

**PRE PRODUCTION PLANNING AND LEADTIME REDUCTION USING
SIX SIGMA**

by

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A Research Paper

Submitted in Partial Fulfillment of the

Requirements for the

Masters of Science Degree

in

Management Technology

Approved: 3 Semester Credits



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May, 2004

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ABSTRACT

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Pre Production and Lead time reduction using Six Sigma

(Title of Thesis)

Management Technology

(Graduate Major)

Dr. John Dzissah May 2003 42

(Research Advisor) (Date) (No. of Pages)

Publication Manual of the American Psychological Association.-5th ed.

(Manual Style)

Companies now look to get competitive by cutting down costs associated with operation and also beat competition by cutting their turnaround times. Six- Sigma has been known to be a chosen process improvement methodology and companies are now looking at it as a new age mantra, to improve process variations and help make profits.

The main objective of this study is to reduce the lead-times associated with the Pre-production department and also improve the internal process variation.

The literature review provides a basic background into Six Sigma. The methodology used for this study breaks down six sigma into its 5 basic steps of define, measure, analyze, improve and control, each part helps attain the final goal of reducing the downtimes associated with the lead-times. The scope of the project is to identify critical area of opportunity for improvement by analyzing the required, missed and incorrect information, define and document future state of pre-production planning processes and achieve full implementation and complete compliance of the future state.

ACKNOWLEDGEMENTS

Sincerely thanks to Dr. John Dzissah, my research director, for his professional direction and timely help to complete this research. In addition, deep thanks to Mr. Fazi Amirahmadi, Senior Management Engineer, New Wisconsin Outreach center, who provided me the opportunity to work on the project and help provide me with all the vital inputs. Finally, I want thank my parents for being a pillar of support and motivation at all times even though geographical boundaries separate them from me.

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Chapter 1

Introduction

Organizations today look to improve their business processes. The main objective being increasing the productivity by decreasing the process variation, leading to defect reduction and vast improvement in profits, employee morale and quality of product. Six-Sigma has been known to be a chosen process improvement methodology and companies are now looking at it as a new age mantra, which will improve process variations and help make profits.

Conceptualized by Bill Smith an engineer from Motorola, Six Sigma is a performance target that applies to a single critical-to-quality (CTQ), not to the total product. It is important to pay attention to the processes, because final outcomes or results are dictated by what happens during the process. When businesses create a better process, they eliminate opportunities for defects before they occur. By reducing the variation during creation of the products and services, it's possible for any business to achieve six-sigma quality. Every aspect of a business can improve its cost and profitability dramatically by using the Six Sigma breakthrough strategy.

This paper begins with a basic overview of the company for which this project/field problem was undertaken. It will detail why Six Sigma would be a major improvement to the current process. Finally the results of the project and further recommendation will be presented.

Statement of the study:

The goal of the project is to analyze Pre-Production planning processes to identify major areas of opportunity by reducing lead-time by 50%.

Needs for the study

Six Sigma was the best process improvement tool for the company for which this process was undertaken. The company for which this project was undertaken is in metal fabrication and machining business since 1965. They offer a complete range of services including fabrication, machining, welding, painting, assembly, and testing. The lead-time for taking orders needed to be reduced by 50% by analyzing the pre production process. The current pre-production process was more or less split up into 3 distinct departments- Customer Account Manager/Estimating, Quality and Engineering. The Customer Account Manager is responsible for reviewing the request for Quote from existing customer and will record the pertinent information. The same is forwarded to an estimator who makes efforts to ensure the customer requirements are defined and that the company has the ability to meet those requirements. Validations are done through various quote forms. The estimator passes the documents on to the Quality department, which in turn are passed on to engineering to check for requirements.. The information obtained is thus passed back to the customer account manager to be given as feedback to the customer. The company decided to go lean initially to improve process flow, but then opted the six sigma way to cut down process variations and streamline business processes.

Significance of Study

The company for which this project was undertaken is in metal fabrication and machining business since 1965. They offer a complete range of services including fabrication, machining, welding, painting, assembly, and testing. The pre production process, described above, goes through a series of touches resulting in increased lead times. There is no proper communication that exists between the departments as a result orders take much longer to get to the production or shop floor. The need for a step-by-step implementation of Six Sigma is therefore significant.

Research Delimitations

The scope of the project is identify critical area of opportunity for improvement by analyzing the required, missed and incorrect information, define and document Future State of pre-production Planning Processes and achieve full implementation and complete compliance of the future state. No efforts will be made to analyze the actual production process and its implications. The research is limited only to the Pre-production process.

Assumptions

1. The company has a basic understanding of Six Sigma and is willing to accept future changes in the system.
2. No money is available for buying new equipment or assigning new people to the operation.
3. Team will implement any decision based on good data and analysis.

Definition of terms

Six Sigma: A quality measure and improvement program developed by Motorola that focuses on the control of a process to the point of \pm six sigma (standard deviations) from a centerline, or 3.4 defects per million items. It includes identifying factors critical to quality as determined by the customer, reducing process variation and improving capabilities, increasing stability and designing systems to support the six-sigma goal.

(Bridge field group. Com)

Pre Production Process: Series of steps that go into a system prior to the actual production process on the shop floor.

Touches: The number of times the information is passed on from one department to another and vice versa.

Lead-time: (Retailing definition). The amount of time determined by a merchandiser to be necessary to add on to the purchasing period in order to assure that sufficient merchandise will be on hand until the particular order is received. (American Marketing Association, 2003)

Chapter 2

Some claim that Six Sigma has its origins in Statistical Process Control (SPC), others in Total Quality Management (TQM). With the concept of the normal curve, Carl Frederick Gauss (1777-1855) first identified the roots of Six Sigma as a measurement standard. As a measurement standard in product variation, Six Sigma can be traced back to the 1920's when Walter Shewhart showed that three sigma from the mean is the point where a process requires correction. Many measurement standards (Cpk, Zero Defects, etc.) later came on the scene but credit for coining the term "Six Sigma" goes to a Motorola engineer named Bill Smith. Motorola felt that the concept of measuring defect per thousand opportunities did not provide enough information. Motorola developed this new standard and created the methodology and needed cultural change associated with it. Six Sigma helped Motorola realize powerful bottom-line results in their organization - documented more than \$16 Billion in savings as a result of their Six Sigma efforts. (Motorola, 2004). GE Aircraft Engines in Canada also uses Six Sigma Green Belts to perfect paperwork when GE Canada imports a marine and industrial engine, parts and tooling for a Canadian customer. In addition to cutting customer's costs, Green Belts in these companies have reduced border delays by 50 percent. (Pande & Cavanagh, 2003).

Consequently, countless number of companies have now implemented and initiated Six Sigma methodologies to improve their business processes and bring in efficiencies. Companies such as Motorola and GE have seen tremendous improvements in costs and financial benefits. Implementing Six Sigma into their corporate culture improved processes, maximizes business performance, and adds to your bottom line. What makes

Six Sigma work is well-chosen training and a top-down commitment that infiltrates any organization. Thus, Six Sigma needs to be business driven rather than technology driven and companies across the world are now understanding the need to streamline their business processes and achieving 3.4 million defects per million opportunities. (Peter Pande, 2002).

Until, recently many companies were not sure that quality of service could even be measured but now through the application of Six Sigma, quality can be measured by clearly defining the processes that occur in a service, and identifying those processes important to customer satisfaction.

Benefits of Six Sigma: (Robert P. & Roland, 1998)

1. Generates sustained success: Six Sigma creates the skills and culture for constant revival.
2. Sets a performance goal for everyone: Anyone who understands customer requirements can assess their performance against the six sigma goal of 99.9997 percent “perfect”- a standard so high that it makes previous “excellent” business processes look very weak.
3. Enhances value to customer: This means learning what value means to the customer and planning how to deliver it to them profitably.
4. Accelerates the rate of improvement: With information technology setting the pace by doubling its performance to cost ratio every 18 months, the customer expectation for improvement gets more demanding.

5. Promotes learning and executes strategic change: Introducing new products, launching new ventures, entering new markets, acquiring new organizations enhances education and learning. The communication is what matters.

Overview of the Six-Sigma Strategy

Six Sigma initiatives can be carried out in various stages and various steps. One such approach is to Design, Measure, Analyze, Improve and Control (DMAIC). It is to a data-driven quality strategy for improving processes, and forms an integral part of the company's Six Sigma quality initiative. Each step in the cyclical DMAIC Process is required to ensure the best possible results.

The Process steps:

Define the Customer, issues that are critical to quality, and the Business Process involves the followings:.

1. Define who customers are, what their requirements are for products and services, and what their expectations are.
2. Define project boundaries - the stop and start of the process
3. Define the process to be improved by mapping the process flow

Measure the performance of the Core Business Process involves.

1. Developing a data collection plan for the process
2. Collecting data from many sources to determine types of defects and metrics

3. Comparing customer survey results to determine shortfall

Analyze the data collected and process map to determine root causes of defects and opportunities for improvement involves

1. Identifying gaps between current performance and goal performance
2. Prioritizing opportunities to improve
3. Identifying sources of variation

Improve the target process by designing creative solutions to fix and prevent problems involves.

1. Creating innovative solutions using technology and discipline
2. Developing and deploying implementation plan

Control the improvements to keep the process on the new course involves

1. Preventing reverting back to the "old way"
2. Requiring the development, documentation and implementation of an ongoing monitoring plan
3. Institutionalize the improvements through the modification of systems and structures (staffing, training, incentives).

Chapter 3

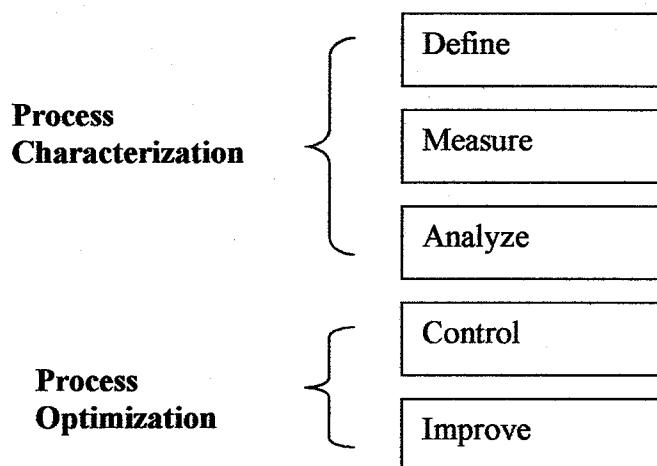
Methodology

The approach for this field problem was qualitative and the study provided an in depth scrutiny of the program situations, events, employee interactions and observed behavior. Qualitative research is exploratory and open-minded which was applicable to this study (Patton, 1987).

Methodology:

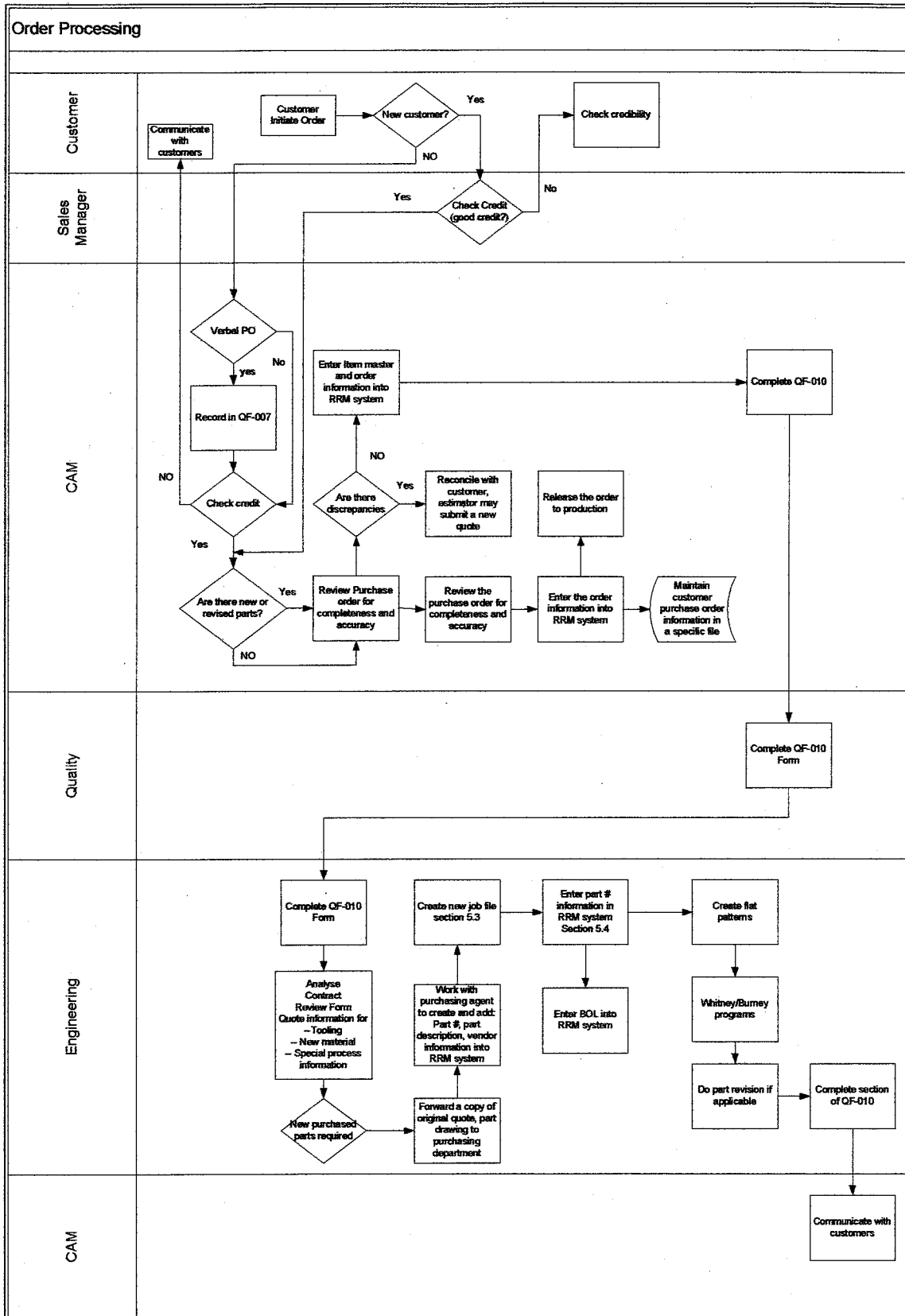
1. Design
2. Measure
3. Analyze
4. Control:
5. Improve

Figure 3.1: Six Sigma Methodology



The current process flow was designed and studied. The process flow is as shown

Figure 4.2: Cross Functional chart



DEFINE:

The project needs were evaluated through meeting and data collection techniques to determine the customers, define the customer expectation and also the scope and focus of the project. The researcher uses process maps to identify critical Inputs and Outputs (X's and Y's). The purpose is to understand the current state, its issues, the potential cost savings and gained productivity.

The define phase was initiated by interviewing various levels within the organization to define the current state. The Project Team selected includes individuals from various departments which are the Customer Account Manager, the Estimating, Quality and Engineering. Interviews were conducted with people in charge of pre production plan in different departments to assist in identifying areas of opportunity to reduce the lead time and number of missed/incorrect information. The interview covered the areas below:

- Definition of the Current State: research and document the current stage
- Definition of the Future State
- Data Collection
- Process Analysis

The next step was to identify who the customers were. The study identified customer's of the project to be:

- Outside Clients/Customers
- Sales
- Production/Manufacturing area

Customer Expectations were analyzed and key factors were considered which included:

- Reducing lead times
- Reducing the amount/number of missed/incorrect information
- Reducing the number of Adjustments/Touches

MEASURE:

This step in the Six Sigma process of the field part was incorporated for data collection and also to visualize the current state with the help of numbers. The researcher spent most of the time reviewing the ‘nuts and bolts’ of understanding and carrying out good measures, which in turn helped identify relative strengths and weaknesses in and between your processes- a key input to good project selection for the analyze phase (Peter Pande, 2002).

Types of information or data collected were:

- Customer Name
- Due date from Customer
- Lead times for related departments
- Number of Errors
- Types of Errors
- Missed information
- Number of touches/Adjustments for each department.
- Roll Through yield for the pre production process
- Measure the current Z values of the process

ANALYSE:

The researcher evaluated the data to determine variables and relationships between the variables that may have an impact on the pre production process lead-time. Tools used for analyze included graphs, correlation and regression analysis and pareto charts.

The objective being:

- a) To visually determine if there exists a significant correlation among the variables
- b) Help determine what impact the input and output variables may have on the process
- c) To gain a better understanding of the variables and relationships between them.
- d) To isolate key pieces of information, that is critical to explain the number of defective products.

IMPROVE:

This phase focuses on discovering the key variables that cause the problem and proposing alternate solutions to solve the problem in the problem statement and support the goal statement.

The objective was to identify and put into place and maintained. The methodology used was:

- 1) Create FMEA (Failure modes and effects analysis) to identify an improvement to the process

- 2) Cause and Effect Analysis
- 3) Used checklists to reduce the number of missed and/or inaccurate information
- 4) Create a list of action items

CONTROL:

Finally the control phase ensured that the same problem didn't occur by continuously monitoring the process and to 'maintain the gain'. The methodology used was:

- 1) Create control chart to communicate action items for process to process owners
- 2) Communicate to the management the necessary approvals and buy-in to the process change and owners for control.

Chapter 4:

RESULTS OF THE STUDY

Define:

Much of the define phase was spent understanding the present set up. The researcher identified the input and output variables of the system in order to understand what impact the variables had on the problem. For this purpose the SIPOC (Supplier, Inputs, Processes, Outputs and Customers) as shown in table 4.1 was created.

Table 4.1: SIPOC (Supplier, Inputs, Processes, Output and Customers)

Suppliers	Inputs	Processes	Outputs	Customers
Outside	Customer	Customer Account	QF-010	Outside
Clients	Information	Manager	Form	clients and
Customers	PO #	Estimating	Other	customers
	RFQ	Department	supporting	Sales
	Parts	Quality department	documents	department
	Information	Engineering		Production %
		department		Manufacturing
				dept.

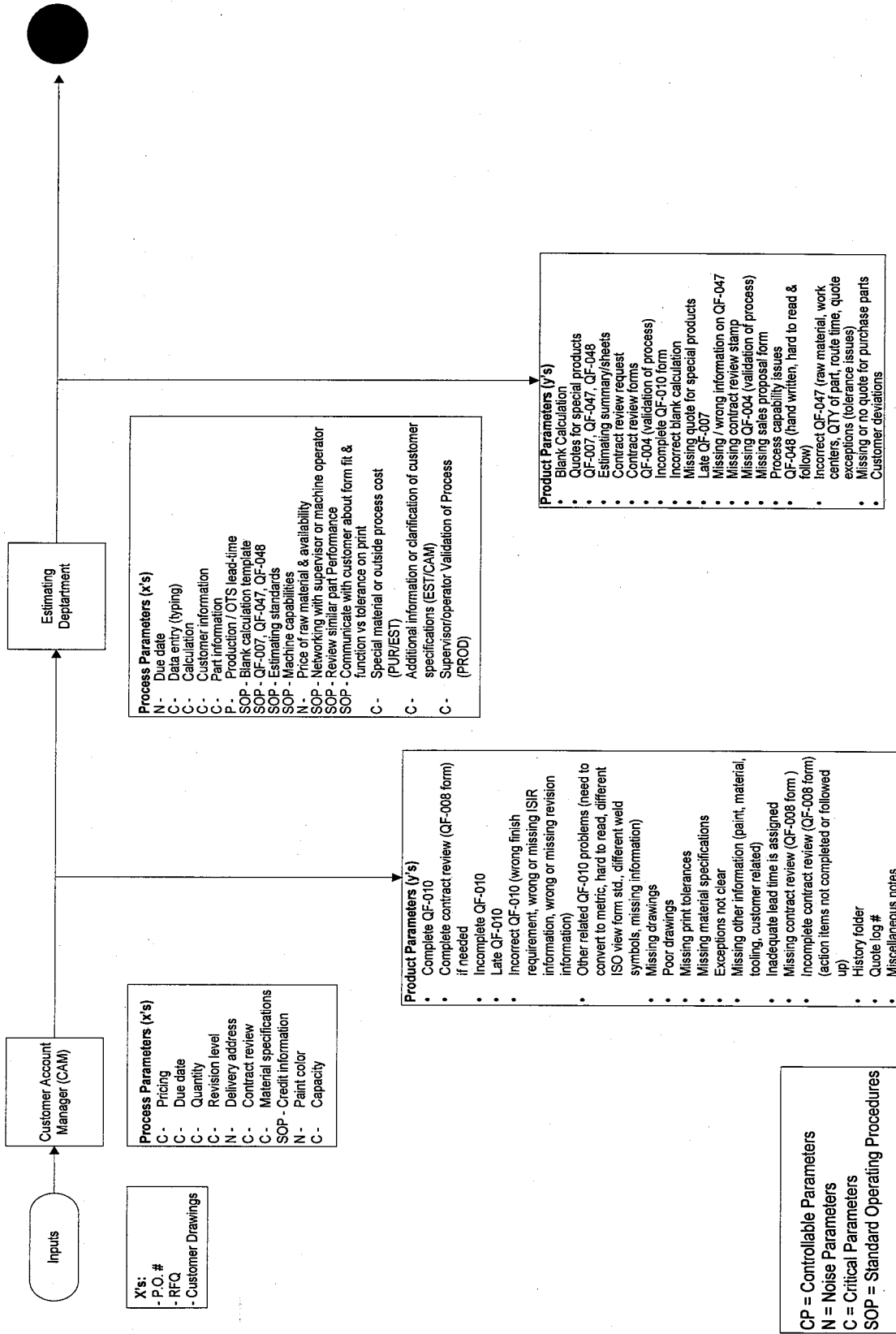
The current state of the Pre Production Planning Process was defined along with the goals of the project. The objective being to reduce the lead-time for Pre Production Process by 50%, eliminate the number of missed or incorrect information and reduce the number of touches/adjustments to 5-6 touches per QF-010.

Measure:

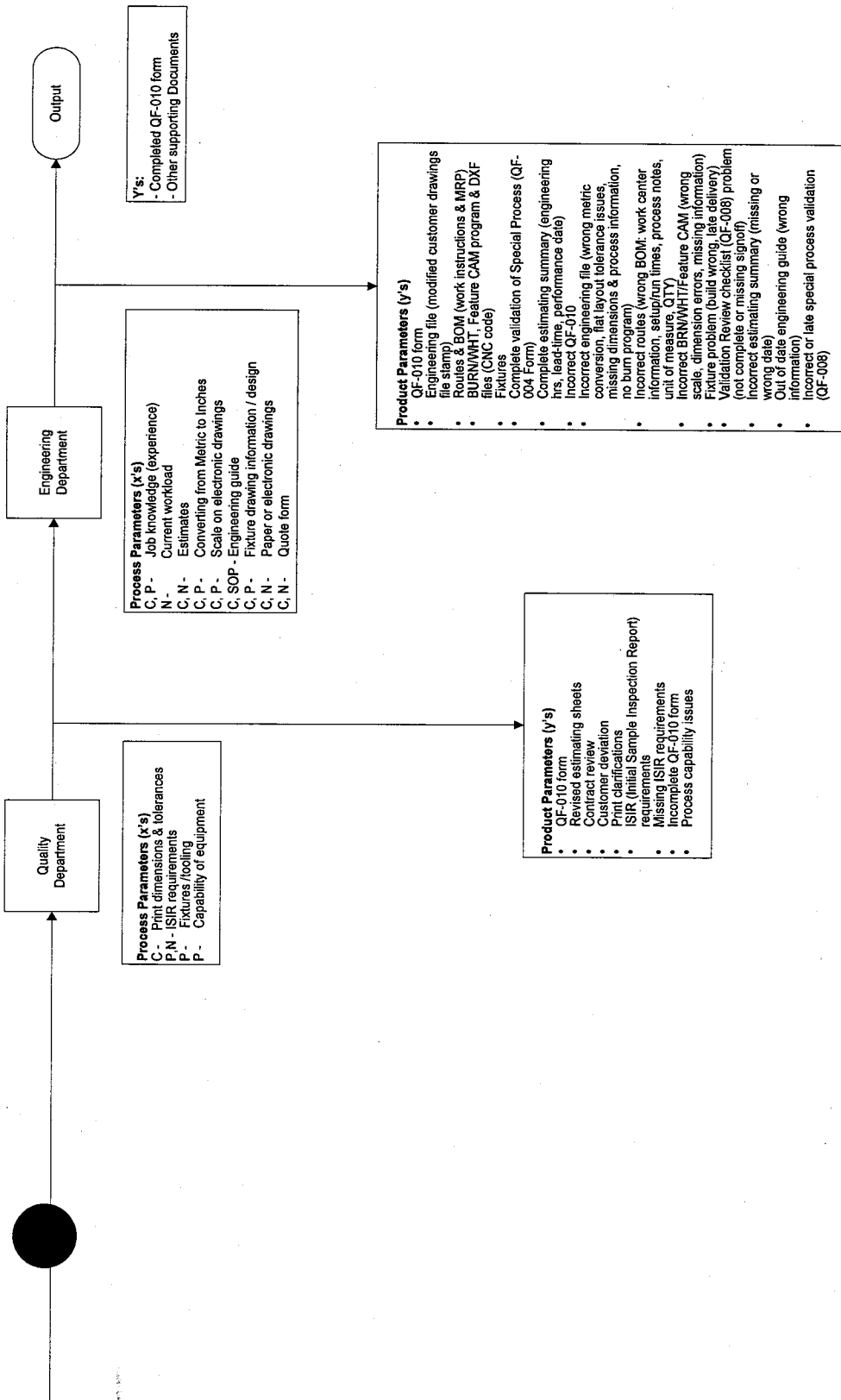
The researcher began measuring the process capability of the process, in order to see if the process was under control and also to define the input/output variables of the process and validate the measurement system. Existing documents and procedures used in creation of the QF-010 forms were reviewed.

Process Mapping: the entire process was mapped as shown below, through each of the processes, i.e. Customer Account Manager, Estimating, Quality and Engineering. Activities at each individual department were studied and identified as critical, value adding and non value adding.

Pre Production Process Map

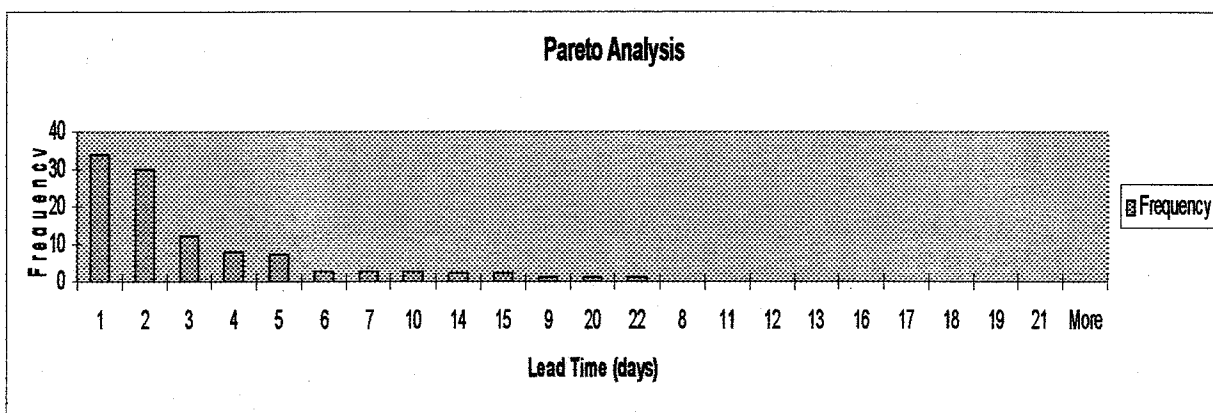


Pre Production Process Process Map



In order to track the number of missed or incorrect information and also the number of touches related to lead times, data from clients were gathered over a period of 6 months. The data gathered had the customer names, due dates from the customer, lead times for related department, error and types of errors, number of touches for each department.

Table 4. 3: Pareto Analysis



LeadTime	1	2	3	4	5	6	7	10	14	15	9	20	22	More
Frequency	34	30	12	8	7	3	3	3	2	2	1	1	1	0
%	32%	28%	11%	7%	7%	3%	3%	3%	2%	2%	1%	1%	1%	0
Total %	32%	60%	71%	79%	85%	88%	91%	93%	95%	97%	98%	99%	100%	0

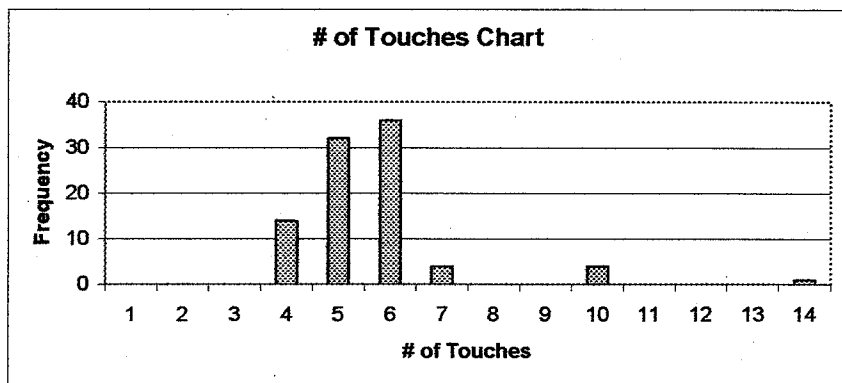
The table 4.3 indicated that about 85% of the Request for Quotes (RFQs) takes only 5-day to process. This was an indication that there were two types of Request for Quotes (RFQs). The first type needs less time to go through the system and the second type of

RFQs need more time for estimation, quality, and engineering. Also based on the available data, RFQs from certain customers needed more time to process. The researcher also recorded the types of customers that took longer to process. Therefore, the decision was to treat these RFQs differently. So it was now important to focus on those RFQs that took only 5-day or less (85% of RFQs).

Since the present number of touches was unacceptable by the management, the need to monitor them and cut them down was important. Graphs were thus drawn which helped identify the maximum and minimum number of touches between departments.

Table 4.4: Number of Touches and Frequency

# of Touches	Frequency
1	0
2	0
3	0
4	14
5	32
6	36
7	4
8	0
9	0
10	4
11	0
12	0
13	0
14	1



Average number of touches = 5.6

Minimum number of touches = 4

Maximum number of touches = 14

The researcher captured the different types of errors and the maximum numbers of errors were generated by the Customer Account Manager, followed by the Engineering department.

Table 4.5: Number of Errors by department

Department	Number of Errors
Estimating	1
Sales	2
Quality	0
Engineering	6
Customer Account Manager	12

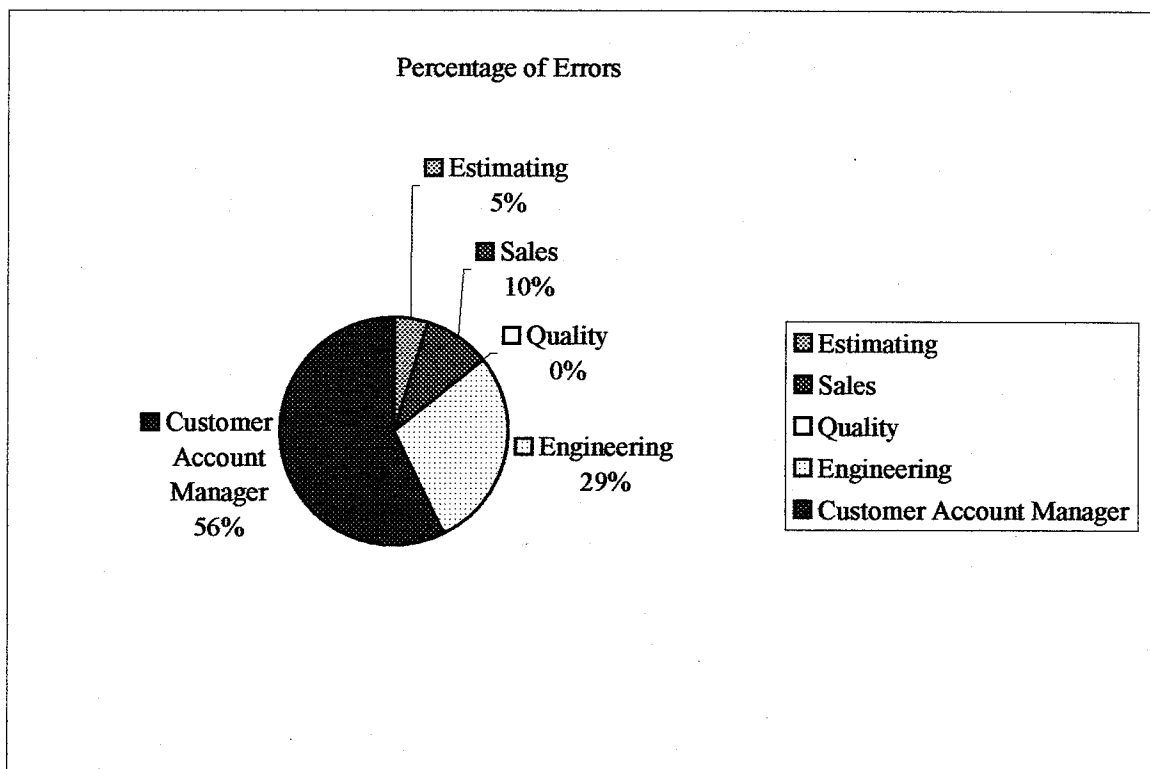


Figure 4.3 : Error percentages by Department

The next step was to identify the process capability of the system was then identified. The assumption made was, if the Pre production Process (RFQ) had a lead-time for more than 2 days then it accounted for a defect. Keeping this in mind the results were tabulated as follows:

Table 4. 6: Rolled Throughput Yield (RTY)

	Pre Production Process	Pre Production Process (RFQ) is defective if the lead time is more than 2 days
Units In	91	=units out
# Opportunities/unit	1	
Total Opportunities	91	
# First Time Pass	64	=Average First Pass
Scrap	0	=Total Scrap
# Reworked Defects	27	
# Defects	27	=Total Defects*
FPY	70.33%	=First Pass YIELD
Y _{TP}	70.33%	=Throughput YIELD
DPO	0.297	=Total Defects per opportunity
RTY (Y _{TP1} *Y _{TP2} ...)	70.33%	=Rolled Throughput Yield
RTY (exp(-TDPO))	74.33%	= e-DPO = RTY

1-RTY	0.297	
Z from table zlt	0.535 sigma	
Pp	0.17833	
Zst = Zlt + 1.5	2.035 sigma	=296,350 DPPM
Cp	0.67833	

Table 4.6 above showed the process to be incapable with its process capability being less than 1. Moreover the total defects per opportunity accounted for .297 defects which did not even account anywhere close to the 3.4 million defects per million opportunities which was a Six Sigma standard. The present process accounted for 296,350 defects per

million opportunities. The objective was to bring the process capability to a value greater than 1 and to reduce the number of variations within the system.

ANALYSE:

In order to evaluate the data and determine variables and relationships between variables that may have an impact on the pre production process lead-time, the researcher drew graphs to visually determine the following:

- a) To visually determine if there exists a significant correlation among the variables
- b) Help understand what impact the input and output variables may have on the process
- c) To gain a better understanding of the variables

Table 4.7: Correlation among: Total number of Touches (Max 5-6), Total number of ERRORS, and Total # of ERRORS

	<i>Total # of Touches (Max 5-6)</i>	<i>Total # of ERRORS</i>	<i>Total # of ERRORS</i>
Total # of Touches (Max 5-6)	1		
Total # of ERRORS	0.46794698	1	
Order Processing Lead Time (Quality + Engin.) days	-0.040179547	-0.088784709	1

There seemed to be a positive correlation between the total number of errors and the total number of touches. In other words, as the number of touches increased the possibility or the likelihood of it resulting in an error thus increased.

Table 4. 8: Correlation among: QUALITY DEPT (days), ENG DEPT (days), and Order Processing Lead Time (Quality + Engineering) days

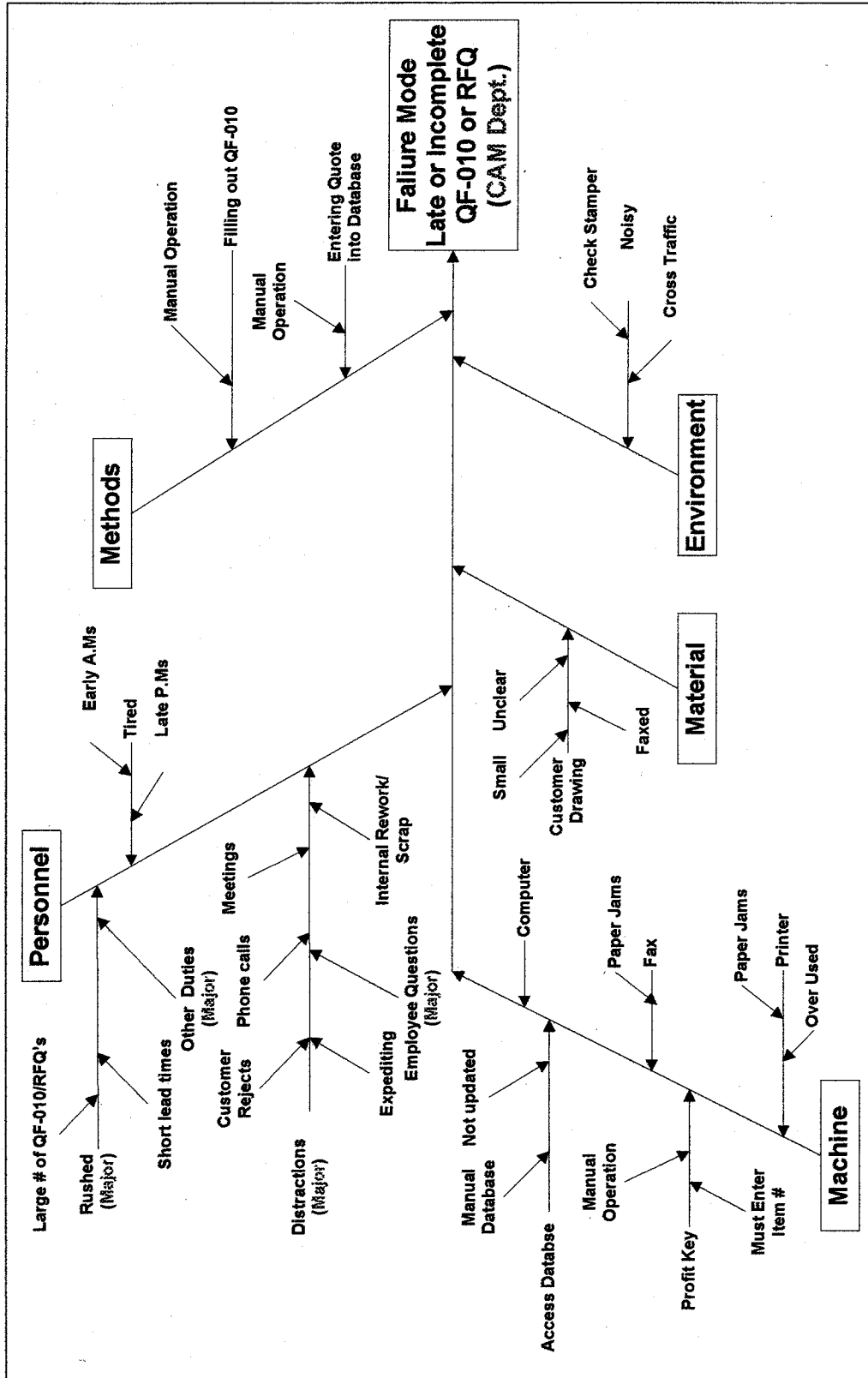
	QUALITY DEPT (days)	ENG DEPT (days)	Order Procesing Lead Time (Quality + Engin.) days
QUALITY DEPT (days)	1		
ENG DEPT (days)	-0.017624268	1	
Order Procesing Lead Time (Quality + Engin.) days	0.666935701	0.733245289	1

However there exists a negative correlation between the order processing lead-time (in days) between the quality and engineering department and the total number of touches.

IMPROVE:

In order to put into place and maintain an improvement to the process, the researcher drew a series of cause and effect diagrams for each department, in order to identify the areas, which directly or indirectly effect lead times. Detailed below in table 4.9 is the cause and effect diagram for the Customer Account Managers department.

Table 4.9: Cause and Effect



FMEA (Failure Modes and Effects Analysis)

In order to anticipate problems so that steps can be taken to counteract them and reduce and eliminate them, the researcher developed the basic model for a FMEA by brainstorming all the potential ways the anticipated change in a process or service could fail. The failures were then listed down and potential causes of these failures were then identified.

As seen in table 4.10 a and b, failure modes for each department were tabulated and its corresponding RPN (Risk Priority number) was tabulated. A rating scale was thus formulated as follows:

- S – Severity: what is the effect or impact?
- O- Occurrences: How often you think type of failure could occur?
- D – Detection: What controls or measures are in place that would increase your chances of detecting this failure.

The above rating scale is then used to identify the Risk Priority Number and the researcher then assigned responsibilities to carry through the actions. The main objective was to identify ways in which a change in a process, product, or service may cause unintended problems- so that appropriate countermeasures can be developed.

Table 4.10 a: CAM FMEA

Part/process	Failure Mode (External Customer)	Failure Effects	SEV	Causes	OCC	Controls	DET	RPN	Action Recommended
CAM	Late or Incomplete QF-010 or RFQ	Delay requesting Quote from Est.	6	Lack of resource due to other duties	7	NONE	8	336	Develop Delegation List and review Open Quote database to include Performance Measures
		Delay entering RFQ in Quote Log	4	Lack of resource due to other duties	6	Est. Dept.	1	24	Develop Delegation List and review Open Quote database to include Performance Measures
		Forward incomplete RFQ	5	Interruptions	7	Est. Dept.	3	105	Evaluate/Develop Check List
		Delay requesting addition info from cust. required for quoting	7	Lack of resource due to other duties	6	Est. Dept.	4	168	Develop Delegation List for times of increased sales
		Delay entering order into Profit Key	7	Lack of resource due to other duties	4	P.O. Status Report	5	216	Develop Delegation List for times of increased sales
		Delay processing QF-010 form	7	Lack of resource due to other duties	6	P.O. Status Report	5	288	Develop Delegation List for times of increased sales
		Forward incomplete QF-010	4	Interruptions	6	Quality/Eng. Review of QF-010	4	120	Evaluate/Develop Check List
		Delay requesting addition info from cust. required for processing	7	Lack of resource due to other duties	6	Quality/Eng. Review of QF-010	5	240	Develop Delegation List for times of increased sales
		Overlook inspection requirements	8	Interruptions	6	Shipping Pick List	3	144	Evaluate/Develop Check List
		Overlook finish requirements	9	Interruptions	6	Quality/Eng. Review of QF-010 & ISIR System	4	216	Evaluate/Develop Check List
		Delay scheduling W.O.'s	7	Lack of resource due to other duties	6	Planned Order Report	4	192	Develop Delegation List for times of increased sales
		Delay Filing QF-010	3	Lack of resource due to other duties	10	Visual	4	200	Develop Delegation List for times of increased sales

Part/process	Failure Mode (External Customer)	Failure Effects	SEV	Causes	OCC	Controls	DET	RPN	Action Recommended
Estimating	Late or Incomplete RFQ	Late Quote	5	Incomplete / Missing prints or Specs.	5	Quote Log	1	25	Develop CAM check list.
		Quote Wrong Mat'l	7	Incomplete / Missing prints or Specs.	3	Eng Dept or Contract Review	4	70	Develop quote check list.
		Non-Conforming Product	8	Incomplete / Missing prints or Specs.	3	Eng Dept, Contract Review & ISIR System	2	28	Develop quote check list.
		Low or No Gross Margin	6	Incomplete / Missing prints or Specs.	4	Contract Review	5	96	Develop quote check list & Project Review.
		Late Customer Delivery	7	Incomplete / Missing prints or Specs.	3	Open Order Spreadsheet	2	12	Develop CAM check list.
		Quote wrong work center	3	Incomplete / Missing prints or Specs.	3	Eng Dept, Contract Review or Supervisor Review	1	6	Review/Revise Quote Procedures & Training
Part/process	Failure Mode (External Customer)	Failure Effects	SEV	Causes	OCC	Controls	DET	RPN	Action Recommended
Quality	Late or Incomplete QF-010 or RFQ	Non-Conforming Product @ Customer	8	Poor Review of Prints	5	Contract/ENG review & ISIR	3	147	Review/Improve Contract review/Project Management
		Late shipment due to print issue	7	Poor Review of Prints	6	Contract/ENG review & ISIR	3	105	Review/Improve Contract review/Project Management
		Late shipment due to Sale Prop, Form	7	Incomplete Order packet	3	Quality/ENG review	2	60	Review/Revise Quote Procedures & Training
		Late shipment due to Quote Form	7	Incomplete Order packet	3	Quality/ENG review	2	60	Review/Revise Quote Procedures & Training

Part/process	Failure Mode (External Customer)	Failure Effects	SEV	Causes	OCC	Controls	DET	RPN	Action Recommended
Engineering	Incorrect BRN/WHT / Feature CAM (wrong scale, dimension errors, missing information)	Late Shipment	7	Bad part dimensionally or bad code.	5	Actual Production/ISIR	2	70	Review Procedures/Training, Increase use of E-files
		Work Center Down time	5	Bad part dimensionally or bad code.	10	Actual Production.	2	100	Review Procedures/Training, Increase use of E-files
		Non-conforming Part (D&S)	6	Bad part dimensionally or bad code.	6	Actual Production/ISIR	2	72	Review Procedures/Training, Increase use of E-files
		Non-conforming Part (Customer)	9	Bad part dimensionally or bad code.	4	Actual Production/ISIR	2	72	Review Procedures/Training, Increase use of E-files
		Machine Damage	8	Bad part dimensionally or bad code.	4	Actual Production.	2	64	Review Procedures/Training, Increase use of E-files
		Dept. Trust/feature cam	4	Bad part dimensionally or bad code.	9	Actual Production.	2	72	Review Procedures/Training, Increase use of E-files
		Dept. Trust/parkson	3	Bad part dimensionally or bad code.	7	Actual Production.	2	42	Review Procedures/Training, Increase use of E-files
		Tooling Damage	6	Bad part dimensionally or bad code.	4	Actual Production.	2	48	Review Procedures/Training, Increase use of E-files
		Lost Prod due to rework (Eng)	3	Bad part dimensionally or bad code.	5	Actual Production.	2	30	Review Procedures/Training, Increase use of E-files
		no program	6	Missing or Bad Code	4	Actual Production.	2	48	Review Procedures/Training, Increase use of E-files

CONTROL:

It was important to make sure the changes made in the process was maintained and improved upon. Checklists were thus incorporated for each department and they were used as action items and implemented.

Inputs needed from Customer to CAM for revised/new parts (Unquoted)

- RFQ or revision notification from customer
- Customer information (accurate and updated)
 - ◆ Company Information
 - ◆ Delivery address
- Parts Information
 - ◆ Quantity
 - ◆ Delivery date
 - ◆ Material Specification
 - ◆ Customer Bill of Material
 - ◆ List of Customer supplied products
 - ◆ Paint Color
 - ◆ Tooling availability
 - ◆ Drawings
 - Good quality drawing
 - Current Revision Level
 - Legible Specifications & tolerance

Activities at CAM

- Request for contract Review or a validation check
- Credit check
- Enter RFQ in Quote Log & assign Quote Number
- Create History Folder
- Forward Information to Estimating

Inputs needed from Customer to CAM for New Part (Quoted)

- P.O. from customer
- Customer information (accurate and updated)
 - ◆ Company Information
 - ◆ Delivery address
- Parts Information
 - ◆ Quantity
 - ◆ Due Date
 - ◆ Revision Level
 - ◆ Paint Color

Activities at CAM

- Request for contract Review or a validation check
- Credit check
- Compare Current Revision & Paint color to Quote
- Request Electronic Files when possible (DXF, DWG or STEP)

- Update Open Order Report
- Initiate QF-010 form
 - Review QF-010 form for required information
- Forward QF-010 form and following information
 - Contract Review Form (When Available)
 - Current & Legible Customer Drawings & Bill of Materials
 - Estimate Form
 - Sales Proposal
 - Validation of Special Process (When Available)
 - Purchase or Outside Service quote information
 - List of Customer Supplied products
 - Fixture information (When Available)
 - Part Estimate Summary (When Available)

Inputs needed from CAM to Estimating for revised/new parts (Unquoted)

- Updated RFQ-10 form
- Customer information (see inputs to CAM)
- Parts Information (see inputs to CAM)
- History folder
- Quote log number
- Miscellaneous notes

Activities at Estimating

- Data entry and calculation
- Blank calculation template
- Production / OTS lead-time
- Creation of QF-007, QF-047, QF-048 forms
- Checking machine capabilities
- Pricing of raw material & availability
- Networking with supervisor or machine operator
- Review similar part performance
- Communicate with customer about form fit & function vs tolerance on print
- Clarification of customer specifications (EST/CAM)
- Supervisor/Operator Validation of Process QF-004 (PROD)
- Request Quote for New Purchase or Outside Services
- Request Contract Review as required
- Request Process Validation for new special process

Inputs needed from Estimating to CAM for revised/new parts (Unquoted)

- Customer information (see inputs to CAM)
- Parts Information (see inputs to CAM)
- History folder
- Quote log number
- Miscellaneous notes
- Special material or outside process cost (PUR/EST)

- QF-007, QF-047, QF-048 forms
- QF-004 (validation of process)
- Clarification of customer specifications
- Blank Calculation
- Quotes for special products
- Contract review request (contract review stamp)
- Sales proposal form
- Process capability issues
- Estimating sheets

Activities at CAM

- Initiate QF-10 form (Open Order)
- File Information (Order Pending)
- Conduct Contact Review (Open Order)
- Request Process Validation Completion (Open Order)

Inputs needed from CAM to Quality Existing/revised/new parts

- Updated RFQ-10 form
- Customer information (see inputs to CAM)
- Parts Information (see inputs to CAM)
- Miscellaneous notes
- Special material or outside process cost (PUR/EST)
- QF-007, QF-047, QF-048 forms

- QF-004 (validation of process)
- QF-008
- Clarification of customer specifications
- Blank Calculation
- Quotes for special products
- Contract review form
- Sales proposal form
- Process capability issues
- Estimating sheets
- Customer deviations

Activities at Quality

- Update QF-10 form
- Define ISIR requirements
- Review Quality Gauges & fixture requirements
- Review Capability of equipment
- Check the dimensions & tolerances
- Revise estimating sheets
- Check customer deviations
- Check contract review form
- Develop Quality Plan

Inputs needed from Quality to Engineering Existing/revised/new parts

- Updated RFQ-10 form
- Customer information (see inputs to CAM)
- Parts Information (see inputs to CAM)
- Miscellaneous notes
- Special material or outside process cost (PUR/EST)
- QF-007, QF-047, QF-048 forms
- QF-004 (process validation form)
- QF-008
- Clarification of customer specifications
- Blank Calculation
- Quotes for special products
- Contract review form QF-008
- Sales proposal form
- Process capability issues
- Estimating sheets
- Customer deviations
- Quality Plans & Quality requirements

Activities at Engineering

- Check contract review form
- Check for Customer supplied tooling
- Check for required new material

- Check for special process information
- For new parts, forward a copy of original quote, part drawings to purchasing department
- Work with purchasing department to create part number & description, lead-time information, vendor information. Enter the information into RRM system
- Create a new job file and enter the part information
- Enter BOM & BOL information into RRM system
- Create flat patterns
- Create BURN/WHT, Feature CAM program & DXF files (CNC code)
- Do part revision
- Update QF-10 form
- Check the dimensions & tolerances on drawings
- Revise estimating sheets
- Converting information (metric to inches, weld symbols, drawing views...)
- Initiate the Design/Construction of fixtures
- Check lead-time, standard template, location checklist
- Complete validation of Special Process Form
- Complete estimating summary (engineering hrs, lead-time, performance date)

Inputs needed from Engineering to CAM for Existing/revised/new parts

- Updated RFQ-10 form
- Customer information (see inputs to CAM)
- Parts Information (see inputs to CAM)

- Miscellaneous notes
- Special material or outside process cost (PUR/EST)
- QF-007, QF-047, QF-048 forms
- QF-004 (process validation form)
- QF-008
- Clarification of customer specifications
- Blank Calculation
- Quotes for special products
- Contract review form QF-008
- Sales proposal form
- Process capability issues
- Estimating sheets
- Customer deviations

Activities at CAM for contacting Customer

- Review available to release & tooling dates
- Review Contract Review for completion
- Schedule Work Orders
- File Customer Information

Chapter 5:

CONCLUSIONS AND RECOMMENDATIONS

The objective was to reduce the number of touches and the lead-time associated with the pre-production process. A Six Sigma methodology was used to reduce the variations in lead times and touches. The 5 six sigma methodology steps of define, measure, analyze, improve and Control were used to study the process and also to identify defective areas and help improve the business process.

The first stage of the process- 'Define' was used to study the current stage, its issues and potential cost savings associated with it. Customer expectations were analyzed and key factors such as lead times, number of missed/incorrect touches and number of adjustments were analyzed. The next step 'Measure' was used to visualize the current set up with numbers. The process capability of the system was found out along with the type of errors and also the number of touches. The 'Analyze' phase was used to analyse the data gathered. Correlations between engineering, quality and the number of errors were determined. The 'Improve' phase saw cause and effect diagrams drawn in order to pinpoint areas of failure. FMEA were drawn to recommend action for areas that had a high priority risk value. Series of checklists were used as 'control' tools to make changes to the system.

- 1) The readings in the measure phase show very high variation within the system. The present process accounted for 296,350 defects per million opportunities (As opposed to 3.4 defects per million opportunities associated with Six Sigma). The objective was to bring the process capability to a value greater than 1 and to reduce the number of variations within the system.
- 2) The cause and effect diagram shows large inconsistencies from the part of the customer with regard to the drawing given by them to the company. As a result the number of touches between the customer and the company were increasing. Efforts were made to standardize the template with each customer in order to cut down in variation arising from wrong customer drawings.
- 3) A detailed process map showed missing information arising from each department and that was passed on with out being corrected. Hence the use of checklists at the end of each process held each department more accountable for their work.
- 4) The Pareto table indicated that about 85% of the RFQs take only 5-day to process. This was an indication that there were two types of RFQs. The first type needs less time to go through the system and the second type of RFQs need more time for estimation, quality, and engineering. Also based on the available data, RFQs from certain customers needed more time to process. Therefore, the decision was to treat these RFQs differently. So it was now important to focus on those RFQs that took only 5-day or less (85% of Request For Quotes).
- 5) Some customers showed fewer touches with zero defects than others. This to a large extent can be further minimizing by standardizing quote forms.

- 6) Training within the department was also seen as a factor to cut lead times down, since some individuals took fewer than 5 touches with most orders.
- 7) The FMEA helped identify potential areas of failure. In the CAM department, lack of resources seemed to be the main cause for late or incomplete QF-010 forms or the RFQ. Performance measures and delegation lists were thus incorporated to help streamline the process. Additionally review in procedures and training helped cut down missing information and thus trimmed the internal process.

Recommendations:

Checklists were used as control tools. Based on the recommendation provided by the researcher, the various departments has seen a decrease in the number of touches and also cut lead times down to a significant extent. New responsibilities will have to be taken to further reduce the numbers hours available to process orders.

- 1) In December, department checklist to reduce the occurrences of missing information and customer errors were incorporated.
- 2) Estimating department started to standardize quote form and did some cross training to reduce the number of touches.
- 3) In January 4 new orders with zero errors 3 less touches and process time reduction of around 25%. Unfortunately due to capacity constraints our processing day average was 5 days.
- 4) In February we processed 18 new orders again with zero rejects, 7 less touches and again around 20 % reduction in process time.

The process average has improved to a large extent. At his point in time however, the company is seeing a reduction in orders being processed in March. In the future, they hope to find a better handle on things starting April.

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