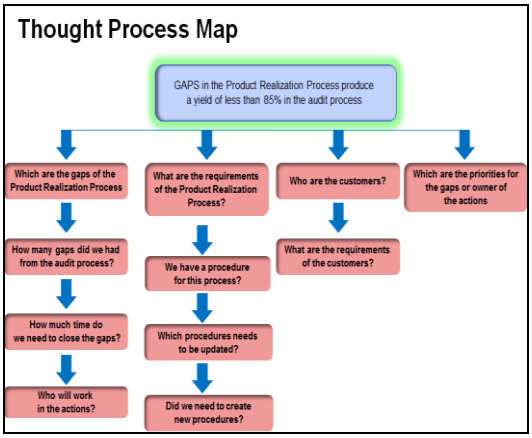

Figure 2
TMAP

The most important benefits of using the TMAP in the project is it ensures that nothing is left out or missed. It is an effective tool for ensuring all potential questions and issues of the project. This tool helps us to provide a visual map that tracks the development of ideas and issues.

Table 2
Action Log

Action	Description	Date
Which are the gaps of the process	Review the audits results	2/28/2016
How many gaps are?	Review the audits results	2/28/2016
How much time to close the gaps?	Verify who are going to be responsible	2/28/2016
Which are the requirements?	Review the requirements	2/28/2016
We have a procedure for this process?	Verify the procedures that are affected	2/28/2016
Did we need to create new procedures?	Verify if we need to create procedures	2/28/2016
What are the requirements of the customers?	Review the requirements	2/28/2016
Which are the priorities?	Verify which are going to be the priorities to close the gaps	2/28/2016

Through the TMAP the team identified the questions that we had for the project and help us to answer those questions and determined some of the action that we need to followed in order to complete the improvement of the process. The team wants to know which are the most important requirements that we need to follow to be in compliance with the process and also which are the customer requirements that we need to improve the process.

Measure - As part of this Measure phase the SIPOC and the VOC tool was performed in order to determine what the customer wants and needs and also to determine the inputs and outputs of the processes using the SIPOC tool. /

Every Standard Work is audited and the nonconformities are documented into a database. All nonconformities were validated and evidence of the defects was also documented.

The results of the SIPOC and the VOC were showed below in Figure 3 and Table 3 respectively.

Supplier	Input		Process	Output		Customer	Impact
	Description	Quantified Measure		Description	Quantified Measure		
Process Owners	Std Work	Proj #	Audit process	Audit Plan	Monthly	Managers and Supervisors	9
Auditors	Audit Plan	Audit Schedule		Schedule			7
		Audit Notification		Audit Results			8
		Std Work		Report			10

Figure 3
SIPOC

From the SIPOC analysis it can be determined that the customers wants accurate results from the audit and the nonconformities shall be supported with evidence, to work on the different issues that were identified form the audit. The customer wants to improve the audit results and maintain the AS9100 certification. They understand that this process helps to achieve a better customer satisfaction and also maintain the customers with the company.

Table 3
VOC

Voice of the Customer	Key Customer Issues	Critical Customer Requirements
What does the customer want from us?	We need to identify the issues that prevent us from satisfying our customers	We should summarize key issues and translate them into specific and measurable requirements
Customers want to reduce defects in the Product Realization process	Process Owners does not undertsand the Product Realization process and requirements	Training
Customer want to improve the audit yield		
Customers wants accurate results from the audit	Develop a mature process to get and analyze the audit results	Develop a tool

In the VOC it was noted that the greatest concern was to reduce the defects of the Product Realization process and improve the yield of this process during the audit process. The customers understand the importance of followed the Product Realization process and understood the requirement of the process. This improvement will be very beneficial not only for the projects but also to increase the satisfaction of the customer. It will gave the opportunity to have more job and task related to the same process.

The area to be focused will be the Product Realization Process audit results reducing the defects that were found in the Standard of Works.

Analyze Phase – A Pareto Chart (Figure # 5) was created with the intention of obtaining a visual indicator of which requirement of the Product Realization process is causing the greatest defects during the audit. This Pareto will help to identify those requirements that are causing problem and will help to identified which sub-process needs to be worked in order to achieve a better yield in the audit process. The Pareto represents the most common sources of defects, the highest occurring type of defect, or the most frequent reasons for customer complaints. The Pareto principle states that, for many events, roughly 80% of the effects come from 20% of the causes.

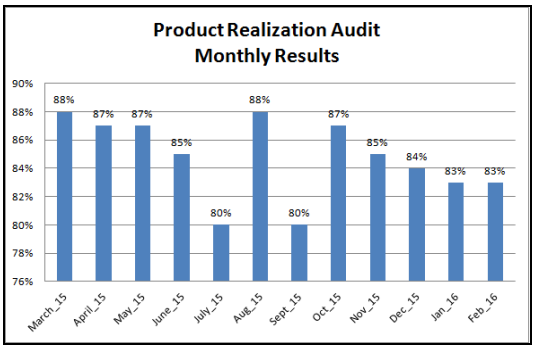

Figure 4
First Pass Yield Trend

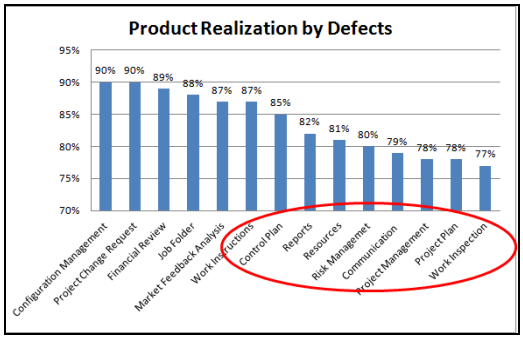

Figure 5
First Pass Yield

It is observed that the FPY (First Pass Yield) in the last four months decrease to an average of 84%.

The top ten defects were identified from the last audits and identified the most common defects.

From the Figure 5 (which represents the top offender in a Pareto graph) was observed that the top offenders in the Product Realization Process are; Work Inspection, Project Plan, Project Management, Communication, Risk Management, Resources, Reports, Control Plan and Work Instructions.

The Analysis of the data collected shows that the Work Inspection, Project Plan, Project Management, Communication, Risk Management, Resources, Reports, Control Plan and Work Instructions are the major offenders that are affected the Product Realization process. If we attack those sub-processes we can reduce the defects on the process and improve the audit yield of this process. All of those sub-process cause that the product realization does not met the requirements and the owners of this process are not followed the procedure to be in compliance with the product realization process.

In order to reduce those defects a cause and effect diagram was generated to determine the potential contributors to reduce those defects. Since all the major offenders are related to requirements related to the product realization process the cause and effects diagram was created to determine which contributors are affecting that the product realization process were followed.

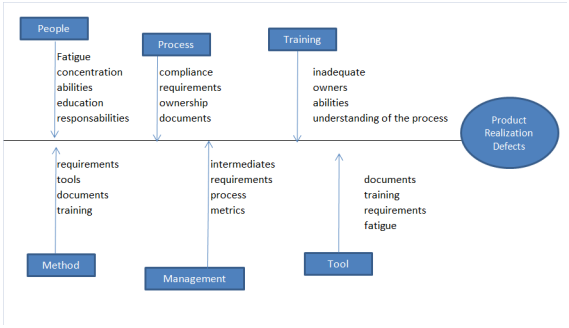

Figure 6
Fish Bone Diagram or Cause and Effect Diagram

From the Cause and effect diagram (see figure 6) it was determine that the most potential contributors that affect the Product Realization process are; definition of requirements, training and documentation. The team can conclude that the Product Realization process had a lot of requirements that the people that manage this process does not understand and does not had the appropriated tools to manage and be in compliance with the process. If we attack these issues we can improve the yield of the audit results in the product realization process. The team can conclude that the process owners had issues to provide evidence of the process because they not had the adequate training to understand the requirements of the process and also they not had the appropriated tools to document the requirements and provide the evidence.

Improve Phase – 5 Whys is an iterative interrogative technique used to explore the cause-and-effect relationships underlying a particular problem. The primary goal of the technique is to determine the root cause of a defect or problem by repeating the question "Why?" Each question forms the basis of the next question. The "5" in the name derives from an empirical observation on the number of iterations typically required to resolve the problem [4].

The technique was formally developed by Sakichi Toyoda and was used within the Toyota Motor Corporation during the evolution of its manufacturing methodologies. In other companies, it appears in other forms. Under Ricardo Semler, Semco practices "three whys" and broadens the practice to cover goal setting and decision making. Not all problems have a single root cause. If one wishes to uncover multiple root causes, the method must be repeated asking a different sequence of questions each time.

The method provides no hard and fast rules about what lines of questions to explore, or how long to continue the search for additional root causes. Thus, even when the method is closely followed, the outcome still depends upon the knowledge and persistence of the people involved.

In the improve phase the team will use a 5'why tool to determine the root cause for the non-conforming of the audit process and will help us to determine why the employees are not followed the

process. 5 Whys is an interrogative technique used to explore the cause-and-effect relationships underlying a particular problem. The primary goal of the technique is to determine the root cause of a defect or problem by repeating the question "Why?" Each question forms the basis of the next question. The "5" in the name derives from an empirical observation on the number of iterations typically required to resolve the problem. The 5 Whys is a great tool that does not involve data segmentation, hypothesis testing or other advanced statistical tools, and in many cases can be completed without a data collection plan [4].

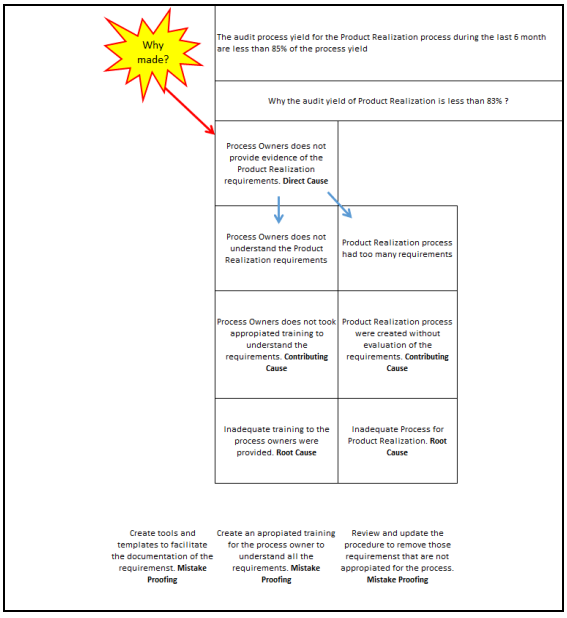

Figure 7
5'Whys

Based on the 5'why results the team can determined that the problem that we had to achieve a better results for the audit yield it's that the employees do not have the appropriated training to understand the requirements of the process and also another issue that we identified using the 5' why tool is that the process had too many requirements and we need to identified which are the ones that we need to be in compliance with the AS9100 certification and also provide a better explanation of the requirements.

During the improvement phase we determine that we need to revise the process and improve the procedure to provide a better understanding of the requirements to the process owners. Also a training for all the process owners will be created in order to provide them a better understanding of the process and some templates and tools will be created to help the process owner to document the evidence and requirements that they need.

Another tool that was used during the improvement phase was the Failure Mode and Effect Analysis.

A successful FMEA activity helps to identify potential failure modes based on experience with similar products and processes or based on common physics of failure logic. It is widely used in development and manufacturing industries in various phases of the product life cycle [2]. Effects analysis refers to studying the consequences of those failures on different system levels.

Risk Type	Risk Event	Impact of Risk Event	SEV	Risk Causes	OCC	Current Controls	DET	RPN	Response	Recommended Mitigation	Actions Taken	SEV	OCC	DET	RPN
Technical	Lack of knowledge	Lack of knowledge about the existing process and /or taking more time	10	Lack of knowledge about the Product Realization process	8	Monthly inspection process	10	800	Mitigate	Training to all employees	Management to review the attendance sheet	10	8	2	160
Technical / Schedule	Lack of enough Process Owners	Process Owners are assigned to more than 5 projects	9	Managers does not assigned process owner	7	Management made the assignments	10	630	Mitigate	Management made the assignments	Management shall distribute the projects and assigned more resources	6	6	2	72
Technical	Reviewing Product Realization requirements	Inability to identify gaps	10	Lack of knowledge about the Product Realization process	8	Monthly inspection process	10	800	Mitigate	Assigned more people in the project	N/A	10	8	2	160
Technical	Identify Gaps	Incorrect or missed gaps identified	10	Lack of knowledge about the Product Realization process	5	For each process there us a responsible to update as necessary	10	500	Accept	N/A	Prioritize the gaps for the closure and identification process	8	2	2	32
Technical	Not able to close gaps	Final product would not be delivered on time	10	Not enough personnel to close the gaps	7	None	10	700	Mitigate	N/A	Prioritize the gaps for the closure and identification process	8	2	2	32
Technical	Not able to provide training on time	Traning will not provided on time	10	Process owners does not attend to the training as schedule	3	None	10	300	Accept	Taking the attendeance and provide the list to management	Create more trainign sections	10	5	2	100
Cost / Schedule	Not able to update procedures	Final product would not be delivered on time	10	Not enough personnel to making the changes	4	For each process there us a responsible to update as necessary	10	400	Accept	Assigned more people in the project	N/A	10	8	2	160

Figure 8
FMEA

Functional analyses are needed as an input to determine correct failure modes, at all system levels. An FMEA is used to structure Mitigation for Risk reduction based on either failure effect severity reduction or based on lowering the probability of failure or both. The FMEA is in principle a full inductive analysis; however the failure probability can only be estimated or reduced by understanding the failure mechanism. Ideally this probability shall be lowered to "impossible to occur" by eliminating the root causes. The figure 8 shows the FMEA for this project, using this tool we can determined that we need to work with the following risk in order to avoid potential failures; lack of knowledge, identify gaps, training and

release of the procedures with the new requirements.

Control Phase – Product Realization procedure were evaluated and updated for each of the requirements that were identify as necessary for the AS9100 compliance also a Monthly Inspection process were created in order to help the departments to identify their gaps before the audits and work with the evidence that they need. This inspection system will help them to understand better the requirements. The inspectors that has been assigned to each department were trained in each of the requirements and also get the AS9100 certification to get a better understanding of the requirements and they will help the process owner to understand the process and also provide training to them if is necessary.

CONCLUSION

The Product Realization process has been improved during the last two audits that were performed an increment from 83% to 97% was achieved using the DMAIC tools. The first goal of the project was achieve to increase the audit yield. The results of the audit demonstrate that we achieve these goals and also a survey to the customer was cerate and the results of the survey demonstrate that the customers are very satisfied with the improvements that were made to the process.

The second goal of the project was to reduce the risk to lose project and the AS900 certification that can represent 150,000 per year. This risk was eliminated because the customers were very satisfied and provides more work to the company.

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